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Boutique Academic Coaching & Tutoring

AP MICROECONOMICS · COURSE REVIEW AND PRACTICE

AP Microeconomics Mastery.

Every unit on the exam: clear explanations, worked graph and calculation examples, practice problems with full explanations, free-response practice, and a full-length practice exam, with a bonus second exam as a separate PDF.

INSIDE

Basic Economic Concepts · Supply and Demand · Production, Cost, and Perfect Competition · Imperfect Competition · Factor Markets · Market Failure and the Role of Government · Practice Exam · Reference



Table of Contents.

Six content areas of AP Microeconomics, an exam toolkit, a full practice exam, and a reference section.

Contents

Each section has an explanation, worked examples, and practice problems. Answers and explanations close every chapter. Click any entry to jump to that page.

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Welcome to AP Microeconomics.

The ideas, the graphs, the calculations, and the practice you need for the exam.

Welcome How to Use This Book

A complete AP Microeconomics course: clear explanations, worked examples, practice problems with full explanations, and practice exams.

What is inside

All six content areas of AP Microeconomics, in order. Start Here covers the exam and the graphing and calculation habits that earn points. Chapters 1 to 6 hold the course; each has explanations, worked examples, three practice sets per section, a 30-question multiple-choice set and four free-response questions. A full practice exam (plus a bonus second exam as a separate PDF) and a reference section close the book.

Your situation	Study plan
Taking the course now	Work one chapter at a time as your class does, then do that chapter's multiple-choice and free-response sets.
Starting 6 weeks before the exam	Read Start Here, then do two sections a day, mark weak chapters, and take the practice exam at the end of week 4.
Final week	Redo missed problems, drill the graph gallery and formula sheet, and take the bonus Practice Exam 2 (separate PDF) under timed conditions.

A routine that works

- 1. Read.** Study the key boxes, then work each example yourself before reading its solution.
- 2. Practice.** Do every Set A problem, then Sets B and C. Write your answers before you look.
- 3. Check.** Compare with the answers and explanations at the end of the chapter. Mark mistakes and note the reason, not just the right answer.
- 4. Review.** Return to missed problems the next day, then do the multiple-choice and free-response sections and the practice exams.

Graphs earn points

Label both axes, every curve, the equilibrium or profit-maximizing point, and shaded areas. Draw one clear graph for each question part.

Calculations

Show the formula, substitution, and units. A correct number with no setup often earns no credit.

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Start Here: The Exam and Your Toolkit.

3 sections with explanations and worked examples, then 42 practice problems. Answers and full explanations are at the end of the chapter.

0.1 The AP Microeconomics Exam: Format, Scoring, and Study Plan

Learn exactly how the exam is built and scored, where students lose points, and how to organize your preparation.

AP Microeconomics is a two-hour-ten-minute exam built from two sections. **Section I** is 60 multiple-choice questions in 70 minutes, each with five choices, and it is worth two-thirds of your score. **Section II** is three free-response questions (FRQs) in 60 minutes, worth the remaining third. Calculators are allowed on both sections, and there is no penalty for wrong answers, so you should never leave a multiple-choice question blank.

Part	Questions	Time	Weight	Per-item time
Section I: multiple choice	60	70 min	66.7%	about 70 seconds
FRQ 1 (long)	1, worth 10 points	about 25 min	16.7%	graph, calculations, explanations
FRQ 2 (short)	1, worth 5 points	about 17 min	8.3%	usually one graph
FRQ 3 (short)	1, worth 5 points	about 17 min	8.3%	often a market-failure or factor-market scenario

Exam facts to memorize

Multiple choice: 60 questions, 70 minutes, 66.7% of the score, no wrong-answer penalty.

Free response: 3 questions, 60 minutes, 33.3% of the score. The long question is worth 10 points; each short question is worth 5.

Your raw composite is converted to the 1 to 5 AP score. Exact cut points move a little each year, so aim for mastery of every unit instead of chasing a percentage.

The exam covers six units, but they are not weighted equally. Supply and demand and the cost and perfect-competition unit together make up nearly half the exam, and the ideas in them (marginal thinking, graphs, surplus) reappear in every other unit.

Unit	Topic	Approximate exam weight
1	Basic economic concepts (scarcity, opportunity cost, PPC, comparative advantage)	12 to 15%
2	Supply and demand (equilibrium, elasticity, controls, surplus, taxes, trade)	20 to 25%
3	Production, cost, and perfect competition	22 to 25%
4	Imperfect competition (monopoly, monopolistic competition, oligopoly, game theory)	15 to 22%
5	Factor markets (labor demand, MRP, hiring rule)	10 to 13%
6	Market failure and the role of government (externalities, public goods, inequality)	8 to 13%

How FRQs are scored. Each FRQ is split into lettered parts, and every part is worth one or more independent points. A grader follows a rubric and gives a point when your response contains the required element, even if a different part of your answer is wrong. The most common point patterns are:

- ◆ **Graph points:** correct axis labels (for example Price and Quantity, or Wage and Quantity of Labor), correctly labeled curves, and the equilibrium or optimum marked with a dotted line to each axis.
- ◆ **Shift points:** the right curve moves in the right direction and the new curve is labeled (for example D2).
- ◆ **Calculation points:** a correct number, usually with work shown. A correct answer with units and the setup is safest.
- ◆ **Direction points:** a statement such as "price rises" or "profit is zero".

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- ◆ **Explanation points:** a reason using the words because, so, or therefore. A direction without a reason earns nothing on an "explain" part.

Where students lose points. Almost all lost points come from a short list of habits, and each one is fixable with practice:

- ◆ Unlabeled axes or curves, or labeling a marginal revenue curve as demand.
- ◆ Marking Q^* but not P^* , or drawing the dotted line only to one axis.
- ◆ Saying "it increases" without naming what increases (price, quantity, profit, or demand).
- ◆ Answering a different question: the part asks for the long run and you describe the short run.
- ◆ Writing a number with no work when the part says "show your work".
- ◆ Contradicting yourself, for example drawing a leftward shift and then saying demand increases.

EXAMPLE 1: BUILDING A TIME BUDGET

You want to finish all 60 multiple-choice questions with 10 minutes left over to revisit flagged items. How many seconds can you spend per question on the first pass?

SOLUTION

Total time is 70 minutes. Reserve 10 minutes for review, leaving 60 minutes for the first pass.

60 minutes = 3,600 seconds. Divide by 60 questions: $3,600 / 60 = 60$ seconds per question.

Rule: if a question is not moving after about 60 seconds, eliminate what you can, guess, flag it, and move on. Graph and calculation items often take longer, so bank time on quick recall items.

EXAMPLE 2: SHOULD YOU GUESS?

There is no penalty for wrong answers. You have 8 questions left with 20 seconds remaining. Compare the expected number of correct answers from random guessing with the expected number after eliminating two choices on each question.

SOLUTION

Random guess among 5 choices: probability of success is $1/5 = 0.20$. Expected correct = $8 \times 0.20 = 1.6$.

After eliminating two wrong choices, 3 remain: probability $1/3$. Expected correct = $8 \times (1/3) = \text{about } 2.67$.

Conclusion: always answer every item, and spend spare seconds eliminating choices, because each eliminated choice raises the chance of a point.

EXAMPLE 3: SCORING A SHORT FRQ

FRQ stem (5 points): Demand for a good sold by perfectly competitive firms increases. (a) Draw a correctly labeled market graph and show the change in equilibrium. (b) What happens to the short-run profit of a typical firm? (c) Explain what happens to the number of firms in the long run. A student writes: a graph with labeled axes, D and S, equilibrium P_1 and Q_1 , and a shifted curve labeled D_2 with a new price P_2 shown by dotted lines. For (b) the student writes "profit goes up". For (c) the student writes "firms enter because profits are positive, which shifts supply right and lowers price back to the minimum of ATC". How many of the 5 points are earned?

SOLUTION

Part (a) typically has 2 points: one for labeled axes and curves with equilibrium, one for the rightward demand shift with higher P and Q . The student earns both: 2 points.

Part (b) is 1 point for stating that economic profit becomes positive (price exceeds ATC). "Profit goes up" is vague but points the right way; a strict grader wants "positive economic profit". Treat as earned, with the warning that precise wording is safer: 1 point.

Part (c) is 2 points: entry occurs because of positive profit, and supply shifts right until price falls to minimum ATC and profit is zero. The student gives both: 2 points.

Total: 5 of 5. Notice every point came from a specific, checkable element, which is how you should write.

Exam tip

Read the command word first. "Calculate" wants a number, "explain" wants a because, "draw" wants a labeled graph. Underline the word, answer exactly that, then stop. Extra correct statements do not earn extra points, and a wrong extra statement that contradicts your answer can cost you the point.

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Study plans. Both plans below assume you complete the lessons and the practice sets in each unit and then do timed mixed practice. In either plan, the last two weeks should be cumulative: do not study units in isolation near the exam, because the exam mixes them.

Week	6-week plan (about 6 hours a week)	12-week plan (about 3 hours a week)
1	Units 1 and 2	Unit 1 plus the graph and calculation toolkit
2	Unit 3	Unit 2, part 1 (equilibrium, shifts)
3	Unit 4	Unit 2, part 2 (elasticity, surplus, controls, taxes)
4	Units 5 and 6	Unit 3, part 1 (production and costs)
5	Graph drills and FRQ practice, all units	Unit 3, part 2 (perfect competition)
6	Two full timed practice exams, then error review	Unit 4, part 1 (monopoly)
7		Unit 4, part 2 (monopolistic competition, oligopoly, games)
8		Unit 5
9		Unit 6
10		Mixed multiple-choice sets and FRQ drills
11		Full timed practice exam 1 and error review
12		Full timed practice exam 2 and formula and graph review

A simple weekly routine works with either plan: read the lesson and redraw every graph from memory, do the exercises without notes, correct them, and keep an error log with three columns: the question, why you missed it (concept, graph, calculation, misread), and the rule that fixes it. Review the log every weekend. Patterns in the log show you which unit deserves extra time.

The five-step FRQ routine

1. Read every part first and note which graphs you need.
2. Draw the graph large, with both axes labeled and every curve named.
3. Mark dotted lines for each equilibrium quantity and price.
4. Answer each part in its own labeled space with a direction and a because.
5. Re-read the stem for units, time frame (short or long run), and the exact question.

Practice

SET A Check Your Understanding

Answer each item in two to four sentences.

1. A student has 2 hours for MC practice and wants to simulate the real exam pace. How many questions should they attempt, and why?
2. What fraction of the final score comes from FRQ 1 alone, and what fraction from FRQ 2 and 3 combined?
3. Name the two units with the heaviest approximate weights and give a reason why strong performance in them helps in the other units.
4. A student's FRQ answer says "the price will change." Rewrite it into a response that could earn a point if a minimum wage above equilibrium is imposed, and say what was missing.
5. List three details that must appear on any graph in an FRQ to avoid losing a graph point.
6. You spent 3 minutes stuck on a tough MC question with 4 choices left unresolved. What is the best action and why?

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. How many multiple-choice questions are on AP Microeconomics and how long is that section?
(A) 50 questions in 60 minutes (B) 60 questions in 70 minutes
(C) 60 questions in 60 minutes (D) 70 questions in 90 minutes
(E) 45 questions in 70 minutes
8. Which statement about scoring is correct?
(A) Wrong multiple-choice answers lose one-quarter point
(B) Each FRQ is worth the same number of points
(C) Calculators are not allowed on the exam
(D) There is no penalty for wrong multiple-choice answers
(E) Only the long FRQ is scored by rubric
9. Which pairing of unit and approximate weight is most accurate?
(A) Unit 1, 30 to 35% (B) Unit 5, 25 to 30% (C) Unit 6, 40%
(D) Unit 4, 5% (E) Unit 2, 20 to 25%
10. A student draws the correct market graph for an FRQ but does not label the vertical axis and does not name the demand curve. What is the most likely result?
(A) Loss of the graph-labeling point, though later parts may still earn points
(B) Full credit, since the shape is correct
(C) Loss of all points on the question
(D) Loss of one point only on the calculation
(E) No effect, because only explanations are scored
11. On an "explain" part, which response is most likely to earn the point when a tax is placed on sellers?
(A) Quantity falls.
(B) Price goes up and quantity goes down.
(C) Supply decreases because the tax raises sellers' costs, so price rises and quantity falls.
(D) The market is hurt by the tax.
(E) The tax is bad for the economy.
12. A student has 6 hours a week for 6 weeks before the exam. Which plan best matches the strategy recommended in this lesson?
(A) Study Unit 1 for four weeks, then everything else in the last week
(B) Only memorize definitions and skip graphs
(C) Do only FRQs because they are worth more
(D) Cover each unit once, then spend the final weeks on mixed practice, timed exams, and an error log
(E) Take one full exam on the last night

SET C Apply and Extend

Write a complete response. Scoring points are listed in the model answers.

13. Create a 6-week study schedule for a student with 5 hours a week who is weakest in graphs. Give the weekly focus for each week and name one activity that builds graph skill.
14. A student's answer to a 5-point FRQ earns: graph labels 0 (axes unlabeled), shift 1, new equilibrium 1, explanation 0 (no reason), calculation 1. Total 3 of 5. Identify the two habits that cost points and write a short checklist that would have prevented both.

0.2 Graphs and Labels That Earn Points

Learn the standard form and the labels for the graphs the exam asks you to draw, and how graders award graph points.

On the AP exam you earn graph points for details, not for artistic skill. A sketch that is slightly crooked but fully labeled earns every point; a beautiful sketch with no labels earns none. This lesson shows the standard form of each graph you will be asked to draw, with a checklist you can apply every time.

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The graph-label checklist

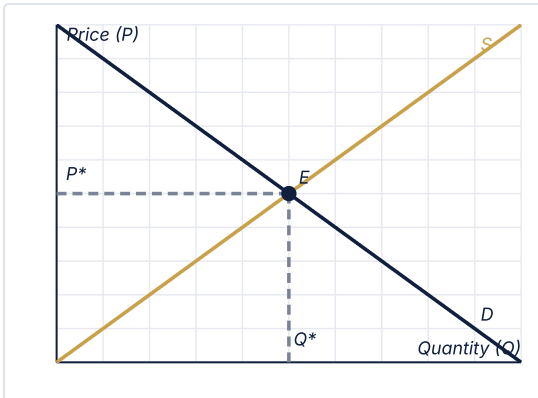
Vertical axis: Price (P), Wage (W), or Price and Costs, depending on the graph. Horizontal axis: Quantity (Q), or Quantity of Labor (L).

Every curve is named: D, S, MR, MC, ATC, AVC, MSB, MSC, and so on. A shifted curve gets a new name such as D2.

Every equilibrium or optimum is marked with a point and dotted lines to BOTH axes, with the values labeled P^* and Q^* (or P_1 , Q_1 and P_2 , Q_2).

Shaded areas are named in words: consumer surplus, producer surplus, deadweight loss, profit, or loss.

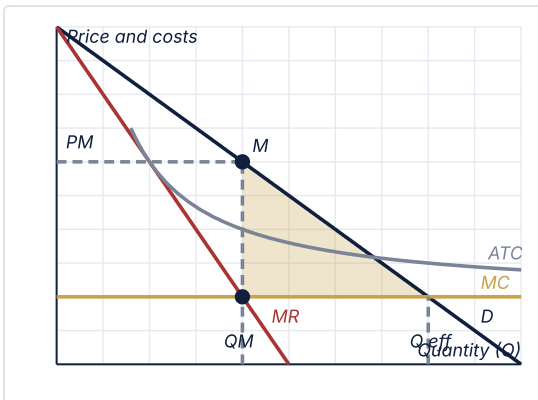
Supply and demand. Demand slopes down because of the law of demand and supply slopes up because higher prices cover higher marginal costs. Equilibrium E is where they cross, and the dotted lines identify P^* and Q^* . To show a change, draw the original curves first, then add the one shifted curve with its new name. Do not erase the original curves: the comparison is the answer.



Supply and demand: axes P and Q, both curves named, dotted lines from E to both axes, with P^* and Q^* written.

Cost curves and the perfectly competitive firm. In the firm graph, price is a horizontal line because the firm is a price taker, so that line is demand, marginal revenue, and average revenue at once (label it $P = MR = D$). The marginal cost curve is U-shaped to rising, and it crosses both ATC and AVC at their minimum points. Find the output where $P = MR$ meets MC, drop a dotted line to Q^* , then compare price to ATC at that quantity.

Monopoly. The demand curve slopes down, and MR lies below it, with twice the slope for a straight-line demand. Produce where $MR = MC$ (the quantity), then travel up to demand for the price. The price is read off demand, never off MR or MC. If the marginal cost is also drawn flat, the efficient quantity is where demand meets MC, so deadweight loss is the triangle between demand and MC from the monopoly quantity to that efficient quantity.



Monopoly: find $MR = MC$, go UP to demand for the price. The shaded triangle is deadweight loss; profit is the rectangle between PM and ATC out to QM.

Monopolistic competition. In the short run the graph looks like a monopoly with profit or loss. In the long run, entry shifts each firm's demand left until demand is tangent to ATC at the $MR = MC$ quantity, and economic profit is zero. The firm still prices above marginal cost and produces to the left of minimum ATC, which means excess capacity.

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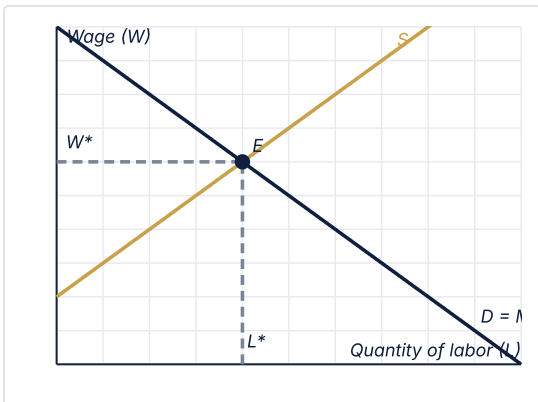
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Monopolistic competition, long run: D is tangent to ATC at the quantity where $MR = MC$, so economic profit is zero.

Labor market. Wage goes on the vertical axis and the quantity of labor on the horizontal axis. In the firm's view of a competitive labor market the wage is a horizontal line (the supply of labor to the firm), and the firm hires labor until MRP equals the wage. In the market view, labor demand slopes down and labor supply slopes up, and the intersection gives the market wage W^* and employment L^* .



Labor market: firms demand labor (MRP), households supply it, and the wage is the price.

Externalities. For a negative externality, draw a social cost curve above the private cost curve by the size of the external cost; the market produces where private supply meets demand, and the efficient output is where social cost meets demand. For a positive externality, draw the social benefit curve above demand. Deadweight loss is the triangle between the social curves over the units that should not (or should) be produced.

Graph	Vertical axis	Curves to label	Mark and shade
Market	P	D, S (and D2 or S2)	E, P^* , Q^* , consumer and producer surplus
Price control	P	D, S, ceiling or floor line	Q_d , Q_s , shortage or surplus, deadweight loss
Competitive firm	Price and costs	MC, ATC, AVC, $P = MR = D$	Q^* , profit or loss rectangle, shutdown point
Monopoly	Price and costs	D, MR, MC, ATC	QM, PM, profit rectangle, deadweight loss
Monopolistic competition	Price and costs	D, MR, MC, ATC	Tangency, QM, zero profit in long run
Labor market	W	$D = MRP$, S	W^* , L^*
Externality	Price and cost	$D = MSB$, $S = MPC$, MSC (or MSB)	Market and optimum quantities, deadweight loss

Three rules that decide most graphs

Quantity is chosen where marginal benefit equals marginal cost ($MR = MC$ for a firm, $MSB = MSC$ for society).

Price is read from demand at that quantity, except for a price taker, whose price is given.

Profit or loss is the rectangle between price and ATC at the chosen quantity.

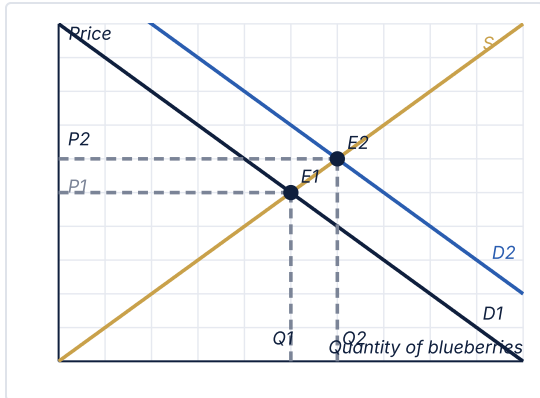
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EXAMPLE 1: SHOWING A CHANGE IN DEMAND

A new health study increases consumers' preference for blueberries. Draw and label the blueberry market, show the effect, and state the changes in price and quantity.

**SOLUTION**

Draw the original market: axes labeled Price and Quantity of blueberries, curves D_1 and S , equilibrium E_1 at P_1 and Q_1 .

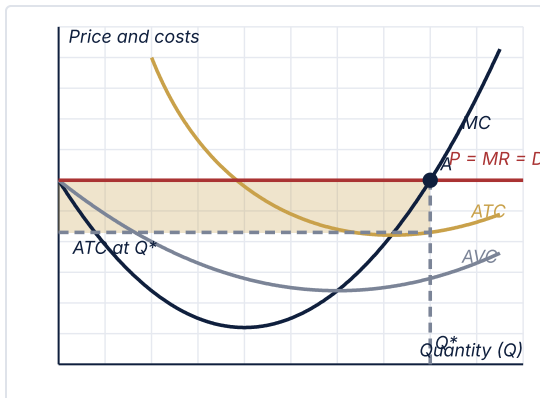
The study changes tastes, a demand determinant, so D shifts right to D_2 . Supply is not affected.

The new equilibrium E_2 lies up and to the right along S . Price rises to P_2 and quantity rises to Q_2 .

Written answer: "Demand increases because tastes changed in favor of blueberries; the equilibrium price and quantity both rise."

EXAMPLE 2: READING A COMPETITIVE-FIRM GRAPH

In the graph, the market price is \$6 and the firm's costs are shown (read ATC at $Q = 8$ as about \$4.30). Identify the profit-maximizing quantity and compute economic profit.



Perfectly competitive firm: the shaded rectangle (price minus ATC , times Q^*) is economic profit.

SOLUTION

Profit is maximized where $MR = MC$. The price line meets MC at A , and a dotted line down gives $Q^* = 8$.

At $Q^* = 8$, ATC is about \$4.30, which is below price, so the firm earns positive economic profit.

Profit per unit = $6 - 4.30 = \$1.70$. Total profit = $1.70 \times 8 = \$13.60$, the shaded rectangle.

Long-run implication: positive profit attracts entry, which lowers price until price equals minimum ATC .

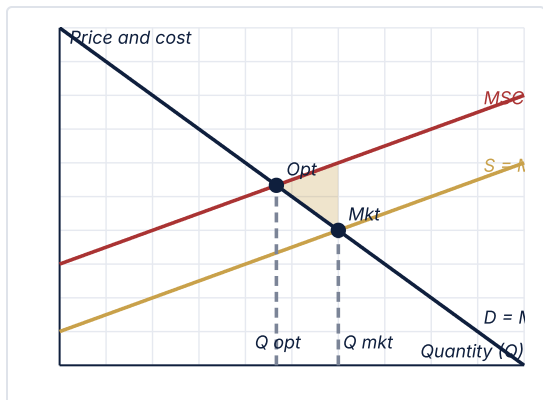
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EXAMPLE 3: NEGATIVE EXTERNALITY

A factory's private marginal cost is $MPC = 1 + 0.5Q$ and its pollution adds \$2 per unit, so $MSC = 3 + 0.5Q$. Demand is $P = 10 - Q$. Find the market quantity, the efficient quantity, and the deadweight loss.

**SOLUTION**

Market: set $D = MPC$. $10 - Q = 1 + 0.5Q$ gives $9 = 1.5Q$, so $Q = 6$ and $P = \$4$.

Efficient: set $D = MSC$. $10 - Q = 3 + 0.5Q$ gives $7 = 1.5Q$, so $Q = 14/3$, about 4.67, and P is about \$5.33.

Deadweight loss is the triangle between MSC and D from 4.67 to 6. At $Q = 6$, $MSC = 6$ and $D = 4$, a gap of \$2. Base = $6 - 4.67 = 1.33$.

$DWL = 0.5 \times 1.33 \times 2 = \text{about } \$1.33$. The market overproduces because the producer ignores the external cost.

Common mistakes

(1) Reading monopoly price off the MR or MC curve instead of up to demand. (2) Drawing MR above demand. (3) Forgetting that a competitive firm's demand is horizontal while the market demand slopes down. (4) Shading profit with ATC at the wrong quantity: always use the Q^* where $MR = MC$. (5) Shifting a curve without renaming it. (6) Leaving out P^* or Q^* .

Practice**SET A Check Your Understanding**

Answer each item in two to four sentences or with a calculation. Show your work.

1. In the competitive-firm graph, which four lines or curves must appear and how is each labeled?
2. A student draws a monopoly graph and reads the price off the $MR = MC$ intersection. What is wrong and how is it fixed?
3. In the labor market graph, name the axes and the two curves. What do the two curves represent?
4. Describe exactly how to show consumer surplus and producer surplus on a standard market graph.
5. In the long-run monopolistic competition graph, what two relationships must hold between curves, and what do they imply about profit?
6. A student shifts supply right but writes "price rises". Explain the inconsistency and give a corrected conclusion.

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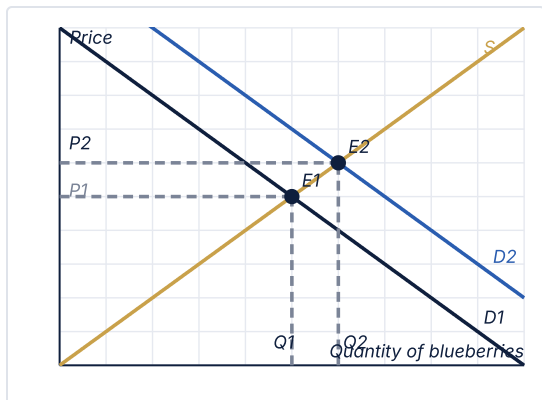
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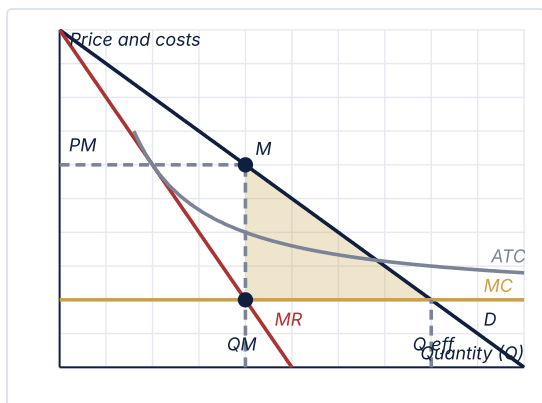
SET B Exam-Style Multiple Choice

Choose the best answer.

7. The graph shows the market for a normal good. Which event could have caused the shift from D_1 to D_2 ?



- (A) A fall in the price of a complement
 (B) A technological improvement in production
 (C) A decrease in the number of buyers
 (D) An increase in the price of a substitute for the producer's input
 (E) A rise in consumer income
8. A monopolist faces the demand, MR, MC (constant at \$2), and ATC curves shown. If D is $P = 10 - Q$, the profit-maximizing monopolist earns economic profit of



Monopoly: find $MR = MC$, go UP to demand for the price. The shaded triangle is deadweight loss; profit is the rectangle between PM and ATC out to QM .

- (A) \$4 (B) \$8 (C) \$6 (D) \$12 (E) \$16
9. For a good with a positive externality, which statement correctly describes the graph?
- (A) Marginal social benefit lies above demand and the efficient quantity exceeds the market quantity
 (B) Marginal social cost lies above supply and the market overproduces
 (C) Demand lies above marginal social benefit and the market underproduces
 (D) Marginal social benefit lies below demand and the efficient quantity is lower
 (E) The market quantity is efficient because buyers and sellers agree

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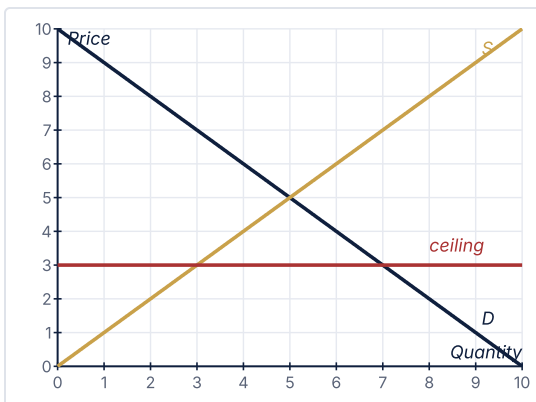
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10. A firm in a perfectly competitive market is shown with price between minimum AVC and minimum ATC. The firm should



- (A) Shut down immediately
 (B) Raise its price to ATC
 (C) Produce where $P = MC$ and accept a loss in the short run
 (D) Produce where ATC is minimized
 (E) Exit the industry immediately without producing
11. Which correctly labeled elements belong on a graph of the market for labor?
- (A) Vertical axis: price of goods; horizontal axis: output
 (B) Vertical axis: interest rate; horizontal axis: savings
 (C) Vertical axis: wage; horizontal axis: output; upward-sloping curve: demand
 (D) Vertical axis: wage; horizontal axis: quantity of labor; downward-sloping curve: demand for labor
 (E) Vertical axis: quantity of labor; horizontal axis: wage
12. In the graph, the government sets a binding price ceiling at \$3. What is the shortage?



- (A) 2 units (B) 4 units (C) 3 units (D) 5 units (E) 7 units

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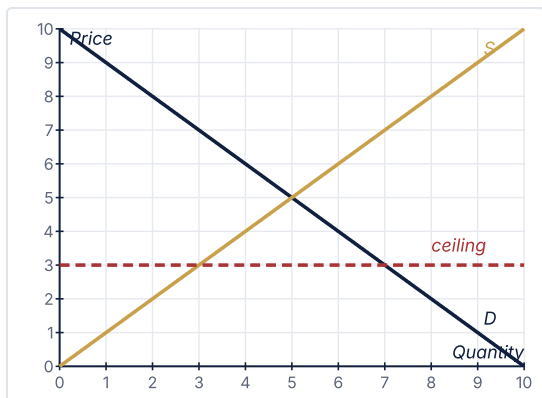
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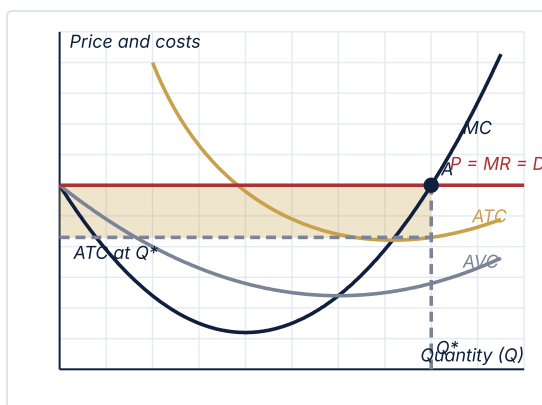
SET C Apply and Extend

Write a complete response. Scoring points are listed in the model answers.

13. The graph shows the market for rental apartments (D: $P = 10 - Q$, S: $P = Q$) with a binding price ceiling of \$3 (dashed). (a) Find the quantities supplied and demanded and the shortage. (b) Calculate the deadweight loss. (c) Explain why the deadweight loss exists.



14. The graph shows a perfectly competitive firm earning profit at the market price. (a) Identify the profit-maximizing quantity and explain how you found it. (b) Shade or describe the profit area. (c) Explain what happens to the market price and to this firm's profit in the long run, and why.



Perfectly competitive firm: the shaded rectangle (price minus ATC, times Q^*) is economic profit.

0.3 Calculations Toolkit and Command Words

Master the formulas and numeric methods used on the exam and learn how each command word controls what you write.

AP Microeconomics rewards precise arithmetic and precise language. Most calculations use a dozen formulas that repeat across units, and nearly every free-response point is attached to a command word that tells you what kind of answer to write. Learn both and you will turn routine problems into reliable points.

Elasticity and revenue formulas

Price elasticity of demand: $E_d = \frac{\% \Delta Q_d}{\% \Delta P}$. Use the absolute value to classify: above 1 elastic, equal to 1 unit elastic, below 1 inelastic.

Midpoint method: $\% \Delta Q = \frac{Q_2 - Q_1}{(Q_2 + Q_1)/2}$ and $\% \Delta P = \frac{P_2 - P_1}{(P_2 + P_1)/2}$. Use it whenever the question says midpoint or gives two points; it gives the same answer for an increase or a decrease.

Income elasticity: $E_Y = \frac{\% \Delta Q}{\% \Delta \text{income}}$ (positive: normal good, above 1 luxury, negative: inferior). Cross-price: $E_{XY} = \frac{\% \Delta Q_X}{\% \Delta P_Y}$ (positive: substitutes, negative: complements).

Total revenue: $TR = P \times Q$. Total revenue test: if demand is elastic, a price increase lowers TR; if inelastic, a price increase raises TR; at unit elasticity TR does not change.

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Cost, profit, and hiring formulas

$$TC = FC + VC; ATC = \frac{TC}{Q}; AVC = \frac{VC}{Q}; AFC = \frac{FC}{Q}; ATC = AVC + AFC.$$

Marginal cost: $MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta VC}{\Delta Q}$. MC crosses ATC and AVC at their minimum points.

Profit: $\pi = TR - TC = (P - ATC) \times Q$. Marginal revenue: $MR = \frac{\Delta TR}{\Delta Q}$; for a price taker $MR = P$. Produce where $MR = MC$.

Marginal product of labor: $MP_L = \frac{\Delta Q}{\Delta L}$. Marginal revenue product: $MRP = MP_L \times MR$ (which equals $MP_L \times P$ for a price-taking seller). Hire until $MRP = W$ (the marginal resource cost).

Efficiency rules: consumer utility maximized when $MU_X/P_X = MU_Y/P_Y$; an economy is allocatively efficient where price equals marginal cost.

Areas on graphs. Surplus and deadweight loss are areas, and most are triangles or rectangles: area of a triangle is one-half base times height, and a rectangle is base times height. Consumer surplus is the triangle between the demand curve and price. Producer surplus is the triangle between price and the supply curve. Deadweight loss is the triangle formed by the units that would have been traded but are not (or are traded but should not be).

EXAMPLE 1: ELASTICITY AND THE TOTAL REVENUE TEST

When the price of a streaming plan rises from \$8 to \$10 per month, quantity demanded falls from 150 to 90 (thousand subscribers). (a) Use the midpoint method to calculate the price elasticity of demand. (b) Classify demand. (c) Show what happens to total revenue.

SOLUTION

$$(a) \% \Delta Q = \frac{90 - 150}{(90 + 150)/2} = \frac{-60}{120} = -50\%. \% \Delta P = \frac{10 - 8}{(10 + 8)/2} = \frac{2}{9} = 22.2\%.$$

$$E_d = \frac{-50\%}{22.2\%} = -2.25, \text{ so the absolute value is } 2.25.$$

(b) 2.25 is greater than 1, so demand is elastic in this range.

(c) TR at \$8 is $8 \times 150 = \$1,200$ thousand. TR at \$10 is $10 \times 90 = \$900$ thousand. TR falls by \$300 thousand, which confirms the total revenue test: raising price when demand is elastic lowers revenue.

Cost tables. Keep one sequence: fill FC first (the TC at $Q = 0$), then $VC = TC - FC$, then ATC, AVC, and MC. MC always sits between the two outputs it spans, and a table row for MC at $Q = 3$ means the cost of the third unit. Use the table below in the next example.

Q	TC	VC	MC	AVC	ATC
0	30	0	-	-	-
1	50	20	20	20	50
2	64	34	14	17	32
3	75	45	11	15	25
4	88	58	13	14.5	22
5	105	75	17	15	21
6	130	100	25	16.67	21.67

EXAMPLE 2: PROFIT MAXIMIZATION FROM A COST TABLE

A perfectly competitive firm has the cost data shown and faces a market price of \$24. (a) Find the profit-maximizing quantity. (b) Calculate economic profit. (c) Should it stay in business in the long run?

SOLUTION

(a) Produce while $P (= MR)$ is at least MC. MC is 17 for the fifth unit, below 24, so produce it. MC is 25 for the sixth unit, above 24, so stop. $Q^* = 5$.

(b) $TR = 24 \times 5 = \$120$. TC at $Q = 5$ is \$105. Profit = $120 - 105 = \$15$. Check: $(P - ATC) \times Q = (24 - 21) \times 5 = \$15$.

(c) Profit is positive, so the firm stays and other firms will want to enter. In the long run entry lowers price toward minimum ATC (about \$21), where profit is zero.

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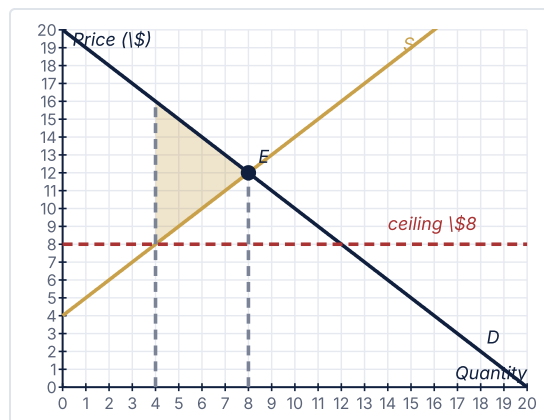
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Workers	Total output	MP of labor	MRP at \$5 per unit
1	10	10	\$50
2	22	12	\$60
3	30	8	\$40
4	36	6	\$30
5	40	4	\$20

Hiring. In the table above, the product sells for \$5 per unit, so MRP is MP times 5. If the market wage is \$25 per hour, the firm hires workers while MRP is at least the wage: the fourth worker adds \$30, which beats \$25, but the fifth adds only \$20. The firm hires four workers. A higher wage of \$45 would cut employment to two.

EXAMPLE 3: CONSUMER SURPLUS, PRODUCER SURPLUS, AND DEADWEIGHT LOSS

Demand is $P = 20 - Q$ and supply is $P = 4 + Q$. (a) Find the equilibrium and calculate consumer and producer surplus. (b) The government sets a price ceiling of \$8. Find the quantity traded and the deadweight loss.



SOLUTION

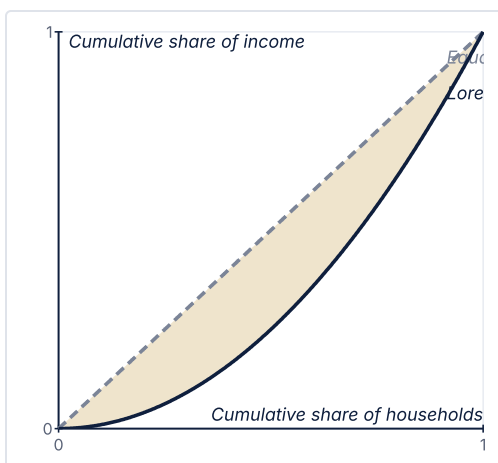
(a) $20 - Q = 4 + Q$ gives $Q = 8$ and $P = \$12$. The demand intercept is 20 and the supply intercept is 4.

$CS = 0.5 \times 8 \times (20 - 12) = \$32$. $PS = 0.5 \times 8 \times (12 - 4) = \$32$. Total surplus = \$64.

(b) At \$8, only 4 units are supplied ($8 = 4 + Q$). Quantity traded is the smaller side, 4. Demand at $Q = 4$ is \$16, supply is \$8.

DWL is the triangle of lost trades from $Q = 4$ to $Q = 8$: $0.5 \times (8 - 4) \times (16 - 8) = \$16$. Total surplus falls from \$64 to \$48.

The Gini coefficient. A Lorenz curve plots the cumulative share of income against the cumulative share of households ordered from poorest to richest. The diagonal is perfect equality. The Gini coefficient equals the area between the diagonal and the Lorenz curve divided by the whole area under the diagonal (one-half). It runs from 0 (equality) to 1 (one household has everything).



Lorenz curve $y = x$ squared. The shaded area is $1/2 - 1/3 = 1/6$, so $Gini = (1/6) / (1/2) = 1/3$, or about 0.33.

Command words. The verb in each part tells you the depth of the response. Match it exactly.

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Command word	What to write	Example of a point-earning response
Identify / State	The answer only, no reasoning needed	"Elastic."
Define	The meaning in a phrase or sentence	"Opportunity cost is the value of the next best alternative given up."
Calculate	A number, with the formula and units shown	" $(24 - 21) \times 5 = \$15$."
Draw / Label	A labeled graph with curves, points, and dotted lines	Market graph with D, S, E, P*, Q*
Show	Add the change to the graph you drew	Draw D2 and label the new equilibrium
Explain	A claim plus a because-reasoning chain	"Quantity falls because the ceiling lowers sellers' willingness to supply."
Describe	State the features or direction clearly	"Price rises and quantity rises."
Compare	Name a similarity or difference using both items	"A monopolist charges more than MC; a competitor charges $P = MC$."
Justify	Give evidence or a calculation that supports the claim	"Elastic because the absolute value is 2.25 which is greater than 1."

Common mistakes

(1) Computing elasticity with the wrong base: if the question says midpoint, divide by the average, not the starting value. (2) Using the price or MR curve for price in monopoly. (3) Mixing MC with ATC in a table: MC uses the change in cost, ATC divides the total. (4) Forgetting the one-half in triangle areas. (5) Answering "explain" with only a direction. (6) Dropping units, such as dollars or percent.

Practice

SET A Check Your Understanding

Answer each item in two to four sentences or with a calculation. Show your work.

- Income rises 10 percent and a household's quantity demanded of restaurant meals rises 15 percent. Calculate the income elasticity and classify the good.
- The price of coffee rises 8 percent and the quantity of tea purchased rises 6 percent. Calculate cross-price elasticity and say what the sign means.
- A firm's total cost is \$200 at 10 units and \$215 at 11 units, with fixed cost of \$50. Calculate MC for the eleventh unit, and ATC and AVC at 10 units.
- A firm sells its product at \$8 per unit. The marginal product of its fifth worker is 3 units, and the wage is \$20. Should it hire the worker? Show the calculation.
- On a Lorenz graph the area between the line of equality and the Lorenz curve is 0.2 and the area under the Lorenz curve is 0.3. Calculate the Gini coefficient.
- A country can produce 20 cars or 60 trucks using its resources. Calculate the opportunity cost of one car in trucks, and of one truck in cars.

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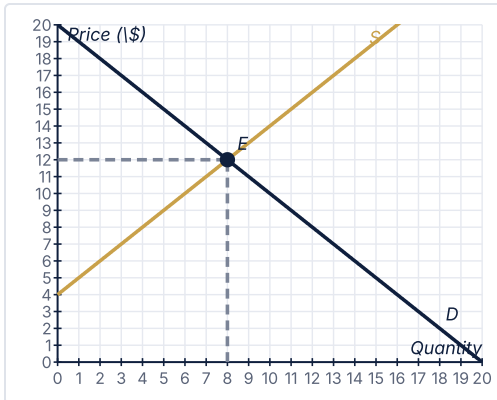
SET B Exam-Style Multiple Choice

Choose the best answer.

7. When the price of a good rises from \$4 to \$6, quantity demanded falls from 120 to 80. Using the midpoint method, the price elasticity of demand (absolute value) is
 (A) 0.50 (B) 0.67 (C) 1.00 (D) 1.50 (E) 2.00
8. A firm sells 50 units at \$10 each and has total costs of \$420. Its economic profit is
 (A) \$ -80 (B) \$ 0 (C) \$ 500 (D) \$ 920 (E) \$ 80
9. Using the table, what is the marginal cost of producing the third unit?

Q	0	1	2	3	4
Total cost (\$)	40	60	76	100	136

- (A) \$ 16 (B) \$ 24 (C) \$ 33 (D) \$ 36 (E) \$ 100
10. In the graph (D: $P = 20 - Q$; S: $P = 4 + Q$), the equilibrium price is \$12. Consumer surplus is



- (A) \$ 16 (B) \$ 48 (C) \$ 64 (D) \$ 32 (E) \$ 96
11. Which response to "Explain why a price floor above equilibrium creates a surplus" is best?
 (A) Because the floor is above equilibrium, quantity supplied rises and quantity demanded falls, so quantity supplied exceeds quantity demanded.
 (B) Surplus occurs because the price is high.
 (C) Quantity supplied is greater than quantity demanded.
 (D) The government is wrong to set prices.
 (E) A surplus is bad for sellers.
12. The area between a country's Lorenz curve and the line of equality is 0.12. The Gini coefficient is
 (A) 0.06 (B) 0.12 (C) 0.38 (D) 0.62 (E) 0.24

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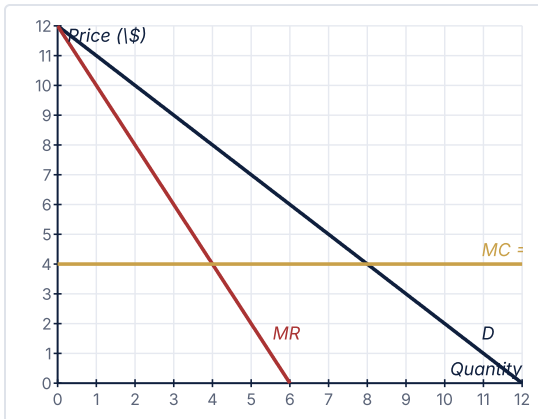
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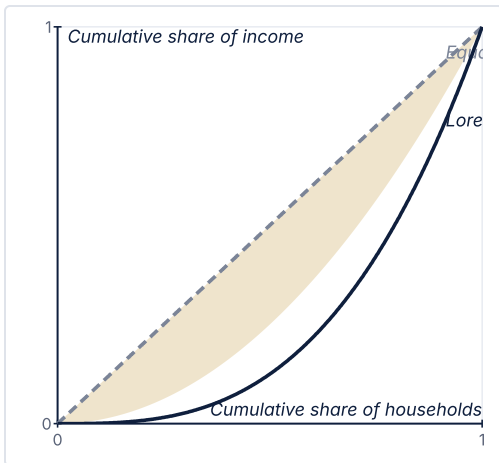
SET C Apply and Extend

Write a complete response. Scoring points are listed in the model answers.

13. A monopolist faces the demand, MR, and cost curves shown ($MC = ATC = \$4$). (a) Find the profit-maximizing quantity and price. (b) Calculate economic profit. (c) Calculate the deadweight loss. (d) Explain why the monopoly outcome is inefficient.



14. The Lorenz curve shown is $y = x$ cubed. (a) Interpret the point (0.5, 0.125). (b) Calculate the Gini coefficient. (c) Explain how a progressive tax with transfers would change the Lorenz curve and the Gini coefficient.

**Answers Start Here: Answers and Explanations**

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

0.1 The AP Microeconomics Exam: Format, Scoring, and Study Plan**SET A · CHECK YOUR UNDERSTANDING**

- At the real pace of 70 seconds per question, 120 minutes is 7,200 seconds, which is about 100 questions; but a full exam has only 60 MC items in 70 minutes. A realistic session is one 60-question set in 70 minutes followed by about 50 minutes reviewing every missed or guessed item. The review is where most learning happens.
- FRQ 1 is half of Section II, which is one-third of the total, so it is $1/6$ or about 16.7% of the score. FRQs 2 and 3 are 25% of Section II each, so together they are another $1/6$, about 16.7%. The long question equals the two short ones combined.
- Unit 2 (supply and demand, about 20 to 25%) and Unit 3 (production, cost, and perfect competition, about 22 to 25%). Together they teach equilibrium graphs, surplus, marginal analysis, and cost curves, and those tools are reused for monopoly, factor markets, and externalities.
- A scoring version: "The quantity of labor demanded falls and the quantity supplied rises, creating a surplus of labor (unemployment), because the wage is above the equilibrium wage." The original named no variable, no direction, and no reason.
- Both axes labeled (such as Price and Quantity), every curve labeled (D, S, MC, ATC, MR, and so on), and the equilibrium or optimum marked with dotted lines to both axes with P^* and Q^* . Shifts also need the new curve labeled, such as D_2 .
- Eliminate any obviously wrong choice, choose the best remaining answer, flag it, and move on. Questions are worth the same single point, so three minutes of time on one question costs the chance to earn points on easier questions later. There is no penalty for a wrong guess.

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SET B · EXAM-STYLE MULTIPLE CHOICE

7. B. The section has 60 questions in 70 minutes. The 60-minute figure belongs to the FRQ section, which is why the 60-60 option tempts students.
8. D. No points are subtracted for wrong answers, so you should answer every question. The quarter-point penalty is a feature of older exams and is why the penalty option sounds familiar.
9. E. Supply and demand carries about 20 to 25%. Factor markets and market failure are the smallest units, so the options that give them 25 to 40% reverse the real emphasis.
10. A. Labels are a specific rubric element, so the student loses that point. Because rubric points are independent, later parts can still earn credit; the option claiming all points are lost overstates the penalty.
11. C. It names the curve that shifts, gives the reason, and states both results. The shorter answer "Price goes up and quantity goes down" gives directions but no reason, which is the classic way to lose an explanation point.
12. D. Spiral review with cumulative, timed practice reflects how the exam mixes units. Doing only FRQs ignores that multiple choice is two-thirds of the score.

SET C · APPLY AND EXTEND

13. Model response (3 points). 1 point: all six units are covered once in the first four weeks (for example weeks 1 to 4: Unit 1 with 2, Unit 3, Unit 4, Units 5 and 6). 1 point: the last two weeks are cumulative, with timed mixed practice and one full exam plus error-log review. 1 point: a graph-building activity such as redrawing each lesson's graph from memory, labeling every curve and dotted line, then checking it, done each week and weighted heavier in the first weeks.
14. Model response (3 points). 1 point: identify unlabeled axes as the first lost point and a missing because-statement as the second. 1 point: checklist item for graphs, such as "label P and Q axes and every curve before drawing shifts". 1 point: checklist item for explanations, such as "every explain part must contain because plus the curve or variable that changes"; with both items, the student would have recovered 2 points for a total of 5.

0.2 Graphs and Labels That Earn Points**SET A · CHECK YOUR UNDERSTANDING**

1. Draw MC (U-shaped, rising), ATC (U-shaped, with MC cutting it at its minimum), AVC (below ATC) and a horizontal price line labeled $P = MR = D$. Add Q^* where MR meets MC. Label both axes (Price and Costs; Quantity).
2. The intersection gives only the profit-maximizing quantity. The monopolist charges the highest price consumers will pay for that quantity, which is read by going up to the demand curve. The corrected price is higher than the $MR = MC$ height.
3. Vertical axis: wage (W). Horizontal axis: quantity of labor (L). The downward-sloping curve is labor demand, which equals the marginal revenue product of labor for firms. The upward-sloping curve is labor supply from workers.
4. Mark the equilibrium price P^* with a horizontal dotted line. Consumer surplus is the triangle below the demand curve and above P^* out to Q^* . Producer surplus is the triangle above the supply curve and below P^* out to Q^* . Name each area in words or with labels.
5. $MR = MC$ determines the quantity, and the demand curve must be tangent to ATC at that quantity so price equals ATC. That gives zero economic profit, so no firms enter or leave. Price is still above MC.
6. A rightward supply shift moves the equilibrium down along the demand curve, so price falls and quantity rises. The written conclusion contradicts the drawing, which can cost both the direction point and the explanation point. Correct statement: price falls and quantity rises.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. E. Higher income raises demand for a normal good, shifting it right. A technology improvement would shift supply, and the other options are not demand increases or move demand left.
8. B. $MR = MC$ at $Q = 4$, price is \$6 from demand, and ATC is $2 + 8/4 = \$4$. Profit = $(6 - 4) \times 4 = \$8$. Choosing \$16 reflects using the price minus MC (4×4).
9. A. The external benefit adds to private benefit, so MSB is above demand and meets supply at a higher quantity than the market chooses. The cost-based statement describes a negative externality.
10. C. Since price exceeds AVC at the $MC = P$ quantity, producing covers variable costs and part of fixed costs, so the loss is smaller than shutting down. Shutdown is correct only when price is below AVC.
11. D. Labor markets use wage as the price and quantity of labor on the horizontal axis; firms' demand slopes down. The other options use the wrong axes or reverse which curve is which.
12. B. At \$3, quantity supplied is 3 (from $S: P = Q$) and quantity demanded is 7 (from $D: 10 - Q = 3$). Shortage = $7 - 3 = 4$. Choosing 7 mistakes quantity demanded for the shortage.

SET C · APPLY AND EXTEND

13. Model response (4 points). (a) 1 point: $Q_s = 3$, $Q_d = 7$, shortage = 4. (b) 1 point for identifying the DWL triangle between D and S from $Q = 3$ to $Q = 5$ (equilibrium is $Q = 5$, $P = \$5$); 1 point for the number: at $Q = 3$ demand price is \$7 and supply price is \$3, so $DWL = 0.5 \times (5 - 3) \times (7 - 3) = \$4$. (c) 1 point: mutually beneficial trades between $Q = 3$ and $Q = 5$ (buyers' willingness to pay exceeds sellers' cost) do not occur because the ceiling reduces quantity traded.
14. Model response (4 points). (a) 1 point: Q^* where $P = MR = MC$ (the price line meets MC, shown as point A). (b) 1 point: profit is the rectangle between P and ATC out to Q^* , with ATC read at Q^* . (c) 1 point: positive economic profit attracts entry, shifting market supply to the right; 1 point: price falls until it equals minimum ATC, and economic profit returns to zero.

0.3 Calculations Toolkit and Command Words

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SET A · CHECK YOUR UNDERSTANDING

1. $E_Y = 15\%/10\% = 1.5$. It is positive, so restaurant meals are a normal good, and it is greater than 1, so they are a luxury (income-elastic) good. The value shows that quantity rises more than proportionally with income.
2. $E_{XY} = 6\%/8\% = 0.75$. The positive sign means tea and coffee are substitutes: when coffee becomes more expensive, consumers buy more tea. A negative value would signal complements.
3. $MC = (215 - 200) / (11 - 10) = \$15$. ATC at 10 = $200 / 10 = \$20$. VC at 10 = $200 - 50 = \$150$, so $AVC = 150 / 10 = \$15$. The gap $ATC - AVC = \$5$ equals AFC ($50 / 10$).
4. $MRP = MP \times P = 3 \times \$8 = \$24$. Because MRP of \$24 exceeds the wage of \$20, the worker adds \$4 more to revenue than to cost, so the firm should hire. It would stop hiring when MRP fell to the wage.
5. The area under the line of equality is $0.2 + 0.3 = 0.5$, as it must be. $Gini = 0.2 / 0.5 = 0.4$. A rise in the Gini coefficient means greater inequality.
6. Giving up 20 cars frees resources for 60 trucks, so 1 car costs $60/20 = 3$ trucks. Reversing it, 1 truck costs $20/60 = 1/3$ car. The two opportunity costs are reciprocals.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. %change in $Q = -40/100 = -40\%$ and %change in $P = 2/5 = 40\%$, so the ratio is 1.00. Using the starting values instead gives $33.3/50 = 0.67$, a common error.
8. E. $TR = 10 \times 50 = \$500$; profit = $500 - 420 = \$80$. The \$500 option reports revenue, not profit.
9. B. $MC = \text{change in total cost} = 100 - 76 = \$24$. The \$33 value is ATC at 3 units ($100/3$), which confuses average with marginal.
10. D. $Q^* = 8$, so $CS = 0.5 \times 8 \times (20 - 12) = \$32$. The \$64 option is the total of CS and PS together.
11. A. It supplies the mechanism: the floor raises the quantity supplied, lowers the quantity demanded, and the gap is the surplus. The statement of the result alone omits the reasoning needed for an explain point.
12. E. The total area under the line of equality is 0.5, so $Gini = 0.12 / 0.5 = 0.24$. Reporting 0.12 forgets to divide by one-half.

SET C · APPLY AND EXTEND

13. Model response (5 points). (a) 1 point: $MR = MC$ gives $12 - 2Q = 4$, so $Q = 4$; price from demand is $12 - 4 = \$8$. (b) 1 point: profit = $(8 - 4) \times 4 = \$16$. (c) 1 point for the efficient quantity $Q = 8$ (where $D = MC$: $12 - Q = 4$); 1 point for $DWL = 0.5 \times (8 - 4) \times (8 - 4) = \$8$. (d) 1 point: price exceeds marginal cost, so units whose value to buyers exceeds their cost go unproduced.
14. Model response (4 points). (a) 1 point: the poorest 50 percent of households receive 12.5 percent of total income. (b) 2 points: area under the Lorenz curve is the integral of x^3 from 0 to 1, which is $1/4$; the area between the curves is $1/2 - 1/4 = 1/4$; $Gini = (1/4) / (1/2) = 0.5$ (1 point for setup, 1 for the value). (c) 1 point: redistribution raises the income share of lower groups, so the Lorenz curve moves toward the line of equality and the Gini coefficient falls.

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Chapter 1: Basic Economic Concepts.

6 sections with explanations and worked examples, then 92 practice problems. Answers and full explanations are at the end of the chapter.

1.1 Scarcity, Opportunity Cost, and Marginal Analysis

You will learn why every economy must make choices, how to measure the true cost of a choice, and how to use marginal reasoning to decide how much of something to do.

Economics is the study of how individuals, firms, and societies make choices when they cannot have everything they want. Every topic in this course, from supply and demand to monopoly to externalities, grows out of one simple fact: scarcity.

Scarcity exists because human wants are unlimited while the **resources** used to satisfy them are limited. Scarcity is not the same as poverty or shortage on a particular day. A billionaire and a student both face it, because both have only 24 hours a day and neither can afford literally everything. Even something that seems abundant, like tap water, uses scarce pipes, labor, and energy to deliver. Only truly free goods, such as air in an open field, escape scarcity, and they are rare.

Definition: Scarcity

Scarcity: unlimited wants versus limited resources.

Because of scarcity, every person, firm, and government must choose, and every choice gives up something else.

Economists sort resources, also called **factors of production**, into four categories. Each earns a specific kind of income, which will matter when you study the circular flow and factor markets.

Factor of production	What it is	Income it earns	Example at a pizzeria
Land (natural resources)	Raw materials and land provided by nature	Rent	The plot the shop sits on, wheat for flour
Labor	Human time and effort, including skills	Wages	Cooks, cashiers, delivery drivers
Capital (physical)	Manufactured goods used to produce other goods	Interest	Ovens, delivery vans, mixers
Entrepreneurship	Organizing the other factors, taking risk, innovating	Profit	The owner who decides to open the shop

Be careful with the word capital. In economics, **capital** means physical tools and equipment, not money. A cash balance is financial capital, but it is not a factor of production because you cannot bake a pizza with it directly.

Because resources are scarce, choosing one use means giving up another. That is a **trade-off**. The cost that matters for decision making is the **opportunity cost**: the value of the next best alternative you give up when you make a choice. Notice three features. First, it is the single best forgone alternative, not the sum of every alternative. Second, it includes implicit costs, such as time and forgone income, not just money you hand over. Third, it is forward looking: it measures what you give up from now on.

Opportunity cost

Opportunity cost = value of the next best alternative given up.

Economic cost = explicit (out-of-pocket) cost + implicit cost (value of forgone alternatives).

Only the best forgone alternative counts, not all of them.

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EXAMPLE 1: COUNTING THE FULL COST

Dana pays \$40 for a three-hour pottery workshop on Saturday afternoon. If she skipped it she could have done freelance editing at \$25 per hour for those three hours, or babysat her cousin for \$15 per hour. She can do only one activity. What is the opportunity cost of attending the workshop?

SOLUTION

Step 1: Identify the explicit cost. The fee is \$40, which is money paid out.

Step 2: Identify the best forgone alternative. Editing pays $3 \times \$25 = \$75$. Babysitting pays $3 \times \$15 = \$45$. The next best alternative is editing, \$75. We do not add the babysitting income, because she could not have done both.

Step 3: Add explicit and implicit costs: $\$40 + \$75 = \$115$.

Conclusion: The economic cost of the workshop is \$115. If the workshop is worth less than \$115 to Dana, she should choose editing instead.

A related idea is the **sunk cost**: a cost already paid that cannot be recovered whatever you do next. Sunk costs are not opportunity costs, because no decision can change them. A rational decision maker ignores them. If you paid \$12 for a movie ticket and the film is dreadful, the \$12 is gone either way. The relevant question is whether the next two hours are better spent at the movie or elsewhere.

Most real decisions are not all-or-nothing. They are about doing a little more or a little less. **Marginal analysis** compares the extra (marginal) benefit of one more unit with the extra (marginal) cost of that unit. **Marginal benefit (MB)** is the additional benefit from one more unit; **marginal cost (MC)** is the additional cost. Marginal benefit usually falls as you do more of something, because the first hour of studying or the first slice of pizza helps more than the fifth. This is the pattern known as diminishing marginal benefit.

The rational choice rule

A rational decision maker chooses the quantity at which $MB \geq MC$ for the last unit and $MB < MC$ for the next unit.

Do more as long as $MB > MC$. Stop when $MB = MC$ (or just before MB drops below MC).

Total net benefit is largest at that quantity.

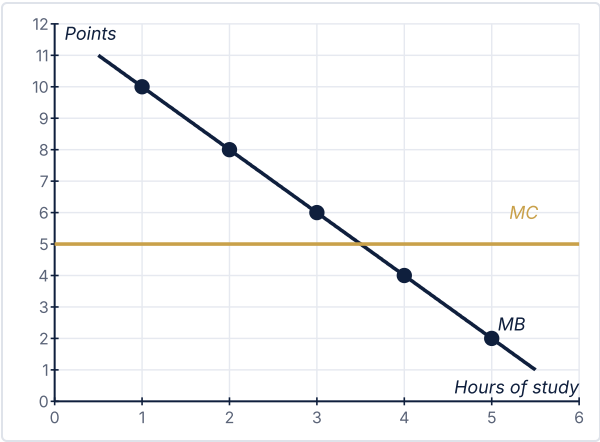
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EXAMPLE 2: HOW MANY HOURS SHOULD MARCUS STUDY?

Marcus is preparing for a chemistry test. The extra points he gains from each additional hour of study and the points-equivalent value of what he gives up in that hour are shown in the table. How many hours should he study, and what is his total net benefit?



Hour of study	Marginal benefit (points)	Marginal cost (points)
1	10	5
2	8	5
3	6	5
4	4	5
5	2	5

SOLUTION

Step 1: Compare MB with MC hour by hour. Hours 1, 2, and 3 have MB (10, 8, 6) greater than MC (5), so each adds more than it costs.

Step 2: Hour 4 has $MB = 4 < MC = 5$, so it reduces his net benefit. He should stop after hour 3.

Step 3: Total benefit of 3 hours = $10 + 8 + 6 = 24$. Total cost = $3 \times 5 = 15$. Net benefit = $24 - 15 = 9$ points.

Step 4: Check: 4 hours gives $28 - 20 = 8$, and 2 hours gives $18 - 10 = 8$. Both are lower than 9, confirming 3 hours is best.

Graph: the MB curve slopes down and crosses the horizontal MC line between 3 and 4 hours; the last hour with MB above MC is hour 3.

Rational choice assumes people respond to **incentives**: rewards and penalties that change the marginal benefit or marginal cost of an action. A higher wage raises the opportunity cost of leisure, so people tend to work more hours. A deposit on bottles raises the benefit of returning them. When you predict a response to a policy or price change, ask which side of the MB and MC comparison changed and in which direction.

The last foundation is the difference between **positive** and **normative** economics. A **positive statement** describes what is, was, or will be, and can be tested against evidence, even if it turns out false. A **normative statement** expresses a value judgment about what ought to be and cannot be settled by data alone. Look for words such as should, ought, fair, unfair, better, or worse. Positive economics supplies facts and predictions; normative economics uses them together with values to recommend policy.

Statement	Type	Why
Raising the minimum wage by \$2 will reduce teen employment by 3 percent.	Positive	A testable prediction, even if it could be wrong
The minimum wage should be raised because workers deserve a living income.	Normative	Contains a value judgment (should, deserve)
Unemployment was 5 percent last year.	Positive	A statement of fact that can be checked
Unemployment is too high.	Normative	'Too high' is a judgment

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EXAMPLE 3: CLASSIFYING AND PREDICTING

A city doubles the fee for a parking permit from \$50 to \$100 per year. (a) Classify the statement, 'The city should not raise permit fees because parking is a basic right.' (b) Classify the statement, 'Higher permit fees will reduce the number of permits sold.' (c) Use incentives to explain the prediction in (b).

SOLUTION

- (a) Normative. It uses 'should' and 'basic right', which express a value judgment that no data can prove or disprove.
 (b) Positive. It predicts a measurable outcome (permits sold) that can be checked against evidence.
 (c) The higher fee raises the cost of owning a permit. For some drivers the marginal benefit of the permit is now below its marginal cost, so they choose not to buy. Incentives work through changes in the costs and benefits at the margin.

Common mistakes

(1) Counting every alternative as part of opportunity cost; only the next best one counts. (2) Treating money already spent as a cost of the next decision; sunk costs should be ignored. (3) Saying a statement is normative just because it is controversial or false; a false claim that can be tested is still positive. (4) Using 'capital' to mean cash. (5) Stopping when MB is high rather than when MB equals MC.

Practice**SET A Check Your Understanding**

Answer each question in complete sentences or with a calculation.

1. Explain why a wealthy person still faces scarcity.
2. A small bakery uses an oven, flour, bakers, and an owner who decided to start the business. Classify each into a factor of production and name the income each factor earns.
3. Leo is given a free festival ticket for Saturday, 9 am to 3 pm. If he does not go, he could work 6 hours at \$16 per hour or babysit 6 hours at \$12 per hour (he could do only one). What is his opportunity cost of attending?
4. Priya paid a non-refundable \$60 for a ski trip. On the day, she is sick and would enjoy staying home at a value of \$20, whereas skiing while ill would be worth only \$10 to her. Using sunk cost reasoning, should she go? Explain.
5. Label each as positive or normative: (i) The poverty rate fell last year. (ii) The government ought to reduce the poverty rate. (iii) Cutting the sugar tax will increase soda sales. (iv) Soda is too cheap.
6. The refund on a returnable bottle rises from 5 cents to 25 cents. Predict the effect on returns and explain it in terms of marginal benefit and marginal cost.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. Tara has a free evening. She can go to a concert (ticket \$30), study for an exam, or work a shift paying \$45. She chooses the concert and would have picked studying second. What is her opportunity cost of attending the concert?
 (A) \$ 30, the ticket price
 (B) \$ 45, the wages from the shift
 (C) \$ 75, the ticket plus the forgone wages
 (D) Zero, because she enjoyed the concert
 (E) The value of studying for the exam
8. Which of the following is an example of capital as a factor of production?
 (A) A truck purchased by a delivery company
 (B) A bank loan taken out to buy the truck
 (C) The delivery driver's skills
 (D) The owner's decision to start the company
 (E) A forest owned by the company
9. A firm's decision about how many workers to hire gives the following marginal values. Each worker costs \$100 per day. Worker 1: MB \$220; worker 2: MB \$160; worker 3: MB \$120; worker 4: MB \$90; worker 5: MB \$60. How many workers will a rational firm hire?
 (A) 0
 (B) 1
 (C) 2
 (D) 3
 (E) 4

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10. Which statement is normative?
- (A) A tax on sugary drinks will reduce consumption of them.
 - (B) The unemployment rate rose to 6 percent last quarter.
 - (C) The government should provide health insurance to everyone because healthcare is a right.
 - (D) Average household income in the country is higher than it was ten years ago.
 - (E) Raising the price of gasoline reduces the quantity of gasoline demanded.
11. Anna bought a nonrefundable \$200 concert package. A week before the show she gets a chance to work a shift paying \$120, which she values at exactly that amount, and the concert is worth \$90 to her now. Which is the correct economic reasoning?
- (A) Go to the concert, since otherwise she wastes \$ 200.
 - (B) Go to the concert, because the \$ 200 makes the opportunity cost zero.
 - (C) Work the shift, because the concert's value (\$ 90) is less than the \$ 120 she gives up, and the \$ 200 is sunk.
 - (D) Work the shift, but only after getting a refund of the \$ 200.
 - (E) Either choice is equally good because the \$ 200 is a cost of both.
12. Which statement about scarcity is correct?
- (A) Scarcity exists only in poor countries.
 - (B) Scarcity arises because production costs are too high.
 - (C) Scarcity would disappear if the economy produced efficiently.
 - (D) Scarcity means wants exceed available resources, so all economies must make choices.
 - (E) Scarcity is the same as a temporary shortage of a good at the current price.

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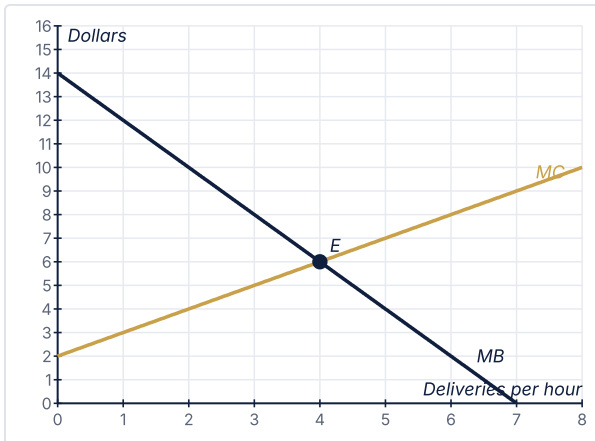
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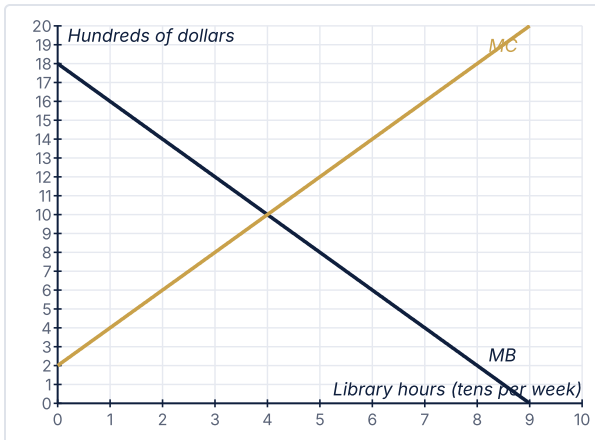
SET C Apply and Extend

Answer fully. Use the graphs.

13. A delivery company decides how many deliveries per hour a courier should make. The marginal benefit (extra revenue per delivery) and marginal cost (fuel, wear, and the courier's time) are graphed. (a) How many deliveries per hour maximize net benefit? (b) Calculate the marginal benefit and marginal cost at that quantity. (c) The cost of fuel rises so that marginal cost is \$8 at every quantity. Explain how the best quantity changes. (d) Is the statement 'The courier ought to be paid more' positive or normative?



14. A town is deciding how many hours per week to keep its public library open. The graph shows the marginal benefit to residents (MB) and marginal cost (MC) of each additional hour (in hundreds of dollars). (a) Identify the quantity at which $MB = MC$ and the value of MB there. (b) Explain why opening 30 hours rather than the optimal level would reduce net benefit. (c) A new budget cut raises the hourly operating cost by \$2 hundred at every quantity. Give the new MC equation and the new best quantity.

**1.2** Production Possibilities Curve

You will learn to read, draw, and calculate with the production possibilities curve (PPC) to show scarcity, opportunity cost, efficiency, and economic growth.

The **production possibilities curve (PPC)**, also called the production possibilities frontier, is a model showing the maximum combinations of two goods an economy can produce in a given period when it uses all its resources fully and efficiently with a fixed level of technology. It is the economy-wide version of an individual's budget constraint: it shows what is possible, and what must be given up to get more of one good.

PPC assumptions

- Only two goods are considered (all else is held fixed).
- Resources (land, labor, capital, entrepreneurship) and technology are fixed.
- Resources are fully employed for points on the curve.
- Output is measured over a specific time period.

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Because the economy can choose among many combinations, the curve slopes downward: more of one good means less of the other. Put the goods on the axes, and every point tells you something.

Location of a point	Meaning	Efficiency
On the curve	Attainable with full use of resources and technology	Productively efficient: more of one good requires less of the other
Inside the curve	Attainable, but resources are idle or misused (unemployment, waste)	Productively inefficient: could have more of one or both goods
Outside the curve	Not attainable with current resources and technology	Unattainable now; possible only after economic growth

Two kinds of efficiency

Productive efficiency: producing at minimum cost, which is any point on the PPC; you cannot make more of one good without making less of another.

Allocative efficiency: producing the specific mix of goods that society values most, where marginal benefit equals marginal cost for each good. Only one point on the PPC is allocatively efficient.

Notice the relationship: allocative efficiency requires productive efficiency (you must be on the curve), but being on the curve does not guarantee that the mix is the one people want. A country that builds only tanks and no food could be on its PPC and still be allocatively inefficient.

Opportunity cost on the PPC. Moving from one point to another along the curve, the opportunity cost of the extra units of one good is the amount of the other good given up. To compute it per unit, divide what you give up by what you gain:

Opportunity cost formula

Opportunity cost of 1 unit of X (in units of Y) = (decrease in Y) / (increase in X).

The opportunity cost of Y is the reciprocal: (decrease in X) / (increase in Y).

In graph terms, the absolute value of the slope of the PPC (with X on the horizontal axis) is the opportunity cost of one more X.

Constant versus increasing opportunity cost. If resources are equally good at producing either good, shifting them from one good to the other always costs the same amount of the other good. The PPC is then a **straight line** and opportunity cost is **constant**. In reality most resources are specialized. Farmland is excellent for corn but poor for making computers, and software engineers are better at designing chips than farming. When an economy first shifts resources toward corn, it uses those best suited for corn, giving up little cloth. As it pushes further, it has to use resources that are less and less suited, so each extra unit of corn costs more cloth. The result is a **bowed-out (concave to the origin) PPC** with **increasing opportunity cost**, which is the law of increasing opportunity cost.

Feature	Straight-line PPC	Bowed-out PPC
Slope	Constant	Gets steeper as you move along the X axis
Opportunity cost	Constant	Increasing
Resources	Equally productive in both goods	Specialized; not perfectly adaptable
Typical use	Simplified trade examples	Realistic economy

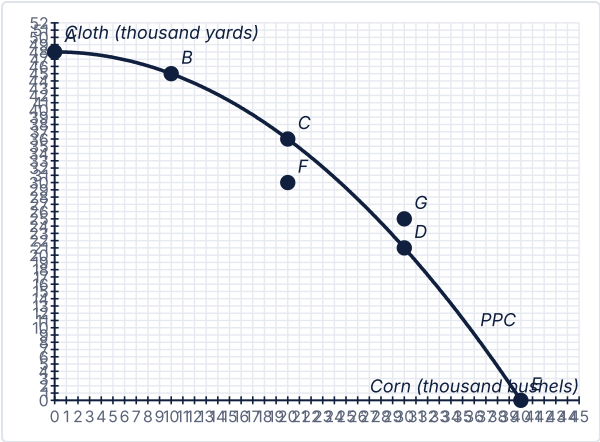
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EXAMPLE 1: READING A PPC FROM A TABLE

An economy produces corn and cloth. Its production possibilities are shown. (a) Find the opportunity cost of corn per unit as it moves from A to B, B to C, C to D, and D to E. (b) What shape does the PPC have, and why? (c) Classify the combinations (20 corn, 30 cloth) and (30 corn, 25 cloth).



Point	Corn (thousand bushels)	Cloth (thousand yards)
A	0	48
B	10	45
C	20	36
D	30	21
E	40	0

SOLUTION

- (a) Each step adds 10 corn. A to B: cloth falls $48 - 45 = 3$, so $3/10 = 0.3$ cloth per corn. B to C: $45 - 36 = 9$, so 0.9. C to D: $36 - 21 = 15$, so 1.5. D to E: $21 - 0 = 21$, so 2.1.
- (b) The opportunity cost of corn rises (0.3, 0.9, 1.5, 2.1), so the PPC is bowed outward. Resources are specialized, and the economy first uses those best suited to corn.
- (c) At 20 corn the frontier is at 36 cloth, so (20, 30) is below the curve (point F): attainable but inefficient, with some resources idle or misused. At 30 corn the frontier is 21 cloth, so (30, 25) lies above the curve (point G): unattainable with current resources and technology.

Shifts of the PPC. The curve shows possibilities at a moment in time, so only changes in resources or technology move it. Economic growth means the PPC shifts outward.

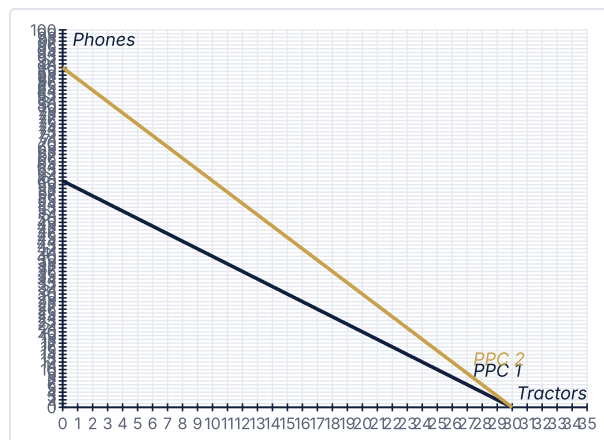
Event	Effect on PPC
Larger labor force, more capital goods, discovery of natural resources	Outward shift in both goods
Better education or training (human capital)	Outward shift in both goods
Technology that improves only good X	Pivot outward on the X axis only; the Y intercept is unchanged
Natural disaster, war damage, loss of labor force	Inward shift
Recession or unemployment	No shift; the economy moves to a point inside the curve
Recovery from a recession	Move from a point inside toward the curve; no shift
Trade or a change in what society prefers	No shift; at most movement along the curve

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EXAMPLE 2: A STRAIGHT-LINE PPC AND TECHNOLOGY

An economy with a fixed labor force can produce at most 60 phones or at most 30 tractors, with constant opportunity cost. A software advance lets it produce at most 90 phones (if all labor makes phones) but it can still make at most 30 tractors. (a) Find the opportunity cost of one tractor before and after. (b) Find the opportunity cost of one phone before and after. (c) Describe the change in the PPC.

**SOLUTION**

- (a) Before: giving up 60 phones to get 30 tractors, so $60/30 = 2$ phones per tractor. After: $90/30 = 3$ phones per tractor.
 (b) Before: $30 \text{ tractors} / 60 \text{ phones} = 0.5$ tractor per phone. After: $30/90 = 1/3$ of a tractor per phone.
 (c) The PPC pivots outward along the phone axis only. Every combination with some phones is now larger, but the maximum tractor output is unchanged. Phones became cheaper in terms of tractors, and tractors became more expensive in terms of phones.

EXAMPLE 3: EVENTS AND THE PPC

For each event, state whether the PPC shifts, and whether the economy moves along or off the curve: (a) unemployment rises sharply; (b) a flood destroys half the country's factories; (c) the government funds a big increase in worker training; (d) the country decides to produce more military goods and fewer consumer goods.

SOLUTION

- (a) No shift. The economy moves from the curve to a point inside it, because labor is idle.
 (b) Inward shift, since the stock of capital is lower and the maximum output of both goods falls.
 (c) Outward shift: better-trained workers are more productive in both goods, an increase in human capital.
 (d) No shift. This is a movement along the curve to a different point. It changes the mix, and it is an allocative question: which point does society prefer?

Common mistakes

(1) Saying a point inside the curve is unattainable; it is attainable but inefficient. (2) Showing economic growth as movement along the curve; growth is an outward shift. (3) Dividing the wrong way: opportunity cost of X is units of Y given up per unit of X. (4) Confusing a recession (move inside) with an inward shift (loss of resources). (5) Assuming every point on the PPC is allocatively efficient; they are all productively efficient but only one matches society's preferences. (6) Drawing a bowed PPC when the question says constant cost.

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Practice

SET A Check Your Understanding

Answer each question with calculations or short explanations.

1. A small economy produces cakes and pies with the combinations: 0 cakes and 60 pies; 10 cakes and 54 pies; 20 cakes and 42 pies; 30 cakes and 0 pies. Calculate the opportunity cost of one cake (in pies) for each move from one combination to the next. Is the opportunity cost constant or increasing?
2. The graph shows a PPC for capital goods and consumer goods. Classify each point as (i) attainable and efficient, (ii) attainable but inefficient, or (iii) unattainable: P (10, 45), Q (10, 30), R (30, 30), S (20, 30).



3. Explain why a typical economy's PPC is bowed outward rather than a straight line.
4. State whether the PPC shifts, and in what direction, for each: (a) a surge of immigration adds workers, (b) an earthquake destroys many factories, (c) a new method of farming raises corn output only, (d) the unemployment rate rises.
5. An economy can produce at most 400 laptops or at most 100 tablets, with constant opportunity cost. What is the opportunity cost of one tablet? If it produces 60 tablets, what is the maximum number of laptops?
6. A country is producing on its PPC but the mix of goods is not what citizens want. Is the country productively efficient? Allocatively efficient? Explain.

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SET B

Exam-Style Multiple Choice

Choose the best answer.

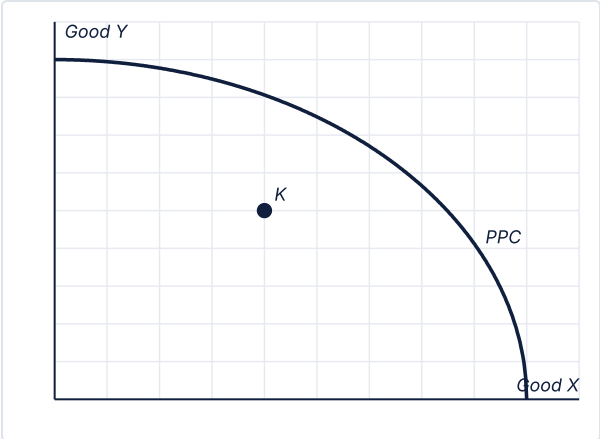
7. The PPC for an economy is bowed outward. This shape reflects
- (A) constant opportunity cost because resources are equally productive in all uses

(B) decreasing opportunity cost as more of a good is produced

(C) increasing opportunity cost because resources are not equally suited to producing both goods

(D) fixed technology only

(E) the scarcity of money in the economy
8. In the graph, the economy is at point K. Which statement is correct?



- (A) The economy is productively efficient at K.

(B) K is unattainable with current resources and technology.

(C) K shows that opportunity cost is zero.

(D) The economy must be at K because the PPC is fixed.

(E) The economy is using resources inefficiently or has unemployment at K.
9. The table shows combinations on a country's PPC. What is the opportunity cost of one additional tractor when moving from C to D?

Point	Tractors	Trucks
A	0	50
B	10	48
C	20	42
D	30	22
E	40	0

- (A) 2 trucks

(B) 0.5 trucks

(C) 1 truck

(D) 3 trucks

(E) 6 trucks
10. Which event would shift an economy's PPC outward?
- (A) A rise in the unemployment rate

(B) A temporary strike that ends within a week

(C) A natural disaster that destroys equipment

(D) An increase in the quality of education that makes workers more productive

(E) A decision to produce more consumer goods and fewer capital goods

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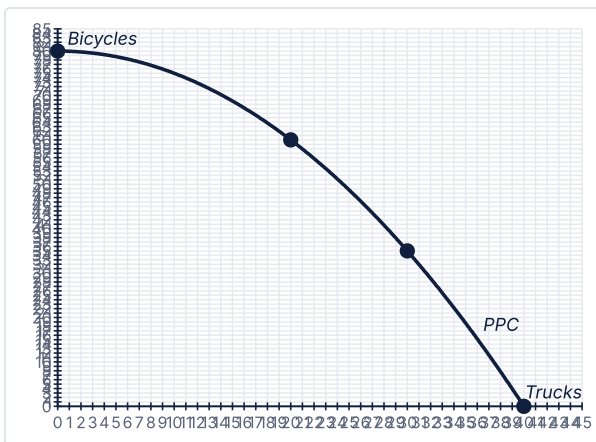
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11. A technological advance doubles the output of good X for a given amount of resources, while there is no change in technology for good Y. The PPC with X on the horizontal axis will
- (A) shift inward
 - (B) pivot outward along the X axis, with the Y intercept unchanged
 - (C) shift outward parallel in both directions
 - (D) pivot outward along the Y axis, with the X intercept unchanged
 - (E) remain unchanged
12. A point on the PPC is allocatively efficient when
- (A) no resources are unemployed
 - (B) the economy is using the least costly production method
 - (C) the economy is at the midpoint of the curve
 - (D) opportunity cost is constant
 - (E) the mix of goods produced is the one society values most

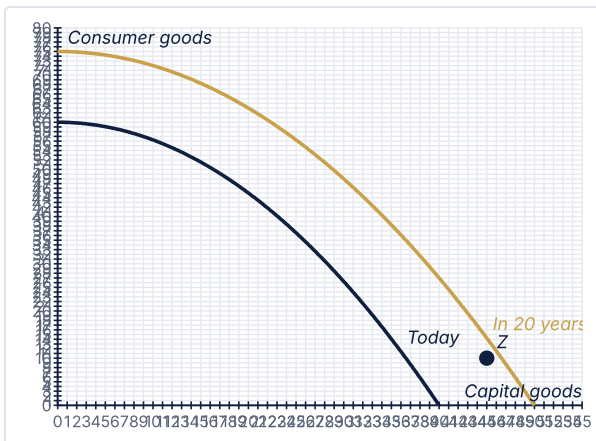
SET C Apply and Extend

Answer fully. Use the graphs.

13. The graph shows the production possibilities of an economy for trucks (horizontal) and bicycles (vertical). Points: (0, 80), (20, 60), (30, 35), (40, 0). (a) Calculate the opportunity cost per truck of moving from 20 to 30 trucks, and from 30 to 40 trucks. (b) Explain what happens to opportunity cost and why. (c) Classify the point (30, 45) and the point (20, 40). (d) A new method makes bicycle production more efficient while truck production stays the same. Describe the change in the PPC.



14. A country has the PPC today shown in navy for capital goods (horizontal) and consumer goods (vertical). Another curve, in gold, shows its PPC in 20 years. (a) Name two factors that could cause the shift. (b) The country chooses to produce many capital goods today, which gives up consumer goods now. Explain why this choice can lead to the shift shown. (c) Is the combination of 45 capital goods and 10 consumer goods attainable today? In 20 years? Explain using the graph.



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1.3

Comparative Advantage and Gains from Trade

You will learn to tell absolute advantage from comparative advantage, compute opportunity costs from output or input tables, find mutually beneficial terms of trade, and show gains from trade on a graph.

Individuals, firms, and countries rarely produce everything they consume. A dentist could probably paint her own office faster than a painter could fix her teeth, yet she hires the painter. The idea behind this choice is the foundation of trade: people and nations gain when each specializes in what it gives up the least to produce.

Absolute advantage is the ability to produce a good using fewer resources (hours, workers) or to produce more output with the same resources. It compares productivity. **Comparative advantage** is the ability to produce a good at a lower **opportunity cost** than another producer. It compares what has to be given up. These two can point in different directions, and the AP exam often tests that gap.

Absolute vs comparative advantage

Absolute advantage: more output per unit of input, or fewer inputs per unit of output.

Comparative advantage: lower opportunity cost.

A producer can have an absolute advantage in everything, but cannot have a comparative advantage in everything (with two goods and two producers).

Why can't one producer have a comparative advantage in both goods? With two goods, the opportunity cost of X is the reciprocal of the opportunity cost of Y. If your opportunity cost of X is lower than mine, your opportunity cost of Y must be higher than mine. So each producer has the lower opportunity cost in exactly one good (unless the opportunity costs are identical, in which case there are no gains from trade).

Computing opportunity cost from tables. The method depends on how the table is built.

Table type	What it shows	Opportunity cost of 1 unit of X
Output table	Units produced in the same time (per hour, per worker)	(units of Y given up) / (units of X gained) = Y output / X output
Input table	Hours (or workers) needed per unit	hours per unit of X / hours per unit of Y (in units of Y)
PPC graph	Maximum of X and Y with all resources	Y intercept / X intercept for a straight-line PPC

Rule for the lowest opportunity cost

Output table: $OC\ of\ X = Y / X$. The smaller number is the comparative advantage in X.

Input table: $OC\ of\ X = (hours\ per\ X) / (hours\ per\ Y)$.

Whoever has the lower OC of a good has the comparative advantage in it; the other has it in the other good.

EXAMPLE 1: IDENTIFY BOTH ADVANTAGES (OUTPUT TABLE)

In one day, one worker in Ardonia can produce 8 bushels of wheat or 4 bolts of cloth. One worker in Belmar can produce 2 bushels of wheat or 2 bolts of cloth. (a) Who has the absolute advantage in each good? (b) Find each country's opportunity cost of each good. (c) Who has the comparative advantage in each good?

SOLUTION

(a) Ardonia produces more of both goods per worker ($8 > 2$ wheat; $4 > 2$ cloth), so Ardonia has the absolute advantage in both.

(b) Ardonia: $OC\ of\ 1\ wheat = 4/8 = 0.5\ cloth$; $OC\ of\ 1\ cloth = 8/4 = 2\ wheat$. Belmar: $OC\ of\ 1\ wheat = 2/2 = 1\ cloth$; $OC\ of\ 1\ cloth = 2/2 = 1\ wheat$.

(c) Wheat: Ardonia $0.5 < Belmar\ 1$, so Ardonia has the comparative advantage in wheat. Cloth: Belmar $1 < Ardonia\ 2$, so Belmar has the comparative advantage in cloth.

Conclusion: Ardonia has the absolute advantage in both goods but the comparative advantage only in wheat.

Specialization and the terms of trade. When each country specializes in its comparative advantage and trades, total output can rise. The **terms of trade** are the rate at which the two goods are exchanged. Trade is voluntary, so each side must get a better deal than it could get by producing the good itself. The terms must therefore lie strictly between the two countries' opportunity costs.

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Terms of trade

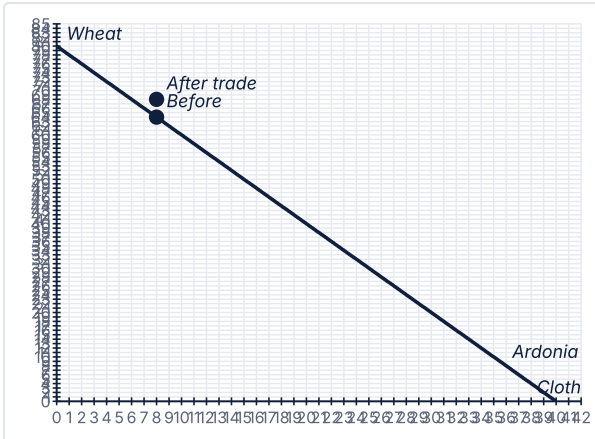
The price of a good must fall between the two producers' opportunity costs of that good.

A producer will buy a good if the trade price is below its own OC of making it, and will sell it if the trade price is above its own OC.

If the price equals someone's OC, that side gains nothing.

EXAMPLE 2: GAINS FROM TRADE ON A GRAPH

Using Example 1, suppose each country has 10 workers. Ardonia can make 80 wheat or 40 cloth, so its PPC is $\text{wheat} = 80 - 2(\text{cloth})$. Before trade, Ardonia produces and consumes 64 wheat and 8 cloth. Belmar can make 20 wheat or 20 cloth and produces 8 wheat and 12 cloth. (a) Find the range of mutually beneficial prices of 1 cloth in wheat. (b) Ardonia specializes in wheat (80) and Belmar in cloth (20). At a price of 1.5 wheat per cloth, Belmar sells 8 cloth to Ardonia. Find what each consumes. (c) Show the result for Ardonia on the graph.



SOLUTION

(a) 1 cloth costs Ardonia 2 wheat and Belmar 1 wheat. Belmar will sell cloth only for more than 1 wheat, and Ardonia will buy it only for less than 2 wheat, so the price must satisfy $1 < \text{price} < 2$ wheat per cloth.

(b) Belmar sells 8 cloth and receives $8 \times 1.5 = 12$ wheat. Belmar consumes $20 - 8 = 12$ cloth and 12 wheat, compared with 12 cloth and 8 wheat before: 4 more wheat and no less cloth. Ardonia pays 12 wheat, consuming $80 - 12 = 68$ wheat and 8 cloth, compared with 64 wheat and 8 cloth: 4 more wheat and no less cloth.

(c) At 8 cloth the PPC would allow only $80 - 16 = 64$ wheat. After trade Ardonia has 68 wheat, a point above the PPC. Trade lets a country consume outside its own PPC.

World output check: before, wheat $64 + 8 = 72$, cloth $8 + 12 = 20$; after specialization, wheat 80 and cloth 20. Total wheat is higher by 8, which is the gain shared by both countries (4 each).

EXAMPLE 3: INPUT TABLE

Hours needed to produce one unit: Alba needs 2 hours per shirt and 4 hours per hat. Boro needs 6 hours per shirt and 8 hours per hat. (a) Who has the absolute advantage? (b) Who has the comparative advantage in shirts? (c) Would a trade price of 1.5 shirts per hat benefit both?

SOLUTION

(a) Alba uses fewer hours for both goods, so Alba has the absolute advantage in both.

(b) OC of a shirt: Alba = $2/4 = 0.5$ hat; Boro = $6/8 = 0.75$ hat. Alba's is lower, so Alba has the comparative advantage in shirts, and Boro in hats.

(c) OC of a hat: Alba = $4/2 = 2$ shirts; Boro = $8/6 = 4/3$, or about 1.33 shirts. Boro (the hat producer) must receive more than 1.33 shirts per hat, and Alba must pay less than 2. A price of 1.5 lies between 1.33 and 2, so both gain.

Specialization also improves skills and uses resources where they are most productive, and the gains from trade do not require that either side be 'the best' at anything. Even if one country is better at everything, the less productive country can still sell the good where its productivity disadvantage is smallest.

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Common mistakes

(1) Using the smaller number in an input table as the comparative advantage; you must compute opportunity cost. (2) Dividing in the wrong direction in an output table. (3) Saying that a country with an absolute advantage in everything cannot gain from trade. (4) Choosing a trade price outside the range of the two opportunity costs, or equal to one of them. (5) Forgetting that trade lets consumption go beyond the PPC, while the PPC itself does not move.

Practice**SET A Check Your Understanding**

Answer each question using calculations or short explanations.

- In one hour Maria can make 10 sandwiches or 5 salads. In one hour Ben can make 6 sandwiches or 4 salads. Calculate each person's opportunity cost of a sandwich and of a salad, and state who has the comparative advantage in each good.
- Hours per unit: Country P needs 3 hours per tractor and 6 hours per truck; Country Q needs 12 hours per tractor and 18 hours per truck. Who has the absolute advantage in each good? Who has the comparative advantage in tractors?
- Using the information about Maria and Ben, between what two prices (in sandwiches per salad) must a trade fall for both to gain?
- Explain why a country that is more productive in every good can still gain from trade.
- Explain why, in a two-good, two-country model, one country cannot have the comparative advantage in both goods.
- A student says, 'Country R takes fewer hours to make both goods, so it should make both and not trade.' Evaluate this statement.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. The table shows output per worker per day. Which statement is correct?

Country	Corn (bushels)	Cloth (yards)
X	12	6
Y	4	4

- (A) Country X has a comparative advantage in both goods.
 (B) Country Y has an absolute advantage in cloth.
 (C) Country Y has a comparative advantage in corn.
 (D) Country X has the absolute advantage in both goods and a comparative advantage in corn.
 (E) Neither country can gain from trade.
8. Hours needed to make one unit are shown. Which country has the lowest opportunity cost of producing a chair?

Country	Hours per chair	Hours per table
Nuvo	4	8
Varo	10	10

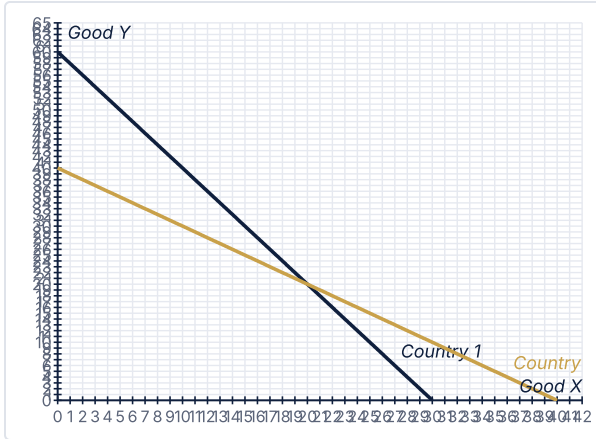
- (A) Nuvo, since $4/8 = 0.5$ table
 (B) Nuvo, since it takes 4 hours per chair
 (C) Varo, since it takes 10 hours per chair
 (D) Varo, since $10/10 = 1$ table
 (E) Both have the same opportunity cost
9. Country A's opportunity cost of one unit of good R is 2 units of S. Country B's opportunity cost of one unit of R is 4 units of S. Which price of 1 R, in units of S, could lead both to gain from trade?
- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5

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10. The graph shows the PPCs for two countries producing goods X (horizontal) and Y (vertical). Which statement is correct?



- (A) Country 1 has a comparative advantage in X.
 (B) Country 2 has a comparative advantage in X.
 (C) Country 2 has a comparative advantage in Y.
 (D) Neither has a comparative advantage.
 (E) Country 1 has an absolute advantage in X.
11. After two countries specialize according to comparative advantage and trade at mutually beneficial terms, which is true?
 (A) Each country's PPC shifts outward.
 (B) Each country must produce both goods.
 (C) Total world output of at least one good must fall.
 (D) The country with the absolute advantage in both goods gains and the other loses.
 (E) Each country can consume at a point outside its own PPC.
12. Tia can bake 6 loaves or paint 2 fences per day. Raj can bake 3 loaves or paint 3 fences per day. Which is correct?
 (A) Raj has the comparative advantage in painting.
 (B) Tia has the comparative advantage in painting.
 (C) Raj has the absolute advantage in baking.
 (D) Tia has an absolute advantage in painting.
 (E) Raj has a comparative advantage in baking.

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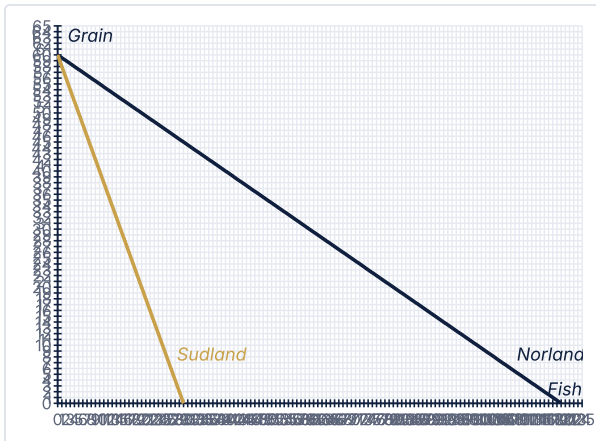
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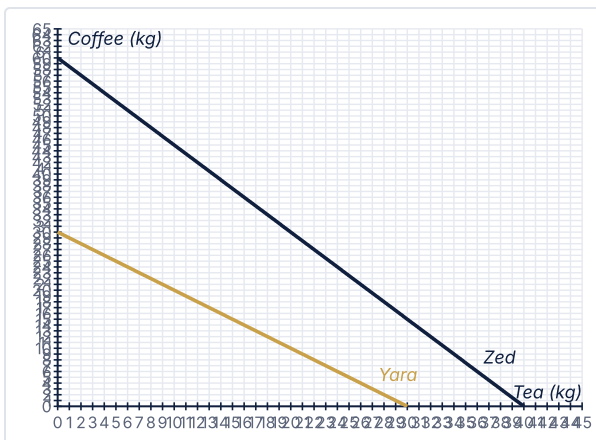
SET C Apply and Extend

Answer fully. Use the graph.

13. With 10 workers each, Norland can produce 120 fish or 60 units of grain, and Sudland can produce 30 fish or 60 units of grain. The PPCs (fish on the horizontal axis) are shown. (a) Calculate each country's opportunity cost of a fish and of a unit of grain. (b) State each country's comparative advantage and each country's absolute advantage. (c) Give the range of mutually beneficial prices of 1 fish in grain, and say whether a price of 1 grain per fish works. (d) Sudland produces 15 fish and 30 grain before trade. After specializing, it produces 60 grain and trades 25 grain for 25 fish. Show that Sudland consumes beyond its PPC.



14. Zed and Yara each have 120 hours. Zed needs 2 hours per kilogram of coffee and 3 hours per kilogram of tea. Yara needs 4 hours per kilogram of coffee and 4 hours per kilogram of tea. The PPCs (tea on the horizontal axis) are shown. (a) Find who has the absolute advantage in each good. (b) Find each country's opportunity cost of a kilogram of tea in coffee and state the comparative advantages. (c) Which of these prices (coffee per kilogram of tea) allows both countries to gain: 0.8, 1.25, 1.6? Explain. (d) Explain, using the graph, why Yara still benefits even though Zed is better at both.

**1.4 Economic Systems, Property Rights, and the Circular Flow**

You will learn how societies answer the basic economic questions, how markets, commands, and mixed systems differ, why property rights matter, and how the circular flow shows the links between households, firms, and government.

Scarcity forces every society to answer three basic questions: **what** to produce, **how** to produce it (which resources and methods), and **for whom** (how output is distributed). An **economic system** is the set of institutions a society uses to answer them. The systems differ mainly in who makes the decisions, who owns the resources, and what coordinates the choices.

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Feature	Traditional	Command	Market
Who decides	Custom and habit; roles passed on by family	Central government planners	Millions of households and firms acting on their own
Resource ownership	Often communal or by family	State owns most capital and land	Private individuals and firms
Coordination	Tradition	Plans and orders	Prices and voluntary exchange
Strength	Stability	Can direct resources toward national goals quickly	Efficiency, innovation, variety, responds to consumer wants
Weakness	Little growth or change	Poor information, weak incentives, shortages and surpluses	Inequality, externalities, public goods may be under-provided
Examples	Some isolated farming or hunting communities	North Korea, Cuba (heavily state controlled)	Closest real examples are market-oriented, such as Hong Kong and the United States

In a **market economy**, prices serve as signals. If buyers want more of a good, its price rises, which both rewards the producers who make it and tells other firms to enter. Adam Smith described this as the **invisible hand**: individuals pursuing their own interests, guided by prices, are led to produce what society wants without anyone directing them. The profit motive pushes firms to use scarce resources efficiently, because wasting resources lowers profit.

In a **command economy**, planners cannot easily know what millions of people want or what every factory can produce. When prices do not reflect scarcity, the result is often shortages of some goods and surpluses of others, and workers and managers have little reward for innovation or effort. That does not make a plan impossible, but it explains why planned systems usually perform less efficiently.

Market vs command

Market economy: private ownership, decentralized decisions, prices coordinate, self-interest and profit as incentives.

Command economy: government ownership and central planning; the state answers what, how, and for whom.

Almost every real economy is a mixed economy that combines both.

Real economies are **mixed economies**: a market system in which government also plays a role. Think of a spectrum. At one end is complete government control, at the other end complete private control, and every country lies somewhere between. The United States relies mostly on markets but the government provides national defense, public schools, and a safety net, regulates industries, and taxes income. Other countries have more state ownership or more extensive social programs.

Property rights are the legal rights to own, use, and sell resources and what they produce. Markets depend on them. If you cannot be sure you will keep the gains from your work or investment, you have little reason to work, invest, or take care of the asset. When no one owns a resource, such as an open pasture or ocean fishery, each user has an incentive to take as much as possible, and the resource can be overused. Secure property rights, enforceable contracts, and a legal system to settle disputes lower the cost of doing business and encourage investment and growth.

Why property rights matter

They give owners the incentive to invest, innovate, and maintain assets, since they keep the rewards.

They allow trade, because you can only sell what you legally own.

They reduce overuse of resources that no one owns.

Without them, resources tend to be used less productively and growth slows.

The **circular flow model** simplifies the economy to show how money, goods, and resources move between decision makers. There are two sets of participants and two sets of markets:

- ◆ **Households** own the factors of production. They sell (supply) land, labor, capital, and entrepreneurship in **factor markets** (resource markets) and buy (demand) goods and services in **product markets**.
- ◆ **Firms** buy (demand) resources in factor markets, using them to produce goods and services, which they sell (supply) in product markets.
- ◆ Real flows: resources move from households to firms; goods and services move from firms to households.
- ◆ Money flows move in the opposite direction: households pay firms for products (firms' revenue, households' consumption spending), and firms pay households for resources as wages, rent, interest, and profit (households' income).

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Circular flow summary

Product market: households buy, firms sell. Factor market: households sell, firms buy.
Money flows: spending (households to firms in product markets) and income (firms to households in factor markets).
In the simplest model, total income equals total spending, so the flow continues without end.

EXAMPLE 1: FOLLOWING THE FLOWS

Jada works at a bakery and is paid \$500 in wages for the week. She spends \$120 of it on groceries from a supermarket. (a) In which market does Jada's work take place, and who supplies and who demands? (b) In which market is her grocery purchase, and who supplies and who demands? (c) Describe the money flow and the real flow in each market.

SOLUTION

- (a) Her work takes place in the factor (labor) market. Jada, as a household, supplies labor; the bakery, a firm, demands it.
- (b) Her grocery purchase is in the product market. The supermarket (firm) supplies the groceries; Jada (household) demands them.
- (c) In the labor market, the real flow is Jada's labor going to the bakery, and the money flow is the \$500 wages going from the bakery to Jada. In the product market, the real flow is groceries going from the supermarket to Jada, and the money flow is the \$120 going from Jada to the supermarket.

The basic model is easily extended. Households save part of income, and financial markets turn saving into loans for firms' investment. The government collects taxes from households and firms and spends on goods, services, and transfer payments. The foreign sector adds exports (money in from abroad) and imports (money out). Each addition is a leakage from the circular flow (saving, taxes, imports) or an injection into it (investment, government spending, exports).

EXAMPLE 2: INCOME AND SPENDING

In a simple economy with no government, saving, or foreign sector, households receive these payments from firms: wages \$800, rent \$100, interest \$60, profit \$140 (all in millions). (a) What is total household income? (b) What is total spending in the product market if all income is spent? (c) Now suppose households save \$100 of income and financial markets lend all of it to firms for investment. What is the total flow of spending received by firms?

SOLUTION

- (a) Total income = $800 + 100 + 60 + 140 = \$1,100$ million.
- (b) If all income is spent, households spend \$1,100 million in the product markets, which equals firms' revenue.
- (c) Households spend $1,100 - 100 = \$1,000$ million on consumption. Firms borrow the saved \$100 million and use it to buy capital goods, adding \$100 million of investment spending. Total spending received by firms = $1,000 + 100 = \$1,100$ million. Saving is a leakage that is returned to the flow through investment in the financial market.

What is the role of government in a mixed economy? Economists point to several functions: enforcing property rights and contracts; providing **public goods** such as national defense; correcting **externalities** (for example, taxing pollution or subsidizing education); promoting competition and regulating monopolies; redistributing income through taxes and transfers; and stabilizing the economy. Government intervention involves trade-offs: it can improve efficiency or equity but also have costs and unintended consequences.

Government action	Role it illustrates
Enforcing a contract between a seller and a buyer	Protecting property rights and contracts
Building a lighthouse used by all ships	Providing a public good
Taxing factory pollution	Correcting a negative externality
Blocking a merger that would create a monopoly	Promoting competition
Providing food assistance to low-income families	Redistributing income

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EXAMPLE 3: MATCHING SYSTEMS AND INCENTIVES

Country K's government sets the price of bread and decides how many farms grow wheat. Farmers who exceed the quota receive no extra pay. Country L lets farmers choose crops and sell at market prices, but the government taxes sales to fund free schools. (a) Which country is closer to a command economy? (b) Explain the incentive problem in Country K. (c) Why is Country L a mixed economy?

SOLUTION

- (a) Country K, because the government decides what is produced and sets prices.
- (b) Farmers keep none of the reward for extra effort, so the marginal benefit of producing more is zero, while the fixed price does not signal how scarce wheat actually is. Output is likely to be lower, and shortages or surpluses of bread are likely.
- (c) Country L answers most questions through markets with private choices and prices, but the government still provides a service, free schools, funded by taxes. It combines market allocation with a government role.

Common mistakes

(1) Saying households 'buy' resources in factor markets; households supply resources and firms buy them. (2) Mixing up real flows and money flows, which go in opposite directions. (3) Thinking any real economy is purely market or purely command; they are mixed. (4) Treating 'property rights' as only physical possessions; they include contracts and intellectual property. (5) Assuming the government has no role in a market economy.

Practice**SET A Check Your Understanding**

Answer each question in complete sentences.

1. Name the three basic economic questions and explain how each is answered in a market economy.
2. For each description, name the economic system: (i) a ministry sets the output quotas of every factory; (ii) a village grows the same crops by the same methods as its ancestors; (iii) prices set by supply and demand decide what is produced, and the government runs public schools.
3. In the circular flow, a family pays \$40 to a plumber. Identify the market, who is the supplier, and the direction of the money flow and the real flow.
4. In a simple economy, households receive wages of \$1,500, rent of \$200, interest of \$100, and profit of \$300 (in millions). If households save nothing, what is the total revenue of firms? If households save \$150 and it is fully borrowed and spent by firms, what is total spending received by firms?
5. Explain how a lack of secure property rights could reduce a farmer's willingness to improve the land.
6. Give two examples of ways the government functions in a mixed economy and name the role each illustrates.

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which of the following best describes a command economy?
- (A) Resources are privately owned and prices allocate goods.
 - (B) Custom determines what is produced and who gets it.
 - (C) Government enforces property rights but otherwise leaves decisions to markets.
 - (D) Households and firms trade without any government.
 - (E) Most decisions about production are made by central planners.
8. In the circular flow model, which transaction takes place in a factor market?
- (A) A firm pays wages to a worker for her labor.
 - (B) A household buys a pair of shoes.
 - (C) A firm sells computers to a household.
 - (D) A household buys a share of stock.
 - (E) The government sends a tax refund to a household.
9. Which of the following is most likely to occur when property rights are weak?
- (A) Individuals invest more in capital and innovation.
 - (B) Owners are more likely to maintain their property carefully.
 - (C) Resources without clear owners are likely to be overused.
 - (D) The cost of contracts falls.
 - (E) Economic growth accelerates.
10. In the simple circular flow, which statement about money and real flows is correct?
- (A) Money and real flows both go from households to firms in the product market.
 - (B) In the product market, goods flow from firms to households and money flows from households to firms.
 - (C) In the factor market, labor flows from firms to households.
 - (D) Wages flow from households to firms in return for products.
 - (E) Revenue flows from firms to households in the product market.
11. In a country's economy, markets determine most prices, and the government provides public schools and regulates pollution. This economy is best described as
- | | |
|---------------------------------|---------------------------|
| (A) a command economy | (B) a traditional economy |
| (C) a pure market economy | (D) a mixed economy |
| (E) an economy without scarcity | |
12. In a simple economy, households earn wages of \$600, rent of \$50, interest of \$70, and profit of \$80. They spend all income. What is the total spending in the product market?
- | | | | | |
|------------|------------|------------|------------|------------|
| (A) \$ 560 | (B) \$ 620 | (C) \$ 680 | (D) \$ 750 | (E) \$ 800 |
|------------|------------|------------|------------|------------|

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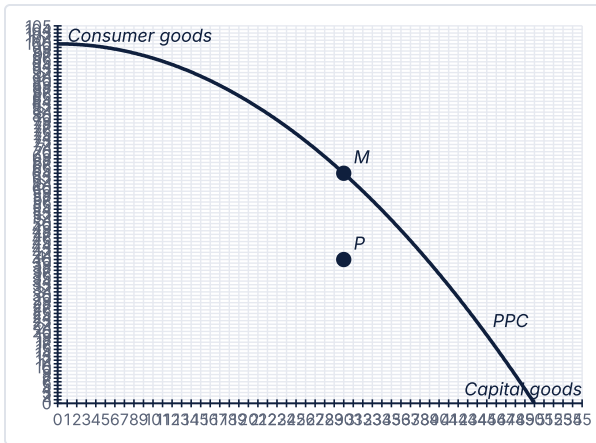
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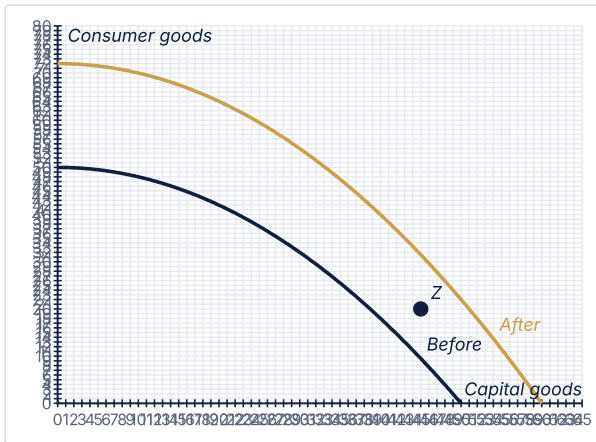
SET C Apply and Extend

Answer fully. Use the graphs.

13. An economy produces capital goods (horizontal) and consumer goods (vertical) with the PPC shown. Under central planning, the economy operates at point P (30 capital goods, 40 consumer goods). After market reforms, it operates at point M (30, 64). (a) Classify P and M in terms of productive efficiency. (b) Give two reasons a command economy might operate inside its PPC. (c) Explain what the PPC does not tell us about whether M is allocatively efficient, and name a way a market economy tries to answer that question.



14. A country strengthens its legal system so that contracts and ownership are reliably enforced. Over the next generation, its PPC shifts from the navy curve to the gold curve. (a) Explain two ways stronger property rights could cause this shift. (b) Is the combination of 45 capital goods and 20 consumer goods attainable before the reform? After? Use the graph and calculation. (c) Explain whether the shift of the PPC means that society has solved the problem of scarcity.

**1.5 Multiple-Choice Practice: Basic Economic Concepts**

Twenty AP-style multiple-choice questions on scarcity, opportunity cost, the production possibilities curve, comparative advantage, and economic systems.

Choose the best answer to each question. Some items include tables or graphs. Check each answer against the explanation, especially the reason the most tempting wrong choice fails.

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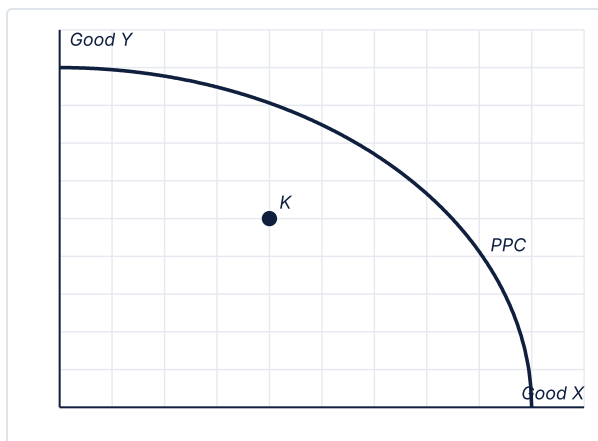
SET A Core Concepts

Choose the best answer.

- Which statement best defines scarcity?
 - A good is sold out at the current price
 - Human wants exceed the resources available to satisfy them
 - A country has a low level of income
 - Resources are in short supply only in poor countries
 - Prices are rising throughout the economy
- Sam spends Saturday at a free concert. He could instead have worked 5 hours at \$12 per hour or tutored for 4 hours at \$20 per hour (he can do only one). What is his opportunity cost of attending the concert?
 - \$0, because the ticket was free
 - \$60
 - \$80
 - \$100
 - \$140
- The table shows the marginal benefit (MB) of each unit of an activity and a constant marginal cost (MC) of \$5 per unit. How many units maximize net benefit?

Unit	MB (\$)
1	30
2	24
3	18
4	12
5	6

- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
- Which of the following is a normative statement?
 - Taxes on the wealthy should be raised to make society fairer.
 - A higher minimum wage will reduce the number of jobs available to teenagers.
 - The poverty rate was 11 percent last year.
 - Gasoline demand falls when its price rises.
 - Inflation was higher in 2022 than in 2019.
 - The graph shows an economy's production possibilities curve. Point K is



- attainable and productively efficient
- unattainable with current resources
- evidence of increasing opportunity cost
- attainable but productively inefficient
- a point where all resources are fully employed

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6. A production possibilities curve is bowed outward because
 (A) technology is constantly improving
 (B) resources are not equally suited to producing both goods, so opportunity cost rises
 (C) consumers prefer variety
 (D) all resources are equally productive in both goods
 (E) the economy is operating inefficiently
7. Output per hour: Lena makes 12 muffins or 6 loaves of bread; Omar makes 8 muffins or 2 loaves. Which statement is correct?
 (A) Lena has the comparative advantage in muffins because she makes more of them.
 (B) Omar has the absolute advantage in muffins.
 (C) Neither has a comparative advantage.
 (D) Lena has the comparative advantage in both goods.
 (E) Omar has the comparative advantage in muffins, even though Lena has the absolute advantage in both goods.

SET B Applications and Data

Choose the best answer.

8. Hours needed per unit: Fenn needs 3 hours per coat and 6 hours per pair of boots. Gorm needs 4 hours per coat and 12 hours per pair of boots. Which country has the comparative advantage in boots?
 (A) Fenn, because its opportunity cost of a pair of boots is 2 coats, versus 3 coats in Gorm
 (B) Gorm, because boots take it 12 hours
 (C) Fenn, because 6 hours is less than 12 hours, which makes it the only producer
 (D) Gorm, because its opportunity cost of boots is 3 coats, which is lower
 (E) Neither, because Fenn has the absolute advantage in both goods
9. Country A's opportunity cost of 1 widget is 3 gadgets, and Country B's is 5 gadgets. Which price of 1 widget (in gadgets) would allow both countries to gain from trade?
 (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
10. The table shows points on a country's PPC. What is the opportunity cost of one additional unit of X when moving from 20 to 30 units of X?

Units of X	Units of Y
0	60
10	50
20	30
30	0

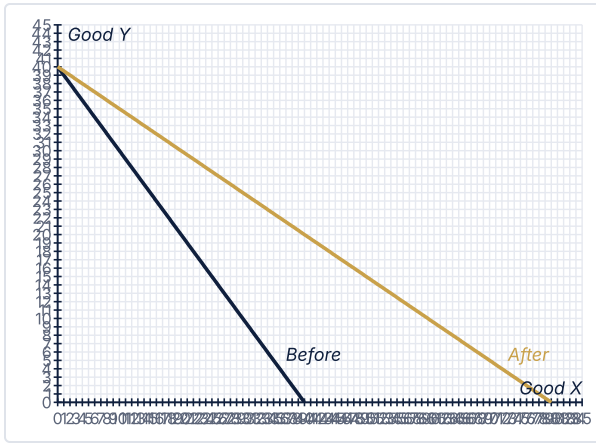
- (A) 1 unit of Y (B) 2 units of Y (C) 3 units of Y
 (D) 10 units of Y (E) 30 units of Y

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11. The graph shows an economy's PPC before (navy) and after (gold) an event. Which event is most likely?



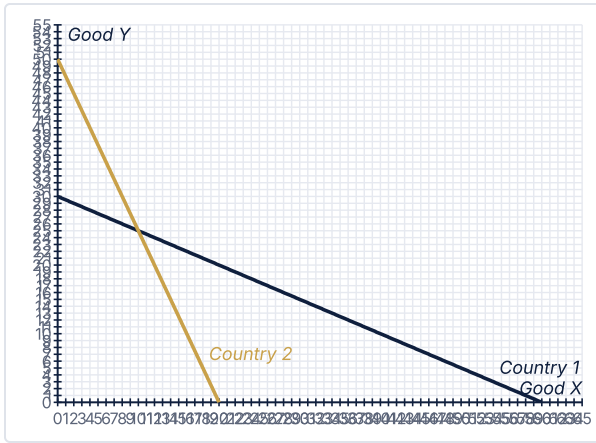
- (A) An increase in the unemployment rate
 (B) A technological advance that improves production of good X only
 (C) A flood that destroys much of the capital stock
 (D) A decision to produce more of good Y
 (E) A proportional increase in the labor force
12. In the circular flow model, a hospital hires a nurse. This transaction occurs in the
 (A) product market, where the hospital supplies services
 (B) financial market, where savings are lent
 (C) product market, where the nurse demands labor
 (D) factor market, where the hospital supplies labor
 (E) factor market, where the nurse (a household) supplies labor and the hospital (a firm) demands it
13. Mina paid a nonrefundable \$90 to attend a seminar. On the day, she could earn \$60 working instead, and she values the seminar at only \$40 now. What should she do and why?
 (A) Work, because the \$90 is sunk and \$60 exceeds the seminar's value of \$40
 (B) Attend, because otherwise she wastes \$90
 (C) Attend, because the seminar's value of \$40 exceeds its remaining cost
 (D) Work, because she lost \$90 either way and so the decision is a tie
 (E) Attend, since \$90 is more than \$60

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14. The graph shows the PPCs of two countries producing goods X and Y. Which statement is correct?



- (A) Country 2 has the comparative advantage in X.
- (B) Country 1 has the comparative advantage in Y.
- (C) Country 1 has the comparative advantage in X; Country 2 has it in Y.
- (D) Neither country has a comparative advantage.
- (E) Country 2 has the absolute advantage in X.

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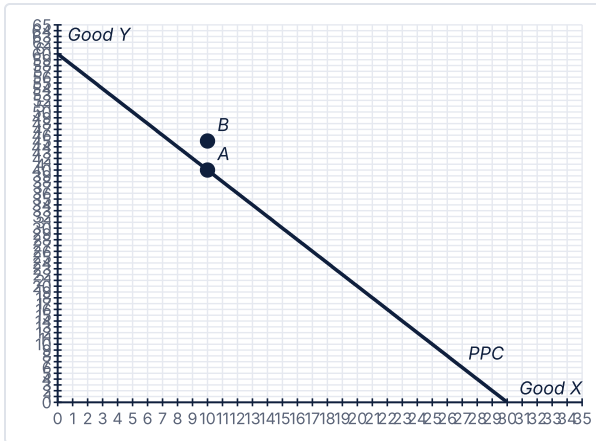
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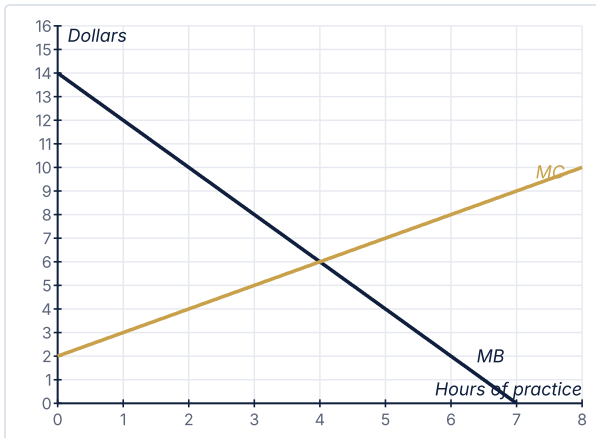
SET C Exam-Level Stretch

Choose the best answer.

15. Rosa leaves a job paying \$50,000 per year to run her own shop in a building she owns. In a year the shop earns \$120,000 in revenue and pays \$70,000 in explicit costs (wages, supplies, utilities). Ignoring any other implicit costs, her economic profit is
 (A) \$ 50,000 (B) \$ 70,000 (C) \$ 120,000 (D) \$ 0 (E) -\$ 50,000
16. A country's PPC is shown with two consumption points. Before trade it consumes at point A. After specializing and trading, it consumes at point B. Which statement is correct?



- (A) The PPC must have shifted outward because B is above it.
 (B) Trade allows the country to consume at B, which is outside its own PPC.
 (C) B is unattainable because it lies outside the PPC.
 (D) Point B shows that the country gave up the comparative advantage.
 (E) B is possible only if the country's resources have grown.
17. The graph shows the marginal benefit (MB) and marginal cost (MC) of hours of practice. If the marginal cost rises by \$3 at every quantity, so that new $MC = 5 + x$, what happens to the optimal number of hours?



- (A) It rises from 4 to 5 (B) It falls from 4 to 2 (C) It stays at 4
 (D) It falls from 6 to 5 (E) It falls from 4 to 3
18. Compare (1) a severe recession with high unemployment and (2) an earthquake that destroys factories and equipment. Which describes the effect on the PPC?
- (A) (1) is a move to a point inside the PPC; (2) is an inward shift of the PPC
 (B) (1) is an inward shift; (2) is a move inside the PPC
 (C) Both are inward shifts
 (D) Both are movements to a point inside the PPC
 (E) Neither changes the PPC or the location of the economy

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19. Country X can make 20 wheat or 10 oil per worker-day; Country Y can make 10 wheat or 10 oil. Which proposed trade, in which X sends 10 wheat to Y, would benefit both countries?
- (A) Y sends 3 oil to X (B) Y sends 4 oil to X (C) Y sends 5 oil to X
(D) Y sends 8 oil to X (E) Y sends 10 oil to X
20. Fishers share an unowned lake and the fish stock is rapidly declining. The best economic explanation is that
- (A) fishers are irrational and do not respond to incentives
(B) the government has set prices too high
(C) no one holds property rights, so each fisher ignores the cost that extra fishing imposes on others
(D) fish are not scarce
(E) a command economy is allocating the lake

1.6 Free-Response Practice: Basic Economic Concepts

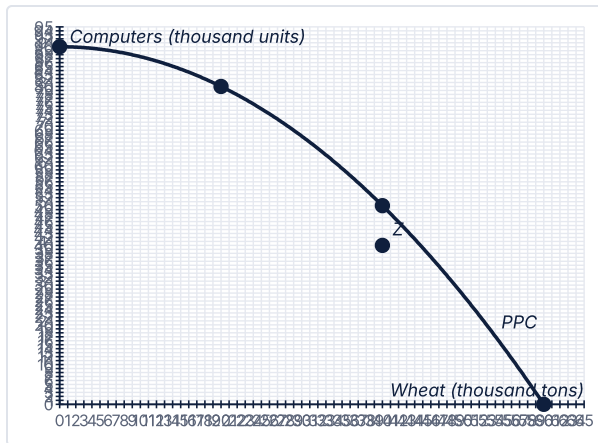
Four free-response questions on the PPC, comparative advantage, economic systems, and marginal analysis.

Each question is worth about 5 to 6 points. Show your work, label graphs, and state your reasoning in complete sentences. Compare your response with the scoring points in the model answers.

QUESTION 1 PPC and Opportunity Cost

The production possibilities curve shown is for an economy that produces wheat (horizontal axis, thousands of tons) and computers (vertical axis, thousands of units). Points on the curve are (0, 90), (20, 80), (40, 50), and (60, 0).

1. (a) Calculate the opportunity cost per ton of wheat of moving from 20 to 40 thousand tons of wheat, and from 40 to 60 thousand tons. State whether the opportunity cost is increasing, constant, or decreasing.



2. (b) Point Z is 40 wheat and 40 computers. Is Z attainable? Is it productively efficient? Explain.
3. (c) Explain why the PPC has this shape.
4. (d) A software breakthrough raises computer output but does not change wheat output. Describe the change in the PPC and the opportunity cost of one ton of wheat.

QUESTION 2 Comparative Advantage and Trade

In one day of work, Alpha can produce 30 shirts or 10 jackets. In the same time, Beta can produce 20 shirts or 5 jackets. Each can produce any combination along a straight-line PPC.

5. (a) Which country has the absolute advantage in producing shirts? In jackets?
6. (b) Calculate each country's opportunity cost of producing one shirt and one jacket.
7. (c) Identify the country with the comparative advantage in each good, and give the range of prices of a jacket, in shirts, at which both countries gain from trade.
8. (d) Explain whether a price of 2 shirts per jacket would be acceptable, and why specialization by both countries raises total output.

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QUESTION 3 Economic Systems and the Circular Flow

Answer the following about how economies are organized.

9. (a) Describe two differences between a market economy and a command economy.
10. (b) A bakery hires a worker and pays her a weekly wage. Identify the market in the circular flow model in which this occurs, state who is the supplier and who is the demander, and describe the direction of the money flow and of the resource flow.
11. (c) Explain how secure property rights encourage investment in a market economy.
12. (d) Identify one role the government plays in a mixed economy and explain why it is needed.

QUESTION 4 Marginal Analysis and Rational Choice

A small firm decides how many hours of overtime to run each day. Each overtime hour has a marginal cost of \$40. The marginal benefit of each hour is shown. The firm has already paid a nonrefundable \$100 fee to lease the building for the day.

13. (a) How many hours of overtime should the firm run? Explain using marginal analysis.

Overtime hour	Marginal benefit (\$)
1	90
2	70
3	50
4	30
5	10

14. (b) Calculate the firm's total net benefit from overtime at the quantity chosen in (a).
15. (c) Does the nonrefundable \$100 fee affect the answer to (a)? Explain.
16. (d) The marginal cost of an overtime hour rises to \$60. Find the new optimal number of hours, and classify as positive or normative: 'The firm should treat its workers fairly.'

Answers Chapter 1: Answers and Explanations

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

1.1 Scarcity, Opportunity Cost, and Marginal Analysis**SET A · CHECK YOUR UNDERSTANDING**

1. Scarcity means wants exceed the resources available. A wealthy person has more money but still only 24 hours a day and cannot buy everything that exists. Choosing a yacht means not buying a different luxury, and an hour at a meeting is an hour not spent elsewhere. Scarcity is about the gap between unlimited wants and limited resources at every income level.
2. Oven = capital (earns interest); flour = land or natural resources, as a raw material (earns rent); bakers = labor (earn wages); the owner who organizes the business and takes the risk = entrepreneurship (earns profit). The oven is capital because it is a produced good used to make other goods, and money is not capital in this sense.
3. Only the best forgone alternative counts. Working pays $6 \times \$16 = \$96$ and babysitting pays $6 \times \$12 = \$72$, so the next best alternative is working for \$96. His opportunity cost is \$96, even though the ticket was free in money terms. Adding the babysitting income would be a mistake because he could not do both.
4. Priya should stay home. The \$60 is a sunk cost: it is gone whether she skis or not, so it must be ignored. The only relevant comparison is staying home (value \$20) versus skiing sick (value \$10). Staying home has the higher value, so she should stay.
5. (i) Positive: a fact that can be checked. (ii) Normative: 'ought' is a value judgment. (iii) Positive: a testable prediction. (iv) Normative: 'too cheap' reflects a judgment about what the price should be.
6. Returns should rise. The higher refund increases the marginal benefit of returning one more bottle, while the marginal cost (time and effort of the trip) is unchanged. More bottles now have $MB \geq MC$, so people return more of them. This is an example of people responding to incentives.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. E. The opportunity cost is the value of the next best alternative, which is studying. The ticket price is an explicit cost, not the opportunity cost, and the shift's \$45 is not the next best alternative because she ranks studying higher. Adding the ticket and the wages double counts costs and ignores the 'next best' rule.
8. A. A truck is a produced good used to make delivery services, so it is capital. The loan is financial capital, not a factor of production; skills are labor; the decision to start the firm is entrepreneurship; the forest is land.
9. D. Hire while MB is at least the \$100 cost: workers 1 (220), 2 (160), and 3 (120) pass, but worker 4 adds only \$90, below \$100. So hire 3. Hiring 4 would come from comparing totals rather than the marginal worker.

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10. E. 'Should' and 'is a right' are value judgments. The other statements can all be tested against data even if they might be false, so they are positive. Choosing the unemployment statement confuses 'important fact' with 'opinion'.
11. B. The \$200 is sunk and must be ignored. The forward-looking comparison is \$90 (concert) versus \$120 (shift), so she works. Going to the concert to avoid 'wasting' the \$200 is the classic sunk-cost fallacy.
12. B. Scarcity is the gap between unlimited wants and limited resources, and it applies in every economy. It is not limited to poor countries, efficiency does not remove it, and it is different from a market shortage at a particular price.

SET C · APPLY AND EXTEND

13. (a) 4 deliveries per hour, where the MB and MC curves intersect (1 point). (b) $MB = 14 - 2(4) = \$6$ and $MC = 2 + 4 = \$6$, so $MB = MC$ at point E (1 point). (c) With $MC = \$8$: set $14 - 2x = 8$, so $x = 3$. Fuel costs raise the cost of each delivery, so the courier makes fewer deliveries, 3 per hour (1 point for direction and the number). (d) Normative, because 'ought' expresses a value judgment (1 point).
14. (a) Set $18 - 2x = 2 + 2x$, so $16 = 4x$, $x = 4$, meaning 40 hours; $MB = 18 - 8 = 10$ (hundred dollars) (1 point for 4 / 40 hours, 1 point for $MB = 10$). (b) At 30 hours ($x = 3$, which is below 4) MB (12) exceeds MC (8), so some extra hours still add more benefit than cost; net benefit is left unclaimed. Opening more than 40 hours would instead make MC exceed MB (1 point: link the comparison of MB and MC to the lost net benefit). (c) New $MC = 4 + 2x$. Set $18 - 2x = 4 + 2x$, so $14 = 4x$ and $x = 3.5$, or 35 hours; higher costs reduce the best amount of the service (1 point equation, 1 point quantity).

1.2 Production Possibilities Curve

SET A · CHECK YOUR UNDERSTANDING

1. Each move changes cakes by 10. 0 to 10 cakes: pies fall 6, so 0.6 pie per cake. 10 to 20: pies fall 12, so 1.2 pies per cake. 20 to 30: pies fall 42, so 4.2 pies per cake. The opportunity cost rises (0.6, 1.2, 4.2), so it is increasing and the PPC is bowed outward.
2. P: (i) attainable and efficient, since $60 - 1.5(10) = 45$, so P is on the curve. Q: (ii) attainable but inefficient, since it is below the curve at $x = 10$. R: (iii) unattainable; the frontier at $x = 30$ is 15, and 30 is above that. S: (i) on the curve, since $60 - 1.5(20) = 30$. Note that in this straight-line PPC the opportunity cost of one capital good is 1.5 consumer goods everywhere.
3. Resources are not equally good at making every good. When the economy shifts resources toward more of a good, it first uses the resources best suited to it (low opportunity cost), then has to use ones that are less suited, so each additional unit costs more of the other good. This law of increasing opportunity cost produces a curve that bows outward. A straight line would require resources that are equally productive in both goods.
4. (a) Outward shift in both goods because the labor force is larger. (b) Inward shift because capital is destroyed. (c) Outward pivot on the corn axis only; the other good's maximum does not change. (d) No shift; the economy moves to a point inside the PPC because resources are underused.
5. The opportunity cost of one tablet is $400/100 = 4$ laptops. Producing 60 tablets uses up $60 \times 4 = 240$ laptops of potential output, so the maximum number of laptops is $400 - 240 = 160$.
6. It is productively efficient because it is on the PPC, so it cannot raise one output without lowering the other. It is not allocatively efficient because the mix does not match what society values most, meaning marginal benefit is not equal to marginal cost for each good. A different point on the PPC would be better for society.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. A bowed PPC arises because resources are specialized, so each additional unit of one good costs more of the other. Constant opportunity cost (the tempting alternative) would produce a straight line, not a bowed one.
8. E. K lies inside the PPC, so it is attainable but resources are idle or wasted. It is not productively efficient, since both goods could be increased; the answer that it is productively efficient confuses 'inside' with 'on' the curve.
9. A. From C to D tractors rise by 10 and trucks fall from 42 to 22, a loss of 20, so $20/10 = 2$ trucks per tractor. The tempting 6 comes from using the B to C change (a total loss of 6 trucks between B and C), which is the wrong interval.
10. D. Better education raises human capital and increases productive capacity in both goods, so the PPC shifts out. Unemployment and a disaster move the economy inside or shift it inward, and choosing a different mix is movement along the curve.
11. B. Improved technology for X only raises the maximum of X, so the X intercept moves outward while the Y intercept stays the same. Parallel shifts need an improvement in both goods.
12. E. Allocative efficiency means the output mix matches society's preferences, so marginal benefit equals marginal cost for each good. Full employment and least-cost production describe productive efficiency, which holds at every point on the PPC.

SET C · APPLY AND EXTEND

13. (a) 20 to 30 trucks: bicycles fall $60 - 35 = 25$, so $25/10 = 2.5$ bicycles per truck. 30 to 40: bicycles fall $35 - 0 = 35$, so 3.5 per truck (1 point each). (b) Opportunity cost rises, because resources are specialized, so as trucks expand the economy must use resources less suited for trucks (1 point). (c) At $x = 30$ the frontier is $80 - 45 = 35$, so (30, 45) is above it: unattainable. At $x = 20$ the frontier is 60, so (20, 40) is inside: attainable but inefficient, with unemployed or misused resources (1 point each). (d) The PPC pivots outward along the bicycle axis: the bicycle intercept rises above 80, the truck intercept stays at 40 (1 point).
14. (a) Any two: more labor force growth, immigration, more capital, better education or training, better technology, discovery of resources (1 point). (b) Capital goods are used to produce more output later, so producing more of them today increases the stock of capital and raises future production capacity, shifting the PPC outward, at the cost of fewer consumer goods now (1 point for the link to capital, 1 point for the present trade-off). (c) Today: the frontier at 45 would need $x \leq 40$, since the x intercept is 40, so 45 capital goods is not attainable today (1 point). In 20 years: future frontier at 45 is $75 - 0.03(2025) = 14.25$ consumer goods, and $10 < 14.25$, so Z is attainable inside the future curve (1 point).

1.3 Comparative Advantage and Gains from Trade

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SET A · CHECK YOUR UNDERSTANDING

1. Maria: OC of a sandwich = $5/10 = 0.5$ salad; OC of a salad = $10/5 = 2$ sandwiches. Ben: OC of a sandwich = $4/6 = 2/3$ salad (about 0.67); OC of a salad = $6/4 = 1.5$ sandwiches. Maria has the lower OC of sandwiches ($0.5 < 0.67$), so she has the comparative advantage in sandwiches. Ben has the lower OC of salads ($1.5 < 2$), so he has the comparative advantage in salads.
2. Country P uses fewer hours for both tractors ($3 < 12$) and trucks ($6 < 18$), so P has the absolute advantage in both. OC of a tractor: $P = 3/6 = 0.5$ truck; $Q = 12/18 = 2/3$ truck. P's is lower, so P has the comparative advantage in tractors (and Q in trucks).
3. The price of a salad must exceed Ben's OC of 1.5 sandwiches (he will sell salads for more than that) and be below Maria's OC of 2 sandwiches (she will buy salads for less than that). So $1.5 < \text{price} < 2$ sandwiches per salad.
4. Gains come from comparative, not absolute, advantage. Even a highly productive country has a lower opportunity cost in one good than the other country does. By specializing in that good and trading, it gets the other good at a lower cost than making it itself, while its partner gets the good it makes more cheaply than it could alone. The partner's disadvantage is smaller in one good, so total output rises.
5. With two goods, the opportunity cost of X is the reciprocal of the opportunity cost of Y. If country 1 has a lower OC of X than country 2, then its OC of Y must be higher than country 2's. So the lower OC is always in different goods, unless the OCs are equal, which means no gains from trade.
6. The statement confuses absolute and comparative advantage. Producing everything alone would use hours that could instead make the good in which Country R has the lower opportunity cost. By specializing and trading, R can have more of both goods. The other country is better at the other good in terms of what it gives up, so both gain.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. D. X produces more of both goods, so it has the absolute advantage in both. OC of corn: $X = 6/12 = 0.5$ cloth; $Y = 4/4 = 1$ cloth, so X has the comparative advantage in corn. A fails because a country cannot have the comparative advantage in both goods.
8. A. OC of a chair = hours per chair / hours per table: Nuvo = $4/8 = 0.5$ table; Varo = $10/10 = 1$ table. Nuvo's is lower. Basing the answer on hours alone ($4 < 10$) shows absolute advantage, not opportunity cost, though it happens to select the same country here.
9. C. The price must lie strictly between 2 and 4 units of S per R, so only 3 works. A price of 2 or 4 would leave one side indifferent, and 1 or 5 is outside both opportunity costs.
10. B. Country 2's PPC is flatter (OC of X = 1 unit of Y) than Country 1's (OC of X = 2 units of Y), so Country 2 has the lower OC of X. Choosing Country 1 reads the larger Y intercept as an advantage in X, which is absolute, not comparative.
11. E. Trade lets each country consume combinations beyond what it could produce alone, but the PPC itself does not shift. Total output rises, not falls, and both countries can gain even if one is more productive at everything.
12. A. OC of painting a fence: Tia = $6/2 = 3$ loaves; Raj = $3/3 = 1$ loaf. Raj's is lower, so he has the comparative advantage in painting. Tia has the absolute advantage in baking ($6 > 3$), and Raj has the absolute advantage in painting ($3 > 2$).

SET C · APPLY AND EXTEND

13. (a) Norland: OC of a fish = $60/120 = 0.5$ grain; OC of a grain = $120/60 = 2$ fish. Sudland: OC of a fish = $60/30 = 2$ grain; OC of a grain = $30/60 = 0.5$ fish (1 point). (b) Norland has the comparative advantage in fish ($0.5 < 2$); Sudland in grain ($0.5 < 2$). Absolute: Norland has more fish ($120 > 30$); both produce 60 grain, so neither has an absolute advantage in grain (1 point). (c) The price of a fish must be between 0.5 and 2 grain; 1 grain per fish lies in that range, so both gain (1 point). (d) Before trade Sudland consumes 15 fish and 30 grain. After trade it consumes 25 fish and $60 - 25 = 35$ grain, more of both. At 25 fish its PPC allows only $60 - 2(25) = 10$ grain, so 35 grain is far above the frontier (1 point).
14. (a) Zed: $2 < 4$ for coffee and $3 < 4$ for tea, so Zed has the absolute advantage in both (1 point). (b) OC of a kg of tea: Zed = $3/2 = 1.5$ coffee; Yara = $4/4 = 1$ coffee. Yara has the lower OC of tea, so it has the comparative advantage in tea; Zed has it in coffee (OC of coffee: Zed $2/3$ tea, Yara 1 tea) (1 point). (c) The price of tea must be between 1 and 1.5 coffee, so only 1.25 works. At 0.8, Yara would sell tea for less than its own cost; at 1.6, Zed would pay more than making it (1 point). (d) The graph shows Yara's PPC is flatter in terms of tea (OC 1) than Zed's (OC 1.5). Yara gives up less coffee for tea, so it should specialize in tea, sell it at a price above 1 coffee and buy coffee, getting a combination beyond its own PPC (1 point).

1.4 Economic Systems, Property Rights, and the Circular Flow**SET A · CHECK YOUR UNDERSTANDING**

1. What to produce: consumers' purchases and the profit-seeking choices of firms decide, signaled by prices. How to produce: firms choose the lowest-cost methods and resource combinations to maximize profit. For whom: goods go to those with the money to pay, and income depends on the resources a person owns and their value in the market. These questions are answered by millions of private choices, not by central direction.
2. (i) Command economy, because the central ministry makes the production decisions. (ii) Traditional economy, because custom determines what, how, and for whom. (iii) Mixed economy (market-oriented), since markets and prices allocate most goods while government provides schooling.
3. The plumber's services are traded in a product market, with the plumber's firm supplying and the family (household) demanding. Money flows from the family to the plumber (firm), and the real flow (the service) goes from the plumber to the family.
4. With no saving, firms' revenue equals total income: $1,500 + 200 + 100 + 300 = \$2,100$ million. If households save 150, consumption is $2,100 - 150 = 1,950$, and firms' investment spending adds 150, so firms receive $1,950 + 150 = \$2,100$ million in total spending.
5. If the farmer might lose the land, or others could take the crops without paying, he cannot count on keeping the benefits of improvements like irrigation or fertilizer. The expected marginal benefit of investing falls below the marginal cost, so he does little or nothing. Secure property rights would let him keep the extra output, encouraging investment and higher productivity.
6. Two examples: building and maintaining national defense, a public good; taxing pollution, which corrects a negative externality. Others: enforcing contracts (protecting property rights), enforcing antitrust laws (promoting competition), or paying unemployment benefits (redistributing income).

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SET B · EXAM-STYLE MULTIPLE CHOICE

7. E. In a command economy, central planners decide what to produce, how, and for whom. The market description (private ownership with prices) is the opposite, and custom-driven choice describes a traditional economy.
8. A. Wages are payments for labor, which households supply in the factor market. Buying shoes or computers occurs in product markets; buying stock occurs in a financial market; and a tax refund is a transfer, not a factor market exchange.
9. C. Without secure ownership, no one captures the long-run benefits of care, so each user has an incentive to take what they can, and resources are overused. The tempting claims about more investment and growth describe the effect of strong, not weak, property rights.
10. B. In the product market, the real flow of goods and services goes from firms to households, while the money payments go the other way. The claim that wages flow from households to firms reverses the factor-market flow.
11. D. Markets set prices but the government also provides schools and regulates pollution, which is a mixed economy. A pure market economy would not include these government roles, and a command economy would have the state set prices.
12. E. Total income = $600 + 50 + 70 + 80 = \$800$, and households spend all of it, so product-market spending is \$800. Leaving out one payment, such as rent, gives the tempting \$750; counting only wages and profit gives \$680.

SET C · APPLY AND EXTEND

13. (a) P is inside the PPC because the frontier at 30 capital goods is $100 - 0.04(900) = 64$, and P has only 40 consumer goods, so P is productively inefficient; M, with 64 consumer goods, lies on the PPC and is productively efficient (1 point each). (b) Any two: planners lack the information that prices provide, so resources are misallocated; workers and managers have little incentive to improve productivity because rewards are not tied to output; innovation is discouraged; shortages and waste result (1 point each, up to 2). (c) A point on the PPC is productively efficient but the PPC does not show which mix society prefers; allocative efficiency requires that the mix matches consumers' wants ($MB = MC$) (1 point). Markets use prices and consumer choices, and firms respond to profit, to move toward the mix people want.
14. (a) Any two: secure property rights raise the incentive to invest in capital and to innovate because owners keep the returns; they allow trade and credit because assets can be sold or used as collateral; they reduce overuse and waste (1 point each, up to 2). (b) Before: the frontier at 45 capital goods is $50 - 0.02(2025) = 9.5$, and $20 > 9.5$, so Z is unattainable. After: the frontier is $72 - 40.5 = 31.5$, and $20 < 31.5$, so Z is attainable (inside the new PPC) (1 point each). (c) No. The PPC shifted outward, so more of both goods is possible, but wants are still unlimited and resources are still limited, so choices and trade-offs still exist (1 point).

1.5 Multiple-Choice Practice: Basic Economic Concepts**SET A · CORE CONCEPTS**

1. B. Scarcity is the gap between unlimited wants and limited resources, and it exists in every economy. A shortage of a particular good at a given price is only one market outcome, not scarcity itself.
2. C. Opportunity cost is the value of the next best alternative: tutoring pays $4 \times 20 = \$80$, which beats working ($5 \times 12 = \$60$). Adding the two options (\$140) is wrong since he could not do both.
3. E. Net benefit is maximized when every unit with MB above MC is included. All five units have MB of 30, 24, 18, 12, and 6, each above the MC of \$5, so the fifth unit still adds net benefit. Stopping at 4 treats a low benefit as a loss.
4. A. 'Should' and 'fairer' express a value judgment that data cannot settle. The other statements are claims about facts or cause and effect that can, in principle, be tested.
5. D. K is inside the curve, so it is attainable but some resources are idle or misused. It is not unattainable; that description fits points outside the PPC.
6. B. Specialized resources cause the opportunity cost of each extra unit to rise as production of a good expands. If resources were equally productive in both goods, the PPC would be a straight line.
7. E. OC of a muffin: Lena = $6/12 = 0.5$ loaf; Omar = $2/8 = 0.25$ loaf. Omar's is lower, so he has the comparative advantage in muffins. Lena's higher output (absolute advantage) does not decide comparative advantage.

SET B · APPLICATIONS AND DATA

8. A. OC of boots: Fenn = $6/3 = 2$ coats; Gorm = $12/4 = 3$ coats. Fenn's is lower. Option D reverses the comparison, and the answer about absolute advantage ignores that only opportunity cost determines comparative advantage.
9. D. The price must be strictly between 3 and 5, so only 4 works. A price of 3 or 5 equals one country's opportunity cost, leaving that country indifferent.
10. C. Moving from 20 to 30 X, Y falls from 30 to 0, a loss of 30 for a gain of 10 X, so $OC = 3$ Y per X. The 30 is the total loss of Y, not the loss per unit of X.
11. B. The Y intercept is unchanged while the X intercept rises, a pivot caused by technology that affects only good X. A proportional rise in labor would shift both intercepts outward.
12. E. Labor is a factor of production, so the exchange is in the factor market with households supplying and firms demanding. The product market involves goods and services, not labor.
13. A. The \$90 is sunk, so it is irrelevant. The forward-looking comparison is \$60 (working) against \$40 (seminar), which favors working. Attending to avoid 'wasting' the \$90 is the sunk-cost fallacy.
14. C. Country 1's PPC is flatter (OC of X = 0.5 Y) than Country 2's (OC of X = 2.5 Y), so Country 1 has the lower opportunity cost of X. Country 2 therefore has the comparative advantage in Y. The tempting choice about Country 2 and X reads the steeper curve as an advantage.

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SET C · EXAM-LEVEL STRETCH

15. D. Economic profit = revenue - explicit costs - implicit costs = 120,000 - 70,000 - 50,000 = 0. The \$50,000 profit comes from ignoring her forgone salary, an implicit cost.
16. B. Trade lets a country consume combinations that it could not produce on its own, even though its PPC has not changed. The idea that B requires a shift confuses production possibilities with consumption possibilities.
17. E. Original: $14 - 2x = 2 + x$ gives $x = 4$. New: $14 - 2x = 5 + x$ gives $x = 3$. A higher marginal cost reduces the optimal quantity; it does not stay at 4.
18. A. A recession leaves productive capacity intact but underused, so the economy moves inside the curve. Destroyed capital reduces capacity, so the PPC shifts inward. Treating both as shifts confuses idle resources with lost resources.
19. D. OC of wheat: $X = 0.5$ oil, $Y = 1$ oil, so the price per wheat must be between 0.5 and 1 oil, or between 5 and 10 oil for 10 wheat. Only 8 oil falls strictly between; 5 and 10 each leave one country indifferent.
20. C. Without ownership, each fisher gains the full benefit of an extra catch but shares the cost of depletion, so the lake is overused. The explanation that fishers are irrational fails because they are responding to incentives, not ignoring them.

1.6 Free-Response Practice: Basic Economic Concepts**QUESTION 1 · PPC AND OPPORTUNITY COST**

1. 1 point: 20 to 40 wheat: computers fall from 80 to 50, so $30/20 = 1.5$ thousand computers per thousand tons of wheat. 1 point: 40 to 60: computers fall from 50 to 0, so $50/20 = 2.5$. 1 point: the opportunity cost is increasing (1.5 then 2.5).
2. 1 point: Z is attainable because it lies inside the PPC (at 40 wheat the frontier is 50 computers, and $40 < 50$). 1 point: Z is not productively efficient, because more computers (up to 50), or more of both goods, could be produced with the same resources.
3. 1 point: the PPC is bowed outward because resources are specialized and not equally suited to both goods. 1 point: as more wheat is produced, resources less suited to wheat are shifted, so each extra unit of wheat costs more computers (law of increasing opportunity cost).
4. 1 point: the PPC pivots outward along the computer axis, with the wheat intercept (60) unchanged and the computer intercept higher. 1 point: the opportunity cost of a ton of wheat rises, since more computers can now be made with the resources used to produce that wheat.

QUESTION 2 · COMPARATIVE ADVANTAGE AND TRADE

5. 1 point: Alpha has the absolute advantage in shirts ($30 > 20$). 1 point: Alpha also has it in jackets ($10 > 5$).
6. 1 point: Alpha's OC of a shirt = $10/30 = 1/3$ jacket; OC of a jacket = $30/10 = 3$ shirts. 1 point: Beta's OC of a shirt = $5/20 = 1/4$ jacket; OC of a jacket = $20/5 = 4$ shirts.
7. 1 point: Beta has the comparative advantage in shirts ($1/4 < 1/3$) and Alpha in jackets ($3 < 4$). 1 point: the price of a jacket must be between 3 and 4 shirts.
8. 1 point: 2 shirts per jacket is not acceptable, because Alpha, the jacket producer, could give up 3 shirts to make a jacket itself, and would not sell one for 2 shirts; the price is below the range. 1 point: each country uses its resources where its opportunity cost is lowest, so the same labor produces more total output, and trade lets both consume more than they could alone.

QUESTION 3 · ECONOMIC SYSTEMS AND THE CIRCULAR FLOW

9. 1 point each for two valid differences, for example: ownership of resources (private versus government); who decides what to produce (millions of private buyers and sellers versus central planners); how prices are set (supply and demand versus government-set); the main incentive (profit and self-interest versus plan quotas).
10. 1 point: it occurs in the factor (resource) market, specifically the labor market. 1 point: the worker (household) supplies labor and the bakery (firm) demands it. 1 point: money (wages) flows from the bakery to the household, while the resource (labor) flows from the household to the bakery.
11. 1 point: owners know they will keep the returns from investing, so the expected marginal benefit of building, improving, or innovating is higher. 1 point: secure rights also let owners sell or borrow against assets, which finances more investment.
12. 1 point: any valid role, such as providing public goods, correcting externalities, enforcing contracts and property rights, promoting competition, or redistributing income. 1 point: a correct reason, for example that private markets alone would underprovide public goods because people can use them without paying.

QUESTION 4 · MARGINAL ANALYSIS AND RATIONAL CHOICE

13. 1 point: 3 hours. 1 point: the firm should add each hour while marginal benefit is at least marginal cost: hours 1 to 3 have MB of 90, 70, and 50, which are above 40, but hour 4 has MB of 30, which is below 40.
14. 1 point: total benefit = $90 + 70 + 50 = \$210$. 1 point: total cost = $3 \times 40 = \$120$. Net benefit = $210 - 120 = \$90$.
15. 1 point: no. 1 point: the \$100 fee is a sunk cost, already paid and not recoverable whatever the firm decides, so it does not change the marginal benefit or marginal cost of any overtime hour.
16. 1 point: with $MC = \$60$, only hours 1 and 2 (MB of 90 and 70) exceed the cost, so the optimum is 2 hours. 1 point: the statement about treating workers fairly is normative, because it contains a value judgment (should, fairly).

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Chapter 2: Supply and Demand.

10 sections with explanations and worked examples, then 148 practice problems. Answers and full explanations are at the end of the chapter.

2.1 Demand and the Law of Demand

Learn what demand is, why the demand curve slopes down, and how to tell a shift from a movement along the curve.

Demand is the relationship between the price of a good and the quantity consumers are both willing and able to buy at each price, during a specific period, holding everything else constant. Both words matter: a wish you cannot pay for is not demand. Economists hold other influences fixed with the phrase **ceteris paribus** (all else equal), so that the effect of price can be seen alone.

Be exact with two terms. **Quantity demanded** is one number: how much buyers want at one particular price, a single point on the curve.

Demand is the whole relationship, the entire schedule or the entire curve. Only a change in the good's own price changes the quantity demanded. Everything else changes demand.

Law of demand

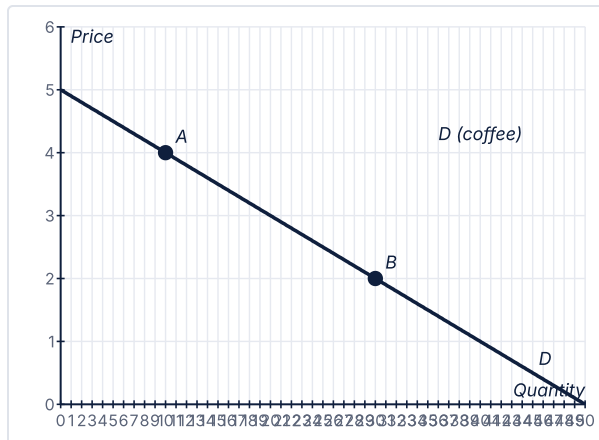
As the price of a good rises, the quantity demanded falls, and as the price falls, the quantity demanded rises, *ceteris paribus*.

The demand curve therefore slopes downward. Price is on the vertical axis and quantity on the horizontal axis.

A **demand schedule** is a table of prices and quantities demanded. Plotting it gives the **demand curve**. Here is a market for coffee, in thousands of cups per day:

Price per cup	Quantity demanded (thousands)
\$1	40
\$2	30
\$3	20
\$4	10
\$5	0

Why does the curve slope downward? Three reasons work together. The **substitution effect**: when coffee gets pricier relative to tea, buyers switch some purchases to tea. The **income effect**: a higher price shrinks the buying power of a fixed income, so you can afford fewer cups. And **diminishing marginal utility**: each extra cup is worth a bit less to you than the one before, so you will only buy additional cups at lower prices.



The demand curve for coffee. Moving from A to B is a movement along D caused by a price decrease.

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Shift vs. movement

A change in the good's own price causes a movement along the demand curve (a change in quantity demanded).

A change in any other determinant shifts the whole curve: right is an increase in demand, left is a decrease in demand.

The **determinants of demand** are the non-price factors that shift the curve. A handy memory aid is **TRIBE**:

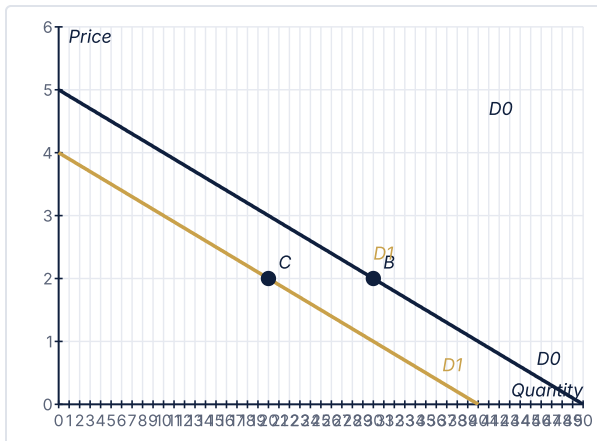
Determinant	Demand increases (shifts right) when...	Demand decreases (shifts left) when...
Tastes	the good becomes more fashionable or popular	the good goes out of style
Related goods	a substitute gets more expensive, or a complement gets cheaper	a substitute gets cheaper, or a complement gets more expensive
Income	income rises (normal good), or income falls (inferior good)	income falls (normal good), or income rises (inferior good)
Population (number of buyers)	more buyers enter the market	buyers leave the market
Expectations	buyers expect a higher future price or higher future income	buyers expect a lower future price

Normal goods are goods whose demand rises when income rises (restaurant meals, new cars). **Inferior goods** are goods whose demand falls when income rises (instant noodles, bus rides for people who can then afford cars). Whether a good is inferior depends on the buyers: it is a statement about the sign of the income response, not about quality.

Substitutes can replace each other, so a rise in the price of one raises demand for the other (coffee and tea). **Complements** are used together, so a rise in the price of one lowers demand for the other (coffee and cream). Expectations can matter too: if shoppers think a price will jump next month, demand rises today.

EXAMPLE 1: MOVEMENT OR SHIFT?

Using the coffee schedule above ($Q_d = 50 - 10P$), (a) the price falls from \$4 to \$2. (b) Then consumer income falls, and coffee is a normal good, so that 10 thousand fewer cups are demanded at every price. Describe each change and find the new quantity demanded at \$2.



Demand decreases from D_0 to D_1 .

SOLUTION

(a) Price is the good's own price, so this is a movement down along D_0 from 10 to 30 thousand cups. Quantity demanded rises; demand does not change.

(b) Income is a determinant, so demand decreases: the curve shifts left. The new schedule is $Q_d = 40 - 10P$.

At \$2 the new quantity demanded is $40 - 20 = 20$ thousand cups, down from 30.

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EXAMPLE 2: CLASSIFY THE EVENT

For each event, state which determinant changes, the direction of the shift, and the curve affected: (a) a health study praises green tea, effect on the demand for green tea; (b) the price of cream cheese rises, effect on the demand for bagels; (c) incomes rise and the good is ramen noodles, an inferior good.

SOLUTION

(a) Tastes: demand for green tea increases (shift right).

(b) Bagels and cream cheese are complements. A higher price for cream cheese lowers the quantity of cream cheese bought, so the demand for bagels decreases (shift left).

(c) Income rises and the good is inferior, so demand for ramen decreases (shift left). Mixing up this direction is the most common slip on inferior goods.

Common mistakes

1) Saying 'demand falls' when only the price rose. A price change is a change in quantity demanded and a movement along the curve. 2) Treating 'a change in the price of the good' as a shifter. It never is. 3) Reversing the direction for complements: the price of the complement and the demand for the good move in opposite directions. 4) Shifting the curve 'up' or 'down' when describing a change in demand: say right/increase or left/decrease. 5) Forgetting that a rise in income lowers demand for an inferior good.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

- State the law of demand and give the economic reason a price cut raises quantity demanded for a good like bottled water.
- Use $Q_d = 50 - 10P$. Compute the quantity demanded at $P = \$3.50$ and the price at which $Q_d = 0$.
- The price of gasoline rises 30 percent. Does this change the demand for gasoline? Explain with the correct terms.
- Name the determinant and the direction of the demand shift: a heat wave hits and the good is air conditioners (a) when customers expect prices to double next month, and (b) when a new tax cuts household income, and air conditioners are normal goods.
- Define normal and inferior goods. A student's income rises from \$20,000 to \$30,000 and her monthly purchases of store-brand cereal fall. Is store-brand cereal normal or inferior for her?
- Explain why a rise in the price of tennis rackets decreases the demand for tennis balls but increases the demand for badminton rackets.

SET B Exam-Style Multiple Choice

Choose the best answer.

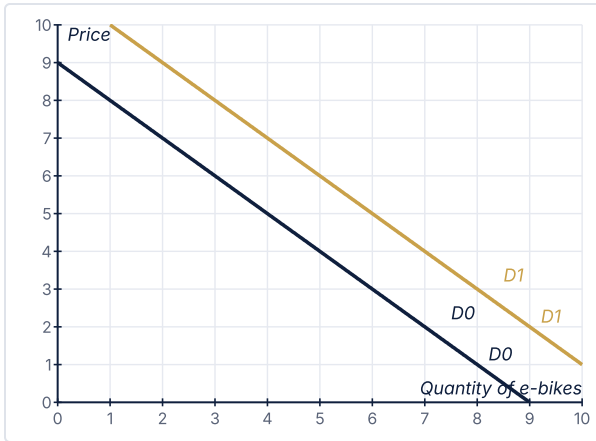
- Which of the following causes a movement along the demand curve for pizza rather than a shift of it?
 - (A) A decrease in the price of pizza
 - (B) A decrease in the price of burgers, a substitute
 - (C) An increase in consumer income, pizza being a normal good
 - (D) A news report that pizza is unhealthy
 - (E) An increase in the number of pizza buyers
- The price of coffee rises and, as a result, the demand for coffee creamer falls. Coffee and creamer are
 - (A) substitutes
 - (B) both inferior goods
 - (C) both normal goods
 - (D) complements
 - (E) unrelated goods
- When income increases, the demand for used textbooks decreases. Used textbooks are
 - (A) normal goods
 - (B) inferior goods
 - (C) substitutes for new textbooks
 - (D) complements for new textbooks
 - (E) luxury goods

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10. The graph shows demand moving from D_0 to D_1 in the market for electric bikes. Which could explain it?



- (A) A fall in the price of electric bikes
(B) A rise in the price of bike batteries, a complement
(C) A rise in the price of gasoline, a substitute commuting fuel for cars
(D) A decrease in the number of commuters
(E) An expectation that bike prices will fall next year
11. Along a demand curve, which of the following is held constant?
(A) The price of the good
(B) The quantity demanded
(C) Total revenue
(D) The quantity supplied
(E) Consumer income and the prices of related goods
12. Which statement about the income effect of a price change is correct?
(A) A lower price raises the buying power of a given income and so raises purchases
(B) It means consumers switch to cheaper goods
(C) It occurs only for inferior goods
(D) It means that higher income raises demand
(E) It shifts the demand curve to the right

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SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The graph shows the starting demand curve D_0 for tablet computers. Copy it and label axes. (a) Show the effect on the market of a fall in the price of tablet apps, which are complements. (b) Show a separate movement caused by a fall in the price of tablets. (c) State the changes in demand and quantity demanded in each case.



14. A town's incomes rise 10 percent. The monthly quantity of hot dogs bought at \$4 falls from 800 to 650, while the quantity of steaks bought at \$4 rises. (a) Classify each good. (b) Explain the demand shift for each. (c) Using the midpoint of the hot dog change, state the percentage change in quantity (use 650 and 800).

2.2 Supply and the Law of Supply

Learn what supply is, why the supply curve slopes upward, and how input prices, technology, taxes and subsidies shift it.

Supply is the relationship between the price of a good and the quantity producers are willing and able to sell at each price, during a specific period, *ceteris paribus*. As with demand, keep two ideas apart. **Quantity supplied** is one number at one price (a point). **Supply** is the whole schedule or curve.

Law of supply

As the price of a good rises, the quantity supplied rises, and as the price falls, the quantity supplied falls, *ceteris paribus*. The supply curve slopes upward. Price is on the vertical axis and quantity on the horizontal axis.

Why do sellers offer more at higher prices? First, producing extra units usually costs more per unit, because of **increasing opportunity cost**: to expand, a firm must pull inputs away from other uses or use less suitable ones. A higher price covers those higher costs and makes expansion profitable. Second, a high price pulls new sellers into the market and encourages existing ones to work harder. Third, a price rise makes this good's profit larger than that of the best alternative, so resources move into it.

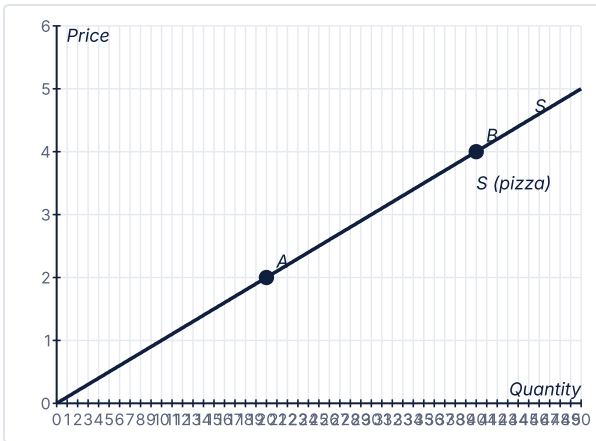
A **supply schedule** lists prices and quantities supplied, and the **supply curve** is its graph. Here is a market for pizzas in a small city, in hundreds per week:

Price per pizza	Quantity supplied (hundreds)
\$1	10
\$2	20
\$3	30
\$4	40
\$5	50

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Supply of pizza: $Q_s = 10P$. A price rise from \$2 to \$4 moves the market from A to B along S.

Shift vs. movement for supply

A change in the good's own price causes a movement along the supply curve (a change in quantity supplied).

A change in any other determinant shifts the curve: right is an increase in supply (more at every price), left is a decrease in supply.

The **determinants of supply** all work by changing the cost or profitability of producing. A useful memory aid is **ROTTEN**:

Determinant	Supply increases (shifts right) when...	Supply decreases (shifts left) when...
Resource (input) prices	wages, materials or energy get cheaper	input prices rise
Other goods' prices (opportunity cost)	the price of an alternative product the firm could make falls	the alternative product's price rises
Technology	a cost-cutting innovation arrives	technology is lost, or a disaster damages capital
Taxes and subsidies	a per-unit subsidy is given, or a tax is removed	a per-unit tax or costly regulation is added
Expectations	sellers expect lower future prices and sell now	sellers expect higher future prices and hold back
Number of sellers	new firms enter	firms exit

Notice how the logic of cost works. A **per-unit tax** is an added cost, so supply decreases by the amount of the tax at every quantity, which shifts the curve up (equivalently, left). A **subsidy** is a negative cost, so supply increases and the curve shifts down (equivalently, right). Taxes and subsidies are the only government actions that shift supply directly in the basic model. Price controls, in contrast, do not shift supply.

The opportunity-cost determinant deserves special care. A farmer can grow corn or soybeans on the same land. If the price of corn rises, growing soybeans is now more costly in terms of forgone corn profit, so the supply of soybeans decreases. Goods that firms can switch between in production are called **substitutes in production**. This is different from substitutes in consumption, where buyers switch.

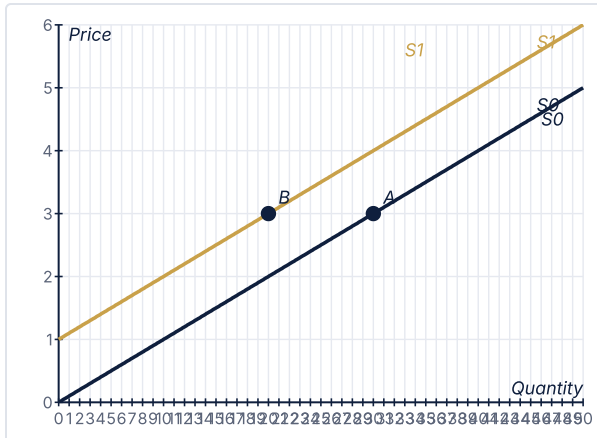
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EXAMPLE 1: MOVEMENT OR SHIFT?

Pizza supply is $Q_s = 10P$ (hundreds per week). (a) What happens to the quantity supplied when the price rises from \$2 to \$4? (b) The price of cheese rises so that every pizza costs \$1 more to make; the supplier needs \$1 more for each quantity. Give the new supply equation and the quantity supplied at \$3.



A \$1 per-pizza cost increase shifts supply from S_0 to S_1 .

SOLUTION

(a) Own-price change, so a movement along S : Q_s rises from 20 to 40 hundred.

(b) Each quantity now requires a price \$1 higher, so the new curve is $P = 1 + Q/10$, or $Q_s = 10(P - 1) = 10P - 10$.

At \$3, $Q_s = 30 - 10 = 20$ hundred, down from 30. This is a decrease in supply: a leftward (upward) shift.

EXAMPLE 2: PREDICT THE SHIFT

For each event, say which determinant is at work and whether supply of the named good increases or decreases: (a) a new oven halves baking time for bakeries; (b) the price of wheat, an input, falls for the bread market; (c) the price of corn rises and the good is soybeans; (d) the government gives dairy farmers \$0.50 per gallon of milk produced.

SOLUTION

(a) Technology improves: supply of bread rises (right).

(b) Lower input price lowers costs: supply of bread increases.

(c) Opportunity cost of growing soybeans rises: supply of soybeans decreases (left).

(d) A subsidy lowers net cost: supply of milk increases, a downward shift of \$0.50 at every quantity.

Common mistakes

1) Calling a price increase an 'increase in supply'. It is an increase in quantity supplied. 2) Shifting the supply curve of the input market itself, when the question concerns the market for the product made with that input. 3) Confusing the direction of tax and subsidy shifts: a tax shifts supply left/up, a subsidy shifts it right/down. 4) Thinking that higher demand raises supply. A demand change causes a movement along supply.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

1. State the law of supply and give one reason the supply curve slopes upward.
2. Using $Q_s = 10P$, compute the quantity supplied at $P = \$2.50$ and the minimum price at which the firm will supply 45 hundred pizzas.
3. A university raises tuition. Does that shift the supply of pizza from campus shops? Explain, then name one thing that would.
4. A government imposes a \$1 per-unit tax on sellers of lemonade. Describe the shift of supply in both vertical and horizontal terms.
5. A farmer can plant wheat or barley. The price of barley falls. What happens to the supply of wheat and why?

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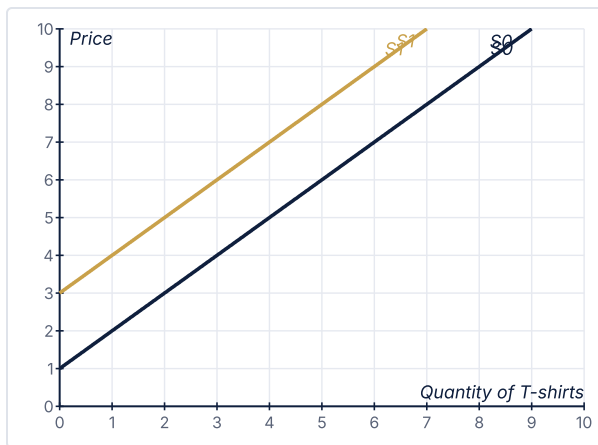
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6. Explain the difference between an increase in supply and an increase in quantity supplied, using a graph description.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which event would shift the supply curve for bicycles to the left?
- (A) The price of bicycles rises
 - (B) A new technology reduces assembly time
 - (C) The price of aluminum, used to make frames, rises
 - (D) The government pays a subsidy to bicycle makers
 - (E) Consumer income rises
8. A rise in the price of milk, *ceteris paribus*, will cause
- (A) an increase in the quantity of milk supplied
 - (B) an increase in the supply of milk
 - (C) a decrease in the supply of milk
 - (D) a decrease in the quantity of milk supplied
 - (E) a leftward shift of the supply curve for butter
9. The graph shows the market for custom T-shirts. The move from S_0 to S_1 could be caused by



- (A) a fall in the price of fabric
 - (B) a new faster printing machine
 - (C) entry of more T-shirt firms
 - (D) a per-shirt tax on sellers
 - (E) a subsidy for printing
10. A farmer can produce either corn or soybeans. If the price of soybeans rises, what happens in the corn market?
- (A) The supply of corn increases
 - (B) The demand for corn increases
 - (C) The quantity of corn supplied rises along the same curve
 - (D) Nothing, because the goods are unrelated
 - (E) The supply of corn decreases
11. A firm's supply curve for a product is best interpreted as showing
- (A) the maximum price consumers will pay for each quantity
 - (B) the minimum price the firm needs to receive to supply each quantity
 - (C) the quantity consumers want at each price
 - (D) how total cost changes with income
 - (E) the price at which profit is zero for every quantity

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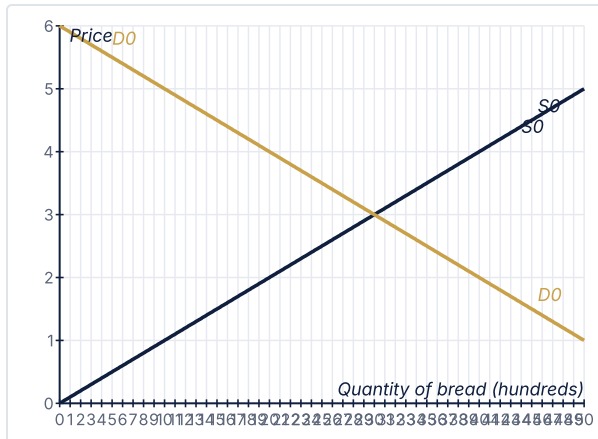
12. Which change leads to an increase in supply of rice in a country?

- (A) A tax on rice producers
- (B) A fall in the price of rice
- (C) A drought ends and weather becomes favorable
- (D) A rise in fertilizer prices
- (E) Producers expect future rice prices to be much higher

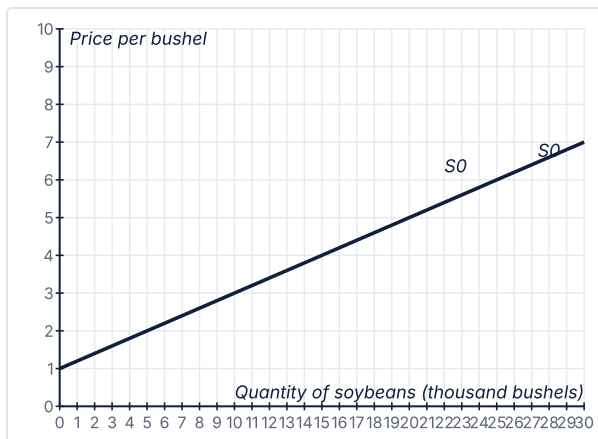
SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The market for bakery bread has supply S_0 and demand D_0 (shown). Bakers' flour price falls. (a) Show on a graph what happens to supply. (b) State whether the change is in supply or quantity supplied and name the determinant. (c) Explain, using the new supply schedule $Q_s = 10P + 10$, how many hundreds of loaves are offered at \$3, compared with the original $Q_s = 10P$.



14. A government gives soybean farmers a subsidy of \$2 per bushel. The original supply curve is $P = 1 + Q/5$ (Q in thousand bushels). (a) Write the new supply curve. (b) At what price will farmers now supply 15 thousand bushels, before and after the subsidy? (c) Explain why this is an increase in supply and not a change in quantity supplied.



2.3 Market Equilibrium and Changes in It

Find the equilibrium of a market, explain surpluses and shortages, and predict how shifts in demand and supply change price and quantity.

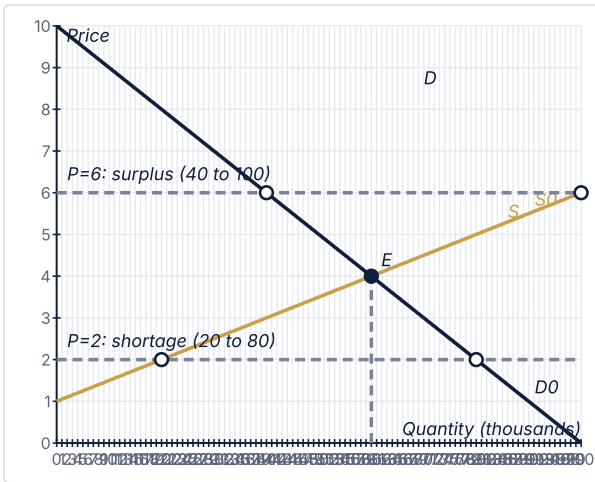
Market equilibrium is the price and quantity at which the quantity demanded equals the quantity supplied. On a graph, it is where the demand and supply curves cross. At the **equilibrium price** (the market-clearing price) every buyer who wants to buy at that price finds a seller, and every seller finds a buyer. The matching quantity is the **equilibrium quantity**.

Take a market with demand $Q_d = 100 - 10P$ and supply $Q_s = 20P - 20$, where Q is in thousands. Set $Q_d = Q_s$: $100 - 10P = 20P - 20$, so $120 = 30P$ and $P = \$4$. Substituting back gives $Q = 60$ thousand. The graph below shows this equilibrium and what happens if the price is set wrongly.

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Equilibrium at \$4 and 60 thousand. Above it there is a surplus; below it there is a shortage.

Surplus and shortage

Surplus (excess supply): quantity supplied exceeds quantity demanded; occurs when the price is above equilibrium. Sellers cut prices, so the price falls toward equilibrium.

Shortage (excess demand): quantity demanded exceeds quantity supplied; occurs when the price is below equilibrium. Buyers bid up the price, so it rises toward equilibrium.

The size of a surplus or shortage is the horizontal gap between the curves: $|Q_s - Q_d|$.

In the graph, at \$6 the quantity demanded is $100 - 60 = 40$ and the quantity supplied is $20(6) - 20 = 100$, a surplus of 60 thousand. At \$2, $Q_d = 80$ and $Q_s = 20$, a shortage of 60 thousand. Unsold inventory pushes sellers to cut prices; unsatisfied buyers push the price up. This self-correcting process is why equilibrium is stable when prices are free to move.

Equilibrium is not permanent. It changes when demand or supply shifts. Use the **four-step method** on every exam question: (1) Draw the initial market and label P_1 , Q_1 . (2) Decide whether the event shifts demand or supply, and which determinant it is. (3) Shift the correct curve in the right direction. (4) Read the new equilibrium and compare P and Q . A shift in one curve causes a movement along the other, never a shift of it.

Four-step method

1) Draw the starting market and mark P_1 , Q_1 . 2) Decide: demand or supply, and which determinant. 3) Shift that one curve in the correct direction. 4) Compare the new equilibrium with the old for price and for quantity.

Event	Curve shift	Equilibrium price	Equilibrium quantity
Demand increases	D right	up	up
Demand decreases	D left	down	down
Supply increases	S right	down	up
Supply decreases	S left	up	down

Now let both curves move. When demand and supply shift at the same time, one of the two outcomes is certain and the other depends on which shift is larger:

Demand	Supply	Price	Quantity
increases	increases	ambiguous	up
increases	decreases	up	ambiguous
decreases	increases	down	ambiguous
decreases	decreases	ambiguous	down

The memory trick: the shifts that point in the same left-right direction agree on quantity; the shifts that point in opposite directions (one left, one right) agree on price. Demand right with supply left both push price up, so price rises; quantity is unclear.

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EXAMPLE 1: FIND EQUILIBRIUM AND DISEQUILIBRIUM

Demand is $Q_d = 100 - 10P$ and supply is $Q_s = 20P - 20$ (thousands). (a) Find the equilibrium. (b) Describe the market at $P = \$6$ and at $P = \$2$.

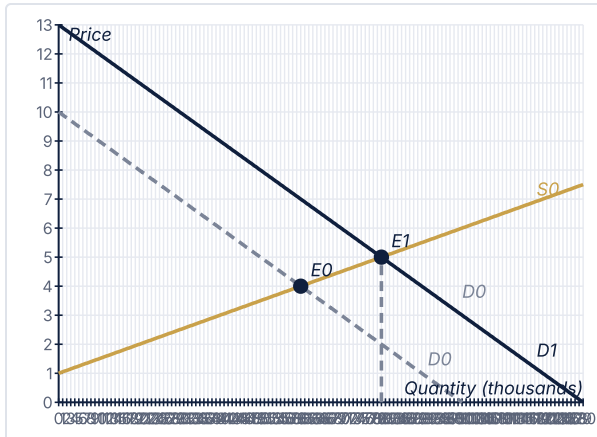
SOLUTION

(a) $100 - 10P = 20P - 20$, so $P = \$4$ and $Q = 100 - 40 = 60$ thousand.

(b) At $\$6$, $Q_d = 40$ and $Q_s = 100$: surplus of 60 thousand, so the price falls. At $\$2$, $Q_d = 80$ and $Q_s = 20$: shortage of 60 thousand, so the price rises.

EXAMPLE 2: A SINGLE SHIFT

Incomes rise and the good is normal, so the demand becomes $Q_d = 130 - 10P$. Supply is unchanged. Find the new equilibrium and state the effect.



Demand increases from D_0 to D_1 , moving the equilibrium up along S_0 .

SOLUTION

Set $130 - 10P = 20P - 20$, so $150 = 30P$ and $P = \$5$, then $Q = 130 - 50 = 80$ thousand.

Price rose from $\$4$ to $\$5$ and quantity from 60 to 80 thousand. Supply did not shift: the market moved up along S_0 (quantity supplied rose, supply did not change).

EXAMPLE 3: TWO SHIFTS AT ONCE

A hurricane damages orange groves, and a health report praises orange juice. Using the original market, predict the price and quantity of orange juice and test with numbers: demand becomes $Q_d = 130 - 10P$ and supply becomes $Q_s = 20P - 60$.

SOLUTION

The hurricane raises cost and destroys capacity: supply decreases (left). The report changes tastes: demand increases (right).

Both shifts raise price, so price definitely rises. Quantity is ambiguous: demand pushes it up, supply pushes it down.

Numerically, $130 - 10P = 20P - 60$ gives $P = 190/30 = \$6.33$ and $Q = 130 - 63.3 = 66.7$ thousand, up from 60. With a larger supply fall, quantity could have dropped. The size of the shifts decides it.

Exam tip

Write the direction of each shift, then state the result for price and for quantity separately. If a result is ambiguous, say 'cannot be determined without knowing the relative size of the shifts'. Never claim that a shift in demand shifts the supply curve; show it as a movement along S .

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Practice

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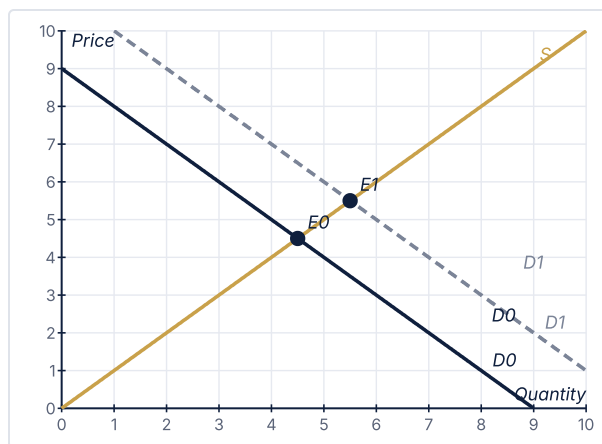
Answer each item in 2 to 4 sentences or show the calculation.

1. Define equilibrium price. Why does a price above equilibrium not last in a free market?
2. Use $Q_d = 100 - 10P$ and $Q_s = 20P - 20$. Compute the quantity and the size of the shortage at $P = \$3$.
3. Gas prices rise and fewer people buy new SUVs. Show with the four-step method what happens to the equilibrium price and quantity in the market for new SUVs.
4. Technology lowers the cost of making tablets. What happens to equilibrium price and quantity of tablets? Describe the movement along demand.
5. Demand for lattes increases and supply of lattes increases. State the effect on price and quantity.
6. A student says: 'The price of corn rose, so farmers supplied more corn, and the supply curve shifted right.' Identify and correct the error.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. In a market, at the current price there is a surplus. Which will occur?
 - (A) Price falls until quantity demanded equals quantity supplied
 - (B) Price rises until the shortage ends
 - (C) Demand shifts left
 - (D) Supply shifts right
 - (E) Nothing, because the surplus is stable
8. If demand for a good increases and supply decreases, which is certain?
 - (A) Equilibrium quantity rises
 - (B) Equilibrium quantity falls
 - (C) Equilibrium price rises
 - (D) Equilibrium price falls
 - (E) Equilibrium price and quantity both rise
9. Consumer tastes shift away from cotton shirts at the same time as a cheaper harvesting technology lowers cotton costs. What happens to the equilibrium quantity of cotton?
 - (A) It rises
 - (B) It falls
 - (C) It stays the same
 - (D) It cannot be determined without knowing the relative size of the shifts
 - (E) It rises, and price rises too
10. The graph shows a market initially at E_0 and then a new equilibrium at E_1 . Which event is consistent with the move?



- (A) An increase in the price of a complement
- (B) A decrease in the price of a complement
- (C) A fall in input prices
- (D) A rise in a per-unit tax on sellers
- (E) A technological advance in production

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11. At the market-clearing price,
- (A) there is a small shortage that pulls the price up
 - (B) sellers earn zero profit
 - (C) consumers pay exactly what they were willing to pay for every unit
 - (D) there is a surplus equal to the shortage
 - (E) the quantity demanded equals the quantity supplied
12. Use the table. The market price is \$3. Which of the following is true?

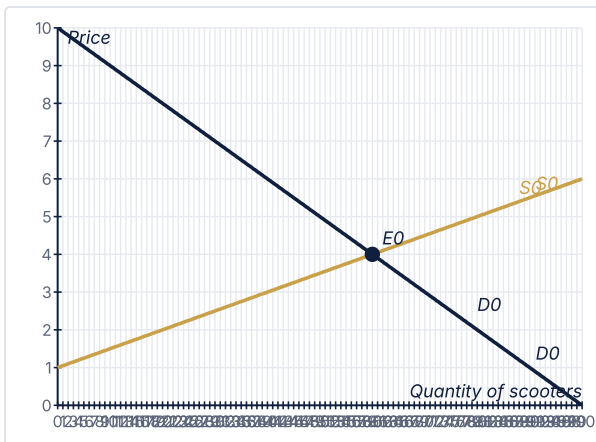
Price	Qd	Qs
\$2	80	20
\$3	70	40
\$4	60	60
\$5	50	80

- (A) There is a surplus of 30 units
- (B) There is a shortage of 70 units
- (C) There is a shortage of 30 units
- (D) The market is in equilibrium
- (E) There is a surplus of 40 units

SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The market for electric scooters has D_0 and S_0 (shown). A study reports that scooters are unsafe, and at the same time the price of lithium batteries (an input) falls. (a) Identify the determinant for each event and the direction of each shift. (b) Draw the new curves and state what happens to equilibrium price and quantity, or whether either is ambiguous. (c) Explain why the result for the other variable cannot be determined.



14. Demand for a new video game is $Q_d = 90 - 10P$ and supply is $Q_s = 20P - 30$ (thousands of copies). (a) Find the equilibrium price and quantity. (b) A rival game is released, which is a substitute, and demand falls to $Q_d = 60 - 10P$. Find the new equilibrium and the change in price. (c) At the old price, state whether there would be a surplus or shortage in the new situation and its size.

2.4 Price Controls: Ceilings and Floors

Learn when price ceilings and floors bind, and how they create shortages and surpluses with real examples like rent control and the minimum wage.

A **price control** is a legal limit on how high or low a price may go. Governments use them to make a good affordable or to protect sellers' income. There are two types. A **price ceiling** is a legal maximum price. A **price floor** is a legal minimum price. The key analytic question is always the same: does the limit prevent the market from reaching its equilibrium price?

Binding vs. nonbinding

A price ceiling is **binding** only if it is set below the equilibrium price. Set at or above equilibrium, it has no effect (nonbinding).

A price floor is **binding** only if it is set above the equilibrium price. Set at or below equilibrium, it has no effect.

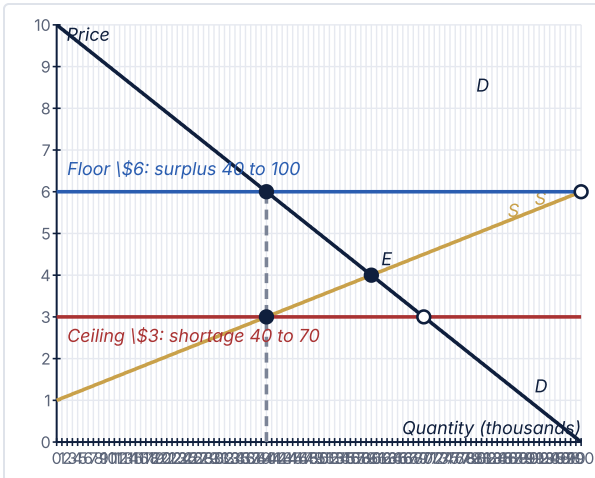
Rule of thumb: a binding control always pushes the price away from equilibrium and in the direction of its stated goal.

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Take the market with $Q_d = 100 - 10P$ and $Q_s = 20P - 20$ (thousands). The equilibrium is \$4 and 60 thousand. A ceiling of \$5 or a floor of \$3 changes nothing. But a ceiling of \$3 is binding. At \$3, buyers want $100 - 30 = 70$ thousand while sellers offer only $20(3) - 20 = 40$ thousand, a **shortage** of 30 thousand. A floor at \$6 is also binding: $Q_d = 40$ and $Q_s = 100$, a **surplus** of 60 thousand.



A binding ceiling at \$3 creates a shortage; a binding floor at \$6 creates a surplus.

Quantity traded under a binding control

Quantity traded = the smaller of quantity demanded and quantity supplied (the short side).

Shortage or surplus = the horizontal gap between the curves at the controlled price.

Notice an important rule: when a control binds, the quantity actually traded is the **smaller** of quantity demanded and quantity supplied (the short side of the market). Under both the ceiling at \$3 and the floor at \$6, only 40 thousand units change hands, less than the 60 thousand at equilibrium. That is why a binding control reduces the number of mutually beneficial trades.

	Price ceiling (binding)	Price floor (binding)
Set relative to equilibrium	below	above
Result	shortage ($Q_d > Q_s$)	surplus ($Q_s > Q_d$)
Quantity traded	falls to Q_s	falls to Q_d
Who gains	buyers who still get the good	sellers who still sell
Typical side effects	queues, quality decline, black markets, search costs	unsold goods, government storage costs, unemployment (labor)
Examples	rent control, price caps on gasoline	minimum wage, agricultural price supports

Shortage effects. When the ceiling holds the price below equilibrium, goods are rationed by something other than price: long waiting lists, first-come first-served, or favoritism. Sellers have little reason to maintain quality, so quality falls. A **black market** can appear, where the good is sold illegally above the ceiling. The black-market price can rise as high as the demand curve at the restricted quantity: here, with 40 thousand units available, buyers would pay up to $P = 10 - 40/10 = \$6$.

Rent control is the classic ceiling. Landlords supply fewer apartments over time (conversion to condos, less maintenance), while more people want rent-controlled apartments. The result: a shortage of housing and lower quality. **Minimum wage** is a floor in the labor market. Here the wage is the 'price' and workers supply the 'quantity'. A binding minimum wage raises the wage for those who keep jobs but reduces the quantity of labor demanded, and more people want jobs: the surplus of labor is unemployment. (In practice the size of the effect depends on how elastic labor demand is and on how far above equilibrium the minimum is set.)

Price supports are floors for farm goods. If the government sets the support price above equilibrium, farmers produce a surplus. To keep the price from falling, the government must buy the surplus (or pay farmers not to produce it). Farmers gain, taxpayers pay for purchases, and consumers pay higher prices.

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EXAMPLE 1: CEILING OR FLOOR? BINDING?

Using $Q_d = 100 - 10P$ and $Q_s = 20P - 20$, state whether each control is binding and find the surplus or shortage: (a) ceiling \$5; (b) ceiling \$3; (c) floor \$6; (d) floor \$2.

SOLUTION

Equilibrium price is \$4.

(a) \$5 is above equilibrium, so the ceiling is nonbinding: no shortage, $Q = 60$.

(b) \$3 is below equilibrium, binding. $Q_d = 70$, $Q_s = 40$, shortage 30 thousand, quantity traded 40.

(c) \$6 is above equilibrium, binding. $Q_d = 40$, $Q_s = 100$, surplus 60, quantity traded 40.

(d) \$2 is below equilibrium: a nonbinding floor.

EXAMPLE 2: A FARM PRICE SUPPORT

The government guarantees farmers \$6 per unit in the market above and buys all unsold units. Find the quantity the government buys and its spending, and the revenue farmers receive.

SOLUTION

At \$6, $Q_d = 40$ and $Q_s = 100$, so the government buys $100 - 40 = 60$ thousand units.

Government spending = $6 \times 60 = \$360$ thousand. Farmers' total revenue = $6 \times 100 = \$600$ thousand.

Consumers pay \$6 instead of \$4, and taxpayers fund the purchases.

EXAMPLE 3: BLACK MARKET PRICE UNDER RENT CONTROL

Apartment demand is $P = 10 - Q/10$ and supply is $P = 1 + Q/20$. A rent ceiling is set at \$3. Find the quantity available and the maximum black-market rent.

SOLUTION

Supply at \$3: $3 = 1 + Q/20$, so $Q = 40$ (the quantity that landlords provide).

Demand at $Q = 40$: $P = 10 - 4 = \$6$.

So the legal rent is \$3, but renters would pay up to \$6 for these 40 units, which is the incentive for illegal side payments.

Common mistakes

1) Drawing a ceiling above equilibrium and calling it binding. Check the position first. 2) Using the longer side of the market for the quantity traded; use the smaller. 3) Saying that controls shift the demand or supply curve. They do not. They create a gap between quantity demanded and quantity supplied along unchanged curves. 4) Forgetting that in the labor market the wage is the price, so a minimum wage is a floor.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

1. Explain the difference between a price ceiling and a price floor and the condition under which each is binding.
2. Using $Q_d = 100 - 10P$ and $Q_s = 20P - 20$, compute the surplus or shortage with a price of \$5.50.
3. A city caps rents below equilibrium. List three likely consequences and explain one.
4. Why does a binding minimum wage create unemployment? Use quantities of labor supplied and demanded.
5. The government sets a price support of \$6 in the market above with $Q_d = 40$ and $Q_s = 100$ at that price. State the quantity traded without government purchases and with them.
6. A ceiling is set at \$6 in a market whose equilibrium price is \$4. What happens to price and quantity?

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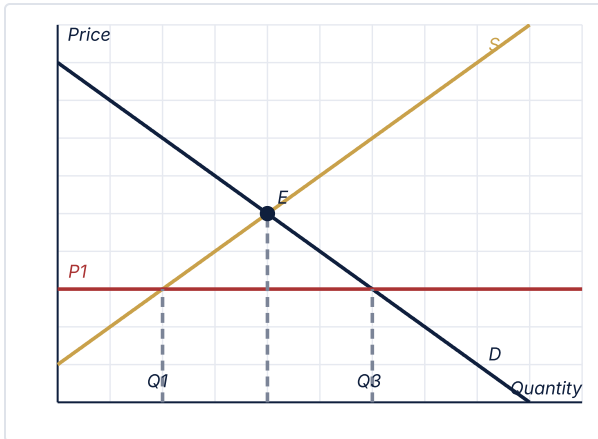
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A binding price ceiling in a market will result in
 (A) a surplus (B) an increase in supply
 (C) a shortage (D) a decrease in demand
 (E) a higher equilibrium price
8. The equilibrium price of wheat is \$5. Which price control would create a surplus?
 (A) A price ceiling of \$7 (B) A price floor of \$4 (C) A price ceiling of \$4
 (D) A price floor of \$5 (E) A price floor of \$7
9. The graph shows a market with a price control at P_1 . Which is true?



- (A) There is a shortage equal to $Q_3 - Q_1$
 (B) There is a surplus equal to $Q_3 - Q_1$
 (C) There is a shortage equal to $Q_2 - Q_1$
 (D) There is no shortage because price is below the equilibrium price
 (E) The quantity traded will be Q_3
10. Which is a likely result of a binding minimum wage in a competitive labor market?
 (A) A shortage of workers
 (B) A decrease in labor supply
 (C) A higher quantity of labor demanded
 (D) Unemployment among low-skilled workers who want jobs at that wage
 (E) No change in employment
11. Which of the following best describes who benefits from a binding price floor on wheat if the government buys the surplus?
 (A) Consumers gain from lower prices
 (B) Farmers gain, while taxpayers and consumers pay
 (C) Farmers and consumers both gain
 (D) Taxpayers gain from lower spending
 (E) Nobody gains or loses
12. A rent ceiling is binding. Over time, which of the following is most likely?
 (A) Rents on uncontrolled apartments fall
 (B) The supply curve shifts to the right
 (C) Landlords reduce maintenance and some units leave the rental market
 (D) Landlords build more apartments
 (E) The quantity demanded falls

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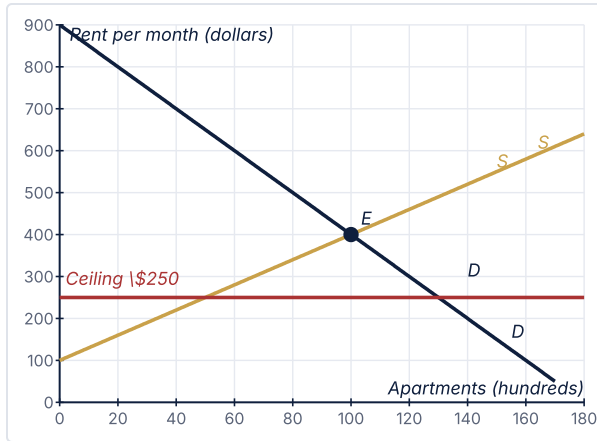
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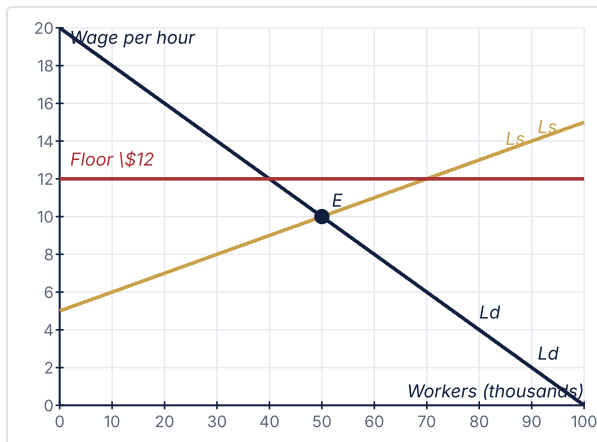
SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The graph shows the market for rental apartments in a college town (rent per month; quantity in hundreds). Demand is $P = 900 - 5Q$ and supply is $P = 100 + 3Q$. (a) Find the equilibrium rent and quantity. (b) The city sets a rent ceiling of \$250. Is it binding? Find the quantity supplied, the quantity demanded and the shortage. (c) What is the most that renters would pay for the available apartments, and what does this imply?



14. The graph shows the market for low-skill labor (wage per hour; workers in thousands). Labor demand is $W = 20 - L/5$ and labor supply is $W = 5 + L/10$. (a) Find the equilibrium wage and employment. (b) A minimum wage of \$12 is imposed. Find employment, the number of people who want jobs, and unemployment. (c) Compare total wages paid before and after and state what that implies about the demand for labor in this range.

**2.5 Elasticity of Demand and Supply**

Calculate price, cross-price, income and supply elasticities with the midpoint method and know what makes demand and supply elastic.

Elasticity measures how strongly one variable responds to a change in another. The most common is the **price elasticity of demand** (E_d), the responsiveness of quantity demanded to a change in price. It matters because it predicts what happens to revenue, how a tax is shared, and how much a price change moves quantity.

Midpoint method (use this on the exam)

$$E_d = \left| \frac{\% \Delta Q_d}{\% \Delta P} \right| \quad \% \Delta Q = \frac{Q_2 - Q_1}{(Q_1 + Q_2)/2}, \quad \% \Delta P = \frac{P_2 - P_1}{(P_1 + P_2)/2}$$

The midpoint formula divides by the average, so the elasticity between two points is the same whether the price rises or falls. Report the absolute value for price elasticity of demand, since price and quantity demanded move in opposite directions.

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Value of E_d	Name	Meaning
$E_d > 1$	Elastic	quantity changes by a larger percentage than price
$E_d = 1$	Unit elastic	equal percentage changes
$0 < E_d < 1$	Inelastic	quantity changes by a smaller percentage than price
$E_d = \infty$	Perfectly elastic	horizontal demand curve; any price rise drives quantity to zero
$E_d = 0$	Perfectly inelastic	vertical demand curve; quantity does not change



Polar cases: perfectly elastic demand (top, horizontal) and perfectly inelastic demand (bottom, vertical).



Determinants of price elasticity of demand. Demand is more elastic when (1) there are many close substitutes, (2) the good is a luxury rather than a necessity, (3) the good takes a large share of the buyer's budget, (4) the market is defined narrowly (a brand of cereal, not food), and (5) buyers have more time to adjust. The last point matters on the exam: demand is more elastic in the long run than in the short run, since people can find substitutes and change habits (for example, buying a more fuel-efficient car).

Good	Key reason	Likely elasticity of demand
Insulin	necessity, no substitute	very inelastic
Salt	tiny share of budget	inelastic
Brand-name cereal	many close substitutes	elastic
Cruise vacation	luxury, large budget share	elastic
Gasoline, 1 month vs 5 years	time to adjust	inelastic short run, more elastic long run

A quick test for any good: ask how easily a buyer could walk away or switch if the price jumped 20 percent. The easier it is, the more elastic the demand. Firms care because elastic demand punishes price increases, while inelastic demand lets them pass costs on to buyers.

Other elasticities. The **cross-price elasticity of demand** is the percentage change in the quantity of good X demanded divided by the percentage change in the price of good Y. It is positive for substitutes and negative for complements. The **income elasticity of demand** is the percentage change in quantity demanded divided by the percentage change in income. It is positive for normal goods (greater than 1 for luxuries), and negative for inferior goods. Keep the sign for these two measures, because the sign carries the meaning.

Signs to memorize

Cross-price elasticity: positive means substitutes, negative means complements, near zero means unrelated.

Income elasticity: positive means normal good (above 1 means luxury), negative means inferior good.

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Price elasticity of supply (E_s) is the percentage change in quantity supplied divided by the percentage change in price, always positive. Supply is more elastic when firms can raise output easily: spare capacity, available inputs, storable goods, and a longer time period. A vertical supply curve (a fixed stock such as beachfront land) is perfectly inelastic; a horizontal one is perfectly elastic. Supply is more elastic in the long run.

EXAMPLE 1: PRICE ELASTICITY OF DEMAND

A bakery lowers the price of a loaf from \$8 to \$6 and its sales rise from 100 to 140 loaves per day. Calculate the price elasticity of demand and classify it.

SOLUTION

% change in quantity = $(140 - 100)/120 = 33.3$ percent.

% change in price = $(6 - 8)/8 = -25.0$ percent.

$E_d = 33.3/25.0 = 1.33$ (absolute value). Since $1.33 > 1$, demand is elastic over this range.

EXAMPLE 2: CROSS-PRICE AND INCOME ELASTICITY

(a) When the price of Brand B rises from \$4 to \$6, the quantity of Brand A bought rises from 80 to 110. (b) When income rises from \$40,000 to \$60,000, bus rides taken fall from 30 to 24 per month. Compute each elasticity and interpret it.

SOLUTION

(a) %Q of A = $30/95 = 31.6$ percent. %P of B = $2/5 = 40$ percent. Cross-price elasticity = 0.79, positive, so A and B are substitutes.

(b) %Q = $-6/27 = -22.2$ percent. %Income = $20,000/50,000 = 40$ percent. Income elasticity = -0.56 , negative, so bus rides are an inferior good.

EXAMPLE 3: PRICE ELASTICITY OF SUPPLY

When the price of a bushel of apples rises from \$10 to \$12, the quantity supplied rises from 50 to 70 bushels. Find the elasticity of supply.

SOLUTION

% change in quantity = $20/60 = 33.3$ percent. % change in price = $2/11 = 18.2$ percent.

$E_s = 33.3/18.2 = 1.83 > 1$, so supply is elastic over this range.

Common mistakes

- 1) Using the starting value as the base instead of the average.
- 2) Confusing elasticity with slope: a straight-line demand curve has a constant slope but its elasticity changes along the curve.
- 3) Dropping the sign in cross-price and income elasticity.
- 4) Calling demand inelastic because quantity fell by a small absolute number. Only percentages count.
- 5) Forgetting that necessities have inelastic demand, and that longer time horizons raise elasticity.

Practice

SET A Check Your Understanding

Answer each item in 2 to 4 sentences or show the calculation.

1. Define the price elasticity of demand and say why economists use the midpoint formula.
2. Price rises from \$5 to \$7 and quantity demanded falls from 200 to 150. Find the elasticity and classify demand.
3. List two factors that make the demand for insulin inelastic and one factor that makes the demand for a specific restaurant's pizza elastic.
4. Explain why the demand for gasoline is more elastic in the long run than in the short run.
5. The cross-price elasticity between Good X and Good Y is -1.4. What is the relationship, and what happens to demand for X if the price of Y rises 10 percent?
6. A good has income elasticity of 1.8. Classify the good. If income rises 5 percent, what is the effect on quantity demanded?

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A price rise from \$10 to \$12 causes quantity demanded to fall from 60 to 40. Using the midpoint method, the price elasticity of demand is approximately
 (A) 0.45 (B) 1.0 (C) 1.5 (D) 2.2 (E) 3.0
8. Which of these goods most likely has the most inelastic demand?
 (A) Insulin for diabetics (B) A specific brand of soda (C) Restaurant meals
 (D) Vacation cruises (E) Name-brand sneakers
9. If the cross-price elasticity of demand between two goods is +2.1, the goods are
 (A) complements (B) substitutes (C) both inferior
 (D) both luxuries (E) unrelated
10. The income elasticity of demand for canned soup is -0.4. Which is correct?
 (A) Canned soup is a luxury good
 (B) Canned soup is a normal good with inelastic demand
 (C) Canned soup is an inferior good
 (D) Canned soup has a downward-sloping demand curve only for the poor
 (E) Canned soup and income are unrelated
11. Which statement about elasticity of supply is correct?
 (A) It is greater in the short run than in the long run
 (B) It is negative because the supply curve slopes upward
 (C) It is zero for goods that are easy to produce
 (D) It does not depend on time
 (E) It is greater when producers have spare capacity and can store the good
12. The graph shows two demand curves through point A. At the same price, which statement is correct?



- (A) Demand D1 is more elastic than D2 at A
 (B) Demand D2 is more elastic than D1 at A
 (C) Both have the same elasticity because they cross
 (D) D1 is perfectly inelastic
 (E) D2 is perfectly elastic

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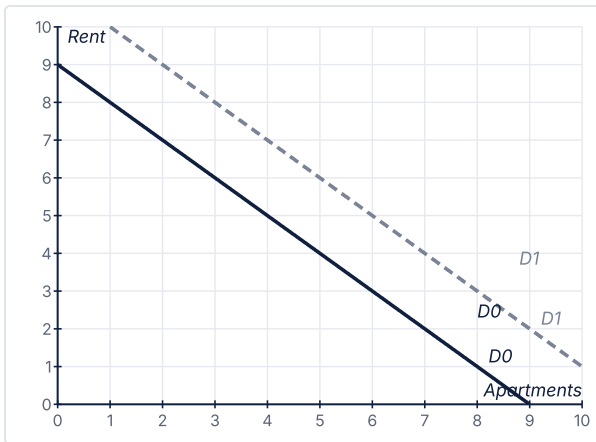
SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The table shows a firm's demand schedule for concert tickets. (a) Compute the price elasticity of demand between \$30 and \$40 using the midpoint method. (b) Classify it. (c) Explain what the result implies about whether the firm should raise the price to increase revenue (state the revenue figures at both prices).

Price	Quantity demanded
\$30	600
\$40	500
\$50	400

14. A town's apartments have supply that is very inelastic in the short run (new buildings take years) but elastic in the long run. (a) Draw a supply curve for the short run and a different one for the long run on a labeled graph. (b) A rise in demand increases the rent. Explain in which period rent rises more and why. (c) State the effect of the time horizon on the elasticity of supply.

**2.6** Elasticity, Total Revenue, and Tax Incidence

Use elasticity to predict total revenue and to find who bears a tax or receives a subsidy.

Sellers and governments both care about what a price change does to **total revenue** (TR), the amount buyers spend and sellers receive: $TR = P \times Q$. When price rises, revenue gets a boost from the higher price on each unit but a hit from selling fewer units. Which effect wins depends on the price elasticity of demand.

Total revenue test

Elastic demand ($E_d > 1$): price and total revenue move in opposite directions. A price cut raises revenue.

Inelastic demand ($E_d < 1$): price and total revenue move in the same direction. A price rise raises revenue.

Unit elastic ($E_d = 1$): a price change leaves total revenue unchanged, and revenue is at its maximum.

A straight-line demand curve has a constant slope, but its elasticity is not constant. At high prices and low quantities, a small change in quantity is a large percentage change, so demand is elastic. At low prices and high quantities, the opposite holds and demand is inelastic. Unit elasticity occurs at the midpoint of the line. Take demand $P = 10 - Q$:

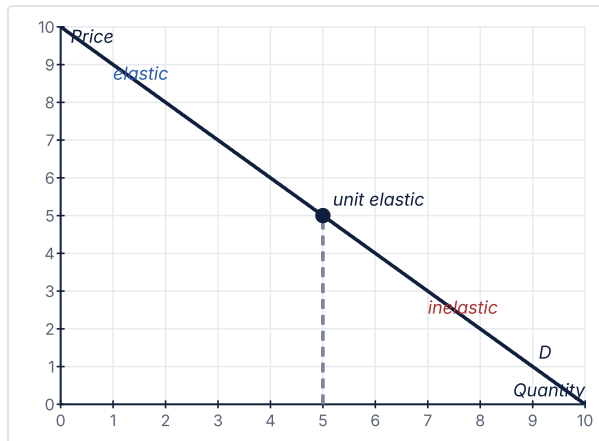
Price	Quantity	Total revenue	E_d at the point (P/Q)	Region
\$9	1	\$9	9	elastic
\$8	2	\$16	4	elastic
\$7	3	\$21	2.33	elastic
\$6	4	\$24	1.5	elastic
\$5	5	\$25	1	unit elastic
\$4	6	\$24	0.67	inelastic

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Price	Quantity	Total revenue	E_d at the point (P/Q)	Region
\$3	7	\$21	0.43	inelastic
\$2	8	\$16	0.25	inelastic
\$1	9	\$9	0.11	inelastic



Linear demand: elastic above the midpoint, unit elastic at the midpoint, inelastic below.

Total revenue is largest at $Q = 5$, where $E_d = 1$. To raise revenue, a firm in the elastic region should cut price, while a firm in the inelastic region should raise it.

Tax incidence describes who actually bears the burden of a tax. It does not matter whether the law taxes the buyer or the seller. A per-unit tax drives a wedge between the price buyers pay (P_b) and the price sellers keep (P_s), with $P_b - P_s = \text{tax}$. The market quantity falls, and the two sides split the burden.

Who pays a tax

The side of the market that is more inelastic (less able to avoid the tax) bears the larger share of the burden.

Buyer burden = P_b minus the old equilibrium price. Seller burden = old equilibrium price minus P_s .

Tax revenue = tax per unit $\times$ new quantity.

Why does the inelastic side pay more? Inelastic buyers do not cut back much when the price rises, so sellers can pass the tax on. Inelastic sellers cannot reduce output easily, so they must accept a lower price. The same logic works for a **subsidy**: the more inelastic side of the market receives the larger share of the benefit, and the government pays tax-per-unit times the new quantity.

	Demand relatively inelastic	Supply relatively inelastic
Buyer share of tax	larger	smaller
Seller share of tax	smaller	larger
Example	gasoline, cigarettes	beachfront hotel rooms, fixed land
Quantity change	small	small

EXAMPLE 1: TOTAL REVENUE TEST

A theater cuts its ticket price from \$10 to \$8 and weekly attendance rises from 100 to 130. Find the elasticity, say whether demand is elastic, and verify with total revenue.

SOLUTION

$\%Q = 30/115 = 26.1$ percent; $\%P = -2/9 = -22.2$ percent; $E_d = 1.17$.

Elastic (above 1), so a price cut should raise revenue.

Check: TR before = $10 \times 100 = \$1,000$; after = $8 \times 130 = \$1,040$. Revenue rose by \$40.

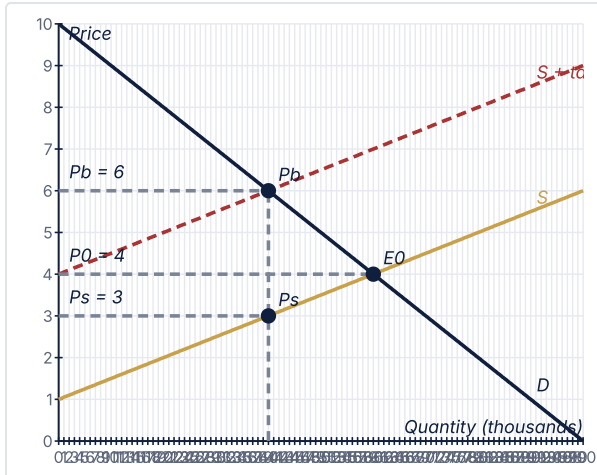
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EXAMPLE 2: PER-UNIT TAX

Demand is $Q_d = 100 - 10P$ and supply is $Q_s = 20P - 20$. The government places a \$3 per-unit tax on sellers. Find P_b , P_s , quantity, who bears the burden, and revenue.



A \$3 tax: buyers pay \$6, sellers keep \$3, quantity falls to 40.

SOLUTION

Sellers receive $P_s = P_b - 3$, so $Q_s = 20(P_b - 3) - 20 = 20P_b - 80$. Set equal to Q_d : $100 - 10P_b = 20P_b - 80$, so $P_b = \$6$ and $Q = 40$.

$P_s = 6 - 3 = \$3$. The old equilibrium was \$4 and 60.

Buyers bear $6 - 4 = \$2$ per unit and sellers bear $4 - 3 = \$1$. Buyers bear two thirds because demand at equilibrium ($E = 0.67$) is more inelastic than supply ($E = 1.33$).

Revenue = $3 \times 40 = \$120$.

EXAMPLE 3: PER-UNIT SUBSIDY

The same market receives a \$3 per-unit subsidy paid to sellers. Find the price paid by buyers, the price received by sellers, the quantity, and the government's cost.

SOLUTION

Sellers receive $P_b + 3$, so $Q_s = 20(P_b + 3) - 20 = 20P_b + 40$. Set equal to $100 - 10P_b$: $P_b = \$2$ and $Q = 80$.

Sellers receive $2 + 3 = \$5$. Buyers' price fell by \$2 (from 4) and sellers' net price rose by \$1.

The government pays $3 \times 80 = \$240$.

Common mistakes

1) Believing that the party who legally pays the tax bears it. The burden depends on elasticities. 2) Using the slope of the demand curve to judge elasticity along a straight line. 3) Reversing the total revenue test: with inelastic demand, raising the price raises revenue. 4) Forgetting that the quantity falls when a tax is imposed, so revenue is the tax times the new quantity, not the old.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

1. State the total revenue test for a price increase when demand is (a) elastic and (b) inelastic.
2. A firm's price falls from \$20 to \$18 and its quantity sold rises from 50 to 53. Calculate the elasticity (midpoint) and the change in total revenue.
3. On the linear demand $P = 10 - Q$, find the quantity that maximizes total revenue and the maximum revenue. What is elasticity there?
4. Explain why a tax on cigarettes raises revenue but does little to cut smoking quantity, using elasticity.

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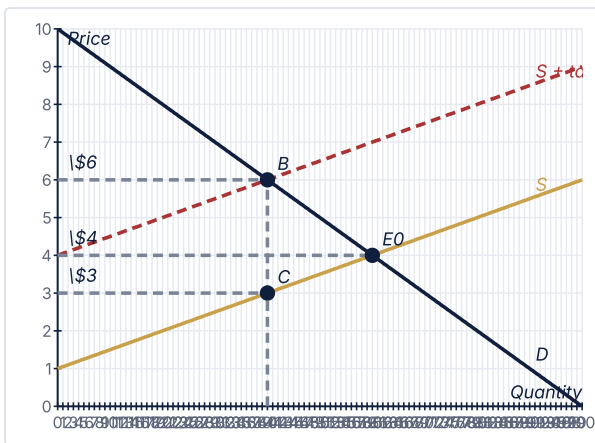
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5. In a market the equilibrium price is \$4. After a per-unit tax, buyers pay \$5.50 and sellers keep \$3.50. Find the tax, each side's burden and which side is more inelastic.
6. Explain how a per-unit subsidy to producers is shared between buyers and sellers.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. If demand for a product is inelastic, an increase in price will cause total revenue to
 - (A) decrease
 - (B) remain unchanged
 - (C) fall to zero
 - (D) increase
 - (E) decrease, then increase
8. A firm facing elastic demand wants to raise revenue. It should
 - (A) raise the price
 - (B) lower the price
 - (C) keep the price unchanged
 - (D) reduce supply
 - (E) raise the price and reduce output
9. At the midpoint of a straight-line demand curve, the price elasticity of demand is
 - (A) equal to 0
 - (B) greater than 1
 - (C) less than 1
 - (D) infinite
 - (E) equal to 1
10. The graph shows a per-unit tax placed on the sellers of a good. Which statement is correct?



- (A) Buyers bear a larger share of the tax than sellers
- (B) Sellers bear a larger share than buyers
- (C) The tax is shared equally
- (D) Buyers bear the entire tax
- (E) The government collects no revenue
11. Supply of a good is perfectly inelastic and demand is downward sloping. A per-unit tax is imposed. Who bears the tax?
 - (A) Buyers bear all of it
 - (B) They split it equally
 - (C) Sellers bear all of it
 - (D) Buyers bear most of it
 - (E) Nobody, because supply is fixed
12. A government subsidy of \$2 per unit paid to producers will most likely lead to
 - (A) a higher price paid by consumers
 - (B) a lower quantity
 - (C) no change in quantity
 - (D) a lower price paid by consumers and a higher quantity
 - (E) a leftward shift of the supply curve

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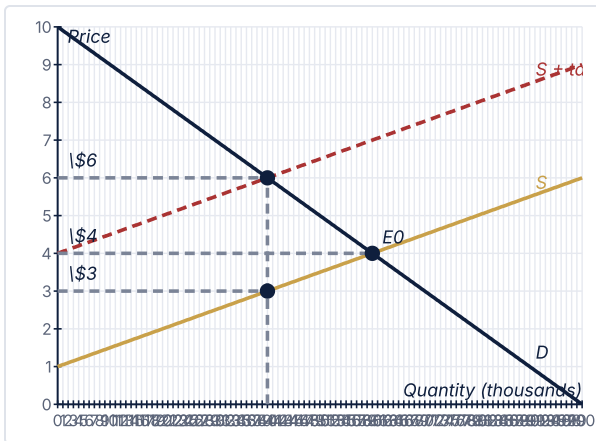
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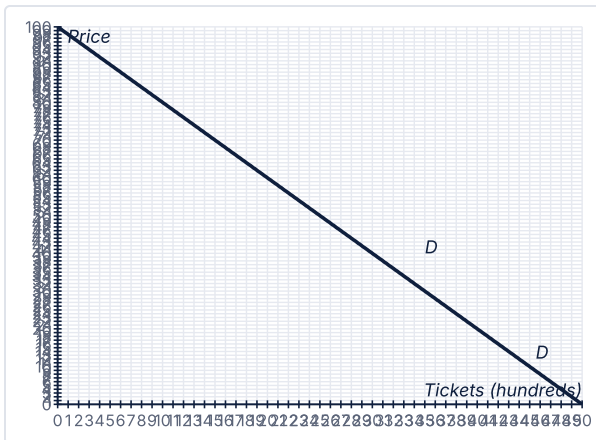
SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The graph shows the market for bottled water with a per-unit tax on sellers that shifts supply from S to $S + t$. (a) Identify the price consumers pay, the price producers receive and the tax per unit. (b) Identify the area of tax revenue and the burden on each side. (c) Suppose demand were more elastic. Explain what happens to the consumers' share of the burden.



14. A concert venue's demand is $P = 100 - 2Q$ (Q in hundreds of tickets). (a) Find the quantity and price at which total revenue is maximized and the maximum revenue. (b) At $P = \$80$, find the quantity, total revenue and elasticity (use $E = (1/|\text{slope}|)(P/Q)$). (c) Explain whether the venue should raise or lower the price from \$80 to increase revenue.

**2.7 Consumer Surplus, Producer Surplus, and Efficiency**

Measure consumer and producer surplus, explain allocative efficiency, and calculate the deadweight loss from taxes and price controls.

Markets do more than set prices; they allocate resources. **Consumer surplus** (CS) is the difference between what consumers are willing to pay and what they actually pay. On a graph it is the area under the demand curve and above the price, out to the quantity traded.

Producer surplus (PS) is the difference between the price producers receive and the minimum they would accept, the area above the supply curve and below the price. **Total surplus** (also called economic or social surplus) is $CS + PS$.

Surplus areas

Consumer surplus = area below D , above price, out to quantity traded.

Producer surplus = area above S , below price, out to quantity traded.

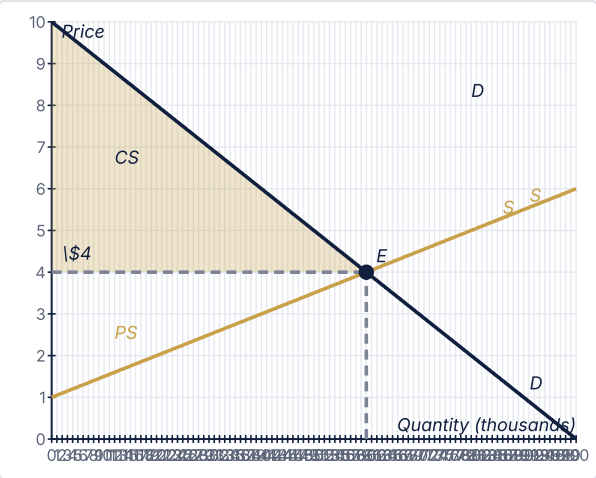
Total surplus = $CS + PS$ = area between D and S out to the quantity traded. For linear curves each area is a triangle (or triangle plus rectangle): area = $\frac{1}{2} \times \text{base} \times \text{height}$.

Use our familiar market: demand $P = 10 - Q/10$ and supply $P = 1 + Q/20$, with Q in thousands and P in dollars. The equilibrium is $Q = 60$ and $P = \$4$. The demand curve meets the vertical axis at \$10 (the highest willingness to pay), and the supply curve at \$1 (the lowest cost). Then $CS = \frac{1}{2}(60)(10 - 4) = \$180$ thousand and $PS = \frac{1}{2}(60)(4 - 1) = \$90$ thousand, so total surplus is \$270 thousand.

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Consumer surplus is the shaded triangle above the equilibrium price and below demand; producer surplus is the triangle between the price and supply.

Allocative efficiency is reached when the quantity produced is the one at which the marginal benefit to buyers (read on the demand curve) equals the marginal cost to sellers (read on the supply curve). At that quantity, total surplus is maximized. Competitive equilibrium is allocatively efficient: every unit whose value to a buyer exceeds its cost to the seller is produced, and no unit that costs more than it is worth is produced.

When a market produces less than the efficient quantity, units whose benefit exceeds their cost go unproduced. The surplus lost on those units is **deadweight loss** (DWL): the triangle between D and S for the units not traded. Binding price controls, taxes, quotas and tariffs all cause deadweight loss by blocking mutually beneficial trades.

Deadweight loss

Deadweight loss = reduction in total surplus compared with the efficient (equilibrium) outcome.
On a graph: the triangle between D and S from the quantity traded out to the equilibrium quantity.
Transfers between consumers, producers and the government are not losses; only surplus that disappears is DWL.

Policy (market above)	Quantity	CS	PS	Gov. revenue	DWL
No intervention	60	\$180	\$90	0	0
Price ceiling \$3	40	\$200	\$40	0	\$30
Price floor \$6 (no purchases)	40	\$80	\$160	0	\$30
\$3 per-unit tax	40	\$80	\$40	\$120	\$30

Read the table. A ceiling transfers surplus from producers to consumers (the rectangle between \$3 and \$6 on the 40 units), and the transfer and the loss are different things. The table shows the tax creating revenue as well as DWL. Whenever you are asked for the change in surplus, compare totals including any government revenue.

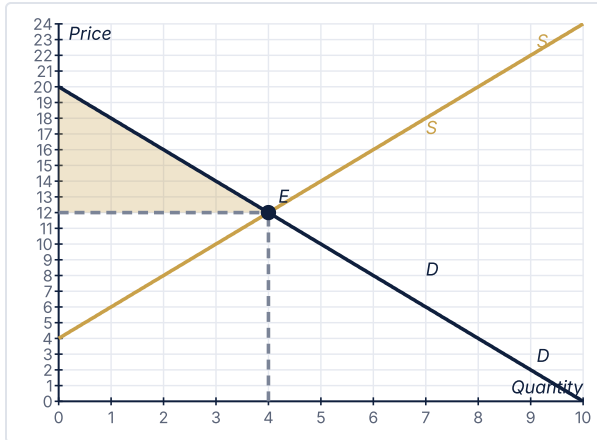
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EXAMPLE 1: SURPLUS AT EQUILIBRIUM

Demand is $P = 20 - 2Q$ and supply is $P = 4 + 2Q$. Find the equilibrium, CS, PS and total surplus.



The shaded area is consumer surplus, \$16.

SOLUTION

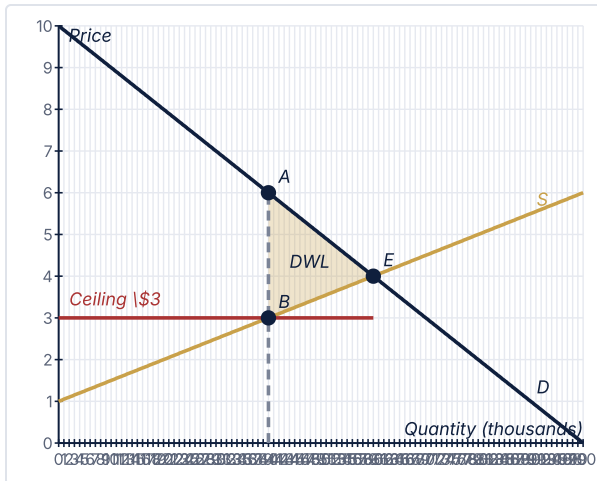
$20 - 2Q = 4 + 2Q$ gives $Q = 4$ and $P = \$12$.

$CS = \frac{1}{2}(4)(20 - 12) = \$16$.

$PS = \frac{1}{2}(4)(12 - 4) = \$16$, so $TS = \$32$. (Check: $TS = \frac{1}{2}(4)(20 - 4) = \$32$.)

EXAMPLE 2: DEADWEIGHT LOSS FROM A PRICE CEILING

Using the main market (equilibrium \$4, 60), a ceiling of \$3 reduces the quantity traded to 40 thousand. Find the deadweight loss and the surplus transferred.



Deadweight loss from the ceiling is triangle A-E-B.

SOLUTION

At $Q = 40$, demand is $P = 10 - 4 = \$6$ and supply is $P = 1 + 2 = \$3$.

$DWL = \frac{1}{2}(60 - 40)(6 - 3) = \$30$ thousand.

Surplus change: CS rises from 180 to 200 (+20) while PS falls from 90 to 40 (-50). The net change is -30, equal to the DWL.

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EXAMPLE 3: SURPLUS AFTER A TAX

A \$3 per-unit tax shrinks the quantity to 40 (buyers pay \$6, sellers keep \$3). Compute CS, PS, tax revenue and the DWL.

SOLUTION

$CS = \frac{1}{2}(40)(10 - 6) = \$80$. $PS = \frac{1}{2}(40)(3 - 1) = \$40$.

Revenue = $3 \times 40 = \$120$.

TS including revenue = $80 + 40 + 120 = \$240$ versus \$270 before, so $DWL = \$30 = \frac{1}{2}(3)(60 - 40)$.

Common mistakes

1) Treating a transfer as a loss: a transfer to consumers or to the government is not DWL. 2) Measuring CS or PS against the wrong price (use the price actually paid or received, and the quantity actually traded). 3) Forgetting that government revenue counts in total surplus. 4) Calling any price or quantity above the market outcome efficient: only the equilibrium (where $MB = MC$) maximizes total surplus.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

1. Define consumer surplus and producer surplus and say where each is found on a supply-and-demand graph.
2. Demand is $P = 20 - 2Q$ and supply is $P = 4 + 2Q$. Compute total surplus at equilibrium and the CS if the price is held at \$10 and $Q = 3$ (price ceiling).
3. Why is the competitive equilibrium allocatively efficient? Use marginal benefit and marginal cost.
4. Using the main market, compute deadweight loss when a price floor of \$6 reduces the quantity traded to 40 thousand.
5. Distinguish between a transfer of surplus and a deadweight loss.
6. A tax is collected on a good. Explain why the revenue to the government does not eliminate the deadweight loss.

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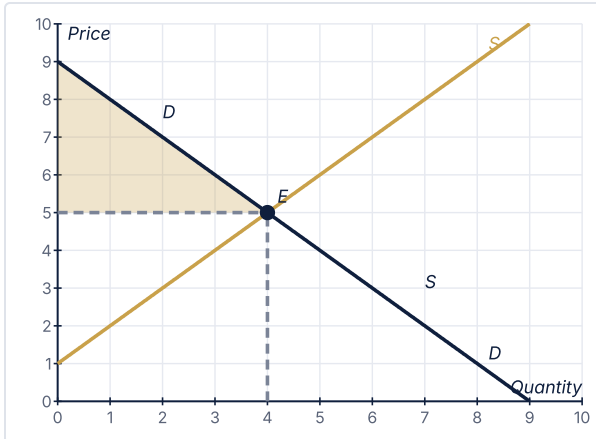
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. Consumer surplus is best defined as
 (A) the price of the good minus its cost of production
 (B) total spending by consumers
 (C) the area under the supply curve
 (D) the shortage that arises at a price ceiling
 (E) the difference between the maximum price buyers are willing to pay and the price they pay
8. In the graph, equilibrium is at E. Consumer surplus is shown by which area?



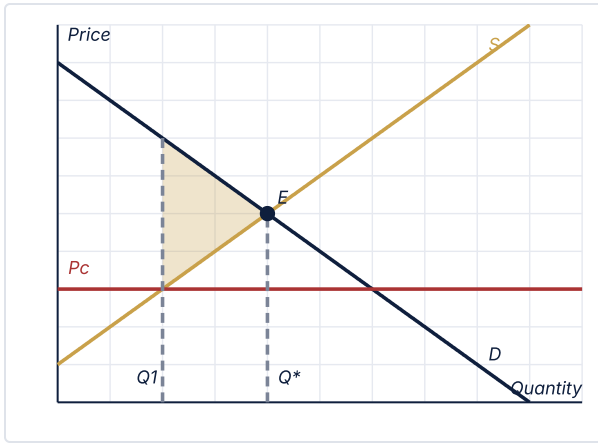
- (A) The triangle bounded by the demand curve, the price axis and the horizontal price line
 (B) The triangle between the supply curve and the price line
 (C) The whole area under demand
 (D) The area between D and S beyond Q^*
 (E) The rectangle $P^* \times Q^*$
9. A price floor is set above the equilibrium price. Total surplus will
 (A) increase because producers earn more
 (B) decrease because some mutually beneficial trades do not occur
 (C) stay the same because CS falls by the same amount PS rises
 (D) increase because consumers earn more
 (E) decrease only if the government buys the surplus
10. Demand is $P = 12 - Q$ and supply is $P = Q$ (equilibrium $Q = 6$, $P = \$6$). Total surplus equals
 (A) \$ 6 (B) \$ 12 (C) \$ 18 (D) \$ 36 (E) \$ 72

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11. The graph shows a binding quota-free price ceiling at P_c . The deadweight loss is area



- (A) the rectangle P_c by Q_1
 (B) the triangle above the equilibrium price
 (C) the triangle between D and S from Q_1 to Q^*
 (D) the whole area below P_c
 (E) the area of consumer surplus
12. A per-unit tax reduces quantity traded. Which is true of the resulting deadweight loss?
- (A) It equals the tax revenue
 (B) It is paid by consumers only
 (C) It disappears if the government spends the revenue wisely
 (D) It is zero if demand is inelastic
 (E) It is the loss of surplus on units whose value exceeds cost but are no longer traded

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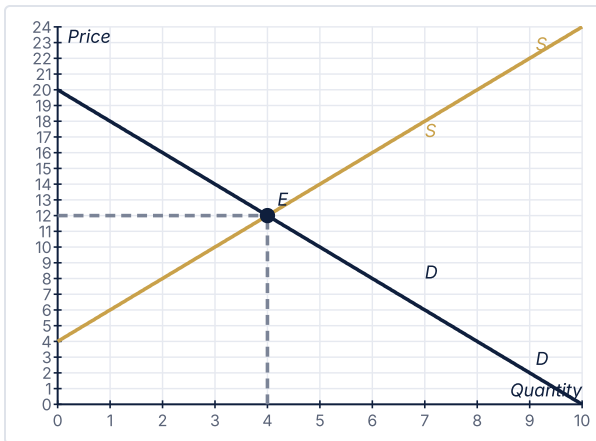
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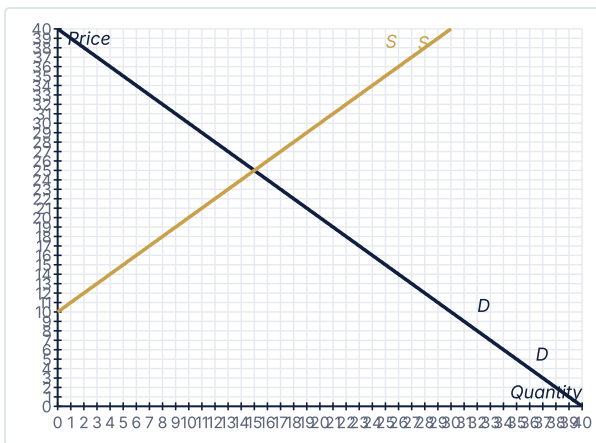
SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The graph shows a market with equilibrium at \$12 and 4 units. (a) Calculate consumer surplus, producer surplus and total surplus. (b) A price ceiling of \$10 is imposed. Supply is $P = 4 + 2Q$ and demand is $P = 20 - 2Q$. Find the quantity traded and the new total surplus. (c) Find the deadweight loss.



14. In a market, demand is $P = 40 - Q$ and supply is $P = 10 + Q$. (a) Find the equilibrium price and quantity. (b) Calculate consumer and producer surplus. (c) The government imposes a quota that limits sales to 10 units. Calculate the deadweight loss.

**2.8 International Trade, Tariffs, and Quotas**

Use the world price to find imports and exports, and analyze the winners, losers and deadweight loss of tariffs and quotas.

A country can buy a good from abroad if the **world price** is lower than its own no-trade price, or sell it abroad if the world price is higher. We assume a small country, so it takes the world price as given: the world supply of imports at that price is perfectly elastic. Domestic demand and supply then determine how much is bought, produced at home, and traded.

Use the domestic market with demand $P = 10 - Q/10$ and supply $P = 1 + Q/20$ (Q in thousands). With no trade (autarky), the price is \$4 and the quantity is 60. Suppose the world price is \$2, below the no-trade price.

Importing country, free trade

World price below the no-trade price: domestic buyers purchase at the world price.

Quantity demanded exceeds domestic quantity supplied; **imports** = $Q_d - Q_s$ at the world price.

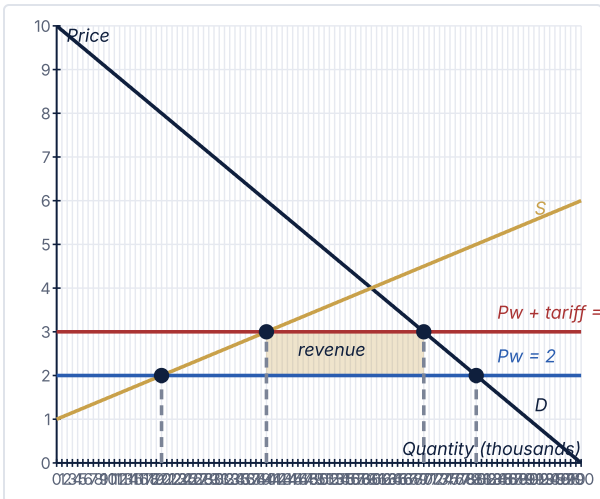
Consumers gain, domestic producers lose, and total surplus rises (gains from trade).

At \$2 domestic buyers want $Q_d = 80$ and domestic firms supply only $Q_s = 20$, so imports are 60 thousand. Consumer surplus rises from \$180 to \$320, and producer surplus falls from \$90 to \$10. Consumers' gain (\$140) exceeds producers' loss (\$80), and total surplus rises from \$270 to \$330, a net gain from trade of \$60.

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Free trade at \$2: imports 60. A \$1 tariff raises the domestic price to \$3 and cuts imports to 30. The shaded rectangle is tariff revenue.

A **tariff** is a tax on imports. A per-unit tariff of \$1 raises the domestic price to the world price plus the tariff, $P_w + t$, which is \$3. Domestic producers expand output from 20 to 40, buyers cut purchases from 80 to 70, and imports fall to 30. The government collects tariff revenue = tariff $\times$ imports = $\$1 \times 30 = \$30$.

Tariff effects (importing country, small)

Domestic price rises by the tariff; imports fall; domestic production rises; domestic consumption falls.

CS falls, domestic PS rises, government collects tariff revenue = $t \times$ imports.

DWL = two triangles: overproduction at home (domestic cost above world price) plus lost consumption.

A **quota** is a legal limit on the quantity of imports. A quota of 30 thousand imports gives the same domestic price (\$3), the same quantity changes and the same DWL as the tariff above, since only 30 thousand units can enter. The difference is who gets the extra \$1 on each import: with a tariff the government gets the revenue; with a quota the importers (license holders) get a **quota rent** of $\$1 \times 30 = \$30$, unless the government auctions the licenses. If foreign firms hold the licenses, the rent leaves the country and makes the quota worse than the tariff.

	Free trade ($P_w = \$2$)	Tariff \$1 (price \$3)	Quota 30 (price \$3)
Consumer surplus	\$320	\$245	\$245
Domestic producer surplus	\$10	\$40	\$40
Government revenue	0	\$30	0 (quota rent \$30 to license holders)
Imports	60	30	30
Deadweight loss	0	\$15	\$15

Notice the pattern: protection helps domestic producers (+\$30), harms domestic consumers (-\$75), and the DWL is \$15. Consumer losses equal producer gains plus revenue (or rent) plus DWL: $75 = 30 + 30 + 15$.

Exporting. If the world price is above the no-trade price, the country exports. With a world price of \$6, domestic buyers purchase $Q_d = 40$, firms produce $Q_s = 100$, and exports are 60 thousand. Producers gain, consumers lose, and total surplus rises from \$270 to \$330 (producers gain \$160; consumers lose \$100).

EXAMPLE 1: IMPORTING A GOOD

The domestic market for solar panels has $Q_d = 100 - 10P$ and $Q_s = 20P - 20$. The world price is \$2. Find imports, CS, PS and the change in total surplus compared with no trade.

SOLUTION

At \$2: $Q_d = 80$, $Q_s = 20$, imports = 60.

$CS = \frac{1}{2}(80)(10 - 2) = \$320$. $PS = \frac{1}{2}(20)(2 - 1) = \$10$, $TS = \$330$.

With no trade, $CS = \$180$, $PS = \$90$, $TS = \$270$, so the gain from trade is \$60.

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EXAMPLE 2: A TARIFF

A \$1 tariff is imposed on the solar panels. Find the new price, imports, tariff revenue, CS, PS and DWL.

SOLUTION

Price = $2 + 1 = \$3$. $Q_d = 70$, $Q_s = 40$, imports = 30.

Tariff revenue = $1 \times 30 = \$30$. $CS = \frac{1}{2}(70)(10 - 3) = \$245$. $PS = \frac{1}{2}(40)(3 - 1) = \$40$.

DWL = $\frac{1}{2}(40 - 20)(1) + \frac{1}{2}(80 - 70)(1) = 10 + 5 = \$15$. Check: $330 - (245 + 40 + 30) = \$15$.

EXAMPLE 3: WHO WINS FROM EXPORTING?

With a world price of \$6, find exports and the change in CS and PS compared with no trade.

SOLUTION

At \$6, $Q_d = 40$, $Q_s = 100$, exports = 60.

$CS = \frac{1}{2}(40)(10 - 6) = \$80$, down from \$180 (-\$100). $PS = \frac{1}{2}(100)(6 - 1) = \$250$, up from \$90 (+\$160).

Net gain = \$60, even though consumers lose.

Common mistakes

1) Forgetting to add the tariff to the world price: the domestic price becomes $P_w + t$. 2) Computing tariff revenue on the old import quantity; use imports after the tariff. 3) Counting tariff revenue as a loss. It is a transfer to the government, and only the two triangles are deadweight loss. 4) Saying quotas and tariffs differ in prices: with the same imports, they give the same domestic price. The difference is who receives the revenue.

Practice**SET A Check Your Understanding**

Answer each item in 2 to 4 sentences or show the calculation.

1. Explain why a country with a no-trade price above the world price becomes an importer and who gains and loses.
2. Using $Q_d = 100 - 10P$ and $Q_s = 20P - 20$ and a world price of \$2.50, find imports.
3. A tariff of \$1 raises the domestic price from \$2 to \$3. Calculate the tariff revenue if imports after the tariff are 30 thousand, and say who receives it.
4. Describe the effect of a tariff on domestic quantity supplied, quantity demanded, and imports.
5. How does an import quota differ from a tariff if both lead to the same domestic price? Who gets the extra revenue?
6. With a world price above the domestic no-trade price, identify who gains and who loses from exports.

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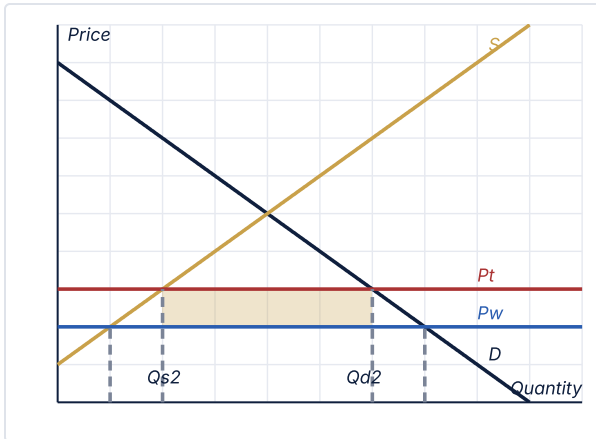
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A small country imports a good. A tariff is imposed. Which is true?
- (A) The domestic price falls
 - (B) The domestic price rises and domestic producers produce more
 - (C) Imports increase
 - (D) Consumer surplus rises
 - (E) The world price rises
8. The graph shows an import market with a world price P_w and a tariff raising the price to P_t . Tariff revenue is represented by the area



- (A) $(P_t - P_w) \times (Q_{d2} - Q_{s2})$
 - (B) $(P_t - P_w) \times Q_{s2}$
 - (C) $(P_t - P_w) \times Q_{d1}$
 - (D) the triangle under the demand curve
 - (E) $(P_t - P_w) \times (Q_{d1} - Q_{s1})$
9. Compared with an equivalent tariff, an import quota (with licenses given to foreign exporters)
- (A) raises the price by more
 - (B) lowers the domestic price
 - (C) gives quota rent to foreign firms instead of revenue to the government
 - (D) increases domestic consumption
 - (E) has no deadweight loss
10. Domestic demand is $Q_d = 100 - 10P$ and supply is $Q_s = 20P - 20$. With free trade at a world price of \$2, imports are
- (A) 20
 - (B) 40
 - (C) 80
 - (D) 60
 - (E) 100
11. The world price of steel is higher than the domestic no-trade price. When trade opens, which group in the exporting country is worse off?
- (A) Domestic steel producers
 - (B) The government
 - (C) Foreign consumers
 - (D) Domestic steel workers in the industry
 - (E) Domestic consumers of steel
12. Which is true about the deadweight loss of a tariff in a small importing country?
- (A) It consists of overproduction at higher domestic cost and lost consumption
 - (B) It equals the tariff revenue
 - (C) It is borne by foreign producers
 - (D) It disappears when imports fall
 - (E) It equals the gain to domestic producers

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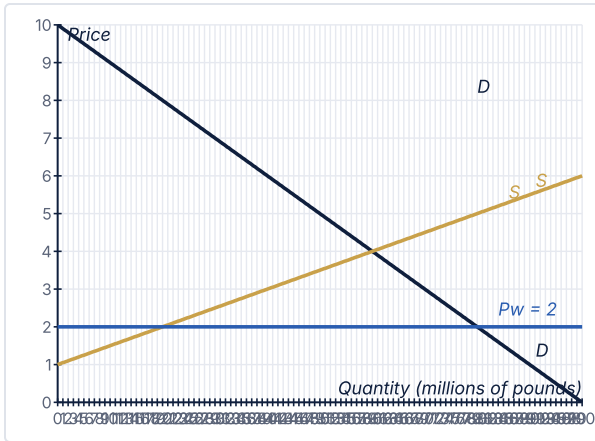
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SET C Apply and Extend

Answer fully. Label graphs and show calculations.

13. The graph shows the domestic market for sugar (price per pound, quantity in millions of pounds) with demand $P = 10 - Q/10$ and supply $P = 1 + Q/20$. The world price is \$2. (a) Find domestic production, consumption and imports under free trade. (b) A \$1 tariff is imposed. Find the new imports and tariff revenue. (c) Calculate the deadweight loss and explain why the tariff lowers total surplus.



14. A country has a quota of 30 thousand imports instead of the tariff. (a) What is the domestic price? (b) Who receives the quota rent, how much, and when might it be lost to the country? (c) Compare consumer surplus, producer surplus and deadweight loss with the tariff case.

Price	Qd	Qs
\$2	80	20
\$3	70	40
\$4	60	60

2.9 Multiple-Choice Practice: Supply and Demand

Twenty exam-style multiple-choice questions covering demand, supply, equilibrium, price controls, elasticity, surplus and trade. Choose the single best answer for each question. Sketch the graph whenever a question describes a market. Every answer explains the right choice and why the most tempting wrong choice fails.

SET A Core Concepts

Choose the best answer.

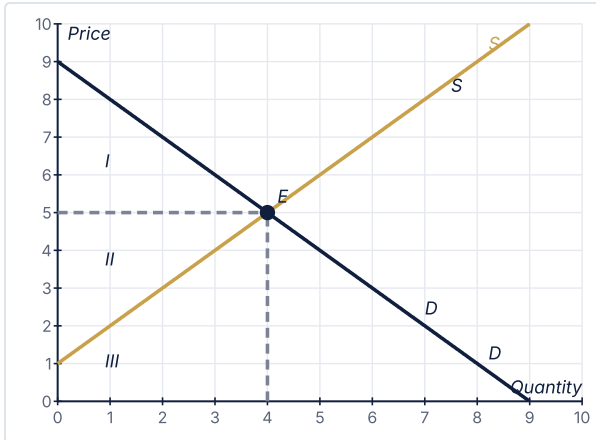
- When her income rises, a student buys fewer cans of store-brand soup. For this student, store-brand soup is
 - a normal good
 - a complement to restaurant meals
 - an inferior good
 - a good with elastic demand
 - a good whose supply has decreased
- The government begins paying electric-car producers a subsidy per car. In the market for electric cars, the equilibrium price and quantity will
 - price falls and quantity rises
 - price rises and quantity rises
 - price falls and quantity falls
 - price rises and quantity falls
 - price is unchanged and quantity rises
- In a free market, a price below the equilibrium price will cause
 - a surplus that puts downward pressure on the price
 - a shortage that puts upward pressure on the price
 - a shift of the demand curve to the right
 - a decrease in supply
 - no change, because equilibrium is stable at all prices

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4. The equilibrium price of apples is \$2. The government sets a minimum price of \$2.50. The result is
 (A) a shortage of apples (B) no effect, because \$2.50 is close to \$2
 (C) an increase in the supply of apples (D) a surplus of apples
 (E) a decrease in the demand for apples
5. When the price of Brand X rises 10 percent, the quantity of Brand Y demanded rises 15 percent. The cross-price elasticity of demand is
 (A) +1.5, so the goods are complements (B) -1.5, so the goods are substitutes
 (C) -0.67, so the goods are complements (D) 0, so the goods are unrelated
 (E) +1.5, so the goods are substitutes
6. In the graph, market equilibrium is at E. Which area represents producer surplus?



- (A) II (B) I (C) III
 (D) I and II (E) II and III
7. A small country imposes a tariff on an imported good. Which group gains?
 (A) Domestic consumers and the government
 (B) Foreign producers and domestic consumers
 (C) Domestic producers of the good and the government
 (D) Domestic consumers only
 (E) Domestic producers and domestic consumers

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SET B Applications and Data

Choose the best answer.

8. The table shows the quantity demanded of a good at two income levels. Which statement is correct?

Price	Qd (income \$30,000)	Qd (income \$40,000)
\$2	90	70
\$4	70	50
\$6	50	30

- (A) The good is normal, and demand increased by 20 at every price
 (B) The change is a movement along the demand curve
 (C) The good is a luxury
 (D) The good is a complement to income
 (E) The good is inferior, and demand decreased by 20 at every price
9. The graph shows a market initially at E0 (price 5, quantity 4) and then at E1 (price 4, quantity 5) after S0 shifts to S1. Which event best explains the shift?



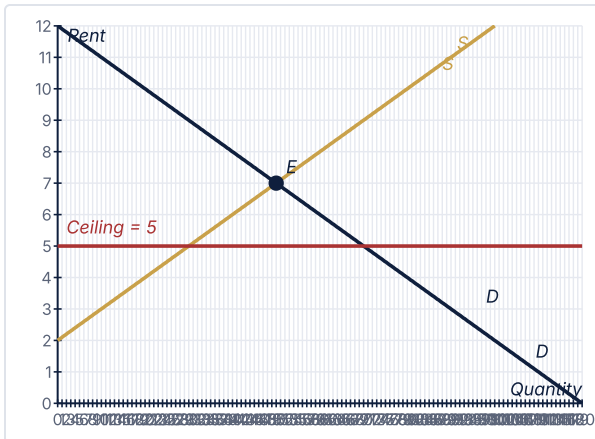
- (A) A rise in the price of a substitute
 (B) A technological advance lowers production costs
 (C) A new per-unit tax on sellers
 (D) An increase in consumer income (normal good)
 (E) An increase in the price of an input
10. Demand is $Q_d = 80 - 5P$ and supply is $Q_s = 10P - 10$. At a price of \$8 the market has
- (A) a shortage of 30 (B) a surplus of 70 (C) a shortage of 70
 (D) a surplus of 30 (E) a surplus of 40

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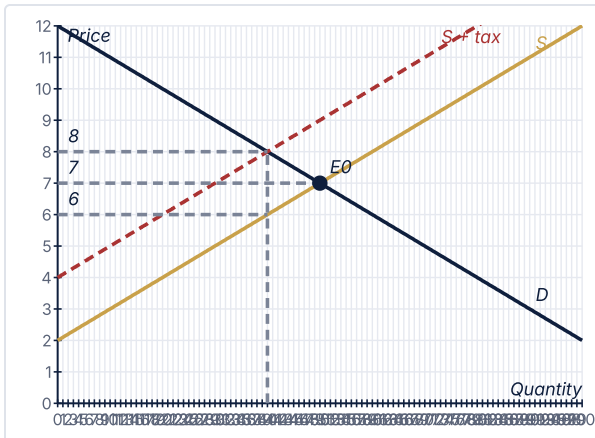
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11. The graph shows the market for apartments (monthly rent in hundreds of dollars, quantity in apartments). Demand is $P = 12 - Q/10$ and supply is $P = 2 + Q/10$. A rent ceiling of 5 hundred dollars is imposed. The shortage is



- (A) 30 units (B) 50 units (C) 40 units (D) 70 units (E) 80 units
12. When price falls from \$5 to \$4, quantity demanded rises from 80 to 110. Using the midpoint method, the price elasticity of demand is about
- (A) 1.4 (B) 0.7 (C) 1.0 (D) 1.8 (E) 2.4
13. The graph shows a market with a \$2 per-unit tax on sellers. The new price paid by buyers is \$8, sellers receive \$6, and the old price was \$7. Which statement is correct?



- (A) Buyers bear all of the tax
 (B) Sellers bear all of the tax
 (C) Buyers bear \$2 and sellers bear \$1
 (D) Buyers and sellers each bear \$1 of the tax per unit
 (E) Buyers bear \$1 and sellers bear \$2
14. Demand is $P = 30 - Q$ and supply is $P = 6 + Q$. At equilibrium, total surplus equals
- (A) \$72 (B) \$144 (C) \$108 (D) \$216 (E) \$288

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SET C Exam-Level Stretch

Choose the best answer.

15. Farmers can grow corn or soybeans on the same land. The price of corn rises, and at the same time consumers' incomes rise (soybeans are a normal good). In the soybean market, the equilibrium
 - (A) price rises, and the change in quantity cannot be determined
 - (B) price rises and quantity rises
 - (C) price rises and quantity falls
 - (D) price falls and quantity cannot be determined
 - (E) price cannot be determined and quantity rises
16. Labor demand is $L = 120 - 8W$ and labor supply is $L = 12W - 40$ (L in thousands). A minimum wage of \$10 is imposed. Compared with the free-market equilibrium, employment
 - (A) falls by 16 thousand, with unemployment of 24 thousand
 - (B) rises by 24 thousand
 - (C) falls to 56 thousand with no unemployment
 - (D) falls by 40 thousand, with a shortage of workers
 - (E) falls by 16 thousand, with unemployment of 40 thousand
17. Restaurant meals' quantity demanded rises 15 percent when income rises 10 percent. Which is correct?
 - (A) Income elasticity is 0.67, so meals are inferior
 - (B) Income elasticity is 1.5, so meals are inferior
 - (C) Income elasticity is 1.5, so meals are a luxury (normal) good
 - (D) Price elasticity of demand is 1.5
 - (E) Income elasticity is 0.67, so meals are a necessity
18. A firm's price elasticity of demand at its current price of \$10 and quantity of 100 is 0.5. If it raises price by 10 percent, total revenue will
 - (A) fall by about 5 percent
 - (B) rise by about 4.5 percent
 - (C) rise by about 10 percent
 - (D) fall by about 4.5 percent
 - (E) remain unchanged
19. Demand is $P = 30 - Q$ and supply is $P = 6 + Q$. A \$6 per-unit tax is imposed on sellers. The deadweight loss is
 - (A) \$9
 - (B) \$6
 - (C) \$18
 - (D) \$27
 - (E) \$54
20. Domestic demand is $Q_d = 120 - 10P$ and supply is $Q_s = 10P - 20$. The world price is \$5. A \$1 per-unit tariff is imposed. Tariff revenue is
 - (A) \$10
 - (B) \$40
 - (C) \$60
 - (D) \$20
 - (E) \$70

2.10 Free-Response Practice: Supply and Demand

Four free-response questions with graph and calculation parts, scored with AP-style point rubrics.

Each question is worth between 8 and 11 points. Draw and label every graph (axes, curves, equilibrium and shifts) and show every calculation; points are awarded for correct labels, directions of change and numerical steps. Check your work against the rubric-style answers.

QUESTION 1 Blueberry market: shifts and elasticity

The market for fresh blueberries is perfectly competitive. Demand is $Q_d = 120 - 10P$ and supply is $Q_s = 20P - 30$, where P is the price in dollars per pound and Q is in thousands of pounds per week.

1. (a) Calculate the equilibrium price and quantity.
2. (b) Draw a correctly labeled graph of the blueberry market showing the equilibrium. Then show and explain the effect on equilibrium price and quantity of a medical report that finds blueberries improve health (assume supply is unchanged).
3. (c) Suppose that the report in (b) and a severe frost that damages blueberry bushes both occur. What happens to the equilibrium price? What happens to the equilibrium quantity? Explain.
4. (d) Using the original demand equation, calculate the price elasticity of demand at the original equilibrium, $E = |\text{slope of } Q| \times (P/Q)$. Is demand elastic or inelastic, and what would a price increase do to total revenue?

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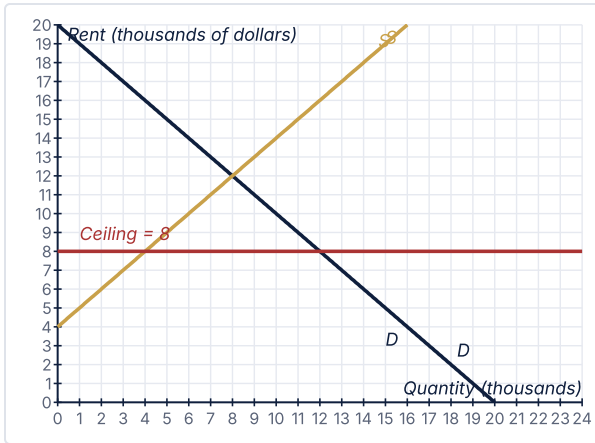
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QUESTION 2 Rent control and surplus

Demand for apartments is $P = 20 - Q$ and supply is $P = 4 + Q$, where P is annual rent in thousands of dollars and Q is in thousands of apartments.

5. (a) The graph shows the market for apartments (rent in thousands of dollars per year, quantity in thousands of units). Identify the equilibrium rent and quantity. The city then sets a rent ceiling of \$8. Is the ceiling binding? Calculate the quantity supplied, the quantity demanded and the shortage.

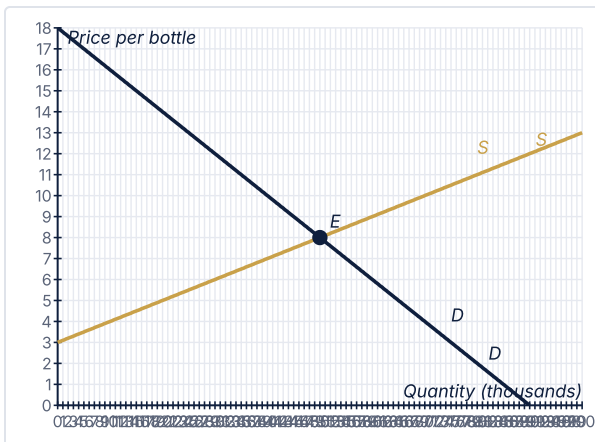


6. (b) Calculate consumer surplus and producer surplus before the ceiling and after it.
 7. (c) Calculate the deadweight loss and explain what it represents.
 8. (d) Landlords and tenants may make illegal side payments. What is the maximum rent tenants would pay for the apartments available, and why?

QUESTION 3 Tax incidence on juice

Analyze the effect of a per-unit tax in the market for fresh juice.

9. (a) The graph shows the market for fresh juice (price per bottle, quantity in thousands). Demand is $Q_d = 90 - 5P$ and supply is $Q_s = 10P - 30$. A tax of \$3 per bottle is placed on sellers. Find the price buyers pay, the price sellers keep, and the new quantity.



10. (b) Calculate how much of the tax is borne by buyers and by sellers. Use the elasticities at the original equilibrium to explain why.
 11. (c) Calculate the tax revenue and the deadweight loss.
 12. (d) If demand were more elastic than in the graph, what would happen to the buyers' share of the tax and to tax revenue? Explain.

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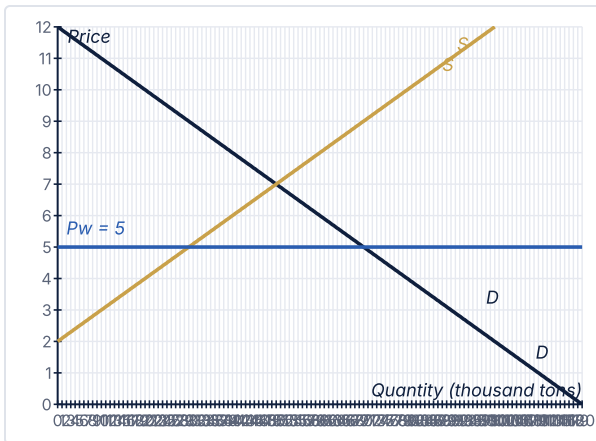
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QUESTION 4 Steel tariff and quota

Analyze the market for steel in a small country that trades at the world price.

13. (a) The graph shows the domestic market for steel (price per ton in hundreds of dollars, quantity in thousands of tons). Demand is $Q_d = 120 - 10P$ and supply is $Q_s = 10P - 20$. The world price is \$5. Under free trade, find domestic production, consumption and imports.



14. (b) Calculate consumer surplus and producer surplus under free trade.
15. (c) A tariff of \$1 per ton is imposed. Find the domestic price, imports, tariff revenue, consumer surplus, producer surplus and deadweight loss.
16. (d) Suppose instead the government sets an import quota of 20 thousand tons. Compare the domestic price and the deadweight loss with part (c), and say who receives the difference between the domestic and world price on each imported ton.

Answers Chapter 2: Answers and Explanations

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

2.1 Demand and the Law of Demand**SET A · CHECK YOUR UNDERSTANDING**

1. Law of demand: price and quantity demanded move in opposite directions, *ceteris paribus*. A price cut makes water cheaper relative to substitutes (substitution effect), and the same income buys more (income effect). Marginal utility also falls with each extra bottle, so buyers need a lower price to buy more.
2. At \$3.50, $Q_d = 50 - 35 = 15$ thousand cups. $Q_d = 0$ when $50 - 10P = 0$, so $P = \$5$. At or above \$5, nobody buys any coffee.
3. No. The price of the good itself changes the quantity demanded, not demand. The market moves up along a stationary demand curve to a smaller quantity demanded. Demand shifts only when a non-price determinant changes.
4. (a) Expectations of a higher future price raise current demand, so demand increases (shift right). (b) Lower income reduces demand for a normal good, so demand decreases (shift left).
5. A normal good has demand that rises with income; an inferior good has demand that falls as income rises. Since her purchases fell when income rose, store-brand cereal is inferior for her.
6. Rackets and balls are complements: when rackets cost more, fewer players take up tennis, so demand for balls shifts left. Badminton and tennis rackets are substitutes: players switch to the cheaper alternative, so demand for badminton rackets shifts right.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. A. Only the good's own price moves the market along a fixed demand curve. B, C, D and E each change a determinant (related-good price, income, tastes, number of buyers) and shift the curve.
8. D. A rise in the price of one good that lowers demand for the other indicates complements. For substitutes, demand for the other good would rise; the trap is confusing a fall in quantity demanded of coffee with a change in its demand.
9. B. A good whose demand falls when income rises is inferior. Normal goods would see demand rise with income; the relation to new textbooks is a separate question not addressed here.
10. C. The rightward shift is an increase in demand. Costlier gasoline pushes commuters toward e-bikes. A fall in the bikes' own price is only a movement along D_0 , while pricier batteries, fewer commuters and expected lower prices would all shift the curve left.
11. E. The curve is drawn *ceteris paribus*: determinants such as income and related prices are fixed. Price and quantity demanded are the variables that move along the curve.
12. A. The income effect is about purchasing power when the good's own price falls; it is a movement along the curve. B describes the substitution effect, and D confuses it with a change in actual income.

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SET C · APPLY AND EXTEND

13. Graph: downward-sloping D_0 with price on the vertical and quantity on the horizontal axis. (a) 1 point: cheaper apps raise demand for tablets, so D_0 shifts right to D_1 , and demand increases. (b) 1 point: a lower tablet price moves the market down along the same D_0 to a larger quantity, which is an increase in quantity demanded, with no change in demand. (c) 1 point: (a) demand increases, (b) quantity demanded increases and demand is unchanged. A common slip is drawing a shift for (b).
14. (a) 1 point: hot dogs are inferior; steaks are normal. (b) 1 point: demand for hot dogs shifts left (decreases) and demand for steaks shifts right (increases), because quantity demanded at the same price changed. (c) 1 point: midpoint change = $(650-800)/((650+800)/2) = -150/725 = -20.7$ percent. The sign is negative because the quantity fell. The price stayed at \$4, so this is a shift in demand and not a movement.

2.2 Supply and the Law of Supply**SET A · CHECK YOUR UNDERSTANDING**

- The law of supply says price and quantity supplied move in the same direction, *ceteris paribus*. One reason: expanding output raises opportunity cost per unit, so sellers need a higher price to be willing to produce more.
- At \$2.50, $Q_s = 25$ hundred. For 45 hundred, the price must be $45/10 = \$4.50$. The supply curve can be read as the minimum price needed for each quantity.
- No. Tuition does not change the cost of pizza production. It might change demand (through income), but not supply. A rise in cheese prices, a new oven, or a per-pizza tax would shift supply.
- The tax is an added cost per unit, so supply decreases. Vertically the curve shifts up by \$1 at every quantity (sellers need \$1 more); horizontally it shifts left, since less is offered at any given price.
- Supply of wheat increases. The lower barley price lowers the opportunity cost of planting wheat, so more land moves to wheat at every wheat price (shift right).
- An increase in quantity supplied is a movement up along a fixed supply curve caused by a higher price. An increase in supply is a rightward shift of the whole curve, caused by a non-price determinant such as cheaper inputs, so more is offered at every price.

SET B · EXAM-STYLE MULTIPLE CHOICE

- C. Higher input prices raise cost and lower supply. A rise in the bicycle price is a movement along S ; technology and subsidies increase supply; income affects demand.
- A. Own-price changes move the market along S , here up to a larger quantity supplied. The trap is calling that 'an increase in supply', which would be a shift.
- D. The curve shifted up (left), meaning higher cost at every quantity: this is the effect of a per-unit tax. Cheaper fabric, new technology, entry and subsidies all shift supply right.
- E. Land moves toward the now more profitable soybeans, so corn supply shifts left. The tempting opposite, B, treats soybeans like a complement in production, which they are not.
- B. The supply curve reflects the marginal opportunity cost of producing each additional unit. A describes the demand curve, and E mixes up cost with profit.
- C. Good weather lowers costs of growing rice at every quantity. A tax and costlier fertilizer reduce supply, and a fall in price is only a movement along S . Expecting higher prices makes sellers hold back, which lowers current supply.

SET C · APPLY AND EXTEND

13. (a) 1 point: S_0 shifts right (down) to S_1 with the vertical intercept lower, since lower costs mean sellers accept lower prices. (b) 1 point: an increase in supply, caused by a lower resource price (input cost), not an increase in quantity supplied. (c) 1 point: at \$3, the original schedule gives 30 hundred loaves; the new one gives $10(3) + 10 = 40$ hundred. So 10 hundred more loaves are offered at the same price.
14. (a) 1 point: the subsidy lowers the price farmers need by \$2 at every quantity, so the new curve is $P = -1 + Q/5$ (S_1 lies \$2 below S_0). (b) 1 point: for 15 thousand bushels farmers needed $P = 1 + 15/5 = \$4$ before the subsidy and need $P = -1 + 15/5 = \$2$ from buyers after it, because the subsidy supplies the other \$2. (c) 1 point: the subsidy is a non-price determinant that lowers cost; more is offered at every price, so the whole curve shifts right (down), which is an increase in supply.

2.3 Market Equilibrium and Changes in It**SET A · CHECK YOUR UNDERSTANDING**

- The equilibrium price is the price at which quantity demanded equals quantity supplied. Above it there is a surplus: unsold goods pile up, sellers cut prices to clear them, and the price falls until the surplus disappears.
- At \$3, $Q_d = 100 - 30 = 70$ and $Q_s = 60 - 20 = 40$. The shortage is $70 - 40 = 30$ thousand. The shortage means price pressure upward.
- Step 1: draw D_0 , S_0 . Step 2: gas is a complement to SUVs, so it affects demand. Step 3: demand decreases (left). Step 4: equilibrium price falls and equilibrium quantity falls, along an unchanged supply curve.
- Supply increases (shift right). The equilibrium price falls and equilibrium quantity rises. The market moves down along the unchanged demand curve, so quantity demanded rises but demand has not changed.
- Quantity definitely rises, because both shifts raise it. Price is ambiguous: higher demand raises it, higher supply lowers it. It depends on which shift is larger.
- The student confuses a movement with a shift. A higher price increases the quantity supplied (a movement up along S) and leaves the curve where it is. The shift would require a non-price cause such as cheaper seed.

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SET B • EXAM-STYLE MULTIPLE CHOICE

7. A. A surplus means that sellers cannot sell everything at the posted price, so they cut price. Demand and supply do not shift in response to a price change; the market moves along the curves.
8. C. Rightward demand and leftward supply both raise price. Quantity could rise, fall, or stay the same depending on the size of the shifts. The last option confuses this case with two increases.
9. D. Lower demand pushes quantity down, while greater supply pushes quantity up, so the net change is ambiguous. Price definitely falls, since both shifts lower it, which rules out the last choice.
10. B. Both price and quantity rose, which means demand increased; a cheaper complement raises demand. Falling input prices or new technology would raise quantity but lower price, and a tax would lower quantity.
11. E. Market clearing means no surplus and no shortage. The distractor about willingness to pay is wrong because most buyers would have paid more than the market price; that gap is consumer surplus.
12. C. At \$3, $Q_d = 70$ and $Q_s = 40$, so the shortage is $70 - 40 = 30$. The surplus answers confuse the direction; the equilibrium is at \$4 where both equal 60.

SET C • APPLY AND EXTEND

13. (a) 1 point: the safety report changes tastes, so demand decreases (left); cheaper batteries lower input costs, so supply increases (right). (b) 1 point: both shifts lower price, so price falls for sure. (c) 1 point: quantity falls with the demand decrease and rises with the supply increase, so the net change depends on which shift is larger and cannot be determined from the information given.
14. (a) 1 point: $90 - 10P = 20P - 30$ gives $P = \$4$, $Q = 50$. (b) 1 point: $60 - 10P = 20P - 30$ gives $90 = 30P$, $P = \$3$ and $Q = 30$; price fell by \$1 and quantity by 20 thousand. (c) 1 point: at the old price \$4, the new $Q_d = 20$ and $Q_s = 50$, a surplus of 30 thousand.

2.4 Price Controls: Ceilings and Floors**SET A • CHECK YOUR UNDERSTANDING**

1. A ceiling is a legal maximum price; it binds only when set below equilibrium. A floor is a legal minimum price; it binds only when set above equilibrium. If not binding, the market stays at equilibrium.
2. At \$5.50, $Q_d = 100 - 55 = 45$ and $Q_s = 110 - 20 = 90$. Surplus = 45 thousand. A price of \$5.50 is above the \$4 equilibrium, so a floor there would bind.
3. Likely: shortage of apartments, lower maintenance and quality, and black-market payments. The shortage occurs because the capped rent lowers the quantity landlords supply while raising the quantity demanded.
4. The wage floor is above equilibrium, so firms hire fewer workers (the quantity of labor demanded falls) while more people want to work (the quantity of labor supplied rises). The difference is unemployment.
5. Without purchases, only 40 thousand units sell, the smaller quantity, and 60 thousand remain unsold. With government purchases of the 60 thousand extra units, 100 thousand units are produced, 40 thousand to consumers and 60 thousand to the government.
6. Nothing changes. The ceiling is above equilibrium, so it is nonbinding. The price stays at \$4 and quantity at 60 thousand.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. C. A binding ceiling holds price below equilibrium, so quantity demanded exceeds quantity supplied. Controls don't shift curves, which rules out the shift answers.
8. E. Only a floor above \$5 causes surplus. A ceiling at \$4 would cause a shortage, and a floor at \$4 or \$5 does not bind.
9. A. At P_1 (below equilibrium) buyers want Q_3 and sellers supply Q_1 , so the shortage is the horizontal gap $Q_3 - Q_1$ and the quantity traded is the smaller quantity Q_1 .
10. D. A floor above equilibrium reduces the quantity of labor demanded and increases the quantity supplied, so there is unemployment. The shortage answer reverses the direction.
11. B. Farmers get the higher price on more units, but consumers pay more and taxpayers fund the purchase. Consumers would only gain from a ceiling.
12. C. The ceiling reduces landlords' returns, so they cut quality and convert units. A fall in quantity demanded is wrong because cheaper rents raise it.

SET C • APPLY AND EXTEND

13. (a) 1 point: $900 - 5Q = 100 + 3Q$ gives $Q = 100$ (10,000 apartments) and rent = \$400. (b) 1 point: the ceiling is below \$400, so it binds. $Q_s: 250 = 100 + 3Q$ gives 50; $Q_d: 250 = 900 - 5Q$ gives 130; shortage = $130 - 50 = 80$ hundred (8,000 apartments). (c) 1 point: with only 50 hundred available, the demand curve shows renters would pay up to $900 - 5(50) = \$650$, which creates a black market or side payments.
14. (a) 1 point: $20 - L/5 = 5 + L/10$ gives $L = 50$ thousand and $W = \$10$. (b) 1 point: at \$12, labor demanded = $5(20 - 12) = 40$ and labor supplied = $10(12 - 5) = 70$, so unemployment = 30 thousand (employment falls from 50 to 40). (c) 1 point: wages paid fall from $10 \times 50 = \$500$ thousand to $12 \times 40 = \$480$ thousand, which shows demand for labor is elastic in this range, since the percentage fall in employment exceeds the percentage wage rise.

2.5 Elasticity of Demand and Supply

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SET A • CHECK YOUR UNDERSTANDING

1. It is the percentage change in quantity demanded divided by the percentage change in price. The midpoint formula divides each change by the average of the two values, so the answer is the same for a price increase and for the reverse decrease.
2. $%Q = -50/175 = -28.6$ percent; $%P = 2/6 = 33.3$ percent. $E_d = 28.6/33.3 = 0.86$ in absolute value. This is less than 1, so demand is inelastic.
3. Insulin has no close substitutes and is a necessity for diabetics, so quantity barely responds to price. Pizza from one restaurant has many substitutes (other restaurants), so buyers switch easily and demand is elastic.
4. In the short run people have limited ways to cut gas use. Over years they can buy efficient cars, move closer to work or use transit, so the same price rise reduces quantity demanded by a larger percentage.
5. Negative cross-price elasticity means complements. A 10 percent rise in the price of Y lowers the quantity of X demanded by about 14 percent at each price (demand for X shifts left).
6. Income elasticity above 1 means a normal good that is a luxury. Quantity demanded rises about $1.8 \times 5 = 9$ percent, which is a rightward shift of demand.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. D. $%Q = -20/50 = -40$ percent and $%P = 2/11 = 18.2$ percent, so $E = 40/18.2 = 2.2$. Dividing by starting values instead would give a different, incorrect number.
8. A. Insulin is a necessity with no close substitutes. Brand-specific goods and luxuries have many substitutes, so their demand is more elastic.
9. B. A positive value means that a price rise for one raises the quantity of the other bought. Complements show negative values.
10. C. A negative sign means demand falls as income rises, which defines an inferior good. 'Normal' requires a positive value.
11. E. Spare capacity and storability allow output to respond quickly. Supply is usually more elastic in the long run, and the elasticity of supply is positive.
12. A. Elasticity at a point equals $(1/|\text{slope}|) \times (P/Q)$. At A, $P/Q = 5/4$ for both; D1 has slope -0.5 ($E = 2.5$) and D2 has slope -2 ($E = 0.63$). Crossing at a point does not make the elasticities equal.

SET C • APPLY AND EXTEND

13. (a) 1 point: $%Q = -100/550 = -18.2$ percent; $%P = 10/35 = 28.6$ percent; $E = 0.64$. (b) 1 point: inelastic, since $E < 1$. (c) 1 point: revenue at $\$30 = 30 \times 600 = \$18,000$ and at $\$40 = 40 \times 500 = \$20,000$, so raising the price raises revenue because demand is inelastic in that range.
14. (a) 1 point: the short-run curve is steep (nearly vertical), the long-run curve is flatter. (b) 1 point: the rent rises more in the short run because quantity supplied cannot easily increase, so more of the demand increase is absorbed by price; in the long run builders add apartments and the price rise is smaller. (c) 1 point: supply is more elastic in the long run because producers have time to expand capacity and shift inputs.

2.6 Elasticity, Total Revenue, and Tax Incidence**SET A • CHECK YOUR UNDERSTANDING**

1. (a) With elastic demand, a price increase lowers total revenue, because the percentage fall in quantity is larger than the percentage rise in price. (b) With inelastic demand, a price increase raises total revenue, because quantity falls by a smaller percentage.
2. $%Q = 3/51.5 = 5.8$ percent; $%P = -2/19 = -10.5$ percent; $E = 0.55$, inelastic. TR before $= 20 \times 50 = \$1,000$; after $= 18 \times 53 = \$954$. Revenue fell by $\$46$, as the test predicts for inelastic demand.
3. $TR = Q(10 - Q)$, maximum at $Q = 5$, $P = \$5$, $TR = \$25$. At that point $E_d = P/Q = 1$, unit elastic.
4. Demand for cigarettes is inelastic because of addiction and few substitutes. Buyers continue purchasing at the higher price, so quantity falls little and buyers pay most of the tax.
5. Tax $= 5.50 - 3.50 = \$2$. Buyers bear $5.50 - 4 = \$1.50$ and sellers bear $4 - 3.50 = \$0.50$. Buyers bear more, so demand is the more inelastic side.
6. A subsidy lowers the price buyers pay and raises the net price sellers receive. The side that is more inelastic receives the larger part of the benefit. The government pays the subsidy times the larger new quantity.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. D. With inelastic demand the percentage drop in quantity is smaller than the percentage price rise, so revenue rises. The opposite result holds for elastic demand.
8. B. With elastic demand, a price cut raises quantity by a larger percentage than the price fall. Raising the price would reduce revenue.
9. E. At the midpoint, the percentage change in quantity equals the percentage change in price, so $E = 1$ and total revenue is at maximum. Elasticity is greater than 1 above it and less than 1 below.
10. A. The buyer's price rises from $\$4$ to $\$6$ (+2) and sellers' net price falls from $\$4$ to $\$3$ (-1), so buyers bear more. Who is legally charged does not matter.
11. C. Perfectly inelastic sellers cannot reduce quantity, so they absorb the tax by accepting a lower price while buyers pay the old price.
12. D. The subsidy increases supply (rightward shift), so equilibrium price falls and quantity rises. The leftward shift describes a tax.

SET C • APPLY AND EXTEND

13. (a) 1 point: consumers pay $\$6$, producers receive $\$3$, tax $= \$3$ per unit. (b) 1 point: revenue is the rectangle from $\$3$ to $\$6$ up to $Q = 40$, $= 3 \times 40 = \$120$; consumers bear $\$2$ per unit ($6 - 4$) and producers $\$1$ ($4 - 3$). (c) 1 point: if demand is more elastic, consumers cut back more when price rises, so sellers must absorb more; the consumers' share falls and quantity falls more.
14. (a) 1 point: $TR = Q(100 - 2Q)$ is maximized at $Q = 25$ hundred, $P = \$50$; $TR = 50 \times 25 = \$1,250$ (hundred dollars). (b) 1 point: at $\$80$, $Q = 10$, $TR = 80 \times 10 = \$800$; $E = (1/2)(80/10) = 4$. (c) 1 point: demand is elastic at $\$80$ ($E = 4 > 1$), so the venue should lower the price toward $\$50$ to raise revenue.

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2.7 Consumer Surplus, Producer Surplus, and Efficiency

SET A • CHECK YOUR UNDERSTANDING

1. Consumer surplus is the difference between willingness to pay and the price paid; it is the area under demand and above the price. Producer surplus is the difference between price received and minimum acceptable price; it is the area above supply and below the price.
2. Equilibrium ($Q = 4$, $P = \$12$): $TS = 1/2(4)(16) = \$32$. At the \$10 ceiling, Q supplied is 3; demand at 3 is \$14. $CS = 1/2(3)(20 - 14) + 3(14 - 10) = 9 + 12 = \$21$.
3. At the equilibrium quantity, marginal benefit (the buyer's willingness to pay on the demand curve) equals marginal cost (on the supply curve). Every unit worth more than its cost is produced, and no wasteful unit is produced, so total surplus is maximized.
4. At $Q = 40$, demand is \$6 and supply is \$3. $DWL = 1/2(60 - 40)(6 - 3) = \$30$ thousand. The floor stops trades of 20 thousand units that buyers valued above their cost.
5. A transfer moves surplus from one group to another without reducing the total, such as consumers gaining the rectangle that producers lose. DWL is surplus that disappears because mutually beneficial trades do not occur.
6. The revenue is a transfer from buyers and sellers to the government, so it counts in total surplus. The DWL is a separate triangle: units whose benefit exceeds cost that are no longer traded because of the tax wedge.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. E. It measures the gain to buyers. A is wrong because it describes producer-side profit, and consumer spending is simply price times quantity.
8. A. CS lies under demand and above the price. The triangle under supply is PS , the rectangle is total spending, and the area beyond Q^* does not exist at the equilibrium.
9. B. The floor cuts the quantity traded below the efficient level, producing DWL . A transfer to producers does not offset the lost trades, which is the trap in the 'stay the same' choice.
10. D. $CS = 1/2(6)(12 - 6) = \$18$ and $PS = 1/2(6)(6 - 0) = \$18$, so $TS = \$36$. \$18 is only one of the two surpluses.
11. C. DWL is the lost surplus on the units between Q_1 and Q^* whose value to buyers exceeds cost. The rectangle is a transfer or spending, not a loss.
12. E. Revenue is a transfer; the DWL is the separate triangle of foregone trades. Spending the revenue does not recover the lost trades, and DWL falls toward zero only if quantity does not change at all (perfectly inelastic).

SET C • APPLY AND EXTEND

13. (a) 1 point: $CS = 1/2(4)(20 - 12) = \$16$; $PS = 1/2(4)(12 - 4) = \$16$; $TS = \$32$. (b) 1 point: at \$10, $Q_s = 3$ and $Q_d = 5$, so 3 units are traded; $CS = 1/2(3)(6) + 3(4) = \$21$ (demand at 3 is \$14), $PS = 1/2(3)(10 - 4) = \$9$, $TS = \$30$. (c) 1 point: $DWL = 32 - 30 = \$2$, equal to $1/2(4 - 3)(14 - 10) = \$2$.
14. (a) 1 point: $40 - Q = 10 + Q$ gives $Q = 15$ and $P = \$25$. (b) 1 point: $CS = 1/2(15)(40 - 25) = \$112.50$; $PS = 1/2(15)(25 - 10) = \$112.50$. (c) 1 point: at $Q = 10$ demand is \$30 and supply is \$20, so $DWL = 1/2(15 - 10)(30 - 20) = \$25$.

2.8 International Trade, Tariffs, and Quotas

SET A • CHECK YOUR UNDERSTANDING

1. Domestic buyers can purchase at the lower world price, so the quantity demanded exceeds domestic quantity supplied and the gap is imported. Consumers gain, domestic producers lose, and the gains outweigh the losses so total surplus rises.
2. At \$2.50: $Q_d = 100 - 25 = 75$, $Q_s = 50 - 20 = 30$, so imports = 45 thousand.
3. Revenue = $1 \times 30 = \$30$ thousand. The government receives it. It is a transfer from consumers, not a deadweight loss.
4. The higher domestic price raises quantity supplied by domestic firms, reduces quantity demanded, and so reduces imports by both effects.
5. A quota limits quantity directly; a tariff taxes it. With the same imports the price, quantities and DWL are the same. A tariff gives revenue to the government, while a quota gives the price gap (quota rent) to whoever holds import licenses.
6. Domestic producers gain, because they sell more at a higher price. Domestic consumers lose because they pay the higher world price. Total surplus rises because the gain is larger than the loss.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. B. A tariff raises the domestic price by the tariff amount, increasing domestic production while cutting consumption and imports. A small country does not affect the world price.
8. A. Revenue is tariff per unit times imports after the tariff, which is the width $Q_d - Q_s$ at the new price. The last choice uses imports before the tariff.
9. C. Both policies restrict imports to the same quantity and give the same domestic price. The revenue is captured by license holders, so a quota leaves the importing country worse off.
10. D. $Q_d = 80$ and $Q_s = 20$, so imports = 60. 80 is only the quantity demanded.
11. E. Exports raise the domestic price to the world price. Consumers lose, producers gain, and the overall surplus rises.
12. A. The two triangles are inefficient production and reduced consumption. Tariff revenue and producer gains are transfers.

SET C • APPLY AND EXTEND

13. (a) 1 point: $Q_s = 20$, $Q_d = 80$ million pounds; imports = 60 million. (b) 1 point: the price is \$3, $Q_d = 70$, $Q_s = 40$, imports = 30; revenue = $1 \times 30 = \$30$ million. (c) 1 point: $DWL = 1/2(20)(1) + 1/2(10)(1) = \$15$ million. The tariff shifts surplus to producers (+\$30) and the government (+\$30) from consumers (-\$75); the remaining \$15 is lost on inefficient domestic production and forgone consumption.
14. (a) 1 point: with imports limited to 30, price adjusts until $Q_d - Q_s = 30$, which occurs at \$3. (b) 1 point: whoever holds the import licenses gets $1 \times 30 = \$30$; if foreign firms hold them the rent leaves the country (the government can capture it by auctioning licenses). (c) 1 point: CS (\$245), PS (\$40) and DWL (\$15) are the same as for the equivalent tariff; only the allocation of the \$30 differs.

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2.9 Multiple-Choice Practice: Supply and Demand

SET A · CORE CONCEPTS

1. C. Demand falls as income rises, which defines an inferior good. The 'normal good' option reverses the sign of the income effect.
2. A. A subsidy lowers production cost, so supply shifts right: price falls and quantity rises. A price rise would need a demand increase or a supply decrease.
3. B. At a price below equilibrium, quantity demanded exceeds quantity supplied. Buyers bid the price up; the curves themselves do not shift.
4. D. A floor above equilibrium is binding, so quantity supplied exceeds quantity demanded. The floor changes quantities along the curves, not the curves themselves.
5. E. Elasticity = $15/10 = +1.5$, and a positive sign means substitutes. The same size with a negative sign would describe complements.
6. A. Producer surplus is below the price and above the supply curve. Area I is consumer surplus, and area III, below S, is the cost of production.
7. C. A tariff raises the domestic price, which helps domestic producers, and raises revenue for the government. Consumers pay the higher price and lose surplus.

SET B · APPLICATIONS AND DATA

8. E. Quantity demanded at every price fell when income rose, so demand decreased and the good is inferior. A movement along the curve would keep the schedule fixed and change price.
9. B. Price fell and quantity rose, which is a supply increase. A substitute's price rise or higher income would shift demand right, raising both price and quantity.
10. D. At \$8, $Q_d = 40$ and $Q_s = 70$, so Q_s exceeds Q_d by 30: a surplus. Equilibrium is at \$6 where both equal 50.
11. C. At a rent of 5: $Q_d = 10(12 - 5) = 70$ and $Q_s = 10(5 - 2) = 30$. The shortage is $70 - 30 = 40$. Seventy is only the quantity demanded.
12. A. $\%Q = 30/95 = 31.6$ percent and $\%P = 1/4.5 = 22.2$ percent, so $E = 1.42$, which is elastic. Dividing by starting values gives $37.5/20 = 1.9$, the common wrong answer.
13. D. Buyers' price rose from 7 to 8 (+1); sellers' net price fell from 7 to 6 (-1). The burdens total \$2. The equal split arises because demand and supply are equally elastic here.
14. B. Equilibrium is $Q = 12$ and $P = \$18$. $CS = 1/2(12)(12) = 72$ and $PS = 1/2(12)(12) = 72$, so $TS = 144$. Choice 72 is only one of the surpluses.

SET C · EXAM-LEVEL STRETCH

15. A. Pricier corn lowers soybean supply, and higher income raises soybean demand. Both raise price; quantity falls with supply and rises with demand, so it is ambiguous.
16. E. Equilibrium: $W = \$8$, $L = 56$. At \$10, firms hire $120 - 80 = 40$ (down 16) and $12(10) - 40 = 80$ want jobs, so unemployment = 40.
17. C. Income elasticity = $15/10 = 1.5 > 1$: a normal good with elastic income response. Inverting the ratio gives 0.67, a common slip.
18. B. Quantity falls about 5 percent: new revenue = $11 \times 95 = 1,045$ versus 1,000, a rise of 4.5 percent. Revenue rises because demand is inelastic.
19. A. With the tax Q falls from 12 to 9, so $DWL = 1/2(6)(12 - 9) = \$9$. The \$54 figure is tax revenue (6×9), a transfer and not a loss.
20. D. The price becomes \$6: $Q_d = 60$, $Q_s = 40$, imports = 20, revenue = $1 \times 20 = \$20$. Forty is the free-trade import quantity at \$5.

2.10 Free-Response Practice: Supply and Demand

QUESTION 1 · BLUEBERRY MARKET: SHIFTS AND ELASTICITY

1. (a) 2 points. 1 point: set $120 - 10P = 20P - 30$, giving $150 = 30P$, so $P = \$5$. 1 point: $Q = 120 - 50 = 70$ thousand pounds (also $20(5) - 30 = 70$).
2. (b) 3 points. 1 point: a graph with price on the vertical axis, quantity on the horizontal, downward D, upward S, equilibrium at \$5 and 70. 1 point: D shifts right (tastes). 1 point: price and quantity both rise (a movement along S).
3. (c) 2 points. 1 point: the frost lowers supply (leftward shift), so price rises for certain because both shifts raise price. 1 point: quantity is ambiguous: higher demand raises it and lower supply reduces it, so it depends on the relative sizes of the shifts.
4. (d) 3 points. 1 point: $E = 10 \times (5/70) = 0.71$. 1 point: demand is inelastic ($E < 1$). 1 point: a price increase raises total revenue, since the percentage fall in quantity is smaller than the percentage rise in price.

QUESTION 2 · RENT CONTROL AND SURPLUS

5. (a) 3 points. 1 point: equilibrium rent \$12 and 8 thousand units ($20 - Q = 4 + Q$). 1 point: binding, since \$8 is below \$12. 1 point: $Q_s = 4$, $Q_d = 12$, shortage = 8 thousand.
6. (b) 3 points. 1 point: before, $CS = 1/2(8)(20 - 12) = \$32$ and $PS = 1/2(8)(12 - 4) = \$32$ (thousand). 1 point: after, 4 units are rented at \$8: demand at $Q = 4$ is \$16, so $CS = 1/2(4)(20 - 16) + 4(16 - 8) = 8 + 32 = \$40$. 1 point: $PS = 1/2(4)(8 - 4) = \$8$.
7. (c) 2 points. 1 point: $DWL =$ total surplus before (64) minus after (48) = \$16, or $1/2(8 - 4)(16 - 8) = \$16$. 1 point: it is the surplus lost on the 4 thousand apartments that tenants value above their cost but are not rented, a loss to society, not a transfer.
8. (d) 2 points. 1 point: at $Q = 4$, demand is $P = 20 - 4 = \$16$ thousand. 1 point: this is the highest willingness to pay for the scarce units, and the gap between \$16 and the legal \$8 creates the incentive for illegal payments or a black market.

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QUESTION 3 · TAX INCIDENCE ON JUICE

9. (a) 3 points. 1 point: original equilibrium: $90 - 5P = 10P - 30$ gives $P = \$8$, $Q = 50$. 1 point: with the tax, $Q_s = 10(P_b - 3) - 30 = 10P_b - 60$; set equal to $90 - 5P_b$: $P_b = \$10$, $Q = 40$. 1 point: $P_s = 10 - 3 = \$7$.
10. (b) 3 points. 1 point: buyers bear $10 - 8 = \$2$ per bottle. 1 point: sellers bear $8 - 7 = \$1$ per bottle. 1 point: at E, demand elasticity = $5 \times (8/50) = 0.8$ and supply elasticity = $10 \times (8/50) = 1.6$; the less elastic side (demand) bears the larger share.
11. (c) 2 points. 1 point: revenue = $3 \times 40 = \$120$ thousand. 1 point: $DWL = 1/2(3)(50 - 40) = \$15$ thousand.
12. (d) 2 points. 1 point: buyers' share falls (they cut back more when the price rises, so sellers absorb more). 1 point: quantity falls more, so revenue (tax $\times$ quantity) and the buyers' burden fall while the DWL rises.

QUESTION 4 · STEEL TARIFF AND QUOTA

13. (a) 2 points. 1 point: at $\$5$, $Q_s = 30$ and $Q_d = 70$. 1 point: imports = $70 - 30 = 40$ thousand tons.
14. (b) 2 points. 1 point: $CS = 1/2(70)(12 - 5) = \$245$. 1 point: $PS = 1/2(30)(5 - 2) = \$45$ (hundred-thousand dollar units).
15. (c) 4 points. 1 point: price = $\$6$. 1 point: $Q_d = 60$, $Q_s = 40$, imports = 20; revenue = $1 \times 20 = \$20$. 1 point: $CS = 1/2(60)(6) = \$180$ and $PS = 1/2(40)(4) = \$80$. 1 point: $DWL = (245 + 45) - (180 + 80 + 20) = \$10$, or $1/2(10)(1) + 1/2(10)(1) = 5 + 5$.
16. (d) 2 points. 1 point: with imports limited to 20, the price adjusts to $\$6$, so the price, quantities and DWL ($\$10$) are the same as with the tariff. 1 point: with the tariff the government receives the $\$1$ per ton; with the quota the license holders receive it (quota rent), which leaves the country if the licenses are held by foreign firms.

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Chapter 3: Production, Cost, and Perfect Competition.

8 sections with explanations and worked examples, then 120 practice problems. Answers and full explanations are at the end of the chapter.

3.1 Production Functions and Diminishing Returns

Learn how output depends on inputs in the short run, and how marginal and average product explain why costs eventually rise.

Every cost curve you will draw in this chapter has a physical story behind it: how much output a firm gets from the inputs it hires. This lesson builds that story. Once you understand **diminishing marginal returns**, the U-shaped cost curves in the next lesson stop being memorized shapes and become predictable.

Short run versus long run. In economics these terms do not mean a fixed number of months. The **short run** is a period in which at least one input cannot be changed, so the firm has a **fixed input** (often capital, such as a factory, an oven, or a lease on land). The **long run** is a period long enough that every input can be changed, so all inputs are variable. A pizza shop can hire another cook next week (variable) but cannot add a second kitchen until its lease ends (fixed). The same time span can be short run for a steel mill and long run for a lemonade stand.

Key definitions

Fixed input: quantity cannot change in the short run. **Variable input:** quantity can change at once (usually labor or raw materials).

Short run: at least one input is fixed. **Long run:** all inputs are variable.

Total product (TP): total output produced with a given amount of the variable input.

Marginal product (MP): extra output from one more unit of the variable input, $MP = \frac{\Delta TP}{\Delta L}$.

Average product (AP): output per unit of the variable input, $AP = \frac{TP}{L}$.

Measuring output. Suppose the only variable input is labor and capital is fixed. Table 1 shows what a small workshop produces as it adds workers. Marginal product is the change in total product from the last worker hired. For example, going from 3 to 4 workers raises output from 34 to 44, so MP of the fourth worker is 10.

Workers	Total product	Marginal product	Average product
0	0	-	-
1	8	8	8.00
2	20	12	10.00
3	34	14	11.33
4	44	10	11.00
5	50	6	10.00
6	52	2	8.67
7	50	-2	7.14

Look at the MP column. It rises for the first three workers because added workers allow specialization: one cuts, one assembles, nobody wastes time switching tasks. Then MP falls to 10, 6, 2, and finally becomes negative when the seventh worker crowds the others and total product actually declines.

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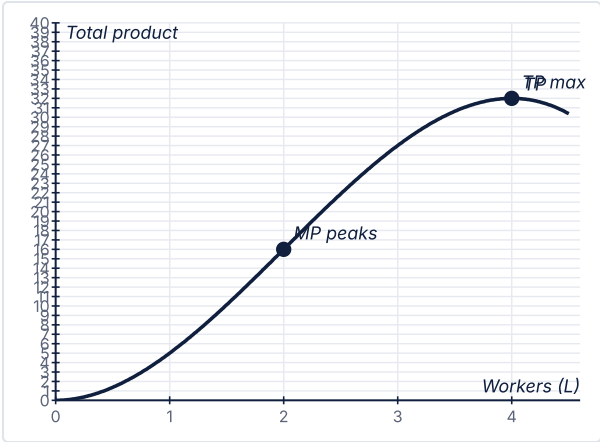
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Law of diminishing marginal returns

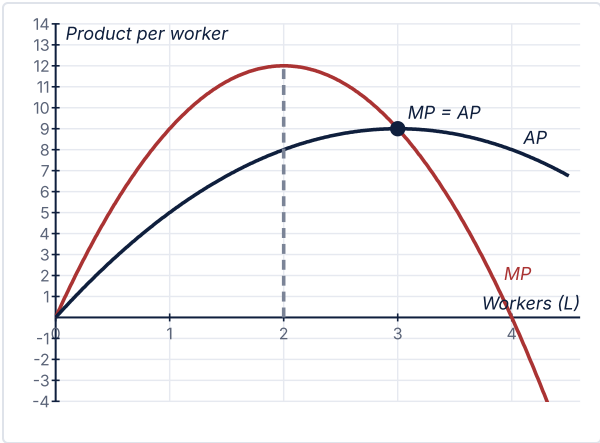
As more of a variable input is added to a fixed amount of other inputs, the marginal product of the variable input eventually decreases.

It is a short-run idea, because it requires some input to be fixed. Diminishing returns does NOT mean total output falls; TP keeps rising as long as MP is positive.

Graphing the three measures. Using a smooth version of the table, the first graph shows TP, which rises at an increasing rate, then at a decreasing rate, reaches a maximum, and would eventually fall. The slope of TP at any point is MP. Diminishing returns begin at the worker where TP stops getting steeper, which is where MP reaches its peak.



Total product for the smooth case $TP = 6L^2 - L^3$. TP is steepest at $L = 2$ (MP is largest) and flat at $L = 4$ (MP = 0).



MP rises to a peak at $L = 2$, where diminishing returns begin, then falls and crosses AP at AP's maximum ($L = 3$). MP reaches zero at $L = 4$, the quantity that maximizes TP.

The MP and AP relationship. MP and AP follow the same logic as a new quiz score and your grade average. When MP is above AP, the next worker pulls the average up, so AP rises. When MP is below AP, AP falls. Therefore MP always crosses AP at the maximum point of AP. In Table 1, MP of the third worker (14) exceeds the previous AP (10), so AP climbs to 11.33. MP of the fourth worker (10) is below 11.33, so AP drops to 11.00. Notice that MP starts falling before AP does: diminishing marginal returns come first, and falling average product follows.

Relationship	What it means
MP > AP	AP is rising
MP < AP	AP is falling
MP = AP	AP is at its maximum
MP > 0	TP is rising
MP = 0	TP is at its maximum

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Relationship	What it means
$MP < 0$	TP is falling (negative returns)

Why this matters for costs. If each worker is paid the same wage, a worker who adds little output makes each extra unit expensive. Marginal cost equals the wage divided by marginal product, so when MP falls, marginal cost rises. That single idea explains the rising portion of the MC curve.

EXAMPLE 1: COMPUTING MP AND AP AND FINDING WHERE RETURNS DIMINISH

A bakery has one oven. Total loaves per hour with 1, 2, 3, 4, 5 bakers are 10, 26, 38, 46, 50. (a) Compute MP and AP for each number of bakers. (b) With which baker do diminishing marginal returns begin? (c) With which baker does AP begin to fall?

SOLUTION

(a) MP: 10, 16, 12, 8, 4 (each is the change in TP; the first baker adds $10 - 0$). AP = TP/L: 10.0, 13.0, 12.67, 11.5, 10.0.

(b) MP peaks at 16 with the second baker and drops to 12 with the third, so diminishing marginal returns begin with the third baker.

(c) AP rises from 10 to 13 with the second baker, then falls to 12.67 with the third. MP (12) is below the old AP (13), so AP falls beginning with the third baker.

Check: MP crosses AP between 2 and 3 bakers, at AP's maximum.

EXAMPLE 2: FROM MARGINAL PRODUCT TO MARGINAL COST

Using Table 1, each worker costs \$120 per day. What is the extra labor cost of each additional unit of output when the fourth worker and the sixth worker are hired?

SOLUTION

Cost per extra unit = wage / MP.

Fourth worker: $120 / 10 = \$12$ per extra unit.

Sixth worker: $120 / 2 = \$60$ per extra unit.

The cost of an extra unit rose fivefold because MP fell from 10 to 2. Falling MP means rising marginal cost.

EXAMPLE 3: READING THE GRAPH

Use the smooth MP and AP graph above ($MP = 12L - 3L^2$, $AP = 6L - L^2$). (a) At what L is AP at its maximum, and what is that maximum? (b) At what L is TP maximized? (c) Is a firm hiring a 3.5th worker experiencing diminishing returns? Is AP rising or falling there?

SOLUTION

(a) MP crosses AP at $L = 3$. $AP = 6(3) - 9 = 9$, and $MP = 12(3) - 27 = 9$. The maximum AP is 9.

(b) TP is maximized where $MP = 0$: $12L - 3L^2 = 0$, so $L = 4$. $TP = 6(16) - 64 = 32$.

(c) Yes. MP is falling for every L above 2, so diminishing returns apply. At $L = 3.5$, $MP = 42 - 36.75 = 5.25$, below $AP = 21 - 12.25 = 8.75$, so AP is falling.

Common mistakes

(1) Saying diminishing returns means output decreases. It means the ADDITIONAL output decreases; total product can still rise. (2) Confusing diminishing returns (short run, one input varies) with decreasing returns to scale (long run, all inputs change). (3) Saying MP crosses AP at the minimum of MP. MP crosses AP at the maximum of AP. (4) Forgetting that average product uses the total number of workers, not just the newest one.

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Practice

SET A Check Your Understanding

Answer in complete sentences or show your calculation.

1. A shirt factory has a fixed building and machines. State whether each is fixed or variable in the short run: the machines, the cloth, the number of sewing hours worked. Then explain what changes in the long run.
2. Total product with 0 to 4 workers is 0, 12, 30, 42, 48. Compute MP for each worker and identify where diminishing marginal returns begin.
3. Using the data in the previous question, compute average product for 1 to 4 workers. Between which worker counts does AP reach its maximum, and how do you know?
4. A student claims that once diminishing returns set in, total output must start to fall. Correct the claim using numbers or a sentence about MP.
5. A farmer adds fertilizer to a fixed field. MP of the last bag is 40 bushels and the previous average product of fertilizer was 55 bushels per bag. Will average product rise or fall? Explain.
6. Each worker costs \$150 per day. The third worker has $MP = 15$ units and the fifth worker has $MP = 5$ units. Find the extra labor cost per unit of output for each and explain the pattern.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which of the following best defines the short run in microeconomics?
 - (A) A period of less than one year
 - (B) A period in which the firm earns a profit
 - (C) A period in which no costs are incurred
 - (D) A period in which at least one input is fixed
 - (E) A period in which price cannot change
8. A firm's total product is 60 with 4 workers and 71 with 5 workers. The marginal product of the fifth worker is
 - (A) 11
 - (B) 5
 - (C) 12
 - (D) 14.2
 - (E) 71
9. The marginal product of labor is 9 and the average product is 12. If another worker is hired, average product will
 - (A) rise because MP is positive
 - (B) rise because TP is rising
 - (C) stay constant
 - (D) fall because TP is falling
 - (E) fall because MP is below AP
10. The graph shows MP and AP of labor. At which quantity of labor do diminishing marginal returns begin?



- (A) 0
- (B) 2
- (C) 3
- (D) 4
- (E) 4.5

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11. The law of diminishing marginal returns applies when
 (A) all inputs are increased in the same proportion
 (B) a firm experiences economies of scale
 (C) one variable input is added to fixed inputs
 (D) the price of the variable input rises
 (E) a firm exits an industry
12. Total product reaches its maximum when
 (A) average product is at its maximum
 (B) marginal product equals average product
 (C) marginal product is at its maximum
 (D) marginal product equals zero
 (E) average product equals zero

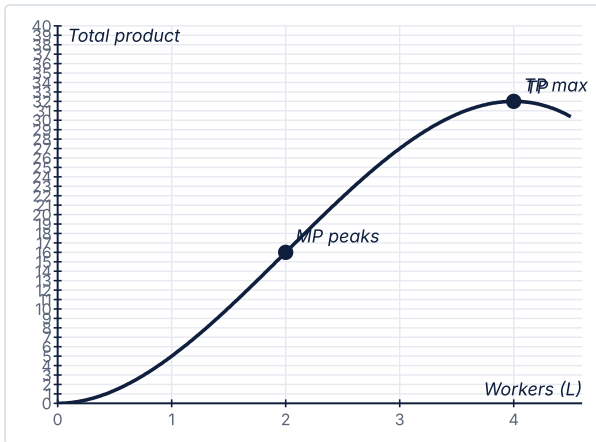
SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A print shop has one printing press (fixed). The table shows output as workers are added.
 (a) Calculate MP of each worker. (b) State the number of workers at which diminishing marginal returns begin and explain your reasoning. (c) Calculate AP for 3 and 4 workers and state whether the marginal product of the 4th worker is above or below the AP of 3 workers, and what that does to AP.

Workers	1	2	3	4	5
Total product	14	34	48	56	60

14. The graph shows total product for a farm with fixed land, as a function of workers.
 (a) Identify the number of workers that maximizes total product and state the value of MP there. (b) Between 0 and 2 workers MP is rising. Explain one reason using specialization. (c) Explain how falling MP after $L = 2$ affects the marginal cost of producing output if the wage is constant.



3.2 Short-Run Costs

Compute fixed, variable, total, average, and marginal costs from tables and graphs, and explain why MC cuts through the minimum points of AVC and ATC.

Costs are the other half of the profit story. This lesson shows how a firm's cost curves are built from the production facts in the last lesson, how to compute each cost measure from a table, and why marginal cost cuts through the bottoms of the average cost curves.

Fixed and variable costs. In the short run a firm has two kinds of costs. **Fixed cost (FC)** does not change with output: rent, insurance, loan payments on equipment. It must be paid even at zero output. **Variable cost (VC)** changes with output: wages, materials, electricity used in production. **Total cost (TC)** is their sum. Fixed costs are the vertical intercept of the TC curve, and TC and VC are parallel curves separated by exactly FC.

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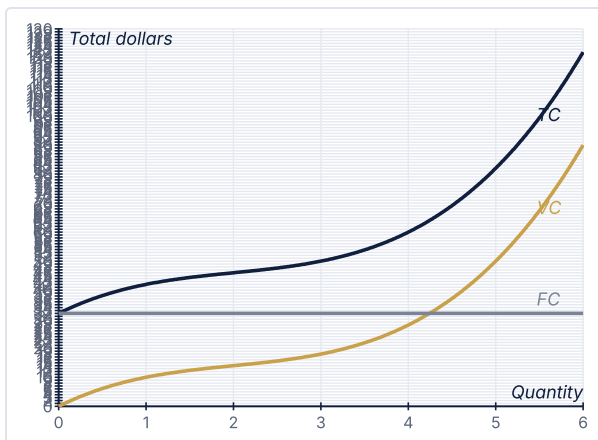
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Cost formulas to memorize

$$TC = FC + VC$$

$$AFC = \frac{FC}{Q}, AVC = \frac{VC}{Q}, ATC = \frac{TC}{Q} = AFC + AVC$$

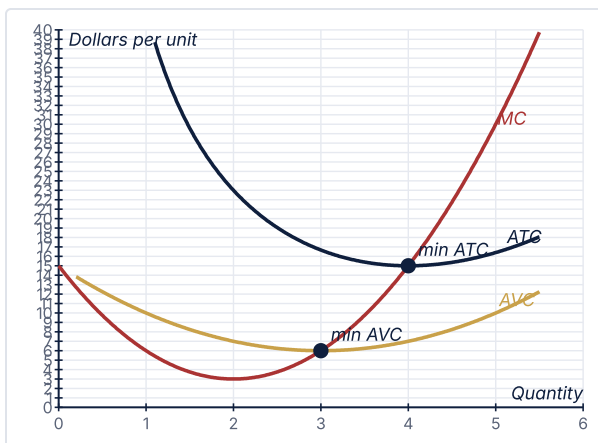
$$MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta VC}{\Delta Q} \text{ (fixed cost does not change, so it never affects MC)}$$



Total curves. FC is flat. VC starts at the origin. TC is VC shifted up by FC. All three get steeper at high output because of diminishing marginal returns.

Where the shapes come from. Because $MC = \text{wage divided by } MP$, the shape of MC mirrors the inverse of marginal product. Early on, MP rises (specialization), so MC falls. Once diminishing marginal returns set in, MP falls and MC rises. That is why the MC curve is typically a check mark or a U that eventually slopes upward.

Average cost curves. AFC always falls as output rises, since the same fixed cost is spread over more units (the spreading effect). AVC first falls, then rises, because it is driven by average product: when AP rises AVC falls, and when AP falls AVC rises. $ATC = AFC + AVC$, so ATC is U-shaped. At low output the falling AFC dominates, and at high output the rising AVC dominates. The vertical gap between ATC and AVC equals AFC, so the gap shrinks as output grows but never disappears.



Per-unit curves from the same firm. MC crosses AVC at its minimum ($Q = 3$, cost 6) and ATC at its minimum ($Q = 4$, cost 15).

The MC rule

MC crosses AVC at the minimum of AVC, and crosses ATC at the minimum of ATC.

When $MC < \text{average}$, the average is falling. When $MC > \text{average}$, the average is rising.

MC reaches its minimum before AVC and ATC do. So the order of minimum points from left to right is MC, then AVC, then ATC.

Why does the rule hold? Marginal cost is the cost of the newest unit, and an average is pulled toward whatever you add. If the next unit costs less than the current average, the average must drop. If it costs more, the average must rise. The turning point is where they are equal, at the bottom of the average curve. Also remember that totals and per-unit measures use different vertical units, so they belong on separate graphs.

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Curve	Shape	Why
AFC	Falls throughout	Fixed cost spread over more units
AVC	U-shaped	Follows average product
ATC	U-shaped	AFC falls, then AVC rise dominates
MC	Falls, then rises	Follows inverse of marginal product

EXAMPLE 1: COMPLETING A COST TABLE

A firm has fixed cost of \$50. Its variable cost is \$84 at 4 units and \$110 at 5 units, with \$66 at 3 units. At $Q = 5$, find TC, AFC, AVC, ATC, and the MC of the fifth unit.

SOLUTION

$TC = FC + VC = 50 + 110 = \$160$.

$AFC = 50 / 5 = \$10$. $AVC = 110 / 5 = \$22$. $ATC = 160 / 5 = \$32$ (check: $10 + 22 = 32$).

MC of the fifth unit = $(160 - 134) / (5 - 4) = \$26$. Using VC gives the same answer: $110 - 84 = 26$.

Since MC (26) is above AVC at 4 units (21) but below ATC at 4 units (33.50), AVC is rising at 5 units while ATC is still falling.

EXAMPLE 2: READING THE MINIMUM POINTS

Use the per-unit graph above. (a) What is AVC at $Q = 4$, and what is AFC at $Q = 4$? (b) At what quantity is ATC minimized, and what is MC there? (c) Is ATC rising or falling at $Q = 5$?

SOLUTION

(a) At $Q = 4$, $ATC = MC = 15$ (the lowest point on ATC). $AVC = 16 - 24 + 15 = 7$. $AFC = ATC - AVC = 15 - 7 = 8$, which matches $FC / Q = 32 / 4 = 8$.

(b) ATC is minimized at $Q = 4$, and $MC = ATC = 15$ there.

(c) At $Q = 5$, $MC = 75 - 60 + 15 = 30$, which is above ATC (16.40), so ATC is rising.

EXAMPLE 3: A CHANGE IN FIXED COST

The firm in Example 1 has its fixed cost rise from \$50 to \$80 (higher rent). Find the new ATC at $Q = 5$ and say what happens to MC and to AVC.

SOLUTION

New TC at $Q = 5 = 80 + 110 = \$190$. New $ATC = 190 / 5 = \$38$, up from \$32.

MC is unchanged: the fifth unit still adds \$26 because VC is unchanged and FC does not vary with output.

AVC is unchanged at \$22. A change in fixed cost shifts only AFC and ATC (and TC, FC), not MC or AVC.

Because MC does not move, the profit-maximizing output in the next lesson does not change either, but profit falls.

Common mistakes

(1) Saying MC crosses ATC at the minimum of MC. It crosses at the minimum of ATC. (2) Putting FC in the MC formula; fixed costs never change MC. (3) Drawing ATC and AVC meeting each other. They never meet, because AFC is always positive; they only get closer. (4) Labelling the vertical axis of a per-unit graph as 'total cost'. Per-unit curves are in dollars per unit.

Practice**SET A Check Your Understanding**

Answer in complete sentences or show your calculation.

1. A firm's total cost is \$240 at 10 units and its fixed cost is \$60. Find VC, AVC, AFC and ATC at 10 units.
2. TC rises from \$134 at 4 units to \$160 at 5 units. Find marginal cost of the fifth unit and explain why fixed cost is irrelevant to this calculation.
3. Explain why average fixed cost declines continuously as output rises, yet ATC eventually rises.

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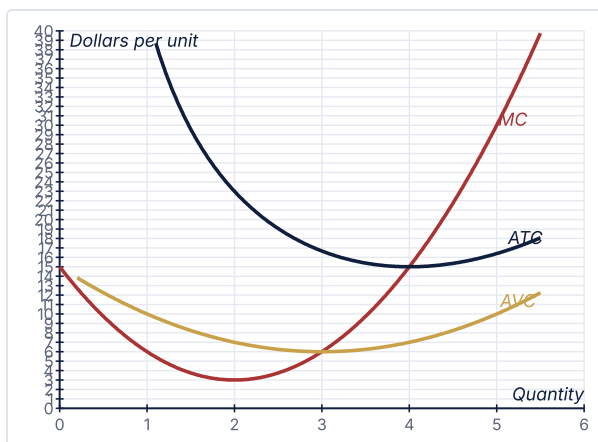
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4. MC is \$12 and ATC is \$15 at the current output. Will producing one more unit raise or lower ATC? What does this say about the position of the output relative to minimum ATC?
5. At 6 units a firm has AVC of \$9 and ATC of \$14. Find total fixed cost. Then find ATC at 12 units if AFC is fixed at that quantity and AVC is \$11.
6. Sketch in words the relative positions of the minimum points of MC, AVC, and ATC from left to right, and explain why.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which cost does NOT change as a firm increases output in the short run?
 - (A) Marginal cost
 - (B) Average variable cost
 - (C) Total fixed cost
 - (D) Average fixed cost
 - (E) Total variable cost
8. A firm produces 50 units with total cost of \$1,000 and average variable cost of \$12. Total fixed cost is
 - (A) \$1,000
 - (B) \$600
 - (C) \$500
 - (D) \$200
 - (E) \$400
9. When marginal cost is above average total cost, then
 - (A) ATC is rising
 - (B) ATC is falling
 - (C) AFC is rising
 - (D) ATC is at its minimum
 - (E) AVC is at its minimum
10. In the graph, at the quantity where MC crosses the ATC curve from below, the ATC curve is at its



- (A) maximum
 - (B) vertical intercept
 - (C) point of inflection
 - (D) minimum
 - (E) horizontal asymptote
11. A rise in the monthly rent of a firm's factory will shift which curves?
 - (A) MC and AVC only
 - (B) ATC and AFC only
 - (C) MC and ATC only
 - (D) AVC and MC
 - (E) MC, AVC, and ATC
12. Marginal cost is rising because of
 - (A) falling average fixed cost
 - (B) economies of scale
 - (C) falling input prices
 - (D) falling total fixed cost
 - (E) diminishing marginal returns

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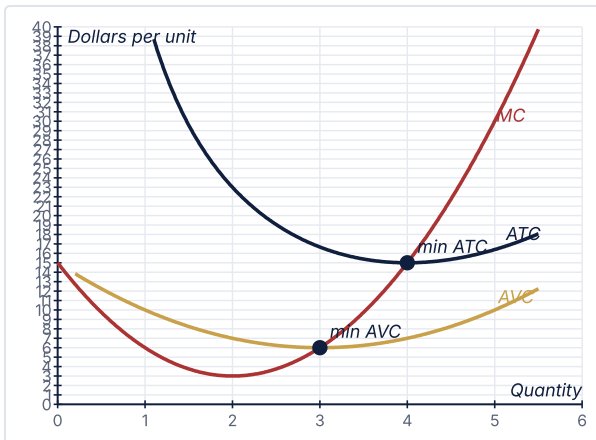
SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A firm has fixed cost of \$40. Its variable cost (in dollars) at each output is shown in the table.
- (a) Calculate ATC and AVC at 3 and 5 units. (b) Of the outputs shown, at which is ATC lowest, and what is the marginal cost of the unit that takes the firm to that output? (c) Explain what happens to the gap between ATC and AVC as output grows.

Q	1	2	3	4	5
VC	30	52	72	100	140

14. The graph below shows a firm's MC, AVC and ATC.
- (a) Identify the quantity at which AVC is minimized and the quantity at which ATC is minimized. (b) Explain why the ATC minimum occurs at a larger quantity than the AVC minimum. (c) Explain what would happen to the curves if the firm's fixed cost rose.

**3.3** Long-Run Costs and Scale

Understand how the LRAC curve is built from short-run curves, how economies and diseconomies of scale arise, and what minimum efficient scale implies for industry structure.

In the long run a firm can choose the size of its factory, the number of machines, and the number of stores. This lesson explains how those choices create the **long-run average total cost (LRAC)** curve, what happens to unit costs as a firm grows, and why some industries have a few giant firms while others have thousands of small ones.

Key definitions

Long-run average total cost (LRAC): the lowest possible average cost of producing each output when all inputs, including plant size, can be changed.

Economies of scale: LRAC falls as output rises. **Constant returns to scale:** LRAC is flat. **Diseconomies of scale:** LRAC rises as output rises.

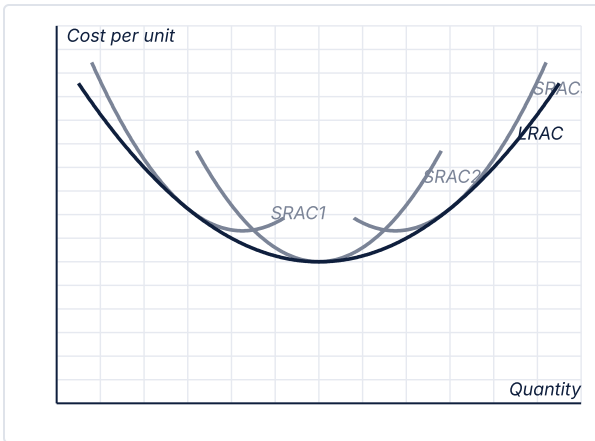
Minimum efficient scale (MES): the smallest output at which LRAC reaches its minimum.

Building the LRAC from short-run curves. Each possible plant size has its own short-run ATC curve. A small plant has high fixed costs per unit if volume is large, but low fixed cost overall. A large plant has high fixed cost but can produce huge volume cheaply. In the long run the firm picks the plant that gives the lowest cost for its planned output. The LRAC is therefore the lower boundary, or envelope, of all the short-run ATC curves. It touches each SRAC at one point, but it is not the bottoms of the SRAC curves.

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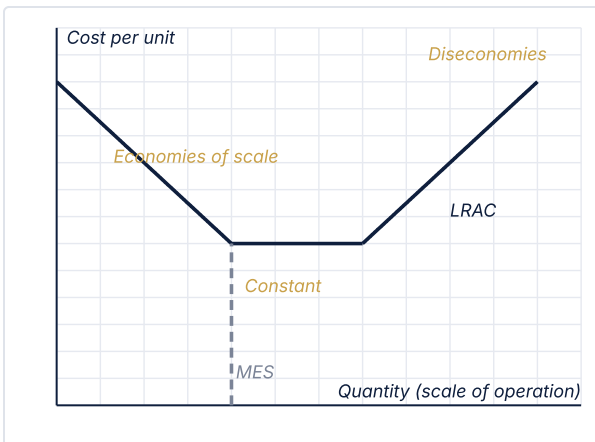
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Three of the many short-run ATC curves (SRAC1, SRAC2, SRAC3) and the LRAC that wraps beneath them. Each SRAC is tangent to the LRAC at one output.

Because the SRAC curves are U-shaped, a firm that has built a plant for one output pays more per unit when it produces any other output in the short run. For example, a plant sized for 3 units produces 3 units at a cost of 8.25 per unit, while the plant sized for 6 units would produce those same 3 units at 11.40 per unit. That is why LRAC lies on or below every SRAC.

Three regions of LRAC. The typical LRAC slopes down, flattens, then slopes up.



A typical LRAC. MES is the output where the downward slope ends.

Region	LRAC	Physical meaning	Typical causes
Economies of scale	Falling	Output rises by a larger percentage than inputs (increasing returns to scale)	Specialization of labor and machines, bulk purchasing, spreading research and advertising costs, cheaper financing
Constant returns to scale	Flat	Output rises by the same percentage as inputs	Benefits of size used up, no new problems yet
Diseconomies of scale	Rising	Output rises by a smaller percentage than inputs (decreasing returns to scale)	Layers of management, poor communication, loss of coordination, worker alienation

Exam tip

Keep the two ideas apart. Diminishing marginal returns is a SHORT-RUN idea: one input varies while another is fixed, and it makes MC and SRAC rise. Economies and diseconomies of scale are LONG-RUN ideas: all inputs change together, and they describe the slope of LRAC. A firm can have diminishing marginal returns and economies of scale at the same time.

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Link between SR and LR

LRAC is the envelope of the SRAC curves, so $LRAC \leq SRAC$ at every output.

At the output where a particular SRAC touches LRAC, the plant size is exactly right for that output.

Where LRAC is falling, each SRAC touches it to the left of that SRAC's own minimum; where LRAC is rising, each SRAC touches it to the right of its minimum. Only at the bottom of LRAC (MES) does the tangent point coincide with an SRAC minimum.

Industry structure. The MES, compared with the size of the market, tells you how many firms an industry can support. If demand at the minimum LRAC price is much bigger than one firm's MES output, there is room for many firms (wheat farming, dry cleaners). If MES is a large part of the market, only a few firms, or one, can reach the lowest cost. A **natural monopoly** exists when LRAC is still falling at the output the whole market demands, so a single firm is cheapest (a local water network).

EXAMPLE 1: CLASSIFYING SCALE EFFECTS

A firm has these long-run total costs. Compute LRAC at each output, identify the ranges of economies, constant returns, and diseconomies of scale, and name the minimum efficient scale.

Output	100	200	300	400	500
Long-run total cost (dollars)	1,000	1,600	2,100	2,800	3,750

SOLUTION

$LRAC = LRTC / Q$: 10.00, 8.00, 7.00, 7.00, 7.50.

From 100 to 300 units LRAC falls (10, 8, 7): economies of scale.

From 300 to 400 LRAC is constant at 7.00: constant returns to scale.

From 400 to 500 LRAC rises (7.00 to 7.50): diseconomies of scale.

MES is 300 units, the smallest output at which LRAC reaches its minimum of 7.

EXAMPLE 2: HOW MANY FIRMS?

Market demand is 600,000 units per year at the long-run price. (a) If the MES is 20,000 units, how many firms can the market support? (b) If the MES is 400,000 units, what market structure is likely?

SOLUTION

(a) $600,000 / 20,000 = 30$ firms, each producing at the minimum LRAC. Many small firms fit, so competition is feasible.

(b) $600,000 / 400,000 = 1.5$, so at most one firm can reach MES and a second could not be efficient. This points to a natural monopoly or a very concentrated industry.

EXAMPLE 3: CHOOSING A PLANT

Use the LRAC graph with SRAC1 (tangent at $Q = 3$) and SRAC2 (tangent at $Q = 6$). A firm expects to produce 6 units per period for years. Which plant should it build, and what would it cost per unit to produce 6 units in each plant? What if demand later fell to 3 units but the plant could not be changed for 5 years?

SOLUTION

Build the plant with SRAC2: at $Q = 6$ its cost per unit is 6, which is on the LRAC.

SRAC1 would give $8.25 - 1.5(3) + 0.6(9) = 9.15$ per unit at $Q = 6$, higher than 6.

If demand falls to 3 and the firm is stuck with SRAC2, cost is $6 + 0.6(9) = 11.40$ per unit, versus 8.25 in the small plant. In the short run it pays more; in the long run it can downsize to SRAC1 and move to the LRAC.

Common mistakes

(1) Drawing the LRAC through the minimum points of every SRAC. (2) Saying economies of scale are caused by diminishing returns; they are different ideas. (3) Concluding that bigger is always cheaper: past the MES, diseconomies can set in. (4) Using 'long run' to mean a calendar period; it means all inputs are variable.

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Practice

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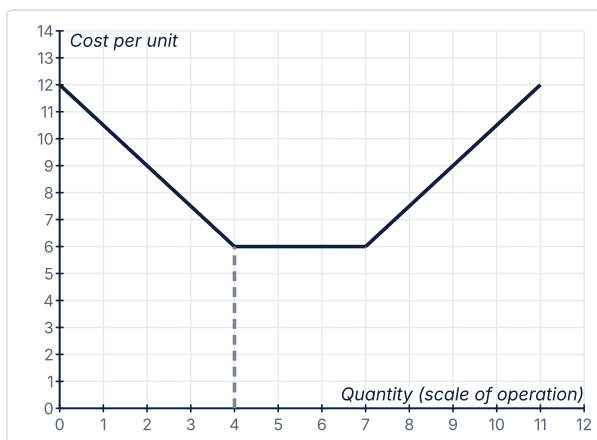
Answer in complete sentences or show your calculation.

1. What is the difference between a short-run ATC curve and the long-run average total cost curve?
2. A firm doubles all inputs and output rises by 60 percent. Is this economies, constant returns, or diseconomies of scale? What happens to LRAC (holding input prices constant)?
3. Give two reasons why a large automobile factory might enjoy economies of scale, and two reasons a very large firm might face diseconomies.
4. Long-run average costs are 14, 11, 9, 9, 12 at outputs 50, 100, 150, 200, 250. State the minimum efficient scale and the output range with constant returns to scale.
5. The market demand at the long-run price is 90,000 units. Each firm needs 30,000 units to reach MES. How many firms can the market support at minimum LRAC? What if MES were 80,000?
6. Explain why diminishing marginal returns and economies of scale do not contradict each other.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. The long-run average total cost curve is best described as
 - (A) the sum of all short-run marginal cost curves
 - (B) the curve that connects the minimum points of each short-run ATC curve
 - (C) the lower boundary of the short-run ATC curves
 - (D) the average of the short-run ATC curves
 - (E) a horizontal line at the lowest short-run ATC
8. A firm increases all inputs by 25 percent and output increases by 40 percent. The firm is experiencing
 - (A) diminishing marginal returns
 - (B) diseconomies of scale
 - (C) constant returns to scale
 - (D) economies of scale
 - (E) negative marginal product
9. Which is most likely a cause of diseconomies of scale?
 - (A) Communication problems among many layers of management
 - (B) Bulk discounts on raw materials
 - (C) Greater specialization of labor
 - (D) Spreading advertising costs over more units
 - (E) Borrowing at a lower interest rate
10. The graph shows an LRAC curve. The minimum efficient scale is at



- (A) $Q = 2$ (B) $Q = 4$ (C) $Q = 7$ (D) $Q = 11$ (E) $Q = 0$

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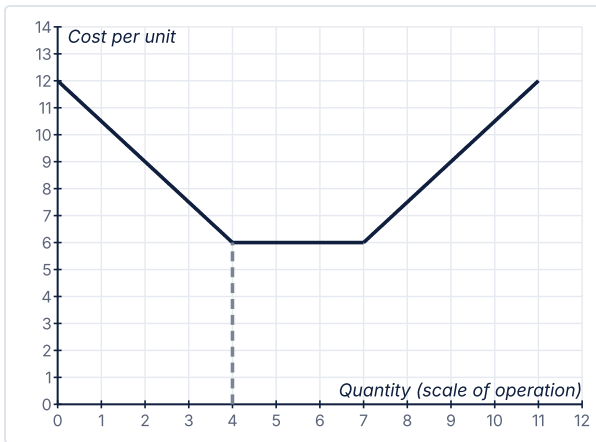
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11. A firm's LRAC is constant over a wide range of output. If market demand is large relative to MES, the industry is most likely to have
 (A) one firm (B) two firms (C) no firms
 (D) only firms with losses (E) many firms
12. Which of the following statements about diminishing marginal returns and economies of scale is correct?
 (A) Both occur only in the long run
 (B) Both occur only in the short run
 (C) Diminishing marginal returns is short run and economies of scale is long run
 (D) Diminishing marginal returns is long run and economies of scale is short run
 (E) They cannot occur in the same firm

SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A firm's long-run average cost is shown in the graph (values are schematic).
 (a) Identify the range of output over which the firm has economies of scale and the range with diseconomies of scale. (b) Identify the minimum efficient scale. (c) Explain how the market demand relative to MES determines whether the industry can have many firms.



14. A bakery chain builds new, larger ovens and stores. Its output rises from 1,000 to 3,000 loaves per day while its total cost rises from \$2,500 to \$6,000.
 (a) Calculate LRAC at each size. (b) State whether these figures show economies or diseconomies of scale. (c) Describe one plausible reason, and explain why this is not an example of diminishing marginal returns.

Daily loaves	Total daily cost
1,000	\$2,500
3,000	\$6,000

3.4 Profit Maximization and Perfect Competition in the Short Run

Learn how a price-taking firm chooses output with $MR = MC$, how to find profit or loss on a graph, and when to shut down.

This lesson puts revenue and cost together. You will learn what makes a market perfectly competitive, how a price-taking firm picks its output, when it earns a profit or a loss, and when it should shut down. The reward at the end: the firm's supply curve falls right out of its cost curves.

Revenue. Total revenue is $TR = P \times Q$. Average revenue is $AR = TR/Q = P$. Marginal revenue is $MR = \frac{\Delta TR}{\Delta Q}$, the extra revenue from selling one more unit. **Accounting versus economic profit.** Accounting profit is total revenue minus **explicit costs** (actual payments such as wages, rent, materials). Economic profit is total revenue minus explicit costs minus **implicit costs**, the opportunity cost of resources the owner already supplies (the salary the owner gave up, the interest forgone on her own savings).

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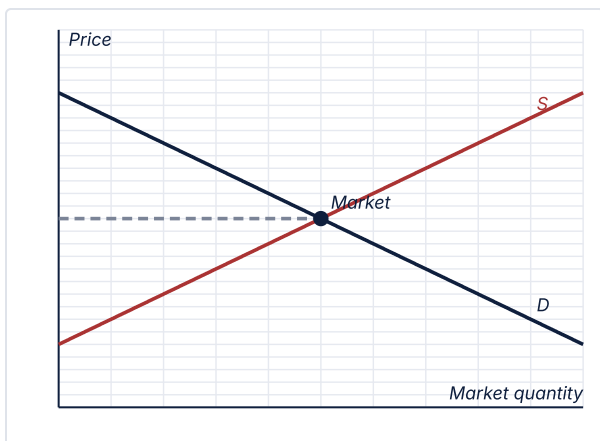
Profit definitions

Accounting profit = $TR - \text{explicit costs}$.

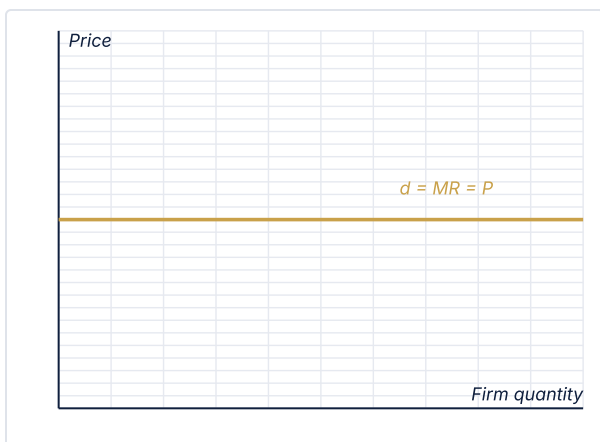
Economic profit = $TR - \text{explicit costs} - \text{implicit costs} = TR - TC$ (TC includes implicit costs).

Normal profit is the return that just covers the owner's implicit costs. When economic profit is zero, the firm earns exactly normal profit, which is enough to keep it in the industry.

Perfect competition. The model has four defining features: many small buyers and sellers, an identical (standardized) product, easy entry and exit, and full information. Because each firm is tiny relative to the market, it is a **price taker**: it accepts the market price set by supply and demand. If it charged more, buyers would go elsewhere; if it charged less, it would give up revenue for nothing. The firm's own demand curve is therefore perfectly elastic (horizontal) at the market price, and for the firm $P = MR = AR = D$.



The market: supply and demand set the price of 15.



The firm: it faces a horizontal demand curve at the market price of 15.

Profit-maximizing rule

Produce the quantity where $MR = MC$. For a perfectly competitive firm $MR = P$, so produce where $P = MC$ on the rising part of MC .

If $MR > MC$, the next unit adds more revenue than cost, so expand. If $MR < MC$, cut back.

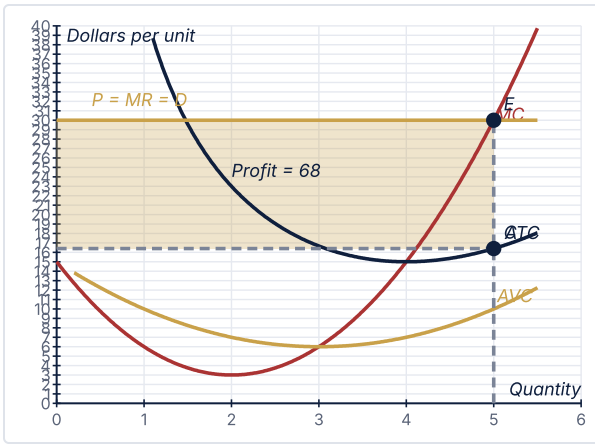
$MR = MC$ tells you the quantity. Compare P with ATC (profit or loss) and with AVC (shut down or not).

Finding profit on the graph. After locating the quantity where $P = MC$, go up to the cost curves. Profit per unit is $P - ATC$ at that quantity, and total profit is $(P - ATC) \times Q$, a rectangle. If P is above ATC the rectangle is profit; if below, it is a loss.

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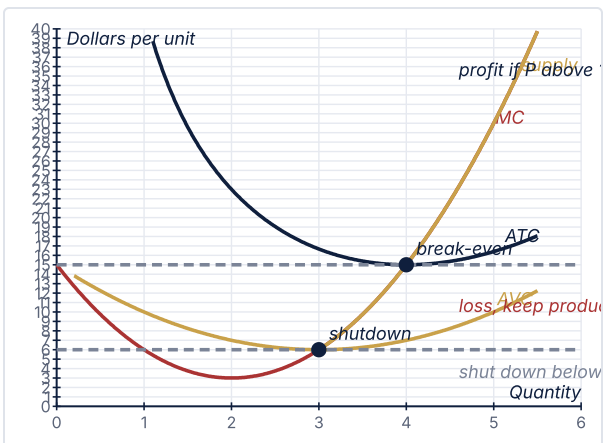
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At $P = 30$ the firm produces $Q = 5$ where $P = MC$. ATC at $Q = 5$ is 16.40, so profit = $(30 - 16.40) \times 5 = 68$, the shaded rectangle.

The shutdown rule. In the short run fixed costs must be paid whether or not the firm produces, so they are sunk and should not affect the decision. The firm compares total revenue with total variable cost. If $P \geq AVC$, the firm covers its variable costs and has something left toward fixed costs, so it keeps producing even at a loss. If $P < AVC$, each unit sold adds more cost than revenue, so it should shut down and lose only its fixed cost.

Price compared with	Decision	Result
$P > ATC$	Produce where $P = MC$	Economic profit
$P = ATC$ (minimum ATC)	Produce where $P = MC$	Zero economic profit (normal profit)
$AVC < P < ATC$	Produce where $P = MC$	Loss smaller than fixed cost; stay open in the short run
$P = \text{minimum } AVC$	Indifferent	Loss equals fixed cost
$P < \text{minimum } AVC$	Shut down ($Q = 0$)	Loss equals fixed cost



Three zones of the MC curve. The firm's short-run supply curve is the part of MC at or above minimum AVC (gold).

Supply curve. Because the firm sets $P = MC$, each market price maps to a quantity along the MC curve, as long as P is at least minimum AVC. So the firm's short-run supply curve is its **MC curve above minimum AVC**. Summing these for all firms gives the market supply curve. A higher input price shifts MC and so shifts supply left.

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EXAMPLE 1: ACCOUNTING AND ECONOMIC PROFIT

Maya owns a catering company. Revenue is \$300,000 and explicit costs (food, staff, rent) are \$180,000. She gave up a \$70,000 job to run it and she invested \$200,000 of her savings, which could earn 5 percent elsewhere. Find accounting profit and economic profit, and state whether she earns more than normal profit.

SOLUTION

Accounting profit = $300,000 - 180,000 = \$120,000$.

Implicit costs = $70,000$ (forgone salary) + $0.05 \times 200,000 = 70,000 + 10,000 = \$80,000$.

Economic profit = $120,000 - 80,000 = \$40,000$.

Economic profit is positive, so she earns more than normal profit. At zero economic profit she would earn exactly the normal profit of \$80,000 and remain in business.

EXAMPLE 2: MR = MC WITH A TABLE

A perfectly competitive firm has the cost data in the table, with fixed cost of 30. Find the profit-maximizing quantity and profit (or loss) at prices of 24, 20, and 11. State whether the firm should operate at each price.

Q	TC	MC	AVC	ATC
0	30	-	-	-
1	50	20	20.00	50.00
2	62	12	16.00	31.00
3	72	10	14.00	24.00
4	86	14	14.00	21.50
5	104	18	14.80	20.80
6	126	22	16.00	21.00
7	152	26	17.43	21.71

SOLUTION

Rule: produce the largest Q for which $MC \leq P$.

$P = 24$: MC is 22 at $Q = 6$ and 26 at $Q = 7$, so $Q = 6$. $TR = 144$, $TC = 126$, profit = \$18. Operate.

$P = 20$: MC is 18 at $Q = 5$ and 22 at $Q = 6$, so $Q = 5$. $TR = 100$, $TC = 104$, loss = \$4. AVC at $Q = 5$ is 14.80, below the price, so it operates; shutting down would lose the whole fixed cost of 30.

$P = 11$: MC is 10 at $Q = 3$, so $Q = 3$. AVC there is 14, above the price of 11. Producing gives $TR = 33$, $TC = 72$, loss = 39. Shutting down loses only 30. The firm should shut down.

EXAMPLE 3: GRAPH WITH THREE PRICES

Use the cost curves above (fixed cost 32). Find output, profit or loss, and the decision at $P = 15$ and $P = 6$.

SOLUTION

$P = 15$: MC = 15 at $Q = 4$ (rising part). ATC at $Q = 4$ is 15, so profit = $(15 - 15) \times 4 = 0$. This is the break-even point at minimum ATC.

$P = 6$: MC = 6 at $Q = 3$ (minimum AVC). $TR = 18$, $VC = 27 - 54 + 45 = 18$, $TC = 50$. Loss = 32, equal to fixed cost, so producing and shutting down give the same loss.

Below 6 the firm shuts down; above 6 it produces where $P = MC$.

Common mistakes

(1) Using ATC instead of AVC in the shutdown rule. (2) Choosing the output where $MC = ATC$; the output rule is $MR = MC$. (3) Calculating profit with price minus marginal cost; use price minus ATC. (4) Forgetting that a loss while $P > AVC$ still means stay open in the short run. (5) Treating normal profit as 'no profit'; zero economic profit includes the owner's opportunity cost.

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Practice

SET A Check Your Understanding

Answer in complete sentences or show your calculation.

1. List the characteristics of perfect competition and explain why a single firm is a price taker.
2. A firm sells 10 units at \$8 and 11 units at \$8. Compute its marginal revenue for the eleventh unit and explain what that tells you about its demand curve.
3. Dana's bakery earns \$90,000 in revenue and pays \$50,000 in explicit costs. Dana could earn \$45,000 working elsewhere. Find accounting and economic profit.
4. At the output the firm chooses, MC is \$9 and the price is \$12. Should the firm increase, decrease, or keep output? Explain with MR.
5. A firm's output at $P = MC$ is 50 units, ATC is \$9, AVC is \$6, and price is \$7. Find profit or loss and the decision.
6. Describe the firm's short-run supply curve in a perfectly competitive market.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. For a perfectly competitive firm, marginal revenue is
 - (A) greater than price
 - (B) less than price
 - (C) equal to price
 - (D) equal to average total cost
 - (E) equal to zero
8. A perfectly competitive firm produces 100 units at $P = \$10$, $ATC = \$7$, $AVC = \$5$. Its economic profit is
 - (A) \$ 300
 - (B) \$ 500
 - (C) \$ 1,000
 - (D) \$ 200
 - (E) -\$ 300
9. Using the data in the table, a perfectly competitive firm produces where $MR = MC$ at $Q = 5$. The firm should

Q	P	AVC	ATC
5	8	9	12

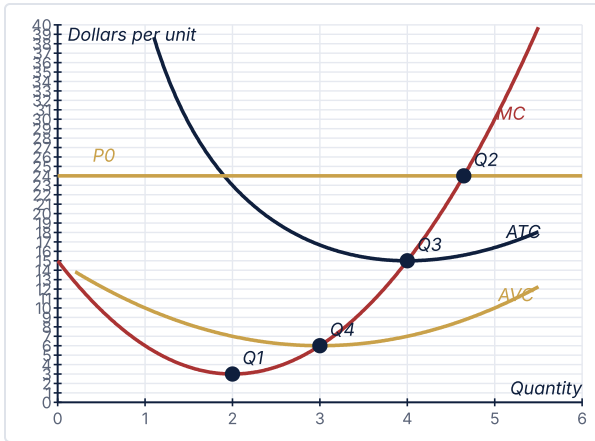
- (A) expand output
 - (B) produce $Q = 5$ and earn a profit
 - (C) raise its price
 - (D) continue producing because fixed costs are sunk
 - (E) shut down in the short run
10. A perfectly competitive firm's total revenue curve is
 - (A) a horizontal line
 - (B) a downward-sloping curve
 - (C) a U-shaped curve
 - (D) a straight line from the origin with slope equal to price
 - (E) a vertical line

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11. In the graph, a perfectly competitive firm faces price P_0 . It maximizes profit at output



- (A) Q1 where MC is at its minimum
 (B) Q2 where P_0 meets the rising MC curve
 (C) Q3 where ATC is at its minimum
 (D) Q4 where AVC is at its minimum
 (E) $Q = 0$, where price exceeds MC
12. Which statement about implicit costs is correct?
- (A) They are included in accounting profit but not economic profit
 (B) They are payments that firms make to other firms
 (C) They are included in economic profit calculations but not accounting profit
 (D) They are always fixed
 (E) They can never be measured

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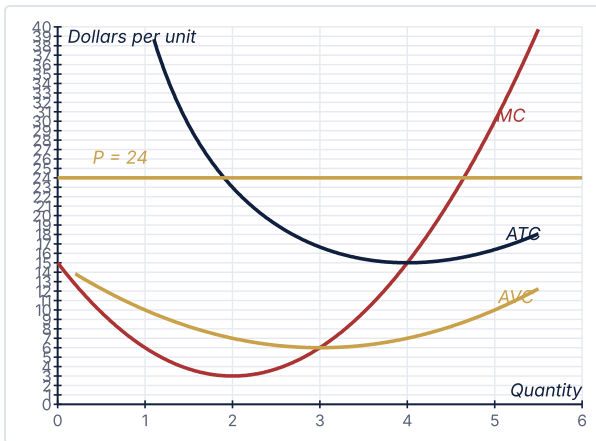
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SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A perfectly competitive firm has the cost curves shown (fixed cost = 32; minimum AVC = 6 at $Q = 3$; minimum ATC = 15 at $Q = 4$). The market price is 24, where $P = MC$ at Q of about 4.65 and ATC is about 15.6.
- (a) State the profit-maximizing rule and identify the output on the graph. (b) Calculate the firm's total economic profit. (c) Explain what the firm would do if the price fell to 5, and justify using AVC.



14. A farm sells identical wheat in a perfectly competitive market. The market price is \$6 per bushel. At the farm's profit-maximizing output of 1,000 bushels, ATC is \$6.50 and AVC is \$5.
- (a) Calculate the farm's total revenue, total cost, and profit or loss. (b) Should the farm produce or shut down in the short run? Explain. (c) Explain why the farm's demand curve is horizontal even though the market demand curve slopes downward.

Item	Value
Price	\$6
Output	1,000 bushels
ATC	\$6.50
AVC	\$5.00

3.5 Perfect Competition in the Long Run

See how entry and exit drive economic profit to zero, how industry cost conditions shape long-run supply, and why the long-run outcome is efficient.

In the short run, firms in a perfectly competitive market can earn profits or suffer losses. In the long run, the freedom to enter and exit pushes every firm toward the same outcome: zero economic profit. This lesson traces that adjustment, shows how it shapes the long-run supply curve, and explains why the long-run result is efficient.

Entry and exit. If firms in an industry earn positive economic profit, outsiders see that their resources earn more here than in their next-best use. New firms **enter**. Market supply shifts right, the market price falls, and profit shrinks for every firm. Entry stops only when price falls to the minimum of ATC and profit is zero. If firms suffer economic losses, some **exit**. Supply shifts left, price rises, and losses shrink until price again equals minimum ATC and economic profit is zero. Notice the signal: the decision to enter or exit follows economic profit; the decision to shut down follows P versus AVC .

Long-run equilibrium in perfect competition

Economic profit = 0 for every firm, so there is no entry or exit.

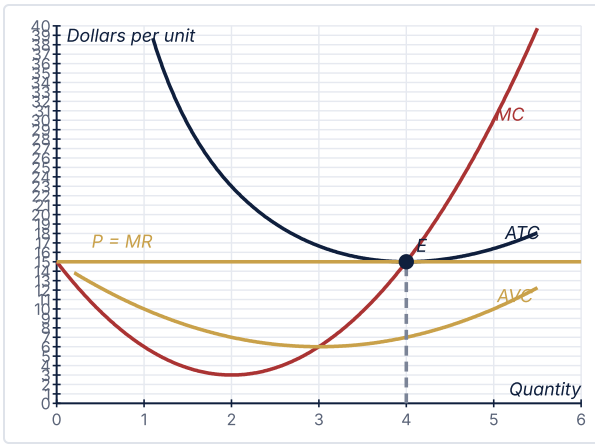
$P = MR = MC = ATC$, and ATC is at its minimum.

Each firm produces at the efficient scale, the output where ATC is lowest.

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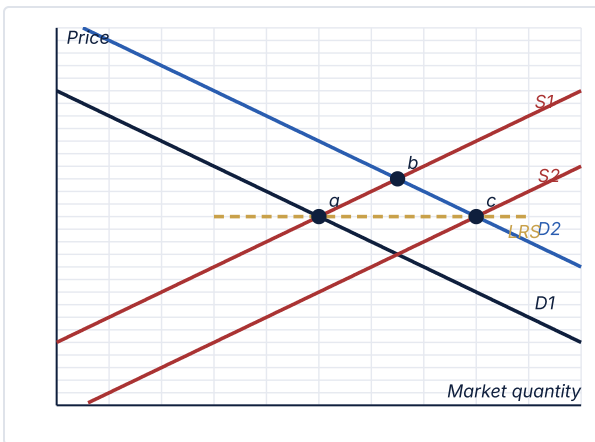
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A typical firm in long-run equilibrium. The price line just touches the bottom of ATC where MC crosses it.

Tracing a demand increase (constant-cost industry). Start at point a, in long-run equilibrium at price 15. Demand rises from D1 to D2. In the short run the supply curve S1 does not move, so price rises to 18 at point b. Each existing firm moves up its MC curve and earns economic profit. New firms enter, supply shifts right from S1 to S2, price falls back, and the process ends at point c, where price returns to 15 (zero profit again) and market quantity is larger. The extra output comes from more firms, not from higher prices.



Demand increases from D1 to D2. Price jumps from 15 to 18 in the short run (a to b), then falls back to 15 as entry shifts supply to S2 (b to c). The line through a and c is the long-run supply curve (LRS).

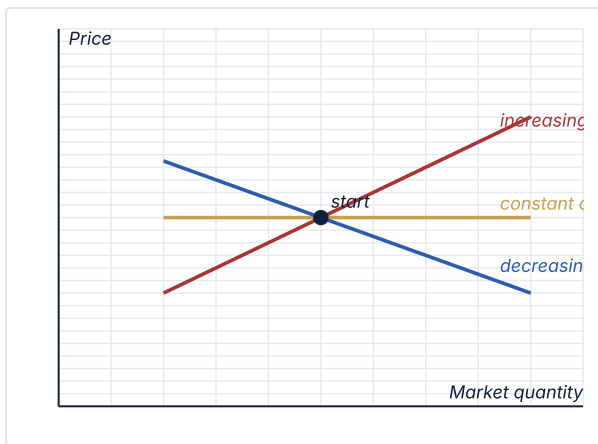
The line connecting the long-run equilibria (a and c) is the **long-run industry supply curve**. Its slope depends on what happens to input costs as the industry grows.

Type of industry	What happens to input prices / costs as industry grows	Long-run supply curve
Constant cost	Unchanged	Horizontal
Increasing cost	Rise (scarce inputs bid up)	Upward sloping
Decreasing cost	Fall (shared technology, cheaper inputs)	Downward sloping

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Long-run supply for three kinds of industries, each starting from the same equilibrium.

Long-run supply

Constant-cost industry: entry does not change input prices, so each firm's cost curves stay put and the new equilibrium has the same price. LRS is horizontal.

Increasing-cost industry: entry bids up input prices (for example specialized labor), which raises ATC for all firms, so price ends higher. LRS slopes up.

Decreasing-cost industry: growth lowers input costs (for example cheaper components from a larger supplier base), so price ends lower. LRS slopes down.

Efficiency. In long-run equilibrium, price equals the minimum of ATC, so each good is produced at the lowest possible cost per unit: **productive efficiency**. Because price is the marginal benefit consumers place on the last unit and MC is the marginal cost of producing it, $P = MC$ gives **allocative efficiency**: the right quantity of the good is produced. Firms in perfect competition are allocatively efficient in the short run too because $P = MC$ at all times, but only in the long run do they also reach productive efficiency, since only then does price equal minimum ATC. Remember that this efficiency is a benchmark; it ignores externalities and income distribution.

EXAMPLE 1: HOW MANY FIRMS?

Each firm in a constant-cost industry has minimum ATC of \$15 at an output of 40 units. Market demand is $Q_D = 1,800 - 40P$. (a) Find the long-run price, market quantity, and number of firms. (b) Demand rises to $Q_D = 2,400 - 40P$. Find the new long-run price, quantity, and number of firms.

SOLUTION

(a) Long-run price = minimum ATC = \$15. Market quantity = $1,800 - 40(15) = 1,200$ units. Number of firms = $1,200 / 40 = 30$.

(b) In a constant-cost industry the long-run price remains \$15. New market quantity = $2,400 - 40(15) = 1,800$ units. Number of firms = $1,800 / 40 = 45$.

So 15 firms entered. The price did not change, so the long-run supply curve is horizontal at 15.

EXAMPLE 2: TRACE A DECREASE IN DEMAND

A perfectly competitive market is in long-run equilibrium. A health report reduces demand for the good. Describe the changes in price, a typical firm's profit, and the number of firms, in the short run and long run.

SOLUTION

Short run: demand falls, price falls below minimum ATC. Each firm moves down its MC curve to a lower output; price is below ATC, so each firm has economic losses (provided $P > AVC$, it keeps producing).

Exit: losses cause some firms to exit in the long run. Market supply shifts left.

Long run: price rises back toward minimum ATC. Remaining firms again earn zero economic profit and produce the original output per firm, but there are fewer firms and lower market quantity (in a constant-cost industry price returns to its original level).

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EXAMPLE 3: SHORT-RUN PROFIT AND EFFICIENCY

Using the earlier cost curves, the market price rises to 24, so a typical firm produces about 4.65 units, with ATC about 15.6. (a) Is the firm allocatively efficient? Productively efficient? (b) What will happen to the price over time and why?

SOLUTION

(a) $P = MC$ at 4.65 units, so it is allocatively efficient. ATC (15.6) is above the minimum ATC (15), so it is not producing at the lowest cost, which means it is not productively efficient.

(b) Profit per firm is about $(24 - 15.6) \times 4.65 = 39$, a positive economic profit. New firms enter, supply shifts right, and the price falls toward 15 where $P = \text{minimum ATC}$ and economic profit is zero.

Common mistakes

(1) Saying firms in long-run equilibrium earn no profit at all. They earn zero ECONOMIC profit, which includes a normal return to the owner. (2) Having the firm's curves shift in a constant-cost industry; only market supply shifts. (3) Saying entry causes price to rise. Entry increases supply and lowers price. (4) Mixing up shutdown (short run, $P < AVC$) with exit (long run, economic losses).

Practice**SET A Check Your Understanding**

Answer in complete sentences or show your calculation.

1. State the three conditions that must hold for a perfectly competitive firm in long-run equilibrium.
2. A perfectly competitive market is in long-run equilibrium. Explain what happens to the number of firms and price when a technological improvement lowers the cost of every firm.
3. Explain the difference between shutting down in the short run and exiting in the long run.
4. In a constant-cost industry, demand increases. Describe the long-run effect on price and quantity and on the long-run supply curve.
5. Each firm in a market produces 50 units at minimum ATC of \$20. At that price the market demands 5,000 units. How many firms operate in long-run equilibrium?
6. Define productive efficiency and allocative efficiency and state when a perfectly competitive market achieves each.

SET B Exam-Style Multiple Choice

Choose the best answer.

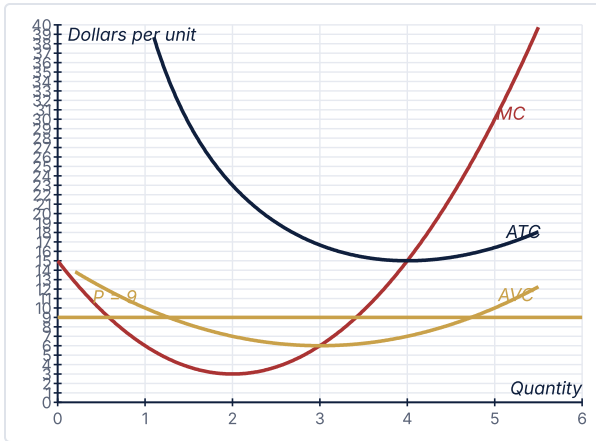
7. A firm in a perfectly competitive market is earning positive economic profit. In the long run, we would expect
 - (A) firms to exit and price to rise
 - (B) firms to enter and price to fall
 - (C) price to rise as demand rises
 - (D) the firm's MC curve to shift left
 - (E) no change because the industry is competitive
8. Which condition characterizes long-run equilibrium for a perfectly competitive firm?
 - (A) $P > ATC$
 - (B) $P = MC < ATC$
 - (C) $P = MC = \text{minimum ATC}$
 - (D) $MR > MC$
 - (E) $P = AVC < ATC$
9. In an increasing-cost industry, an increase in demand results in a long-run
 - (A) unchanged price and higher quantity
 - (B) lower price and higher quantity
 - (C) higher price and lower quantity
 - (D) higher price and higher quantity
 - (E) unchanged price and unchanged quantity

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10. The graph shows a typical competitive firm's cost curves and the market price. In the long run



- (A) firms will enter because the firm earns economic profit
 (B) the market is in long-run equilibrium
 (C) the firm will shut down immediately
 (D) price will fall to restore zero profit
 (E) firms will exit and the price will rise
11. Perfectly competitive firms in the long run are productively efficient because
- (A) price equals minimum average total cost
 (B) price equals marginal cost
 (C) price equals average variable cost
 (D) they earn positive economic profit
 (E) marginal revenue exceeds marginal cost
12. A decreasing-cost industry's long-run supply curve is
- (A) horizontal
 (B) downward sloping
 (C) upward sloping
 (D) vertical
 (E) kinked

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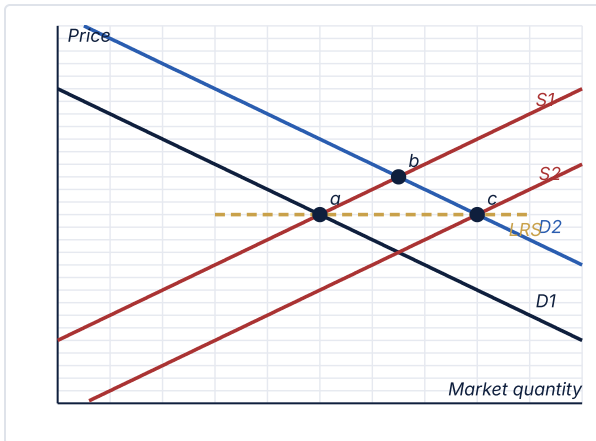
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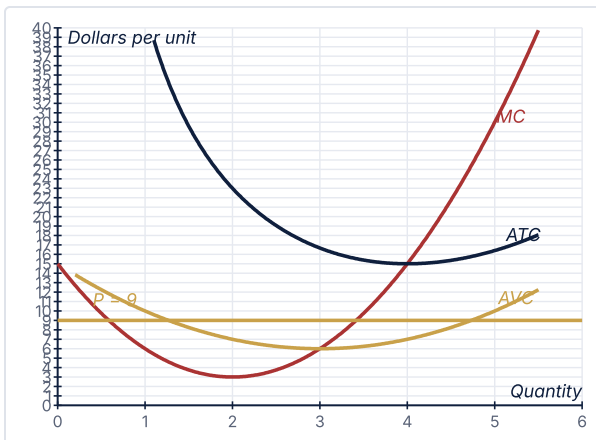
SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A perfectly competitive industry is in long-run equilibrium at price 15 (as in the market graph for a constant-cost industry). Demand then increases from D_1 to D_2 .
- (a) Identify the short-run equilibrium price and what happens to a typical firm's economic profit. (b) Explain the process that returns the market to long-run equilibrium. (c) State the long-run price and the slope of the long-run supply curve, and explain why.



14. A perfectly competitive firm's cost curves are given ($FC = 32$, minimum $ATC = 15$ at $Q = 4$). The market price is 9.
- (a) Is the firm covering its variable costs at the quantity where $P = MC$? (Near the output where $P = MC$, AVC is about 6.2 and ATC is about 15.5.) (b) Does the firm earn economic profit? (c) Describe the long-run adjustment, including the effect on price, and the final long-run price.

**3.6 Cost and Profit Problem Workshop**

Practice the multi-step routine for cost, profit, shutdown, and entry/exit problems that appear in tables, graphs, and free-response questions.

The AP exam does not ask you to repeat definitions. It gives you a firm, a table, or a graph, and asks you to calculate, draw, and explain across several linked steps. This workshop teaches a routine for those multi-step problems and then practices it on three full examples.

The routine for cost and profit problems

1. Write the formulas: $TC = FC + VC$, $ATC = TC/Q$, $AVC = VC/Q$, $MC = \Delta TC / \Delta Q$, $TR = P \times Q$, profit = $TR - TC$.
2. Find the quantity with $MR = MC$ ($P = MC$ for a price taker), using the rising portion of MC .
3. Compare P with ATC (profit or loss) and with AVC (operate or shut down).
4. Compute profit as $(P - ATC) \times Q$ or $TR - TC$, and state the sign.
5. Predict the long run: profit means entry, loss means exit, until $P = \min ATC$.

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FRQ command word	What earns the point
Calculate	Show the formula or setup and the number with units; a bare number may not score
Draw / Label	Axes labeled, curves labeled (MC, ATC, AVC, MR = P), key point marked, quantities and prices on axes
Identify	Give the quantity, price, or area asked for; no explanation needed
Explain	Say what happens AND why, with a cause-and-effect link, referencing a curve or rule
Compare	Name both situations and state the direction (higher, lower, unchanged)

Decision rules at a glance

Short-run output: $P = MC$ (rising part). Short-run shutdown: $P < \text{minimum AVC}$.

Long-run entry: economic profit > 0 . Long-run exit: economic loss. Long-run price in a constant-cost industry: minimum ATC.

Fixed costs shift ATC but never MC, AVC, or the output choice.

Graph drawing checklist. Draw two panels side by side when asked about a market and a firm: the market panel (D and S, equilibrium price) on the left, and the firm panel (MC, ATC, AVC and the horizontal price line) on the right. Make sure the price in the firm panel matches the market equilibrium. Draw MC rising through the minimum of ATC and AVC. Shade profit or loss as a rectangle with Q on the base and the gap between P and ATC as the height.

EXAMPLE 1: A TABLE PROBLEM FROM SHORT RUN TO LONG RUN

A perfectly competitive firm has fixed cost of \$60 and the data in the table (dollars). (a) Find the profit-maximizing quantity and profit (or loss) at $P = \$40$, $P = \$30$, and $P = \$14$. (b) State the shutdown decision at each price. (c) What long-run changes are expected at $P = \$40$ and $P = \$14$?

Q	VC	TC	MC	AVC	ATC
0	0	60	-	-	-
1	20	80	20	20.00	80.00
2	36	96	16	18.00	48.00
3	48	108	12	16.00	36.00
4	66	126	18	16.50	31.50
5	92	152	26	18.40	30.40
6	130	190	38	21.67	31.67

SOLUTION

(a) $P = 40$: $MC(6) = 38 \leq 40$, so $Q = 6$; $TR = 240$, $TC = 190$, profit = \$50. $P = 30$: $MC(5) = 26 \leq 30 < MC(6) = 38$, so $Q = 5$; $TR = 150$, $TC = 152$, loss = \$2. $P = 14$: $MC(3) = 12 \leq 14 < 18$, so $Q = 3$; $TR = 42$, $TC = 108$, loss = \$66.

(b) At $P = 40$ and $P = 30$, P exceeds AVC (21.67 and 18.40), so the firm operates. At $P = 14$, P is less than minimum AVC (16), so shutting down (loss of the \$60 fixed cost) beats producing (loss of \$66): shut down.

(c) At $P = 40$ the firm earns profit, so entry occurs, supply shifts right, and price falls toward minimum ATC (about 30). At $P = 14$ firms lose money, so exit occurs, supply shifts left, and price rises toward about 30.

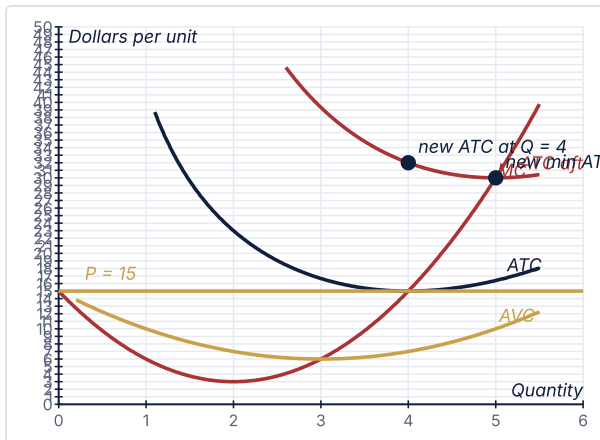
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EXAMPLE 2: A CHANGE IN A FIXED COST

The graph shows a firm in long-run equilibrium at $P = 15$ ($FC = 32$). The government raises an annual license fee, so the firm's fixed cost rises to 100. (a) What happens to the firm's output in the short run, and what is its profit? (b) What happens in the long run to the number of firms, the price, and each firm's output?



SOLUTION

(a) The fee is a fixed cost, so MC and AVC do not move. At $P = 15$ the firm still produces $Q = 4$. New ATC at $Q = 4$ is $100/4 + 7 = 32$ (AVC = 7). Profit = $(15 - 32) \times 4 = -\$68$.

(b) Losses cause exit, shifting market supply left and raising price. The new ATC minimum is at $Q = 5$, where $MC = 30 = \text{new ATC}$ (new $TC = 100 + 50 = 150$, $150/5 = 30$). Long-run price rises to 30, each remaining firm produces 5 units, and there are fewer firms. Economic profit returns to zero.

EXAMPLE 3: MARKET SUPPLY FROM MANY FIRMS

There are 100 identical firms. Each has $TC = 50 + q^2$, so $MC = 2q$ and $AVC = q$. Market demand is $Q_D = 1,200 - 10P$. (a) Derive the market supply curve and find the short-run equilibrium. (b) Find each firm's profit. (c) Predict the long-run adjustment.

SOLUTION

(a) Each firm supplies where $P = MC = 2q$, so $q = P/2$ (valid since $P > AVC$). Market supply = $100 \times P/2 = 50P$. Set $50P = 1,200 - 10P$, so $P = \$20$ and $Q = 1,000$. Each firm produces $q = 10$.

(b) $TR = 20 \times 10 = 200$; $TC = 50 + 100 = 150$; profit = \$50 per firm.

(c) Positive profit attracts entry. Minimum ATC occurs where $ATC = 50/q + q$ is lowest: $q = \sqrt{50}$, about 7.07, with ATC about 14.14. Price falls toward 14.14, where market quantity = $1,200 - 141.4 =$ about 1,059 and each firm makes 7.07, giving about 150 firms.

Exam tip

Always state your final answer in a sentence with the units and the sign (profit or loss), and make your graph match your numbers. Common lost points: measuring profit with MC instead of ATC; using ATC instead of AVC for shutdown; drawing the firm's price line at a different level than the market equilibrium; and omitting the label $MR = P = D$ on the horizontal line.

Change	MC	AVC	ATC	Short-run output at same P	Long-run price
Higher fixed cost (license fee)	No shift	No shift	Up	No change	Up
Higher wage (variable cost)	Up (left)	Up	Up	Falls	Up
Better technology	Down	Down	Down	Rises	Down
Higher demand	No shift	No shift	No shift	Rises	Same (constant cost)

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Practice

SET A Check Your Understanding

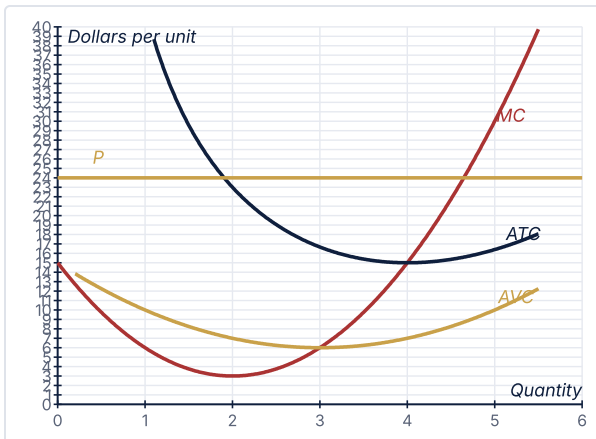
Show your calculation and a short explanation.

1. TC is \$108 at $Q = 3$ and \$126 at $Q = 4$. Find MC of the fourth unit. If $FC = \$60$, find AVC and ATC at $Q = 4$.
2. A perfectly competitive firm faces $P = \$25$, produces 40 units, and has $ATC = \$22$ and $AVC = \$15$. Find profit and the area that shows it on a graph.
3. The price is \$12, and the firm's minimum AVC is \$13 and minimum ATC is \$20. The firm's $P = MC$ output is 20 units. Should it produce? What is the loss if it shuts down if $FC = \$400$?
4. A firm in long-run equilibrium produces 200 units with $ATC = \$12$. Find its total revenue and profit. Then explain why a price of \$14 would not persist.
5. A firm's wage rises, shifting its MC curve up. At an unchanged price, what happens to its profit-maximizing output and to its profit? Explain.
6. Fifty identical firms each supply 8 units at $P = \$10$ and 12 units at $P = \$14$. Find market quantity supplied at each price and say what the market supply curve slope tells you.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. A perfectly competitive firm's total cost at $Q = 10$ is \$220 and at $Q = 11$ is \$245. If the market price is \$22, the firm should
 - (A) increase output because MC (25) exceeds P
 - (B) increase output because P exceeds ATC
 - (C) leave output unchanged
 - (D) decrease output because MC (25) exceeds P (22)
 - (E) shut down
8. A firm's profit-maximizing output is 50, $P = \$9$, $ATC = \$8$, and $AVC = \$6$. Economic profit is
 - (A) \$50
 - (B) \$100
 - (C) \$150
 - (D) \$0
 - (E) \$450
9. The government imposes a higher annual license fee on every firm in a perfectly competitive industry. In the long run, the price
 - (A) falls because costs rise
 - (B) is unchanged because MC is unchanged
 - (C) rises to the new minimum ATC
 - (D) rises only in the short run
 - (E) cannot be predicted
10. The graph shows a perfectly competitive firm. At the price shown, the firm's profit is represented by the area



- (A) 0 to Q^* under the price line
- (B) a rectangle between the price line and MC at Q^*
- (C) the area under MC up to Q^*
- (D) zero because $P = MC$
- (E) a rectangle between the price line and ATC at Q^*

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11. Which change would cause a perfectly competitive firm to produce LESS at the same market price?
 (A) A fall in the price of a variable input (B) A rise in the wage of its workers
 (C) A subsidy to fixed costs (D) A technological improvement
 (E) A fall in rent
12. In long-run equilibrium in a constant-cost competitive industry, a decrease in demand ultimately results in
 (A) the same price, fewer firms (B) lower price, fewer firms
 (C) the same price, the same number of firms (D) higher price, fewer firms
 (E) lower price, more firms

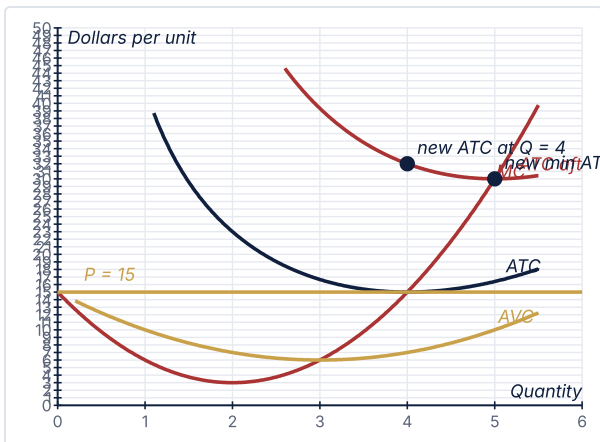
SET C Apply and Extend

Answer fully. Label any graph and show work.

13. A perfectly competitive firm's cost data are shown. The market price is \$30. Fixed cost is \$60.
 (a) Determine the profit-maximizing quantity and calculate economic profit or loss. (b) Should the firm operate or shut down in the short run? Justify. (c) Describe what is expected in the long run and the price toward which the market moves.

Q	VC	TC	MC	AVC	ATC
0	0	60	-	-	-
1	20	80	20	20.00	80.00
2	36	96	16	18.00	48.00
3	48	108	12	16.00	36.00
4	66	126	18	16.50	31.50
5	92	152	26	18.40	30.40
6	130	190	38	21.67	31.67

14. The graph shows a perfectly competitive firm that has been in long-run equilibrium at $P = 15$. Fixed cost rises as a result of a new annual license fee, and the red curve shows the new ATC.
 (a) What is the firm's profit-maximizing output immediately after the fee, and what is its profit? (b) Explain whether MC and AVC shift. (c) Describe the long-run changes in the number of firms and the price.



3.7 Multiple-Choice Practice: Production, Cost, and Perfect Competition

Twenty exam-style multiple-choice questions on production, costs, and perfect competition.

Choose the best answer for each question. Cost curves in graphs are drawn for one firm; use the labels on the axes and the points marked. Read each explanation, including why the best wrong answer fails.

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SET A Core Concepts

Choose the best answer.

1. A firm adds workers to a fixed workshop. Total output with 1 to 5 workers is 10, 24, 36, 44, 48. Diminishing marginal returns first occur with the
 - (A) first worker
 - (B) second worker
 - (C) third worker
 - (D) fourth worker
 - (E) fifth worker
2. The marginal cost curve intersects the average total cost curve at
 - (A) the minimum point of ATC
 - (B) the minimum point of MC
 - (C) the maximum point of ATC
 - (D) the point where AFC is zero
 - (E) the point where AVC is at its minimum
3. A firm has total fixed cost of \$100 and average variable cost of \$15 when it produces 20 units. Its average total cost at 20 units is
 - (A) \$ 5
 - (B) \$ 15
 - (C) \$ 35
 - (D) \$ 17.50
 - (E) \$ 20
4. For a perfectly competitive firm, which of the following is true at every level of output?
 - (A) Marginal revenue is less than price
 - (B) Marginal revenue equals price
 - (C) Marginal revenue equals marginal cost
 - (D) Price equals average total cost
 - (E) Marginal revenue exceeds price
5. A firm doubles all inputs and finds that output more than doubles. This situation is best described as
 - (A) diminishing marginal returns
 - (B) diseconomies of scale
 - (C) negative returns to labor
 - (D) economies of scale
 - (E) a rise in the firm's fixed cost
6. A perfectly competitive industry is in long-run equilibrium. Each firm is earning
 - (A) zero economic profit
 - (B) positive economic profit
 - (C) positive accounting profit but negative economic profit
 - (D) negative economic profit
 - (E) zero total revenue
7. The shutdown rule for a perfectly competitive firm in the short run is to produce zero output when
 - (A) price is below minimum ATC
 - (B) marginal cost is rising
 - (C) price is below minimum AVC
 - (D) total revenue is less than total fixed cost
 - (E) profit is negative

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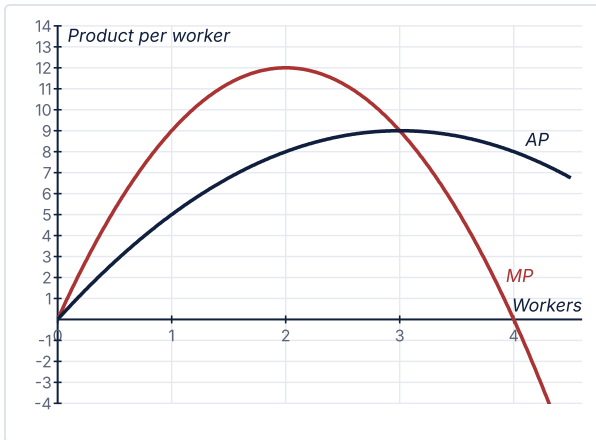
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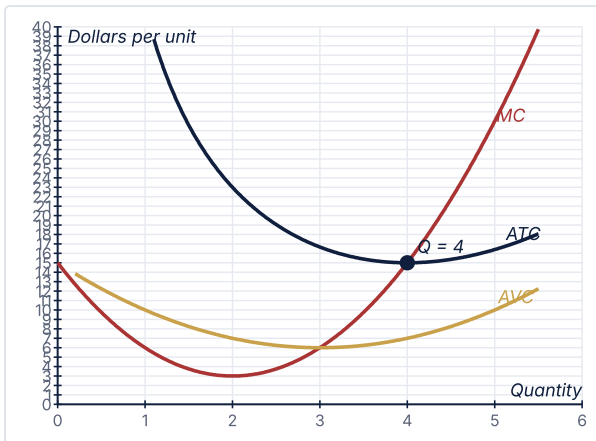
SET B Applications and Data

Choose the best answer.

8. The graph shows marginal product (MP) and average product (AP) of labor. Average product is at its maximum when the number of workers is



- (A) 1 (B) 2 (C) 4 (D) 4.5 (E) 3
9. The graph shows a firm's cost curves, with the output $Q = 4$ marked at the minimum of ATC ($ATC = 15$, $AVC = 7$). Average fixed cost at $Q = 4$ is



- (A) 15 (B) 8 (C) 7 (D) 32 (E) 4
10. A firm's long-run total cost is 120, 200, 270, and 360 at outputs of 10, 20, 30, and 40. The minimum efficient scale is
- (A) 10 (B) 20 (C) 40 (D) 30 (E) 15
11. A perfectly competitive firm has fixed cost of 20 and the cost data in the table. At a price of 14, the firm will

Q	1	2	3	4	5
TC	35	47	57	70	90

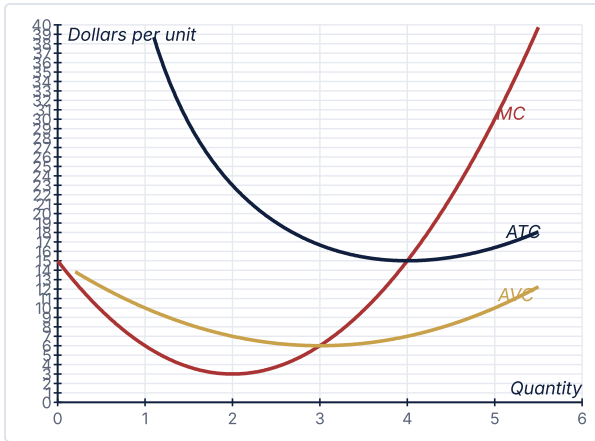
- (A) produce 4 units and lose 14 (B) produce 5 units and lose 10
 (C) produce 4 units and earn a profit of 14 (D) produce 3 units and break even
 (E) shut down and lose 20

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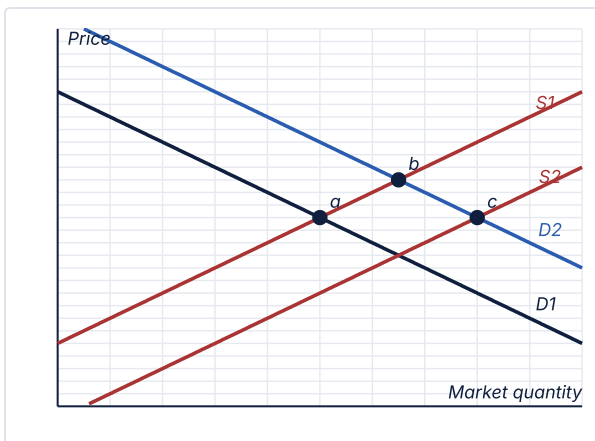
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12. In the graph, below what price will the firm shut down in the short run?



- (A) 3 (B) 15 (C) 6 (D) 32 (E) 8
13. A constant-cost perfectly competitive industry is in long-run equilibrium. Demand increases. After all adjustments, the long-run price is
- (A) higher and quantity is higher (B) lower and quantity is higher
(C) unchanged and quantity is unchanged (D) higher and quantity is lower
(E) unchanged and quantity is higher
14. The graph shows demand increasing from D_1 to D_2 in a constant-cost competitive market that started at a . After entry has fully adjusted, the market is at point



- (A) a (B) c
(C) b (D) the intersection of D_1 and S_2
(E) a point on S_1 above b

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SET C Exam-Level Stretch

Choose the best answer.

15. Each worker is paid \$96 per day. The marginal product of the fourth worker is 12 units and the marginal product of the fifth worker is 8 units. The marginal cost of producing the units contributed by the fifth worker, compared with the fourth worker's, is
(A) \$ 8 per unit, up from \$ 12 (B) \$ 12 per unit, unchanged
(C) \$ 96 per unit, up from \$ 12 (D) \$ 12 per unit, up from \$ 8
(E) \$ 4 per unit, up from \$ 8
16. A firm produces 100 units with average variable cost of \$10 and average total cost of \$14. If its fixed cost doubles, ATC at 100 units becomes
(A) \$ 18 (B) \$ 14 (C) \$ 28 (D) \$ 24 (E) \$ 10
17. At the long-run price, market demand is 120,000 units per year. The minimum efficient scale of a firm is 50,000 units. The greatest number of firms that can each operate at minimum LRAC is
(A) 1 (B) 3 (C) 2 (D) 12 (E) 24
18. A restaurant owner earns total revenue of \$500,000 and pays explicit costs of \$320,000. She gave up a \$90,000 salary and could have earned \$30,000 in interest on the savings she invested in the restaurant. Her economic profit is
(A) \$ 180,000 (B) \$ 150,000 (C) \$ 90,000 (D) -\$ 60,000 (E) \$ 60,000
19. A perfectly competitive industry has a downward-sloping long-run supply curve. When demand increases, in the long run the price
(A) rises, because input prices are bid up
(B) falls, because firms' costs fall as the industry expands
(C) is unchanged, because firms earn zero profit
(D) falls, because firms earn economic profit
(E) rises, because firms exit
20. At the output where $P = MC$, a perfectly competitive firm produces 30 units, with price \$12, AVC \$10, and ATC \$14. The firm should
(A) shut down; its loss would be \$ 60
(B) continue producing; it earns a profit of \$ 60
(C) shut down; its loss is \$ 120 and producing loses less
(D) continue producing; its loss is \$ 60, smaller than its fixed cost of \$ 120
(E) continue producing; it breaks even

3.8 Free-Response Practice: Production, Cost, and Perfect Competition

Four free-response questions on costs, profit maximization, and perfect competition.

Each question is scored by the points named in the model answer. Write full sentences for any explain or justify prompt, show formulas and units for calculations, and label axes and curves on any graph you draw.

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QUESTION 1 Short-run profit and shutdown (long free response)

A perfectly competitive firm has fixed cost of \$50. Its variable costs at each output are shown in the table, along with marginal, average variable, and average total cost. The market price is \$32. (Scoring: 10 points. Show formulas and units; label every graph.)

1. (a) Determine the profit-maximizing quantity and explain your reasoning using marginal revenue and marginal cost.

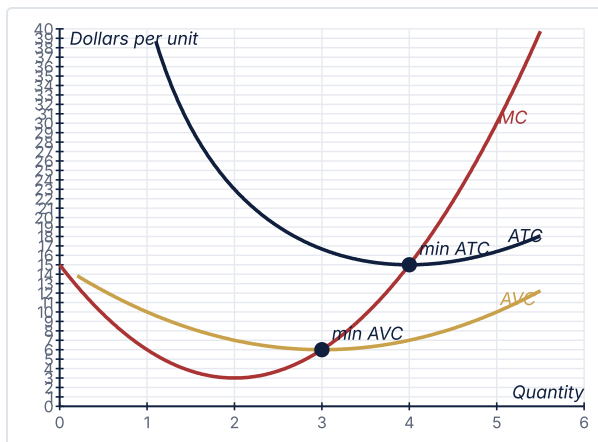
Q	VC	TC	MC	AVC	ATC
1	25	75	25	25.00	75.00
2	42	92	17	21.00	46.00
3	55	105	13	18.33	35.00
4	72	122	17	18.00	30.50
5	95	145	23	19.00	29.00
6	125	175	30	20.83	29.17

2. (b) Calculate the firm's economic profit at that quantity. Draw a correctly labeled graph of the firm showing MR (= P), MC, ATC, and the profit-maximizing quantity, and shade the area of profit.
3. (c) Suppose the price falls to \$15. Will the firm produce or shut down in the short run? Justify using the data.
4. (d) Starting from the original price of \$32, explain what you expect to happen in the long run to the number of firms, the market price, and this firm's economic profit.

QUESTION 2 Cost curves and the firm's supply curve

The graph shows the marginal cost, average variable cost, and average total cost curves for a perfectly competitive firm. Fixed cost is 32. (Scoring: 6 points.)

5. (a) Identify the lowest price at which the firm will produce in the short run and the output it produces at that price. Explain.



6. (b) Identify the price at which the firm earns zero economic profit and the quantity it produces at that price.
7. (c) Describe the firm's short-run supply curve in terms of the curves shown.
8. (d) The wage rate rises. Explain the effect on the firm's supply curve and on its minimum ATC.

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QUESTION 3 Long-run costs and scale

A firm can choose among plant sizes in the long run. Its long-run total cost (LRTC) at five levels of output is shown. (Scoring: 6 points.)

9. (a) Calculate the long-run average total cost at each output.

Output	100	200	300	400	500
LRTC (dollars)	2,000	3,200	4,200	5,600	7,500

10. (b) Identify the range of output with economies of scale, the range with constant returns, and the minimum efficient scale.
 11. (c) Explain one cause of the economies of scale and one cause of the diseconomies of scale.
 12. (d) If the market demand at the long-run price is 2,000 units, state how many firms the market can support at the minimum LRAC and what market structure that suggests.

QUESTION 4 Economic profit, entry, and efficiency

Nina runs a perfectly competitive organic-tomato farm. Annual total revenue is \$240,000 and explicit costs are \$150,000. She gave up a \$60,000 job to manage the farm and invested \$100,000 of her savings that could have earned 4 percent elsewhere. (Scoring: 7 points.)

13. (a) Calculate Nina's accounting profit and her economic profit.
 14. (b) State whether new firms will enter or existing firms will exit the tomato market, and explain.
 15. (c) Explain what happens to the market price and to Nina's economic profit in the long run, assuming a constant-cost industry.
 16. (d) Define productive efficiency and allocative efficiency, and state whether each holds in the long-run equilibrium.

Answers Chapter 3: Answers and Explanations

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

3.1 Production Functions and Diminishing Returns**SET A · CHECK YOUR UNDERSTANDING**

- Machines are fixed; cloth and sewing hours are variable. In the long run the firm can also change the number of machines and the size of the building, so every input is variable. A short run is defined by at least one fixed input, not by a number of months.
- MP is 12, 18, 12, 6. MP peaks with the second worker and falls with the third, so diminishing marginal returns begin with the third worker. Total product still rises throughout because MP stays positive.
- AP is 12, 15, 14, 12. AP peaks at 2 workers (15). Worker 3 has MP of 12, which is below the previous AP of 15, so AP falls. MP crosses AP at the maximum of AP.
- Diminishing returns means MP is falling, not that it is negative. As long as MP is positive, TP continues to rise, just more slowly. TP falls only when $MP < 0$, which is negative returns.
- AP will fall. The new unit's MP (40) is below the existing average (55), so adding it pulls the average down, just as a low quiz score lowers a grade average.
- Third worker: $150 / 15 = \$10$ per unit. Fifth worker: $150 / 5 = \$30$ per unit. Because MP fell while the wage stayed the same, the cost of producing one more unit rose, which is why MC slopes upward when diminishing returns occur.

SET B · EXAM-STYLE MULTIPLE CHOICE

- D. The short run is defined by having at least one fixed input, not by calendar time. Choice A is the tempting but wrong calendar definition.
- E. When MP is below AP, the added worker pulls the average down. TP is still rising ($MP > 0$), which is why choices B and E mix up total and average.
- C. The law describes adding more of one variable input to fixed inputs. Choice A describes returns to scale, a long-run concept.
- A. $MP = \text{change in TP} / \text{change in labor} = (71 - 60) / 1 = 11$. Choice D is the average product of the fifth worker, 71/5.
- B. Diminishing returns begin where MP reaches its peak, at $L = 2$ on this graph. Choice C is where AP peaks, which is later.
- D. TP stops rising when the extra worker adds nothing, $MP = 0$. Choice B is the point where AP is maximized, not TP.

SET C · APPLY AND EXTEND

- (a) 1 point: $MP = 14, 20, 14, 8, 4$. (b) 1 point for the 3rd worker; 1 point for the reason: MP peaks at 20 with the second worker and falls afterward, so each added worker adds less output than the one before. (c) 1 point: $AP(3) = 48/3 = 16$ and $AP(4) = 56/4 = 14$. 1 point: MP of the 4th worker (8) is below the AP of 3 workers (16), so it pulls AP down.
- (a) 1 point: 4 workers. 1 point: $MP = 0$ there because the TP curve is flat at its peak. (b) 1 point: with a few workers, each can specialize in a task (plowing, planting, harvesting) so each added worker raises output by more than the last. (c) 1 point: marginal cost = wage / MP, so when MP falls the cost of each extra unit rises. 1 point: this is why MC slopes upward in the short run, because of diminishing marginal returns.

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3.2 Short-Run Costs

SET A · CHECK YOUR UNDERSTANDING

1. $VC = 240 - 60 = \$180$. $AVC = 180/10 = \$18$, $AFC = 60/10 = \$6$, $ATC = 240/10 = \$24$. Check: $AFC + AVC = 6 + 18 = 24$.
2. $MC = (160 - 134)/(5 - 4) = \$26$. Fixed cost is the same at both output levels, so it cancels when you take the change in total cost. Only the change in variable cost matters.
3. $AFC = FC/Q$ falls because a constant FC is divided by a larger Q. $ATC = AFC + AVC$. Eventually diminishing marginal returns make AVC rise faster than AFC falls, so ATC turns upward.
4. The extra unit costs less than the average, so ATC falls. Output is to the left of the minimum ATC, where MC is below ATC and the ATC curve is downward sloping.
5. AFC at 6 units $= 14 - 9 = \$5$, so $FC = 5 \times 6 = \$30$. At 12 units $AFC = 30/12 = \$2.50$, so $ATC = 2.50 + 11 = \$13.50$.
6. MC reaches its minimum first, then AVC, then ATC. MC falls until diminishing returns begin; AVC keeps falling while MC is below it, so its minimum comes later where MC crosses it; ATC keeps falling longer still because AFC is also falling, so its minimum is furthest right.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. Total fixed cost is constant by definition. Average fixed cost (D) falls with output even though total fixed cost is constant.
8. E. $VC = 12 \times 50 = \$600$, so $FC = 1,000 - 600 = \$400$. Choice B is the variable cost, a common slip.
9. A. An above-average marginal unit pulls the average up. Choice D occurs only when MC equals ATC.
10. D. MC cuts ATC at the bottom of the U, because MC below ATC pulls it down and MC above ATC pulls it up. Choice A confuses a U-shaped curve with a hill.
11. B. Rent is a fixed cost, so it raises TC, AFC, and ATC. MC and AVC are unaffected because they depend only on variable costs.
12. E. As MP falls, each added unit needs more of the variable input, so MC rises. Economies of scale (B) is a long-run idea.

SET C · APPLY AND EXTEND

13. (a) 1 point: $ATC(3) = (40 + 72)/3 = 37.33$ and $ATC(5) = (40 + 140)/5 = 36$. 1 point: $AVC(3) = 72/3 = 24$ and $AVC(5) = 140/5 = 28$. (b) 1 point: ATC values are 70, 46, 37.33, 35, 36, so ATC is lowest at 4 units (35). 1 point: MC of the 4th unit $= 100 - 72 = 28$, which is below ATC and pulled it down; MC of the 5th unit is 40, above 35, so ATC rises. (c) 1 point: the gap equals $AFC = 40/Q$, which shrinks as Q grows, so ATC and AVC converge but never meet.
14. (a) 1 point: AVC minimum at $Q = 3$ (cost 6). 1 point: ATC minimum at $Q = 4$ (cost 15). (b) 1 point: AFC keeps falling after AVC begins to rise, so $ATC = AFC + AVC$ keeps falling until the rise in AVC outweighs the fall in AFC; MC must be above AVC and equal to ATC at that later point. (c) 1 point: ATC and AFC shift up (and the ATC minimum moves right) while MC and AVC do not move, because fixed cost does not affect marginal or variable cost.

3.3 Long-Run Costs and Scale

SET A · CHECK YOUR UNDERSTANDING

1. A short-run ATC curve is drawn for one fixed plant size. The LRAC shows the lowest average cost for each output when the firm can choose any plant size, so it is the lower envelope of all the SRAC curves. LRAC is never above any SRAC.
2. Output rose by less than the 100 percent increase in inputs, so this is decreasing returns to scale, or diseconomies of scale. Cost per unit rises, so LRAC slopes upward over this range.
3. Economies: specialization of workers and machines on an assembly line; spreading design costs and buying parts in bulk at discounts. Diseconomies: management layers and slow communication; difficulty coordinating and monitoring thousands of workers.
4. LRAC reaches its minimum of 9 first at 150 units, so $MES = 150$. The range of constant returns is from 150 to 200 units, where LRAC stays at 9. The 250 output shows diseconomies.
5. $90,000/30,000 = 3$ firms. With MES of 80,000 only one firm can operate at minimum cost ($90,000/80,000 = 1.125$), a natural-monopoly-like situation.
6. Diminishing marginal returns hold when only one input (such as labor) increases while another (capital) is fixed, so each worker adds less. Economies of scale describe what happens when all inputs, including capital, expand together; a larger plant can use specialization and better machines to lower the cost per unit. The two apply to different time frames.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. LRAC shows the lowest cost per unit for each output after choosing the best plant size, the envelope of the SRAC curves. Choice B is the most common misconception.
8. D. Output grows faster than inputs, so unit costs fall: economies of scale. Choice A is a short-run concept with one fixed input.
9. A. Coordination and communication problems in a very large firm raise average cost. The other choices are sources of economies of scale.
10. B. MES is the lowest output at which LRAC reaches its minimum, here $Q = 4$ where the flat portion begins. $Q = 7$ is where diseconomies begin, not where the minimum is first reached.
11. E. With a low MES relative to the market, many firms can each reach minimum cost and compete. A large MES relative to demand (choice A) would imply fewer firms.
12. C. Diminishing returns require a fixed input (short run). Economies of scale involve changing all inputs (long run), and a firm can experience both.

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SET C · APPLY AND EXTEND

13. (a) 1 point: economies of scale from 0 to 4 units where LRAC falls; 1 point: diseconomies above 7 units, where LRAC rises. (b) 1 point: $MES = 4$. (c) 1 point: if market quantity demanded at the minimum price is a large multiple of 4, many firms can operate at MES, so the industry can be competitive. 1 point: if demand is only slightly larger than MES, only one or two firms can reach minimum cost, which leads to concentration.
14. (a) 1 point: $LRAC = 2,500/1,000 = \$2.50$ at 1,000 loaves and $6,000/3,000 = \$2.00$ at 3,000. (b) 1 point: LRAC fell as output tripled, so the firm has economies of scale. (c) 1 point for a plausible reason such as buying flour in bulk or spreading advertising and management costs over more loaves. 1 point: diminishing marginal returns involve adding more of one input to fixed capital in the short run, while here ovens, stores, and labor all expanded, so it is a long-run scale effect.

3.4 Profit Maximization and Perfect Competition in the Short Run**SET A · CHECK YOUR UNDERSTANDING**

- Many small buyers and sellers, an identical product, free entry and exit, and full information. Because each seller supplies a tiny share of the market and buyers can get the identical good elsewhere at the market price, no single firm can raise price without losing all sales, so it takes the market price as given.
- TR rises from \$80 to \$88, so $MR = \$8 = \text{price}$. MR equals price at every output, so the firm's demand curve is horizontal (perfectly elastic) at the market price.
- Accounting profit = $90,000 - 50,000 = \$40,000$. Economic profit = $40,000 - 45,000 = -\$5,000$, a loss relative to her next-best option, so she is earning less than normal profit.
- Increase output. $MR (= P = 12)$ exceeds $MC (9)$, so an extra unit adds more to revenue than to cost. The firm keeps expanding until MC rises to 12.
- Profit per unit is $7 - 9 = -\$2$, so total loss is $2 \times 50 = \$100$. Because $P (7)$ exceeds $AVC (6)$, the firm covers variable costs and should keep producing in the short run, losing less than its fixed cost ($\$150 = 3 \times 50$).
- The firm's short-run supply curve is the portion of its marginal cost curve that lies above minimum average variable cost. At a given price the firm produces where $P = MC$, and below minimum AVC it produces nothing.

SET B · EXAM-STYLE MULTIPLE CHOICE

- C. A price taker sells every extra unit at the market price, so $MR = P$. A downward-sloping demand curve (as for a monopolist) would make MR less than price.
- E. Price is below AVC, so the firm loses less by shutting down (loss = fixed cost) than by producing. Choice D is the tempting error: sunk fixed costs matter only through the comparison of P with AVC.
- B. The rule is $MR = P = MC$ on the rising portion of MC. Choice C is the efficient scale, but is profit maximizing only if P happens to equal minimum ATC.
- A. Profit = $(P - ATC) \times Q = (10 - 7) \times 100 = \$300$. Choice B would use AVC instead of ATC.
- D. $TR = P \times Q$ with constant P is a straight upward ray whose slope is P. A downward-sloping TR would not happen for a price taker.
- C. Implicit costs are opportunity costs of owner-supplied resources, subtracted for economic profit only. Accounting profit subtracts only explicit costs.

SET C · APPLY AND EXTEND

13. (a) 1 point: produce where $MR = MC$, which for a price taker is $P = MC$, at about 4.65 units on the rising part of MC. (b) 1 point for using $(P - ATC) \times Q$: $(24 - 15.6) \times 4.65 = \text{about } \$39$ (accept 38 to 40). 1 point: identify this as positive economic profit. (c) 1 point: minimum AVC is 6, so a price of 5 is below AVC. 1 point: the firm should shut down and produce zero, losing only its fixed cost of 32 rather than a larger loss.
14. (a) 1 point: $TR = 6 \times 1,000 = \$6,000$; $TC = 6.50 \times 1,000 = \$6,500$; loss = \$500. (b) 1 point: produce, because $P (6) > AVC (5)$; 1 point: the revenue covers all variable cost (5,000) and contributes 1,000 toward fixed cost of 1,500, so the loss (500) is smaller than the 1,500 loss from shutting down. (c) 1 point: each farm is so small relative to the market that it cannot affect price, so it can sell any quantity at the market price; market demand slopes down because consumers in total buy less at higher prices.

3.5 Perfect Competition in the Long Run**SET A · CHECK YOUR UNDERSTANDING**

- $P = MR = MC$ (profit maximization), $P = ATC$ (zero economic profit), and ATC at its minimum, so P equals the minimum of ATC. Together this means no firm wishes to enter or exit and each produces at efficient scale.
- The cost curves shift down, so firms earn economic profit at the old price. Entry increases market supply and lowers the price until economic profit is zero at the new, lower minimum ATC. The number of firms rises and the price falls.
- Shutdown is a short-run decision to produce zero output when $P < \text{minimum AVC}$, while the firm still pays fixed costs. Exit is a long-run decision to leave the industry, made when the firm suffers economic losses and expects them to continue, which eliminates fixed costs.
- Short-run price rises, profit attracts entrants, and supply shifts right until price returns to the original minimum ATC. Long-run price is unchanged and quantity is higher, so the long-run supply curve is horizontal.
- Number of firms = $5,000 / 50 = 100$. If demand later increased to 6,500 units at the same long-run price in a constant-cost industry, there would be 130 firms.
- Productive efficiency means producing at the lowest possible average cost, achieved in long-run equilibrium where $P = \text{minimum ATC}$. Allocative efficiency means producing where marginal benefit (price) equals marginal cost, achieved whenever firms set $P = MC$.

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SET B · EXAM-STYLE MULTIPLE CHOICE

7. B. Positive economic profit attracts entry, which increases market supply and lowers price. Choice A would follow from losses.
8. C. Free entry drives price down to the minimum of ATC, where $P = MC = ATC$. Choice B describes a loss, which would cause exit.
9. D. Entry raises input costs, so the new long-run equilibrium has a higher price than before but also more output. Choice A describes a constant-cost industry.
10. E. At $P = 9$ the output where $P = MC$ (about 3.4 units) has ATC of about 15.5, so firms suffer economic losses and exit, which raises the price. Choice C is wrong because P still exceeds AVC (about 6.2) in the short run.
11. A. Productive efficiency means producing at minimum ATC, which free entry and exit enforce. Choice B is allocative efficiency.
12. B. As the industry expands, input costs fall, so the long-run price falls as quantity rises, producing a downward-sloping LRS. Choice A describes constant cost.

SET C · APPLY AND EXTEND

13. (a) 1 point: short-run price rises to 18 (point b). 1 point: typical firms earn positive economic profit because P exceeds ATC. (b) 1 point: profit attracts new firms; 1 point: market supply shifts right (S_1 to S_2), lowering the price until economic profit is zero. (c) 1 point: long-run price returns to 15 (point c) and LRS is horizontal because entry does not raise input costs.
14. (a) 1 point: $P = MC$ at $Q = 2 + \sqrt{2}$, about 3.4 units, where AVC is about 6.2. Since $P = 9$ exceeds AVC, the firm covers variable costs and keeps producing in the short run. (b) 1 point: ATC is about 15.5, above the price, so the firm has an economic loss of about $(9 - 15.5) \times 3.41 = -22$. (c) 1 point: losses cause firms to exit; 1 point: market supply shifts left, raising the price until it reaches minimum ATC of 15, where economic profit is zero and exit stops.

3.6 Cost and Profit Problem Workshop**SET A · CHECK YOUR UNDERSTANDING**

1. $MC = (126 - 108)/1 = \$18$. VC at $Q = 4 = 126 - 60 = 66$, so $AVC = 66/4 = \$16.50$ and $ATC = 126/4 = \$31.50$.
2. Profit = $(25 - 22) \times 40 = \$120$. On the graph it is the rectangle with base 40 and height equal to the gap between the price and ATC at $Q = 40$.
3. P is below minimum AVC, so it should shut down. If it shuts down, the loss equals fixed cost, \$400. Producing would lose more than \$400.
4. $P = ATC = 12$ in long-run equilibrium, so $TR = 12 \times 200 = \$2,400$ and economic profit = 0. At $P = 14$, firms earn economic profit; entry increases supply and drives price back down to 12.
5. The new MC curve intersects the price line at a lower quantity, so output falls. Profit also falls because costs rose at each output and price is unchanged.
6. At $P = 10$: $50 \times 8 = 400$ units. At $P = 14$: $50 \times 12 = 600$ units. The market supply curve slopes upward: a higher price brings greater output from each firm along its MC curve.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. D. MC of the eleventh unit = $245 - 220 = 25$, which is above the price of 22, so that unit loses money and output should fall. Choice A reverses the rule.
9. C. The fee raises fixed cost and ATC, so firms exit until the price equals the higher minimum ATC. Choice B is wrong because long-run price follows ATC, not MC.
11. B. A higher wage raises MC, shifting it up and reducing the quantity at which $P = MC$. Choice C and E change only fixed cost, which does not alter the output decision.
8. A. Profit = $(9 - 8) \times 50 = \$50$. Choice C uses AVC $(9 - 6) \times 50$.
10. E. Profit = $(P - ATC) \times Q$, the rectangle between the price line and ATC at Q^* . Choice B uses MC, which gives the wrong rectangle (it is zero at the optimum).
12. A. Exit shifts supply left until price is back at minimum ATC, so price is unchanged and the number of firms falls. Choice B describes the short run, before exit.

SET C · APPLY AND EXTEND

13. (a) 1 point: $Q = 5$ because $MC(5) = 26$ is the last MC at or below 30 ($MC(6) = 38$). 1 point: $TR = 150$, $TC = 152$, loss = \$2. (b) 1 point: operate, because P (30) exceeds AVC (18.40), so revenue covers variable cost and contributes toward fixed cost. 1 point: shutting down would lose the entire \$60 fixed cost. (c) 1 point: with a loss, firms exit; supply shifts left and price rises toward minimum ATC of about 30.4, where economic profit is zero.
14. (a) 1 point: $Q = 4$ ($P = MC = 15$ does not change). 1 point: new ATC = 32, so profit = $(15 - 32) \times 4 = -\$68$. (b) 1 point: neither shifts, because the fee is fixed and does not vary with output. (c) 1 point: losses cause exit. 1 point: market supply falls, price rises until it equals the new minimum ATC of 30, leaving each firm with zero economic profit and fewer firms in the industry.

3.7 Multiple-Choice Practice: Production, Cost, and Perfect Competition**SET A · CORE CONCEPTS**

1. C. MP is 10, 14, 12, 8, 4. MP peaks at the second worker and first falls with the third. The second worker has the highest MP, so choosing it confuses the peak with the decline.
2. A. When MC equals ATC the average stops falling and starts rising, so the crossing is at the bottom of ATC. The minimum of AVC (distractor) is a different, earlier crossing.
3. E. $AFC = 100/20 = 5$, so $ATC = AFC + AVC = 5 + 15 = 20$. The tempting \$15 is AVC alone and \$5 is AFC alone.
4. B. A price taker sells each unit at the same market price, so $MR = P$ always. $MR = MC$ holds only at the optimum, which is why that choice is tempting but wrong.

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5. D. Output rising more than inputs means unit costs fall, which is economies of scale. Diminishing marginal returns refers to one variable input added to fixed inputs.
6. A. Free entry and exit eliminate economic profit, so $P = \text{minimum ATC}$. The distractor 'positive accounting profit but negative economic profit' would imply exit.
7. C. If P is below AVC , revenue does not cover variable costs, so the firm loses less by closing. Price below ATC alone means a loss but not necessarily a shutdown.

SET B · APPLICATIONS AND DATA

8. E. MP crosses AP at AP 's maximum, which occurs at 3 workers here. Two workers is where MP is at its maximum, not AP .
10. D. $LRAC = 12, 10, 9, 9$, so the minimum $LRAC$ (9) is first reached at 30 units. Output 40 has the same cost but is not the smallest efficient scale.
12. C. The shutdown price is minimum AVC , 6 at $Q = 3$. Fifteen is the break-even price (minimum ATC), where the firm earns zero economic profit but would still produce at lower prices.
14. B. Entry shifts supply to S_2 , taking the market to c , where D_2 meets S_2 at the original price. Point b is the short-run equilibrium before entry.
9. B. $AFC = ATC - AVC = 15 - 7 = 8$ (check: $FC/Q = 32/4$). The tempting choice 32 is total fixed cost, not average.
11. A. MC of units 1 to 5 is 15, 12, 10, 13, 20, so $Q = 4$ ($MC = 13 \leq 14$). $TR = 56$, $TC = 70$, loss = 14. $AVC = 12.50 < 14$, so it operates; shutting down would lose 20.
13. E. Entry shifts supply right until price returns to minimum ATC . The distractor 'higher and quantity is higher' describes an increasing-cost industry.

SET C · EXAM-LEVEL STRETCH

15. D. $MC = \text{wage} / MP$: $96/12 = 8$ and $96/8 = 12$. Falling MP raises MC . The reversed choice confuses MP with MC .
16. A. $AFC = 14 - 10 = 4$, so $FC = 400$. Doubling gives $FC = 800$ and $AFC = 8$, so $ATC = 8 + 10 = 18$. The choice of \$28 doubles the whole ATC , wrongly doubling variable cost.
17. C. $120,000 / 50,000 = 2.4$, so only 2 firms can each reach MES . Three firms would require 150,000 units. This suggests a concentrated industry.
18. E. Accounting profit = $500,000 - 320,000 = 180,000$. Implicit costs = $90,000 + 30,000 = 120,000$, so economic profit = 60,000. The tempting \$90,000 comes from subtracting only the forgone salary, and \$180,000 is accounting profit.
19. B. In a decreasing-cost industry, expansion lowers costs for all firms, so the new long-run equilibrium has a lower price. A constant price describes a constant-cost industry.
20. D. Loss = $(12 - 14) \times 30 = 60$. $FC = (14 - 10) \times 30 = 120$. Since $P > AVC$ the firm loses less by producing (60) than by shutting down (120). The distractor reverses the comparison.

3.8 Free-Response Practice: Production, Cost, and Perfect Competition**QUESTION 1 · SHORT-RUN PROFIT AND SHUTDOWN (LONG FREE RESPONSE)**

1. (a) 1 point: $Q = 6$. 1 point: a profit-maximizing price taker produces where $MR = P = MC$; MC of the sixth unit is 30, below the price of 32, so every unit up to the sixth adds more to revenue than to cost ($MR > MC$), and 6 is the highest output in the table.
2. (b) 1 point: $TR = 32 \times 6 = 192$; $TC = 175$; economic profit = \$17 (or $(32 - 29.17) \times 6 = \text{about } 17$). 1 point: graph with price on the vertical axis and quantity on the horizontal axis, a horizontal line at 32 labeled $MR = P = D$, MC rising through the minimum points of ATC and AVC , and the quantity 6 marked. 1 point: profit rectangle shaded between $P = 32$ and ATC (29.17) from 0 to 6.
3. (c) 1 point: at $P = 15$ the price is below the minimum AVC of 18, so revenue cannot cover variable cost. 1 point: the firm shuts down and produces zero, losing only its fixed cost of \$50 rather than a larger loss from producing.
4. (d) 1 point: the firm earns economic profit, so new firms enter and the number of firms rises. 1 point: market supply increases, which lowers the price toward minimum ATC (about 29). 1 point: economic profit falls to zero in the long run.

QUESTION 2 · COST CURVES AND THE FIRM'S SUPPLY CURVE

5. (a) 1 point: the shutdown price is 6, minimum AVC . 1 point: it produces 3 units at that price (where $P = MC = AVC$); at any lower price it shuts down because $P < AVC$, and at 6 it is indifferent because the loss equals the fixed cost of 32.
6. (b) 1 point: price 15 (minimum ATC), quantity 4, where MC crosses ATC , so $P = ATC$ and profit is zero.
7. (c) 1 point: the supply curve is the part of the MC curve at or above minimum AVC (from 6 upward), because the firm sets $P = MC$ for any price at or above minimum AVC and produces zero below it.
8. (d) 1 point: a higher wage raises variable cost and shifts MC (and AVC and ATC) upward, so supply decreases (shifts left), because at each price the firm produces less. 1 point: minimum ATC rises.

QUESTION 3 · LONG-RUN COSTS AND SCALE

9. (a) 1 point: $LRAC = 20, 16, 14, 14, 15$ (dollars per unit).
10. (b) 1 point: economies of scale from 100 to 300 ($LRAC$ falls); constant returns from 300 to 400. 1 point: $MES = 300$ units, the smallest output at which $LRAC$ is minimized (14). Diseconomies occur above 400.
11. (c) 1 point: economies of scale may come from specialization of labor, bulk purchasing, or spreading fixed costs such as design or advertising over more units. 1 point: diseconomies may come from coordination and communication difficulties among many layers of management.
12. (d) 1 point: $2,000 / 300$ is about 6.7, so 6 or 7 firms (accept 6) can each reach MES , so the market can support several competitors, and a competitive or oligopolistic structure is plausible rather than a natural monopoly.

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QUESTION 4 · ECONOMIC PROFIT, ENTRY, AND EFFICIENCY

13. (a) 1 point: accounting profit = $240,000 - 150,000 = \$90,000$. 1 point: implicit costs = $60,000 + 0.04 \times 100,000 = 64,000$, so economic profit = $90,000 - 64,000 = \$26,000$.
14. (b) 1 point: economic profit is positive, so resources earn more here than in their next-best use, which attracts entry of new firms.
15. (c) 1 point: entry shifts market supply right, lowering the price. 1 point: price falls to minimum ATC, where Nina's economic profit falls to zero (she earns just her normal profit).
16. (d) 1 point: productive efficiency means producing at minimum ATC; allocative efficiency means $P = MC$. 1 point: both hold in the long-run equilibrium, since $P = MC = \text{minimum ATC}$.

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Chapter 4: Imperfect Competition.

8 sections with explanations and worked examples, then 120 practice problems. Answers and full explanations are at the end of the chapter.

4.1 Monopoly

Learn why a monopoly has market power, how it finds its profit-maximizing price and quantity, and why the result is inefficient.

A **monopoly** is a market with a single seller of a product that has no close substitutes. Because the firm is the only seller, it faces the whole market demand curve, and it is a **price maker**: by choosing how much to sell, it also chooses the price. This lesson shows how a monopoly picks its output, why that choice is inefficient, and how to draw and calculate every piece of the graph.

Sources of market power. A monopoly can persist only if something blocks entry. The AP exam expects you to recognize these **barriers to entry**:

- ◆ **Economies of scale (natural monopoly):** average cost keeps falling over so large a range of output that one firm can serve the market more cheaply than two. Water pipes and electric grids are classic cases.
- ◆ **Ownership of a key resource:** a firm that controls the essential input, such as a mine or a unique spring, leaves rivals unable to produce.
- ◆ **Government-created barriers:** patents (20 years of exclusive rights to an invention), copyrights, trademarks, and exclusive licenses or franchises.
- ◆ **Strategic behavior:** predatory pricing, large advertising budgets or network effects that make entry look unprofitable.

Monopoly: key facts

One seller, no close substitutes, high barriers to entry.

The firm's demand curve IS the market demand curve (downward sloping).

Price maker: it chooses a point on the demand curve, not a price outside it.

Why marginal revenue is below price. To sell one more unit the monopoly must lower the price, and the lower price applies to every unit, not just the new one. So the extra revenue from the last unit equals its price minus the revenue lost on all earlier units. That is why $MR < P$ for every unit after the first. For a perfectly competitive firm, $MR = P$ because it sells any amount at the market price.

Linear demand shortcut

If demand is $P = a - bQ$, then total revenue is $aQ - bQ^2$ and $MR = a - 2bQ$.

The MR curve starts at the same vertical intercept as demand and is TWICE as steep, so its horizontal intercept is half of demand's.

$MR > 0$ where demand is elastic, $MR = 0$ at the midpoint (unit elastic), $MR < 0$ where demand is inelastic. A profit-maximizing monopoly never operates on the inelastic part of demand.

Feature	Perfect competition	Monopoly
Demand facing the firm	Horizontal at market price	Market demand, downward sloping
MR versus price	$MR = P$	$MR < P$
Profit-max rule	$MR = MC$ (so $P = MC$)	$MR = MC$, then read price off demand
Long-run profit	Zero economic profit	Can be positive because entry is blocked
Efficiency	Productive and allocative	Neither: $P > MC$, output too low

Maximizing profit. Use the same marginal logic as any firm: if $MR > MC$, one more unit adds to profit, so expand; if $MR < MC$, cut back. Profit is largest where $MR = MC$.

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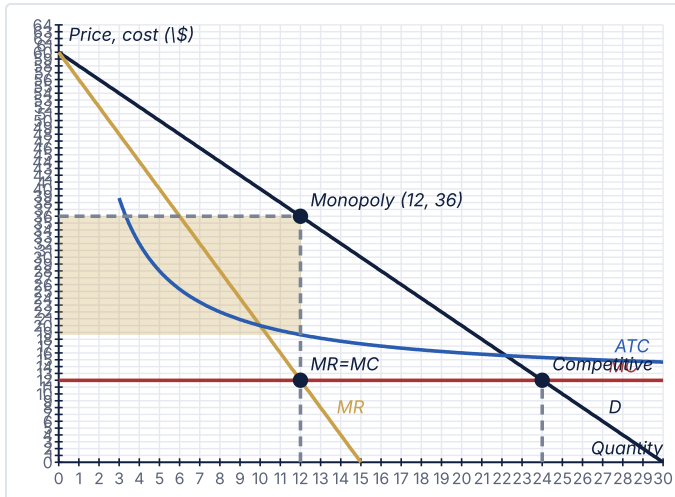
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- 1 **Find the quantity** Set $MR = MC$ (or find the last unit with $MR \geq MC$ in a table). This gives Q_m .
- 2 **Find the price** Go UP from Q_m to the demand curve, not to the MR curve. That height is the price P_m .
- 3 **Find average total cost** Go up from Q_m to the ATC curve to read ATC at that quantity.
- 4 **Compute profit** Profit = $(P - ATC) \times Q$. If $P < ATC$ the firm has a loss; if $P < AVC$ in the short run it shuts down.

EXAMPLE 1: MONOPOLY GRAPH WITH NUMBERS

A monopoly faces demand $P = 60 - 2Q$ (price in dollars). Its marginal cost is constant at \$12 and its fixed cost is \$80, so $ATC = 12 + 80/Q$. (a) Find the profit-maximizing quantity and price. (b) Find profit. (c) Find the deadweight loss relative to perfect competition.

**SOLUTION**

$MR = 60 - 4Q$. Set $MR = MC$: $60 - 4Q = 12$, so $Q = 12$.

Price from demand: $P = 60 - 2(12) = \$36$. Note MR at $Q = 12$ is only \$12.

ATC at $Q = 12$ is $12 + 80/12 = \$18.67$. $TR = 36 \times 12 = \$432$. $TC = 12(12) + 80 = \$224$. Profit = \$208 (equivalently $(36 - 18.67) \times 12$).

Competitive benchmark: $P = MC$ gives $60 - 2Q = 12$, so $Q = 24$. Deadweight loss is the triangle between demand and MC from $Q = 12$ to $Q = 24$: $\frac{1}{2} \times (36 - 12) \times (24 - 12) = \$144$.

The cost of monopoly power. At Q_m the price exceeds marginal cost. The marginal benefit to buyers of the units between Q_m and the competitive quantity is above their marginal cost, yet those units are not produced. The lost surplus on them is the **deadweight loss**. A monopoly is therefore not **allocatively efficient** (P is not equal to MC). It is not **productively efficient** either, because it does not produce at the minimum of ATC. Some surplus also moves from consumers to the firm as profit; that transfer is not a loss to society, but the deadweight loss is.

Deadweight loss of monopoly

DWL = area between demand and MC from Q_m to the quantity where $P = MC$.

For straight lines: $DWL = \frac{1}{2} \times (P_m - MC \text{ at } Q_m) \times (Q_c - Q_m)$.

Positive long-run profit persists because entry is blocked; competition would erase it.

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EXAMPLE 2: READING A TABLE

A monopoly's schedule is below. Fixed cost is \$40 and is included in total cost. Find the profit-maximizing quantity, price and profit.

Q	Price	TR	TC
1	50	50	50
2	45	90	64
3	40	120	84
4	35	140	112
5	30	150	150

SOLUTION

Compute MR = change in TR: 50, 40, 30, 20, 10. Compute MC = change in TC: 14, 20, 28, 38 for units 2 to 5 (and 10 for the first unit above fixed cost).

Compare: unit 3 has $MR\ 30 > MC\ 20$ (produce). Unit 4 has $MR\ 20 < MC\ 28$ (do not produce). So $Q = 3$.

Price at $Q = 3$ is \$40 from the demand column. $TR = \$120$, $TC = \$84$, profit = \$36.

Check: profit at $Q = 2$ is $90 - 64 = \$26$ and at $Q = 4$ is $140 - 112 = \$28$, both below \$36.

EXAMPLE 3: TAX VERSUS FIXED-COST CHANGE

Return to Example 1. (a) A \$30 increase in fixed cost: what happens to price and output? (b) A per-unit tax of \$4 raises MC to \$16. Find the new quantity and price.

SOLUTION

(a) A fixed cost does not change MC or MR, so $MR = MC$ still gives $Q = 12$ and $P = \$36$. Profit falls by \$30 to \$178. The firm does not raise price when only fixed cost rises.

(b) New $MC = 16$: $60 - 4Q = 16$, so $Q = 11$ and $P = 60 - 22 = \$38$.

The price rises by \$2, which is half the \$4 tax. With linear demand a monopoly passes through half of a per-unit cost increase and absorbs the rest.

Common mistakes

(1) Reading the price off the MR curve; always go up to DEMAND. (2) Using MC instead of ATC to compute profit; profit = $(P - ATC) \times Q$. (3) Saying a monopoly charges the highest possible price; it charges the profit-maximizing price, and $MR = MC$ keeps it on the elastic part of demand. (4) Claiming a monopoly always earns a profit; if $P < ATC$ at the best output it still loses money, and it shuts down in the short run only if $P < AVC$.

Practice**SET A Check Your Understanding**

Answer each item. Show your work on calculations.

1. A monopoly's demand is $P = 100 - 5Q$. Find MR at $Q = 6$, and explain in words why MR is below the price.
2. Classify each as a government-created barrier or a market-based barrier: (i) a 20-year drug patent, (ii) a firm owning the only large deposit of a mineral, (iii) a city that issues only one cable franchise, (iv) very large economies of scale.
3. A monopoly faces $P = 40 - Q$ with constant $MC = \$10$. Find its output and price, then the perfectly competitive output, and compute the deadweight loss.
4. Quantities 1 to 5 sell at prices \$90, 80, 70, 60, 50 with total costs \$40, 70, 110, 170, 250. Find the profit-maximizing output, price and profit.
5. Explain why a profit-maximizing monopoly never chooses an output on the inelastic part of its demand curve.
6. A monopoly's demand falls so that its best price is \$9 while ATC at that output is \$11 and AVC is \$7. Should it produce in the short run? Explain.

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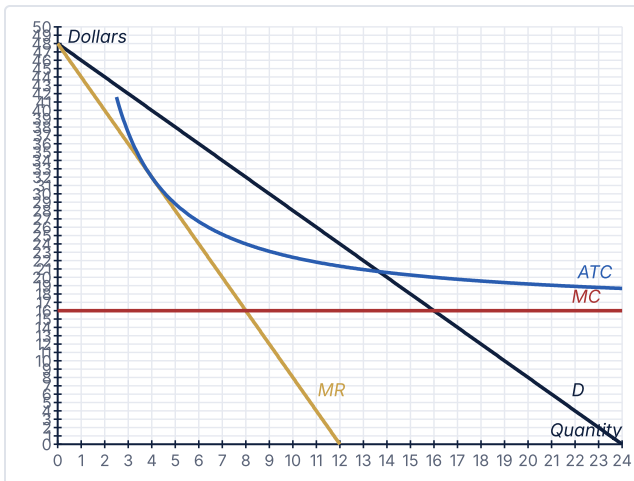
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A monopoly faces the demand curve $P = 80 - 4Q$. What is marginal revenue when $Q = 5$?
 (A) \$60 (B) \$40 (C) \$20 (D) \$80 (E) \$0
8. The graph shows a monopoly. Fixed cost is included in ATC. What is the monopoly's economic profit at its profit-maximizing output?



- (A) \$32 (B) \$48 (C) \$96 (D) \$64 (E) \$128
9. At the profit-maximizing output of a single-price monopoly, which relationship holds?
 (A) $P > MR = MC$ (B) $P = MR = MC$ (C) $P = MC > MR$
 (D) $MR > P = MC$ (E) $P = ATC = MC$
10. Why does a monopoly create deadweight loss?
 (A) It earns positive economic profit
 (B) It charges a price above ATC
 (C) It sells to consumers who value the good very little
 (D) It uses more resources than a competitive firm
 (E) It stops producing while the marginal benefit of the next unit exceeds its marginal cost
11. A profit-maximizing monopoly's fixed cost rises, with no change in variable cost or demand. In the short run the firm will
 (A) raise price and cut output
 (B) cut price and raise output
 (C) leave price and output unchanged and earn less profit
 (D) shut down immediately
 (E) raise price but leave output unchanged
12. Which of the following is a barrier to entry created by government?
 (A) Control of the world supply of a key mineral
 (B) A patent on a new drug
 (C) Economies of scale over a large range of output
 (D) A strong brand built by advertising
 (E) A reputation for cutting prices when rivals enter

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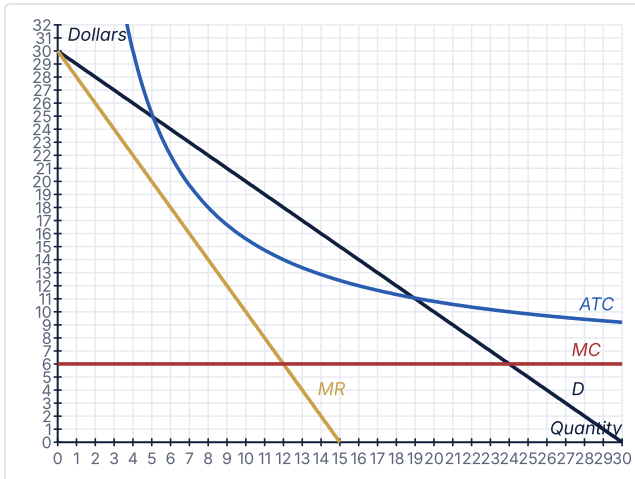
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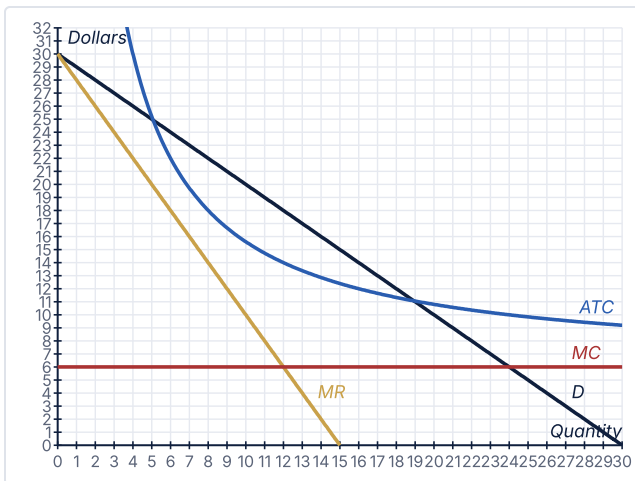
SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. A monopoly faces demand $P = 30 - Q$, with $MC = \$6$ and $ATC = 6 + 96/Q$ (curves shown). (a) Find the profit-maximizing quantity and price. (b) Calculate economic profit. (c) Calculate the deadweight loss. (d) Would you expect the profit to last in the long run? Explain.



14. Use the monopoly in the previous graph ($D: P = 30 - Q$, $MC = \$6$, $ATC = 6 + 96/Q$). A regulator imposes a price ceiling of \$12. (a) Explain why the firm's marginal revenue equals \$12 for output up to the quantity where the ceiling meets demand. (b) Find the new quantity, price and profit. (c) Compare consumer outcomes and deadweight loss with the unregulated case.

**4.2 Price Discrimination**

Understand the conditions for price discrimination, compare perfect and group pricing, and analyze effects on output and surplus.

A firm with market power usually charges one price to everyone. **Price discrimination** means charging different customers different prices for the same good when the price differences are NOT explained by differences in cost. It is a way for a firm to capture surplus that a single price leaves with consumers.

Three conditions for price discrimination

1. Market power: the firm faces a downward-sloping demand curve (a perfectly competitive firm cannot do it).
2. Separable groups: the firm can identify groups or individuals with different willingness to pay or different price elasticity of demand.
3. No resale (arbitrage): customers who get the low price cannot resell to those who would be charged the high price.

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If any condition fails the scheme collapses. A firm that sells a pill at \$5 to one group and \$20 to another will not keep the high-price group if members of the low-price group can resell. This is why airlines require ID, why student tickets cannot be transferred, and why drug companies sell different prices in different countries only where re-importation is blocked.

Types of price discrimination. Economists distinguish three kinds.

Type	What the firm does	Example
First degree (perfect)	Charges each buyer the maximum that buyer will pay	Negotiated car price, individually tailored tuition aid
Second degree	Lower price per unit for larger quantities or different versions chosen by the buyer	Bulk discounts, block pricing for electricity
Third degree (group pricing)	Splits buyers into groups and charges each group its own price	Student, senior and child tickets; airline business versus leisure fares; coupons

Perfect price discrimination. Suppose the firm could charge each customer exactly the most that customer would pay. Then the price of each additional unit equals the height of the demand curve at that unit, so marginal revenue equals demand and the firm expands output until demand meets marginal cost. Output is the same as in perfect competition, so there is no deadweight loss and the market is allocatively efficient. But consumer surplus is zero: the whole surplus goes to the producer as profit.

Perfect discrimination results

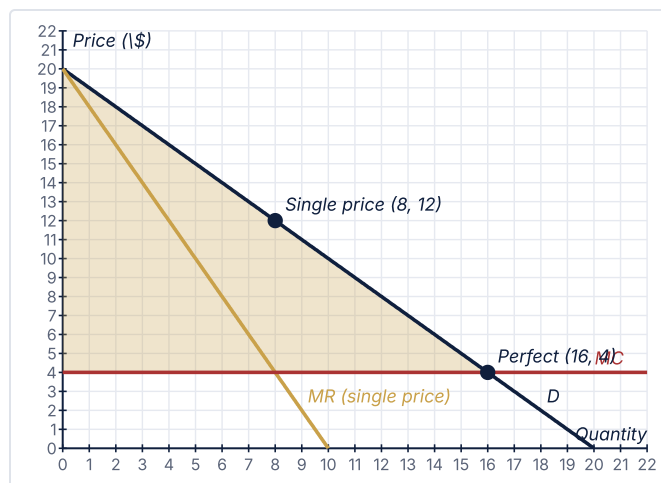
$MR = D$, so the firm produces where $D = MC$ (the efficient quantity).

Deadweight loss = 0; consumer surplus = 0; producer surplus (profit) is the entire area between D and MC .

Efficient, but all the gain goes to the seller.

EXAMPLE 1: SINGLE PRICE VERSUS PERFECT DISCRIMINATION

A firm faces $P = 20 - Q$ with constant $MC = \$4$ and no fixed cost. (a) Find the single-price profit-maximizing output, price and profit. (b) Find the output and profit under perfect price discrimination. (c) Compare consumer surplus and deadweight loss.



SOLUTION

(a) $MR = 20 - 2Q = 4$ gives $Q = 8$ and $P = 12$. Profit = $(12 - 4) \times 8 = \$64$.

(b) With perfect discrimination, produce where $D = MC$: $20 - Q = 4$, so $Q = 16$. Profit is the triangle $\frac{1}{2} \times (20 - 4) \times 16 = \$128$.

(c) Under a single price, consumer surplus is $\frac{1}{2} \times (20 - 12) \times 8 = \$32$ and DWL is $\frac{1}{2} \times (12 - 4) \times (16 - 8) = \$32$. Under perfect discrimination both are zero. Total surplus rises from $64 + 32 = \$96$ to $\$128$, but all of it goes to the firm.

Group pricing (third degree). When the firm splits its market into groups, it treats each as a separate monopoly market and sets $MR = MC$ in each. The group with the more price-elastic demand (more sensitive to price) gets the lower price, and the group with less elastic demand pays more. The profit-maximizing rule is: MR in group 1 = MR in group 2 = MC . If MR were higher in one group, the firm would gain by shifting sales to that group.

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Group pricing rule

Set $MR_1 = MR_2 = MC$. Then charge each group the price on its own demand curve at that quantity.

Lower price for the group with more elastic demand (students, seniors, leisure travelers).

Profit with discrimination is at least as high as with a single price.

EXAMPLE 2: TWO GROUPS

A theater has $MC = \$4$. Adult demand is $P = 20 - Q$ and student demand is $P = 12 - Q$. (a) Find the profit-maximizing prices with discrimination. (b) Compare total profit with the best single price.

SOLUTION

(a) Adults: $MR = 20 - 2Q = 4$, so $Q = 8$ and $P = \$12$. Students: $MR = 12 - 2Q = 4$, so $Q = 4$ and $P = \$8$. The student group (more elastic at its optimum) gets the lower price.

Profit: adults $(12 - 4) \times 8 = \$64$; students $(8 - 4) \times 4 = \$16$. Total $\$80$.

(b) A single price faces the combined demand. Below $\$12$ both groups buy: $Q = (20 - P) + (12 - P) = 32 - 2P$, so $P = 16 - Q/2$ and $MR = 16 - Q$. $MR = MC$ gives $Q = 12$ and $P = \$10$. Profit $= (10 - 4) \times 12 = \$72$. The best single price ($\$10$) gives $\$72$ versus $\$80$ with discrimination.

Note that total output is 12 either way; discrimination changed who buys, not how much, because the demands are linear. Output rises only when discrimination brings in buyers who would otherwise be priced out entirely.

EXAMPLE 3: ELASTICITY MARKUPS

A firm has $MC = \$12$ and sells in two markets. At the optimum, demand in market A has $|\text{elasticity}| = 4$ and in market B $|\text{elasticity}| = 1.5$. Using $MR = P(1 - 1/|E|)$, find each price.

SOLUTION

Set $MR = MC$ in each market, so $P(1 - 1/|E|) = 12$.

Market A: $P \times (1 - 0.25) = 12$, so $P = 12/0.75 = \$16$.

Market B: $P \times (1 - 1/1.5) = 12$, so $P \times 0.3333 = 12$ and $P = \$36$.

The less elastic market pays more than twice as much. This is the logic behind high business-class fares and low advance-purchase leisure fares.

Exam tip

State all three conditions when asked how a firm can price discriminate; omitting 'prevent resale' is a common lost point. On a perfect-discrimination graph the output is where D crosses MC , price varies along D , and the whole area between D and MC is profit. Do not say perfect discrimination creates deadweight loss; it eliminates it.

Practice

SET A Check Your Understanding

Answer each item. Show your work on calculations.

- List the three conditions necessary for a firm to price discriminate and explain why a perfectly competitive firm cannot meet the first.
- Identify the degree of price discrimination: (i) a bakery sells one muffin for $\$3$ or six for $\$12$; (ii) a software firm negotiates a unique price with each corporate client; (iii) a museum charges $\$8$ for adults and $\$4$ for children.
- A firm faces $P = 30 - Q$ and $MC = \$6$ with no fixed cost. Find profit and deadweight loss with (a) a single price and (b) perfect discrimination.
- A movie theater charges less for matinee tickets than for evening tickets. Which group likely has more elastic demand, and why does that lead to a lower price?
- How does perfect price discrimination change consumer surplus, producer surplus and total surplus compared with a single-price monopoly?
- Why do coupons act as a form of price discrimination, and which condition ensures the scheme works?

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which of the following is NOT required for a firm to successfully price discriminate?
- (A) The firm must be able to separate customers into groups
 - (B) The firm must face a downward-sloping demand curve
 - (C) The groups must have different price elasticities of demand
 - (D) The firm must be able to prevent resale among customers
 - (E) The firm must have a positive economic profit before it begins
8. Compared with a single-price monopoly, a perfectly price-discriminating monopoly
- (A) produces a larger output, eliminates deadweight loss and leaves no consumer surplus
 - (B) produces a smaller output and leaves more consumer surplus
 - (C) produces the same output and charges a lower average price
 - (D) produces a larger output and leaves consumer surplus unchanged
 - (E) produces where $MR = MC$ at a lower price for every unit
9. An airline charges business travelers more than vacationers for the same seat. This is consistent with profit maximization if
- (A) vacationers have less elastic demand
 - (B) business travelers have more elastic demand
 - (C) business travelers have less elastic demand than vacationers
 - (D) the cost of serving business travelers is lower
 - (E) both groups have identical elasticities
10. A monopoly sells in two separate markets with the same constant MC. At the current sales, MR in market X is \$14 and MR in market Y is \$9. To raise profit the firm should
- (A) raise the price in market X and lower the price in market Y
 - (B) sell more in Y and less in X
 - (C) raise prices in both markets
 - (D) lower prices in both markets
 - (E) lower the price in market X and raise the price in market Y
11. Which statement about the graph of a perfectly discriminating monopolist with constant MC is correct? (Demand: $P = 20 - Q$, $MC = 4$.)
- (A) Output is 8 and the firm earns \$64
 - (B) Output is 16 and consumer surplus is \$32
 - (C) Output is 16 and profit is \$128
 - (D) Output is 8 and deadweight loss is \$32
 - (E) Output is 16 and every unit sells for \$4
12. A grocery store sells one can of beans for \$1.50 but a case of 12 for \$12. This pricing is best described as
- (A) first-degree price discrimination
 - (B) third-degree price discrimination
 - (C) a cost-based price difference only
 - (D) second-degree price discrimination
 - (E) predatory pricing

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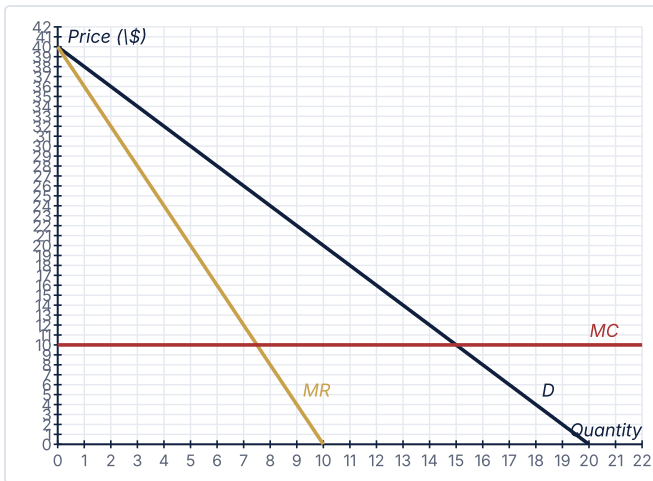
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SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. A firm faces demand $P = 40 - 2Q$ with $MC = \$10$ and no fixed cost (curves shown). (a) Find the single-price quantity, price and profit. (b) Find the quantity and profit under perfect price discrimination. (c) Calculate the deadweight loss and consumer surplus under the single price. (d) Explain who gains and who loses from the switch to perfect discrimination.



14. A ski resort has $MC = \$4$ per lift ticket and two groups. Peak-season skiers have demand $P = 24 - 2Q$ and locals have demand $P = 12 - Q$ (Q in thousands, P in dollars). (a) Find the profit-maximizing quantity and price for each group. (b) Compute total profit (in thousands of dollars). (c) Compute the price elasticity of demand for each group at its optimum and explain how the results match the price difference. (d) Explain what happens if locals can resell tickets to peak skiers.

4.3 Natural Monopoly and Regulation

Analyze natural monopolies, compare marginal-cost, average-cost and cost-plus pricing, and weigh antitrust and regulation trade-offs.

A **natural monopoly** exists when one firm can supply the whole market at a lower average cost than two or more firms could. Utilities such as local water, electric distribution and rail track are typical. This lesson explains why such markets resist competition, what the government can do about it, and the trade-offs of each choice.

Economies of scale are the source. When fixed costs (pipes, wires, track) are huge and the marginal cost of serving one more customer is small, long-run average total cost (ATC) falls over the entire range of quantities the market demands. Marginal cost stays **BELOW** average cost, which is why ATC keeps falling. If two firms split the market, each produces less, each has a higher ATC, and total cost to society rises.

Natural monopoly

Demand cuts the LRAC curve while LRAC is still falling (the minimum efficient scale is larger than market demand).

$MC < ATC$ at every relevant output.

One firm is the lowest-cost way to serve the market, so competition would raise costs.

The unregulated outcome. Left alone, the firm behaves like any monopoly: it sets $MR = MC$, charges the price on the demand curve, earns an economic profit, and produces too little. Price exceeds marginal cost, so there is deadweight loss. Regulators therefore consider other options.

Option	Rule	Price versus cost	Result
Unregulated	$MR = MC$	$P > ATC > MC$	Profit, highest price, largest DWL
Marginal cost (socially optimal) pricing	$P = MC$	$P < ATC$	Allocatively efficient, but the firm loses money; needs a subsidy
Average cost (fair-return) pricing	$P = ATC$	$P > MC$	Zero economic profit, firm survives, small DWL
Break up the firm	Antitrust	Higher ATC for each part	Productively inefficient; not recommended

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The regulatory choices on one graph

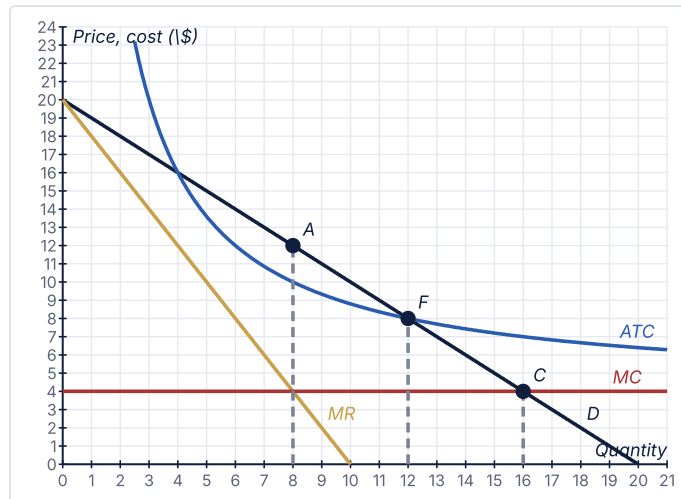
Unregulated: Q where $MR = MC$, price from D (point A).

Fair return: Q where $D = ATC$ (point F). Zero economic profit.

Socially optimal: Q where $D = MC$ (point C). Loss equal to total fixed cost when MC is constant, so a subsidy equal to the loss is needed.

EXAMPLE 1: THREE REGULATORY OUTCOMES

A natural monopoly faces demand $P = 20 - Q$. Its MC is constant at \$4 and $ATC = 4 + 48/Q$. Find quantity, price and profit under (a) no regulation, (b) marginal-cost pricing, (c) average-cost pricing. Then find the deadweight loss in (a) and (c).



SOLUTION

(a) $MR = 20 - 2Q = 4$ gives $Q = 8$, $P = \$12$. ATC at $8 = 4 + 6 = \$10$. Profit = $(12 - 10) \times 8 = \$16$.

(b) $P = MC$: $20 - Q = 4$, so $Q = 16$ and $P = \$4$. ATC at $16 = 4 + 3 = \$7$. Loss per unit = \$3, total loss = \$48, which equals the fixed cost.

(c) $P = ATC$: $20 - Q = 4 + 48/Q$ gives $Q^2 - 16Q + 48 = 0$, so $Q = 12$ (or $Q = 4$, which is on the wrong side). $P = \$8$ and $ATC = 4 + 4 = \$8$, so profit is zero.

DWL: (a) $\frac{1}{2} \times (12 - 4) \times (16 - 8) = \$32$. (c) $\frac{1}{2} \times (8 - 4) \times (16 - 12) = \$8$. Average-cost pricing recovers 24 of the 32 dollars of lost surplus without any subsidy.

Subsidies. To get the efficient outcome ($P = MC$) the government can pay the firm a subsidy equal to its loss, or allow a two-part price (a fixed connection fee plus a per-unit price equal to MC). The cost is that taxpayers must fund the subsidy, and funding it requires taxes that carry their own distortions.

EXAMPLE 2: WHY NOT JUST SPLIT IT UP?

Using Example 1's cost curve, antitrust authorities split the unregulated monopoly (output 8) into two equal firms. Compare average cost.

SOLUTION

One firm producing 8 has $ATC = 4 + 48/8 = \$10$.

Two firms producing 4 each have $ATC = 4 + 48/4 = \$16$ each.

Total cost rises from $8 \times 10 = \$80$ to $8 \times 16 = \$128$. Society wastes \$48 on duplicated fixed cost, and the two firms might still collude, or one might drive out the other. For a natural monopoly, breaking it up is productively inefficient.

How regulators set prices. Under **cost-plus regulation** (rate-of-return regulation) the regulator lets the firm cover its costs plus a normal profit. This approximates average-cost pricing but weakens the incentive to cut costs, because higher costs are passed on in the price; the firm may even gold-plate its capital. Under **price-cap regulation** the regulator fixes the maximum price for several years. The firm keeps any profit from cost cutting, so it has an incentive to be efficient, but a cap set too low can drive it into losses, and a cap set too high lets it keep monopoly profit.

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EXAMPLE 3: PRICE CAP AND INCENTIVES

A regulator imposes a price cap of \$8 on the firm in Example 1. The firm then cuts its fixed cost from \$48 to \$36 by redesigning its network. What are its output and profit?

SOLUTION

With the cap at \$8, $MR = \$8$ up to the quantity where demand equals 8, which is $Q = 12$. Since $8 > MC = 4$, the firm produces 12.

New $ATC = 4 + 36/12 = \$7$. Profit = $(8 - 7) \times 12 = \$12$.

Under cost-plus the regulator would simply lower the price toward \$7, and the saving would go to customers. Under the cap the firm keeps the \$12 until the next review, which rewards cost cutting.

Antitrust and deregulation. For monopolies that are NOT natural, the government uses antitrust law. The Sherman Act (1890) bans monopolization and conspiracies to restrain trade; the Clayton Act (1914) targets mergers that substantially lessen competition, price discrimination and tied sales; the FTC and the Justice Department enforce them. Regulation has its own cost: regulators know less than the firm, and may come to serve the industry they oversee (regulatory capture). Since the 1970s, deregulation of airlines, trucking and telecommunications lowered prices where new technology or entry made competition workable.

Common mistakes

(1) Setting $P = MC$ for a natural monopoly and forgetting the firm loses money because $ATC > MC$. (2) Reading the fair-return price at $MR = MC$; it is where D crosses ATC . (3) Saying breaking up a natural monopoly lowers prices; it raises average cost. (4) Confusing the two regulation styles: cost-plus passes costs on to customers, price caps reward cost reduction.

Practice**SET A Check Your Understanding**

Answer each item. Show your work on calculations.

1. Explain why a firm with falling long-run average cost over the whole range of market demand is a natural monopoly. Give an example.
2. A natural monopoly has demand $P = 14 - Q$, $MC = \$2$ and $ATC = 2 + 24/Q$. Find its unregulated quantity, price and profit.
3. For the same firm, a regulator sets $P = MC$. Find the quantity, the loss, and the subsidy needed to keep the firm operating.
4. Compare cost-plus regulation and price-cap regulation in terms of the firm's incentive to reduce costs.
5. In the same market, antitrust authorities split the unregulated monopoly ($Q = 6$) into two equal firms. Compare average cost before and after, and say what this shows.
6. Why do many regulators choose fair-return ($P = ATC$) pricing rather than marginal-cost pricing?

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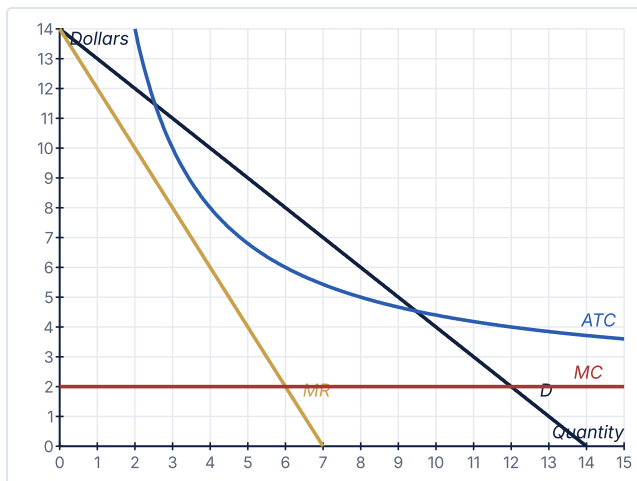
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A natural monopoly arises primarily because
- (A) a patent blocks entry
 - (B) the government prohibits competition
 - (C) the firm controls a scarce resource
 - (D) the firm advertises heavily
 - (E) economies of scale are large relative to market demand
8. The graph shows a natural monopoly ($D: P = 14 - Q$, $MC = 2$, $ATC = 2 + 24/Q$). If the regulator requires $P = MC$, the firm will



- (A) earn zero economic profit at $Q = 12$
 - (B) incur a total loss of \$24
 - (C) earn a profit of \$12 at $Q = 6$
 - (D) incur a total loss of \$12
 - (E) earn a profit of \$24 at $Q = 12$
9. A regulator sets a price cap for a utility for the next five years. Compared with cost-plus regulation, the main efficiency advantage of the cap is that the firm
- (A) is guaranteed a normal profit
 - (B) earns zero economic profit
 - (C) can keep profit from lowering its costs
 - (D) is protected from input price shocks
 - (E) will produce where $P = MC$
10. Which describes a weakness of cost-plus regulation?
- (A) It gives the firm little incentive to hold down costs
 - (B) It forces the firm to price below average cost
 - (C) It always produces a larger deadweight loss than no regulation
 - (D) It allows entry by competing firms
 - (E) It sets price equal to marginal cost
11. Compared with the unregulated monopoly outcome, average-cost (fair-return) pricing leads to
- (A) a higher price and lower quantity
 - (B) a price equal to marginal cost
 - (C) a lower price, higher quantity and zero economic profit
 - (D) a larger deadweight loss
 - (E) a subsidy paid by taxpayers
12. Which U.S. law targets mergers that substantially lessen competition and also bans price discrimination and tied sales?
- (A) The Sherman Act of 1890
 - (B) The Social Security Act
 - (C) The Federal Reserve Act
 - (D) The Taft-Hartley Act
 - (E) The Clayton Act of 1914

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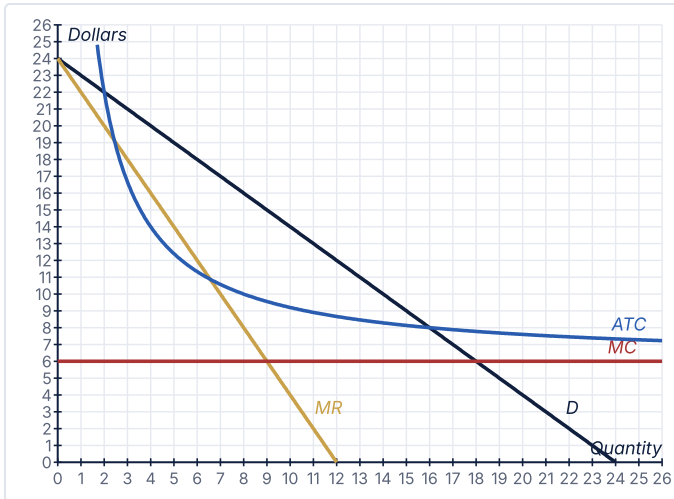
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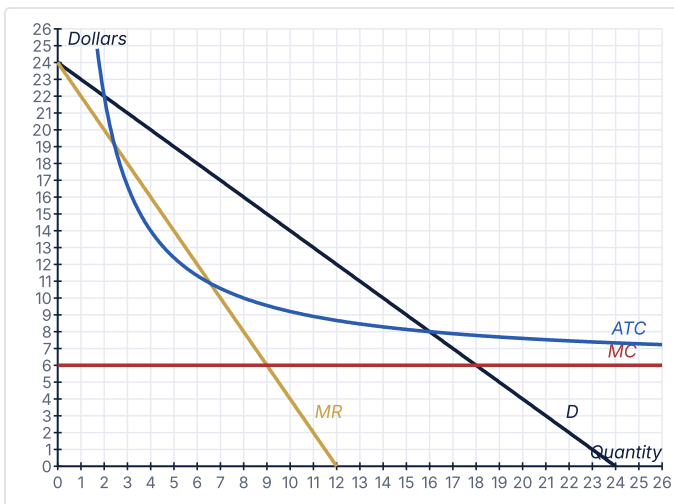
SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. A natural monopoly faces $D: P = 24 - Q$, $MC = \$6$ and $ATC = 6 + 32/Q$ (curves shown). (a) Find the unregulated quantity, price and profit. (b) Find the quantity and price if the regulator sets $P = MC$, and the lump-sum subsidy needed to keep the firm operating. (c) Find the quantity and price under average-cost pricing and the deadweight loss. (d) Which option would you recommend if taxpayer subsidies are politically impossible, and why?



14. Use the natural monopoly in the previous graph ($D: P = 24 - Q$, $MC = \$6$, $ATC = 6 + 32/Q$). (a) Antitrust authorities split the unregulated monopoly's output of 9 into two equal firms. Compare ATC before and after. (b) Instead, the regulator sets a price cap of \$8. Find the firm's output and profit. (c) The firm then cuts its fixed cost from \$32 to \$24. Find its new profit and explain what this shows about price-cap regulation.

**4.4 Monopolistic Competition**

Explain product differentiation, graph short-run and long-run equilibrium, and evaluate excess capacity and advertising.

Monopolistic competition is the most common market structure in everyday life: restaurants, hair salons, clothing brands and gyms. It combines a little monopoly power (each firm sells a distinct product) with the discipline of competition (many rivals and easy entry). Its long-run result is the key AP idea: zero economic profit, but inefficiency.

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Monopolistic competition: defining features

Many sellers, each with a small market share.

Differentiated products: close but not perfect substitutes (quality, style, location, brand).

Free or easy entry and exit.

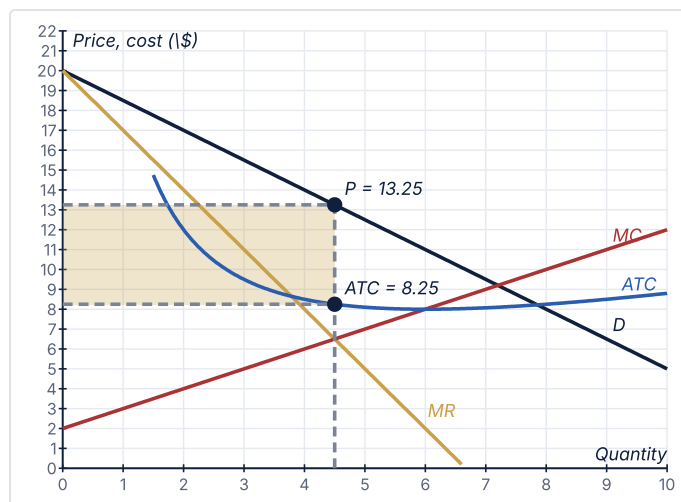
Each firm faces a downward-sloping demand curve, more elastic than a monopolist's because of the many substitutes. Firms are price makers and also compete on non-price features.

Product differentiation is what separates this market from perfect competition. Firms differentiate by physical features, location, service, and image created by advertising. Differentiation gives each firm a loyal following, so a price increase does not lose all its customers; but substitutes are close, so demand is fairly elastic.

Short run. The firm decides like a monopolist. It sets $MR = MC$ to find quantity, then reads the price off its own demand curve. Depending on where price sits relative to ATC, it earns a profit, breaks even or incurs a loss.

EXAMPLE 1: SHORT-RUN PROFIT

A firm has total cost $TC = 18 + 2Q + 0.5Q^2$, so $MC = 2 + Q$ and $ATC = 18/Q + 2 + 0.5Q$. Its demand is $P = 20 - 1.5Q$, so $MR = 20 - 3Q$. Find its short-run quantity, price and profit.



SOLUTION

$MR = MC$: $20 - 3Q = 2 + Q$, so $4Q = 18$ and $Q = 4.5$.

Price from demand: $P = 20 - 1.5(4.5) = \$13.25$.

$ATC = 18/4.5 + 2 + 2.25 = 4 + 2 + 2.25 = \$8.25$.

Profit = $(13.25 - 8.25) \times 4.5 = \$22.50$. Check: $TR = 59.625$, $TC = 18 + 9 + 10.125 = 37.125$, difference $\$22.50$. The shaded rectangle shows this profit.

Long run: entry erodes profit. The $\$22.50$ profit attracts new firms offering similar products. Each entrant takes some customers, so the demand curve facing every existing firm shifts LEFT and becomes more elastic (more substitutes). Entry continues until demand just touches ATC, where economic profit is zero. If instead firms are making losses, firms exit, demand for those that remain shifts right, and the loss disappears.

Long-run equilibrium (monopolistic competition)

$P = ATC$, so economic profit is zero.

Demand is tangent to ATC at the output where $MR = MC$.

$P > MC$ (not allocatively efficient). Output is below the minimum-ATC output (excess capacity), so ATC is not at its minimum (not productively efficient).

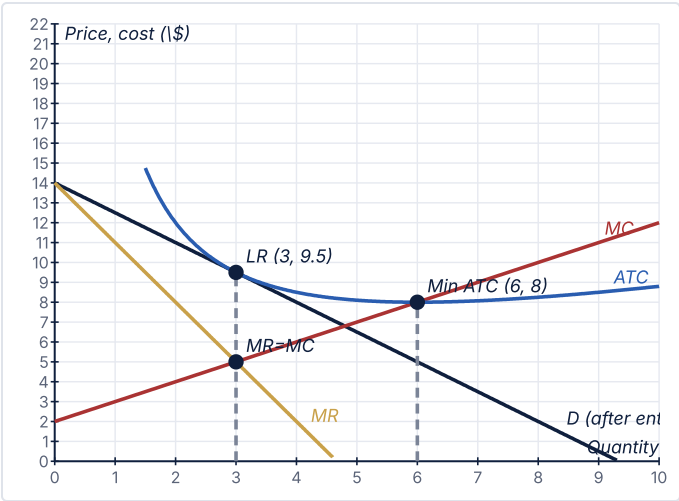
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EXAMPLE 2: LONG-RUN EQUILIBRIUM AND EXCESS CAPACITY

After entry, the firm in Example 1 faces $D = 14 - 1.5Q$ ($MR = 14 - 3Q$). Find the long-run quantity, price and profit, then compare with perfect competition.



SOLUTION

$MR = MC$: $14 - 3Q = 2 + Q$, so $Q = 3$. Then $P = 14 - 4.5 = \$9.50$.
ATC at 3 = $18/3 + 2 + 1.5 = \$9.50$. $P = ATC$, so economic profit is zero and entry stops.
The efficient scale is where ATC is lowest, which is where MC crosses ATC: $2 + Q = 18/Q + 2 + 0.5Q$ gives $Q = 6$ and $ATC = \$8$. The firm produces 3 units, so it has excess capacity of $6 - 3 = 3$ units.
A perfectly competitive firm with the same costs would produce 6 units at $P = MC = ATC = \$8$. The monopolistic competitor charges \$9.50 (above MC of \$5) and produces less.

	Perfect competition	Monopolistic competition	Monopoly
Sellers	Many	Many	One
Product	Identical	Differentiated	Unique
Entry	Free	Free	Blocked
Long-run profit	Zero	Zero	Positive possible
Price vs MC	$P = MC$	$P > MC$	$P > MC$
Productive efficiency	Yes (min ATC)	No (excess capacity)	No

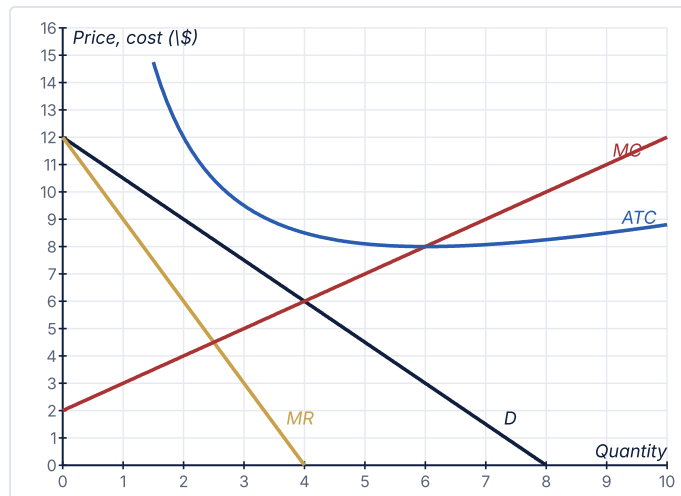
Advertising and differentiation. Advertising and branding try to shift the firm's demand to the right and make it less elastic, which supports a higher price and a short-run profit. In the long run rivals respond with their own campaigns and entry, so profit returns to zero while the firm's costs include the expense of advertising, raising ATC. Critics call this wasteful; defenders note that advertising provides information and that differentiation gives consumers variety they value. This variety is the main benefit offsetting the inefficiency.

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EXAMPLE 3: A SHORT-RUN LOSS

The same cost structure faces weaker demand: $P = 12 - 1.5Q$, $MR = 12 - 3Q$. Find the firm's best output and result, and say what happens in the long run.

**SOLUTION**

$MR = MC$: $12 - 3Q = 2 + Q$, so $Q = 2.5$ and $P = 12 - 3.75 = \$8.25$.

ATC at $2.5 = 7.2 + 2 + 1.25 = \$10.45$. Price is below ATC , so loss per unit = \$2.20 and total loss = \$5.50.

$AVC = 2 + 0.5Q = \$3.25$ at $Q = 2.5$, so price covers AVC and the firm keeps producing in the short run.

In the long run, firms exit, which shifts the remaining firms' demand to the right until $P = ATC$ and the loss is gone.

Common mistakes

(1) Calling long-run monopolistic competition efficient because profit is zero; zero profit does not mean $P = MC$ or minimum ATC . (2) Drawing the long-run demand curve crossing ATC ; it must be tangent to ATC at the $MR = MC$ quantity. (3) Forgetting entry shifts demand LEFT; exit shifts it right. (4) Saying the firm produces at the minimum of ATC ; it produces to the left of the minimum (excess capacity).

Practice**SET A Check Your Understanding**

Answer each item. Show your work on calculations.

- List four characteristics of monopolistic competition and give two real examples.
- A firm has $TC = 18 + 2Q + 0.5Q^2$ and demand $P = 20 - 2.5Q$. Find its profit-maximizing quantity, price and profit.
- Explain step by step how a short-run economic profit disappears in the long run.
- For the cost function above, minimum ATC occurs at $Q = 6$. If a firm's long-run output is 3, how much excess capacity does it have, and what does that imply about ATC ?
- Explain two ways successful advertising could affect a firm's demand curve, and the effect on the firm's price and profit in the short run.
- A firm in this market has demand $P = 8 - 1.5Q$, $MC = 2 + Q$ and $ATC = 18/Q + 2 + 0.5Q$. Find its output, price and result, and decide whether it shuts down.

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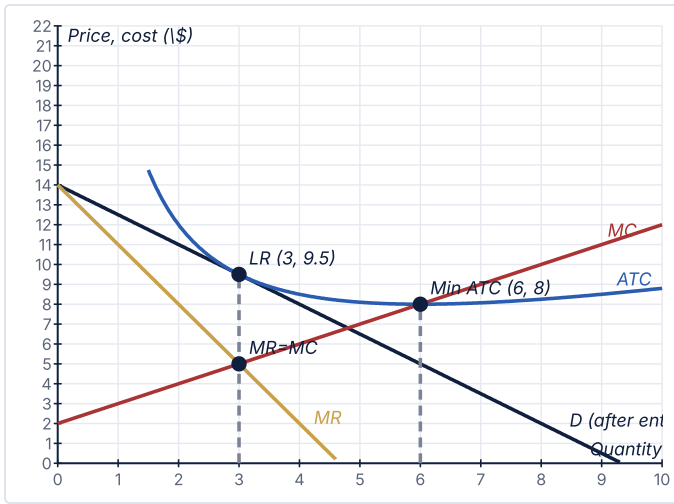
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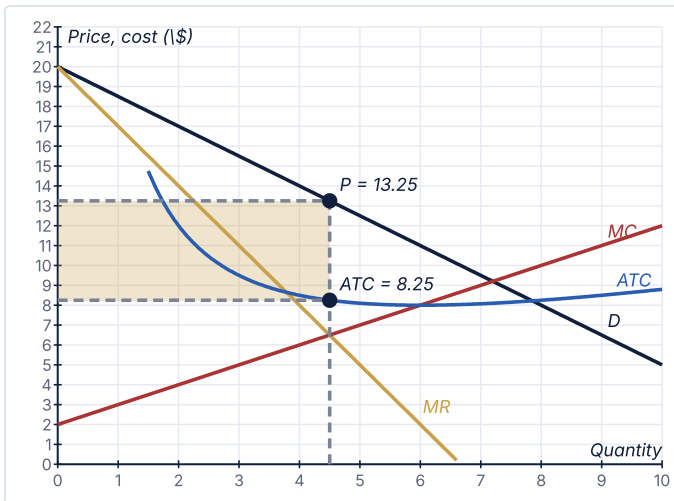
SET B Exam-Style Multiple Choice

Choose the best answer.

7. The graph shows a monopolistically competitive firm in long-run equilibrium (minimum ATC is at $Q = 6$). How much excess capacity does the firm have?



- (A) 0 units (B) 1.5 units (C) 3 units (D) 4.5 units (E) 6 units
8. The graph shows a monopolistically competitive firm in the short run. What is its economic profit?



- (A) \$ 5.00 (B) \$ 12.50 (C) \$ 37.13 (D) \$ 59.63 (E) \$ 22.50
9. When monopolistically competitive firms are earning positive economic profit, which will happen over time?
- (A) Entry occurs and each existing firm's demand shifts left
 (B) Entry occurs and each firm's demand shifts right
 (C) Exit occurs and demand shifts right
 (D) Firms raise price to increase profit further
 (E) Firms produce at the minimum of ATC
10. A successful advertising campaign for a monopolistically competitive firm will most likely, in the short run,
- (A) decrease demand by increasing the number of rivals
 (B) make demand more elastic
 (C) shift marginal cost down
 (D) make demand less elastic and shift it right
 (E) eliminate the possibility of entry

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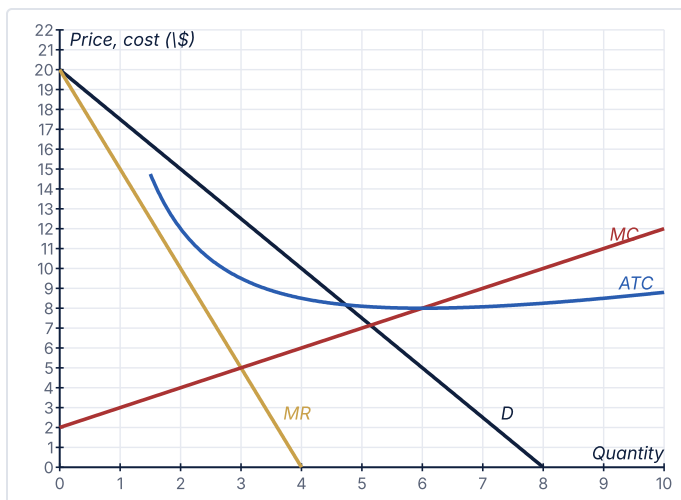
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11. A market has hundreds of restaurants, each with a different menu and location, and entry is easy. This market is best classified as
 (A) perfect competition (B) monopolistic competition (C) oligopoly
 (D) monopoly (E) natural monopoly
12. Compared with a perfectly competitive firm in long-run equilibrium, a monopolistically competitive firm has
 (A) lower price and lower average cost
 (B) higher output and lower price
 (C) a lower price but higher average cost
 (D) a larger positive profit
 (E) higher price, higher average cost and lower output

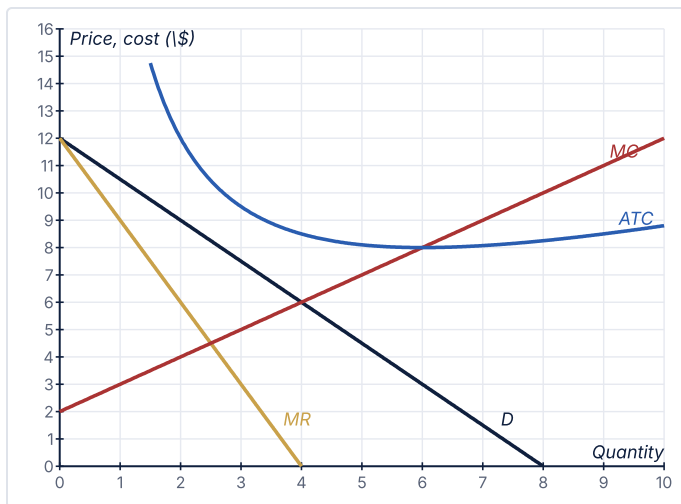
SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. A monopolistically competitive firm has demand $P = 20 - 2.5Q$, $MR = 20 - 5Q$, $MC = 2 + Q$ and $ATC = 18/Q + 2 + 0.5Q$ (curves shown). (a) Find the profit-maximizing quantity and price. (b) Calculate economic profit. (c) Explain what will happen in the market over time, and how this firm's demand curve will change. (d) Describe the firm's price, quantity and profit in the new long-run equilibrium and whether it is allocatively and productively efficient.



14. A firm faces demand $P = 12 - 1.5Q$, $MR = 12 - 3Q$, $MC = 2 + Q$ and $ATC = 18/Q + 2 + 0.5Q$ (curves shown). (a) Find the profit-maximizing quantity, price and economic profit or loss. (b) Should the firm produce or shut down in the short run? Use $AVC = 2 + 0.5Q$. (c) Explain how the market adjusts in the long run. (d) The firm starts a campaign that shifts its demand right. Explain why the long-run benefit is limited.



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4.5 Oligopoly and the Kinked Demand Curve

Describe oligopoly, measure concentration, explain why cartels form and fail, and analyze the kinked demand curve.

An **oligopoly** is a market dominated by a few large firms. Examples include commercial aircraft, wireless service, breakfast cereal and soft drinks. What makes oligopoly different from every other structure is **interdependence**: each firm's best choice of price or output depends on how its few rivals respond. There is no single oligopoly graph; economists use models of collusion, kinked demand and games (next lesson).

Oligopoly: defining features

A few firms with large market shares.

Products may be identical (steel, oil) or differentiated (cars, cereal).

Significant barriers to entry: economies of scale, brand loyalty, control of inputs, patents.

Mutual interdependence: firms must anticipate rivals' reactions.

Measuring concentration. The **four-firm concentration ratio (CR4)** adds the market shares of the four largest firms. The **Herfindahl-Hirschman Index (HHI)** squares each firm's share (in percent) and adds them, so large firms count more. A monopoly has $HHI = 10,000$. Higher values mean less competition. Antitrust agencies examine mergers that would produce a high or sharply rising HHI.

EXAMPLE 1: CR4 AND HHI

Seven firms have market shares of 30%, 25%, 20%, 10%, 5%, 5% and 5%. (a) Find CR4 and HHI. (b) The 10% and 5% firms propose to merge. Find the new HHI.

SOLUTION

(a) $CR4 = 30 + 25 + 20 + 10 = 85$. $HHI = 30^2 + 25^2 + 20^2 + 10^2 + 5^2 + 5^2 + 5^2 = 900 + 625 + 400 + 100 + 25 + 25 + 25 = 2,100$.

(b) After the merger the shares are 30, 25, 20, 15, 5, 5. $HHI = 900 + 625 + 400 + 225 + 25 + 25 = 2,200$.

The HHI rises by 100, which equals $2 \times 10 \times 5$. Regulators watch both the level and the increase.

Collusion and cartels. Oligopolists would earn more if they acted like one monopoly: restrict total output, raise the price and split the profit. A formal agreement to do this is a **cartel**; an unspoken understanding is **tacit collusion**. Price leadership, where one firm announces a price and others follow, is a common tacit method. Explicit collusion is illegal in the United States under the Sherman Act, though international groups such as OPEC operate openly because no court enforces their agreements.

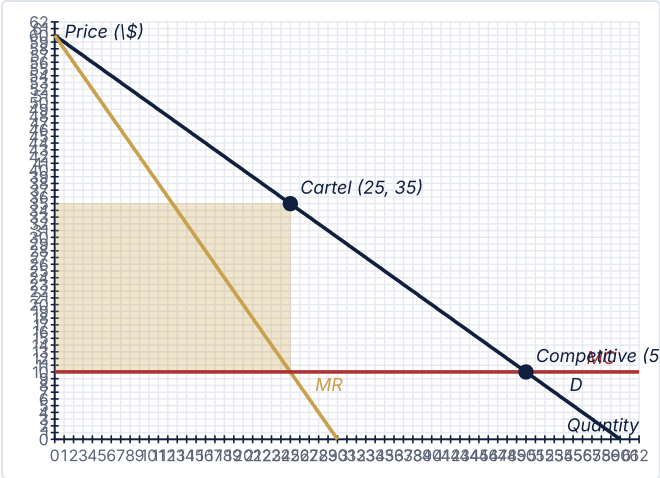
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EXAMPLE 2: CARTEL VERSUS COMPETITION

Two identical firms face market demand $P = 60 - Q$, with $MC = \$10$ and no fixed cost. (a) Find price, output and profit if they form a cartel and split output equally. (b) Find the competitive outcome. (c) Show why a member is tempted to cheat.



SOLUTION

- (a) The cartel acts as a monopoly: $MR = 60 - 2Q = 10$ gives $Q = 25$ and $P = 60 - 25 = \$35$. Profit = $(35 - 10) \times 25 = \$625$. Each firm produces 12.5 and earns \$312.50.
- (b) Competition would set $P = MC = \$10$, giving $Q = 50$ and zero profit.
- (c) Suppose firm A secretly raises output to 15 while B stays at 12.5. Total output is 27.5, so $P = \$32.50$. A earns $22.50 \times 15 = \$337.50$, more than \$312.50, and B earns $22.50 \times 12.5 = \$281.25$, less. Each firm has this temptation, so the cartel tends to break down toward lower prices.

Outcome	Output	Price	Total profit
Cartel (monopoly outcome)	25	\$35	\$625
Cartel with one cheater	27.5	\$32.50	\$618.75
Perfect competition	50	\$10	\$0

Why cartels are unstable

- Each member earns more by secretly producing extra while others restrict output.
- If everyone cheats, price falls toward the competitive level and profits disappear.
- Tools that help hold collusion together: repeated dealing, ability to detect cheating, small number of firms, punishment threats.

The kinked demand curve. One model explains why oligopoly prices are often sticky. A firm believes that if it RAISES its price rivals will not follow, so it loses many customers (demand above the kink is elastic). If it CUTS its price rivals will match, so it gains few customers (demand below the kink is inelastic). The demand curve therefore has a kink at the current price. The marginal revenue curve has a vertical gap beneath the kink, because MR is computed separately for each segment. As long as marginal cost passes through that gap, the profit-maximizing output and price do not change.

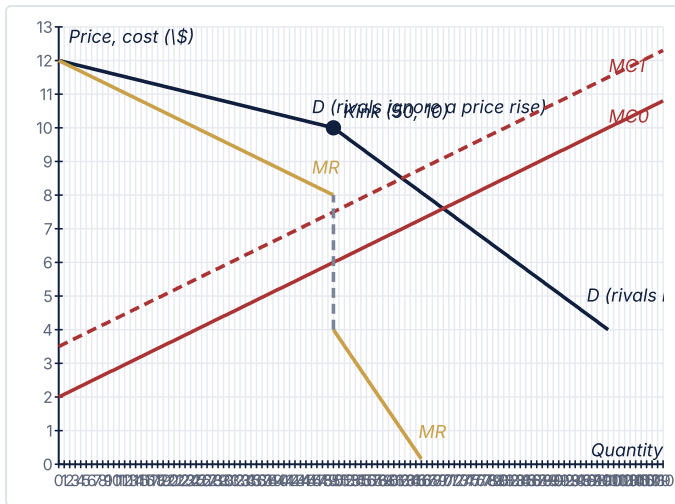
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EXAMPLE 3: COST CHANGES INSIDE THE GAP

In the graph, demand has a kink at $Q = 50$, $P = \$10$. Above the kink $MR = 12 - 0.08Q$; below it $MR = 16 - 0.24Q$. $MC_0 = 2 + 0.08Q$. (a) Find the MR gap at $Q = 50$. (b) Find MC at $Q = 50$ and the profit-maximizing price. (c) MC rises to $MC_1 = 3.5 + 0.08Q$. What happens?

**SOLUTION**

- (a) Upper MR at 50 = $12 - 4 = \$8$. Lower MR at 50 = $16 - 12 = \$4$. The gap runs from \$4 to \$8.
- (b) MC_0 at 50 = $2 + 4 = \$6$, which lies inside the gap. $MR > MC$ for units up to 50 and $MR < MC$ beyond 50, so $Q = 50$ and $P = \$10$.
- (c) MC_1 at 50 = $3.5 + 4 = \$7.50$, still between \$4 and \$8. Output and price stay at 50 and \$10 despite a cost increase. Only a cost change large enough to leave the gap would move the price.

Non-price competition. Because price cutting invites retaliation, oligopolists often compete with advertising, product design, quality, warranties and loyalty programs. These can raise costs but avoid price wars.

Feature	Perfect comp.	Monopolistic comp.	Oligopoly	Monopoly
Number of firms	Many	Many	Few	One
Product	Identical	Differentiated	Identical or differentiated	Unique
Entry barriers	None	Low	High	Very high
Price control	None	Some	Considerable, interdependent	Considerable
Typical LR profit	Zero	Zero	Can be positive	Can be positive

Common mistakes

- (1) Assuming the kinked-demand model explains how the price was set; it only explains why price is sticky once set.
- (2) Drawing the MR gap in the wrong place: it is directly below the kink. (3) Confusing CR4 with HHI; HHI squares market shares and uses all firms. (4) Saying a cartel is stable because it maximizes joint profit; each member has an individual incentive to cheat.

Practice**SET A Check Your Understanding**

Answer each item. Show your work on calculations.

1. Name four characteristics of an oligopoly and explain what 'interdependence' means.
2. Market shares are 40%, 20%, 15%, 10%, 5%, 5% and 5%. Calculate CR4 and HHI.
3. Two firms face $P = 60 - Q$ with $MC = \$10$ and no fixed cost. Find the cartel quantity, price and profit, and each firm's profit if they split equally.

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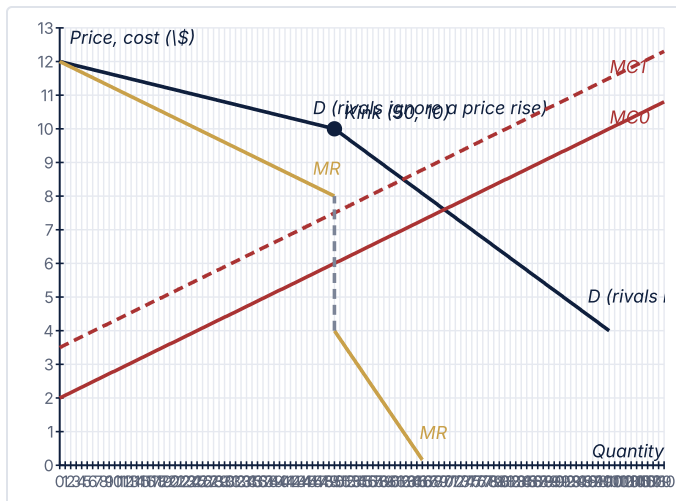
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4. Explain why the demand curve of an oligopolist in the kinked-demand model is elastic above the kink and inelastic below it.
5. Give two examples of non-price competition and explain why oligopolists prefer it to price cutting.
6. Explain why cartels tend to be unstable even though members would earn more by cooperating.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which of the following best describes an oligopoly?
 - (A) Many sellers of identical products with free entry
 - (B) One seller with no close substitutes
 - (C) Many sellers with differentiated products and free entry
 - (D) A market with no barriers to entry
 - (E) A few large firms whose decisions depend on rivals' actions
8. Four firms in an industry have market shares of 50%, 30%, 10% and 10%. What is the HHI?
 - (A) 3,600
 - (B) 10,000
 - (C) 1,000
 - (D) 2,500
 - (E) 100
9. In the kinked-demand graph (kink at $Q = 50$, $P = \$10$, MR gap from \$4 to \$8), MC rises from \$6 to \$7 at $Q = 50$. The firm will



- (A) raise price and cut output
 - (B) cut price and raise output
 - (C) raise price but keep output
 - (D) raise output and keep the price at \$10
 - (E) keep price at \$10 and output at 50
10. The kinked-demand model assumes that rival firms will
 - (A) match both price increases and price decreases
 - (B) ignore both price increases and price decreases
 - (C) ignore price increases and match price decreases
 - (D) match price increases and ignore price decreases
 - (E) always undercut the firm's price
11. Which factor makes a cartel agreement most difficult to maintain?
 - (A) The firms are few in number
 - (B) Each member can increase profit by secretly producing more than its quota
 - (C) Demand for the product is inelastic
 - (D) The firms produce identical products
 - (E) Entry is blocked

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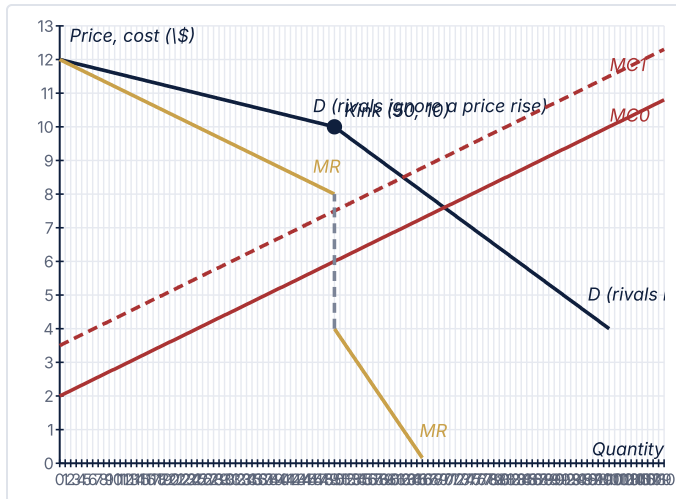
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12. Two of the four largest firms in an industry merge. Which measure will necessarily rise?
- (A) The number of firms in the market
 - (B) The HHI
 - (C) The price elasticity of demand
 - (D) The four-firm concentration ratio only if the merging firms were outside the top four
 - (E) Total market output

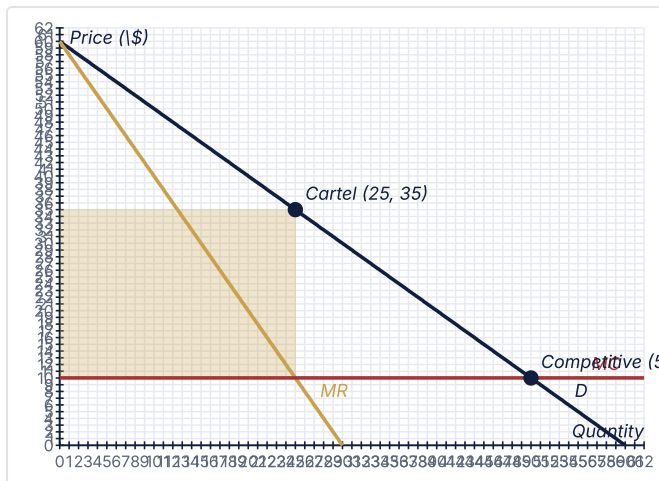
SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. An oligopolist's demand has a kink at $Q = 50$ and $P = \$10$ (curves shown; MC_0 passes through the vertical gap in MR at $Q = 50$). (a) Explain why demand is more elastic above the kink than below it. (b) Identify the profit-maximizing price and quantity and explain using MR and MC . (c) Explain what happens to price and quantity if MC shifts up from MC_0 to MC_1 as shown. (d) State one limitation of this model.



14. Two identical firms form a cartel in a market with demand $P = 60 - Q$ and constant $MC = \$10$ (curves shown, no fixed cost). (a) Find the cartel's price, total output and total profit, and each firm's profit if they split output equally. (b) Find the competitive price and quantity and compare total profit. (c) If one firm secretly increases output from 12.5 to 15 while the other keeps 12.5, calculate each firm's profit. (d) Explain what this implies about the long-run stability of the cartel and why a U.S. firm could face legal risk.



4.6 Game Theory

Read payoff matrices, find dominant strategies and Nash equilibria, and apply the prisoner's dilemma to pricing and advertising. When only a few firms compete, each must think about what the others will do. **Game theory** is the study of strategic decision making: situations where the payoff to each decision maker depends on the choices of the others. It is the main tool for analyzing oligopoly on the AP exam. The key skill is reading a **payoff matrix** and finding the outcome the players will actually reach.

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Game theory vocabulary

Players: the decision makers (firms). Strategies: the actions available to each.

Payoff matrix: a table showing each player's payoff (profit) for every combination of strategies. In each cell, the first number is the row player's payoff and the second is the column player's.

Dominant strategy: a strategy that gives a player the higher payoff no matter what the other player does.

Nash equilibrium: an outcome in which each player's strategy is the best response to the other's, so neither can gain by changing strategy alone.

How to find a Nash equilibrium. Use best responses. Fix the column player's choice and see which row the row player prefers; then fix the row player's choice and see which column the column player prefers. A cell where both are best responses is a Nash equilibrium. A game can have no dominant strategy, one Nash equilibrium, or several.

- 1 **Check for dominant strategies** Compare a player's two payoffs column by column (or row by row). If one strategy is better against every choice of the rival, it is dominant.
- 2 **Find each player's best response** For each possible rival move, circle the best payoff for the player. Do this for both players.
- 3 **Locate the cell with both circles** That cell is a Nash equilibrium. Verify that neither player would switch.
- 4 **Compare with the cooperative cell** Ask whether another cell makes both players better off. If so, the game is a prisoner's dilemma.

EXAMPLE 1: A PRICING PRISONER'S DILEMMA

Two firms each choose a High or Low price. Payoffs are profits in millions of dollars (A first, B second). Find each firm's dominant strategy, the Nash equilibrium, and whether the firms could do better.

	Firm B: High price	Firm B: Low price
Firm A: High price	A: 10, B: 10	A: 4, B: 14
Firm A: Low price	A: 14, B: 4	A: 6, B: 6

SOLUTION

Firm A: if B charges High, A gets 10 from High but 14 from Low, so Low is better. If B charges Low, A gets 4 from High but 6 from Low, so Low is better again. Low is dominant for A.

Firm B has the same payoffs by symmetry, so Low is also dominant for B.

The Nash equilibrium is (Low, Low) with payoffs 6 and 6.

If both charged High they would each earn 10. Both are worse off at the equilibrium than at the cooperative outcome, which is the prisoner's dilemma: each firm's individual incentive pushes both to a result worse for each.

The prisoner's dilemma in oligopoly

Cooperation (hold the price high, restrict output) gives the best joint payoff.

Each firm has an incentive to cheat (cut price, raise output), so the one-time game ends at the lower-payoff cell.

Real-world forms: price wars, excess advertising, cartel cheating (OPEC quotas).

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EXAMPLE 2: NO DOMINANT STRATEGY, TWO EQUILIBRIA

Two rivals each choose Standard 1 or Standard 2 for a new device. Payoffs are shown (A first, B second). Find the Nash equilibria.

	Firm B: Standard 1	Firm B: Standard 2
Firm A: Standard 1	A: 6, B: 6	A: 0, B: 0
Firm A: Standard 2	A: 0, B: 0	A: 4, B: 4

SOLUTION

Firm A: if B picks Standard 1, A gets 6 from Standard 1 and 0 from Standard 2, so Standard 1. If B picks Standard 2, A gets 0 from Standard 1 and 4 from Standard 2, so Standard 2. A has no dominant strategy; the best response depends on B. B is the same. (Standard 1, Standard 1) is a Nash equilibrium because neither firm gains by switching alone (switching gives 0). (Standard 2, Standard 2) is also a Nash equilibrium for the same reason.

So there are two Nash equilibria. The first pays more (6, 6) than the second (4, 4), but the game by itself does not say which will occur; the firms need to coordinate.

Concept	Meaning	How it appears
Dominant strategy	Best choice regardless of rival	One player's row (or column) beats the other in every case
Nash equilibrium	No one gains by switching alone	Both players' best responses meet in one cell
Prisoner's dilemma	Dominant strategies lead to a worse outcome for both	Equilibrium cell is worse for both than another cell
Repeated game	Same game played many times	Threat of punishment can support cooperation

Repeated games. In a one-time game, cheating on a collusive agreement is the dominant strategy. If the same firms meet period after period, a firm that cheats risks retaliation. A simple strategy is **tit-for-tat**: cooperate at first, and then copy whatever the rival did last period. Another is a trigger strategy: cooperate until the rival cheats once, then punish forever by charging the low price. Cooperation can be a Nash equilibrium of the repeated game if the firms expect to compete long enough that the future losses from punishment exceed the one-time gain from cheating. Cooperation unravels if the game has a known last period, since cheating in that period cannot be punished.

EXAMPLE 3: IS CHEATING WORTH IT?

Use the pricing game in Example 1. Suppose both firms hold High prices. If one cheats it earns 14 once, and then both charge Low (6 each) in every later period. Compare three periods of cooperating with three periods that begin with cheating.

SOLUTION

Cooperating for three periods: $10 + 10 + 10 = 30$.

Cheating in period 1: $14 + 6 + 6 = 26$.

Cooperation pays more ($30 > 26$). The gain from cheating is 4 once ($14 - 10$), but the loss is 4 in each later period ($10 - 6$). Over two periods the totals are equal at 20, and cooperation wins whenever more than two periods are expected.

If the firms knew period 3 was the last, each would cheat in period 3, and by working backward, in all periods.

Applications. Game theory explains price wars among airlines and gas stations, escalating advertising budgets in soft drinks, quota cheating in cartels, and decisions to enter a market. An incumbent that threatens a price war to keep out a rival must make the threat **credible**; if fighting hurts the incumbent more than letting the entrant in, the rival will ignore the threat and enter.

Common mistakes

(1) Reading the payoffs in the wrong order: the first number belongs to the row player. (2) Calling the highest-payoff cell the equilibrium; the Nash equilibrium is where best responses meet. (3) Assuming a dominant strategy exists in every game. (4) Forgetting the cooperative outcome in a repeated game is only an equilibrium if players are patient and the game has no known end.

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Practice

SET A Check Your Understanding

Answer each item. Show your work on calculations.

1. Define dominant strategy and Nash equilibrium, and explain how they differ.
2. Two firms choose whether to advertise. Payoffs are profits (A first, B second). Find each firm's dominant strategy and the Nash equilibrium, and say whether this is a prisoner's dilemma.

	Firm B: Advertise	Firm B: Don't advertise
Firm A: Advertise	A: 3, B: 3	A: 7, B: 1
Firm A: Don't advertise	A: 1, B: 7	A: 5, B: 5

3. Find all Nash equilibria in the game below and say whether either firm has a dominant strategy.

	Firm B: Left	Firm B: Right
Firm A: Up	A: 3, B: 2	A: 1, B: 1
Firm A: Down	A: 0, B: 0	A: 2, B: 3

4. In the game below, find any dominant strategy and the Nash equilibrium.

	Firm B: Left	Firm B: Right
Firm A: Top	A: 4, B: 3	A: 2, B: 2
Firm A: Bottom	A: 3, B: 1	A: 1, B: 4

5. In a repeated pricing game, both firms earn 10 when they hold high prices. Cheating earns 14 once, after which both earn 6 each period. Compare the total over four periods from cooperating with cheating in period 1.
6. Explain why a cartel agreement among oligopolists is difficult to sustain in a one-time game, using the terms dominant strategy and prisoner's dilemma.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. A Nash equilibrium is a situation in which
 - (A) each player's payoff is as large as possible
 - (B) no player can improve its payoff by changing its own strategy, given the others' strategies
 - (C) every player has a dominant strategy
 - (D) all players cooperate
 - (E) the total payoff of all players is maximized
8. Two firms choose a large or small plant. How many Nash equilibria does the game have?

	Firm B: Large plant	Firm B: Small plant
Firm A: Large plant	A: -2, B: -2	A: 6, B: 2
Firm A: Small plant	A: 2, B: 6	A: 3, B: 3

- (A) Zero
 - (B) One
 - (C) Two
 - (D) Three
 - (E) Four
9. A dominant strategy is one that
 - (A) gives the highest total payoff to both players
 - (B) is chosen by the larger firm
 - (C) is the best response to any rival strategy
 - (D) is part of every Nash equilibrium of a game
 - (E) maximizes the rival's payoff

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10. Two oligopolists repeatedly interact over an indefinite future. Cooperation on a high price can be sustained mainly because
- (A) each firm's dominant strategy is to hold the price high
 - (B) the threat of future retaliation outweighs the one-time gain from cheating
 - (C) the government enforces the agreement
 - (D) each firm earns more by cutting price
 - (E) the game has a known final period
11. An entrant chooses Enter or Stay out and an incumbent chooses Fight or Accommodate. Payoffs are shown (entrant first). What is the Nash equilibrium?

	Incumbent: Fight	Incumbent: Accommodate
Entrant: Enter	Entrant: -3, Inc: 2	Entrant: 4, Inc: 4
Entrant: Stay out	Entrant: 0, Inc: 6	Entrant: 0, Inc: 7

- (A) Stay out, Fight
 - (B) Enter, Fight
 - (C) Stay out, Accommodate
 - (D) Enter, Accommodate
 - (E) No Nash equilibrium exists
12. In a one-time oligopoly pricing game, both firms charge low prices and each earns less than if both had charged high prices. This outcome illustrates
- (A) a cartel
 - (B) a dominant strategy equilibrium that is also a prisoner's dilemma
 - (C) price discrimination
 - (D) a kinked demand curve
 - (E) a coordination game with two equilibria

SET C Apply and Extend

Answer in complete sentences and show all work. Sketch graphs on paper as needed.

13. Two soft drink firms decide whether to run a large ad campaign. Profits (in millions) are below, with Firm A's profit first. (a) Identify each firm's dominant strategy, if any. (b) State the Nash equilibrium and each firm's profit. (c) Explain why this is a prisoner's dilemma. (d) Explain how repeated interaction might lead the firms to avoid advertising, and what would limit this.

	Firm B: Advertise	Firm B: Don't advertise
Firm A: Advertise	A: 3, B: 3	A: 7, B: 1
Firm A: Don't advertise	A: 1, B: 7	A: 5, B: 5

14. An incumbent monopolist considers whether a new firm will enter. Payoffs are below (entrant first, incumbent second, in millions). (a) Find the Nash equilibrium. (b) The incumbent threatens to fight any entry. Explain why the threat is not credible. (c) The incumbent now builds extra capacity, which changes its payoff from Fight when entry occurs to 5 (second table). Find the new Nash equilibrium and explain the effect.

Second table (after the capacity expansion): Enter/Fight gives Entrant -3 and Incumbent 5; Enter/Accommodate gives 4 and 4; Stay out gives 0 and 8 (Fight) or 0 and 7 (Accommodate).

	Incumbent: Fight	Incumbent: Accommodate
Entrant: Enter	Entrant: -3, Inc: 2	Entrant: 4, Inc: 4
Entrant: Stay out	Entrant: 0, Inc: 6	Entrant: 0, Inc: 7

4.7 Multiple-Choice Practice: Imperfect Competition

Choose the best answer for each question. Set A checks core concepts, Set B uses graphs, tables and calculations, and Set C is exam-level stretch. Each answer explains why the correct choice is right and why the best distractor fails.

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SET A Core Concepts

Choose the best answer.

- For a single-price monopoly, marginal revenue is less than price because
 - the firm must lower the price on all units sold in order to sell one more unit
 - marginal cost rises as output increases
 - the firm faces a perfectly elastic demand curve
 - the firm earns an economic profit
 - consumers have inelastic demand at every price
- A natural monopoly arises primarily when
 - a patent protects an invention for 20 years
 - the government forbids competition
 - economies of scale are large relative to the size of the market
 - a firm owns the only source of a key input
 - firms advertise heavily
- Which of the following is necessary for a firm to practice price discrimination?
 - The firm must be a price taker
 - Marginal cost must be zero
 - The product must be differentiated from rivals' products
 - Demand must be perfectly elastic
 - Buyers who pay the low price must not be able to resell to buyers charged the high price
- Which describes monopolistic competition?
 - A few firms with high barriers to entry
 - Many firms sell differentiated products and entry is easy
 - Many firms sell identical products and take the market price
 - One firm sells a product with no substitutes
 - Firms have no control over price
- The key feature of oligopoly that distinguishes it from the other market structures is that
 - each firm is a price taker
 - entry is easy
 - firms always earn zero profit in the long run
 - each firm's best decision depends on the expected reactions of its rivals
 - each firm sells an identical product
- In game theory, a dominant strategy is one that
 - maximizes the combined payoff of both players
 - is chosen by the larger firm
 - yields the highest payoff to a player whatever strategy the rival chooses
 - yields the highest payoff only if the rival cooperates
 - guarantees that no player wants to change
- In long-run equilibrium, a monopolistically competitive firm earns
 - zero economic profit and charges a price above marginal cost
 - positive economic profit because its product is differentiated
 - zero economic profit and charges a price equal to marginal cost
 - negative economic profit because of excess capacity
 - zero economic profit and produces at minimum ATC

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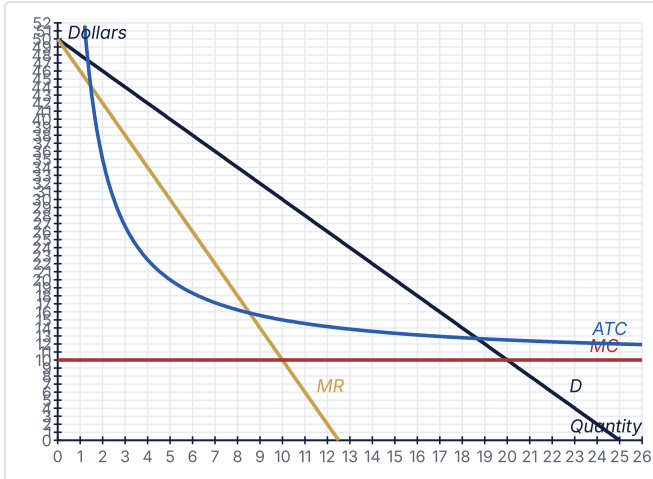
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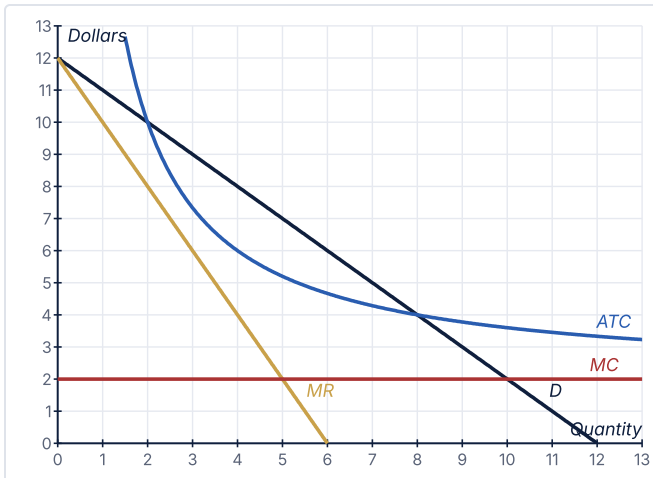
SET B Applications and Data

Choose the best answer. Use the graph or table when one is given.

8. The graph shows a monopoly. What is the deadweight loss relative to perfect competition?



- (A) \$50 (B) \$100 (C) \$150 (D) \$200 (E) \$400
9. The graph shows a natural monopoly ($D: P = 12 - Q$, $MC = 2$, $ATC = 2 + 16/Q$). If the regulator requires price to equal average total cost, quantity will be



- (A) 2 (B) 5 (C) 6 (D) 8 (E) 10
10. A firm with constant $MC = \$6$ and no fixed cost faces demand $P = 18 - Q$. If it can practice perfect price discrimination, its profit is
- (A) \$36 (B) \$54 (C) \$108 (D) \$144 (E) \$72
11. Four firms have the market shares shown. What is the HHI of this industry?

Firm	Market share
Firm 1	45%
Firm 2	25%
Firm 3	20%
Firm 4	10%

- (A) 100 (B) 1,000 (C) 3,150 (D) 3,600 (E) 10,000

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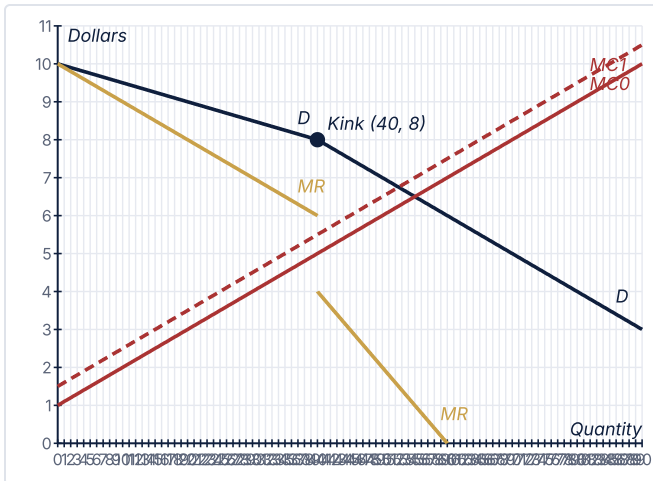
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12. The payoff matrix shows profits for two firms (A first). What is the Nash equilibrium?

	Firm B: Hold price	Firm B: Cut price
Firm A: Hold price	A: 6, B: 6	A: 2, B: 9
Firm A: Cut price	A: 9, B: 2	A: 3, B: 3

- (A) Both firms cut price and each earns 3
 (B) Both firms hold price and each earns 6
 (C) Firm A cuts price and Firm B holds price
 (D) Firm A holds price and Firm B cuts price
 (E) There is no Nash equilibrium
13. The graph shows an oligopolist with a kinked demand curve (kink at $Q = 40$, MR gap from \$4 to \$6). MC shifts up from MC_0 to MC_1 , where $MC_1 = 5.5$ at $Q = 40$. The firm will



- (A) raise price and cut output
 (B) keep price and output unchanged
 (C) cut price and raise output
 (D) keep price unchanged but cut output
 (E) raise price and keep output unchanged
14. A monopoly faces $D: P = 40 - 2Q$ and constant $MC = \$10$ with no fixed cost. A regulator sets a price ceiling of \$20. The firm's output will be
- (A) 5 (B) 7.5 (C) 8 (D) 10 (E) 15

SET C Exam-Level Stretch

Choose the best answer.

15. A monopoly has demand $P = 60 - 2Q$ and constant $MC = \$12$, so its unregulated price is \$36. The government imposes a per-unit tax of \$8 on the firm. The new profit-maximizing price is
- (A) \$36 (B) \$38 (C) \$44 (D) \$48 (E) \$40
16. Demand for a product sold by many differentiated firms rises, and each firm earns a short-run economic profit. What happens as the market adjusts?
- (A) Firms keep their profits because their products are differentiated
 (B) Entry shifts each firm's demand curve to the right
 (C) Entry shifts each existing firm's demand curve to the left until economic profit is zero
 (D) Existing firms expand output to minimum ATC
 (E) Price rises permanently because demand is higher
17. Two firms play a repeated pricing game. Holding the price high earns each firm 8 per period. A firm that cheats earns 12 once, and then both earn 5 per period. What is the smallest number of periods for which cooperating throughout beats cheating in the first period?
- (A) 3 (B) 1 (C) 2 (D) 4 (E) 5
18. Two firms form a cartel facing market demand $P = 100 - Q$ with constant $MC = \$20$ and no fixed cost. Joint profit is maximized at
- (A) \$800 (B) \$1,200 (C) \$2,400 (D) \$3,200 (E) \$1,600

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19. A firm has $MC = \$12$ and sells to two groups. At the profit-maximizing prices, group A's price elasticity of demand (absolute value) is 3 and group B's is 1.5. Using $MR = P(1 - 1/|E|)$, what is the price charged to group B?
- (A) \$18 (B) \$36 (C) \$24 (D) \$48 (E) \$12
20. Which market structure has long-run equilibrium with zero economic profit but price above marginal cost?
- (A) Perfect competition (B) A monopoly protected by barriers to entry
(C) An unregulated natural monopoly (D) Monopolistic competition
(E) A cartel-based oligopoly

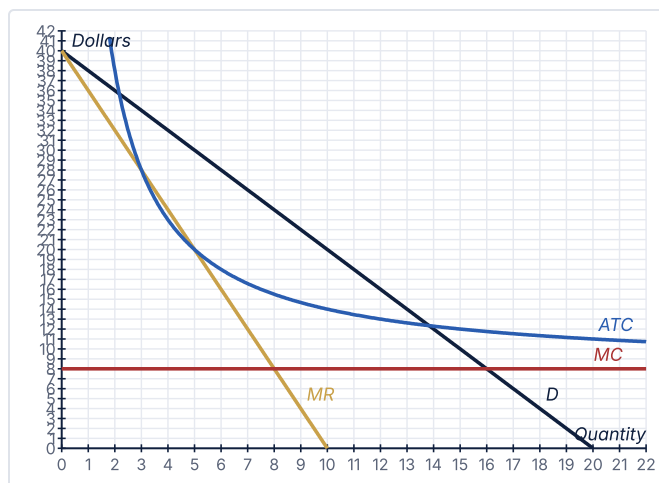
4.8 Free-Response Practice: Imperfect Competition

Each question has 2 to 4 parts. Model answers list the scoring points, usually 1 point for a correct number or statement and 1 point for the explanation. Show every calculation, label graphs fully, and always read price from the demand curve.

QUESTION 1 Monopoly graph and calculations

A monopoly sells a product with market demand $P = 40 - 2Q$, so its marginal revenue is $MR = 40 - 4Q$. Its marginal cost is constant at \$8 per unit and its fixed cost is \$60, so $ATC = 8 + 60/Q$. The curves are shown in part (a).

1. (a) Find the profit-maximizing quantity and price, and explain how the firm decides on each.



2. (b) Calculate the firm's economic profit.
3. (c) Calculate the deadweight loss caused by the monopoly relative to perfect competition, and explain why it arises.
4. (d) Fixed cost rises by \$20. Explain and calculate the effect on the firm's price, quantity and profit.

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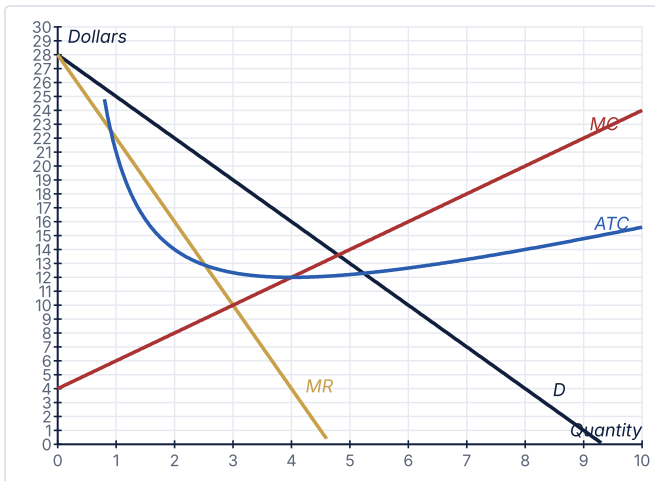
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QUESTION 2 Monopolistic competition

A local coffee shop is one of many shops in a city that sell differentiated coffee drinks, and entry is easy. The shop's demand is $P = 28 - 3Q$ ($MR = 28 - 6Q$), its $MC = 4 + 2Q$, and $ATC = 16/Q + 4 + Q$. The minimum point of ATC occurs at $Q = 4$ where $ATC = \$12$. Curves are shown in part (a).

5. (a) Find the shop's profit-maximizing quantity and price, and its economic profit in the short run.



6. (b) Explain what will happen to the shop's demand curve and economic profit in the long run, and why.
 7. (c) In long-run equilibrium the shop's demand is $P = 20 - 3Q$. Find its quantity, price and excess capacity.
 8. (d) Is the long-run equilibrium allocatively efficient? Productively efficient? Explain, and state one benefit of monopolistic competition that partly offsets the inefficiency.

QUESTION 3 Game theory and oligopoly

Two airlines serving the same route each choose a High fare or a Low fare. The payoff matrix shows each airline's profit (in millions of dollars), with Airline A's profit listed first.

9. (a) Does either airline have a dominant strategy? Identify it and explain.

	Airline B: High fare	Airline B: Low fare
Airline A: High fare	A: 40, B: 40	A: 15, B: 55
Airline A: Low fare	A: 55, B: 15	A: 25, B: 25

10. (b) Identify the Nash equilibrium and the profit each airline earns.
 11. (c) Explain why the airlines do not end up in the outcome that gives them the highest combined profit, and name the type of game this represents.
 12. (d) The airlines now play this game repeatedly for an indefinite number of years. Cheating from (High, High) earns 55 once and then 25 in every later year. Compare three years of cooperating with three years that begin with cheating, and state what the result implies.

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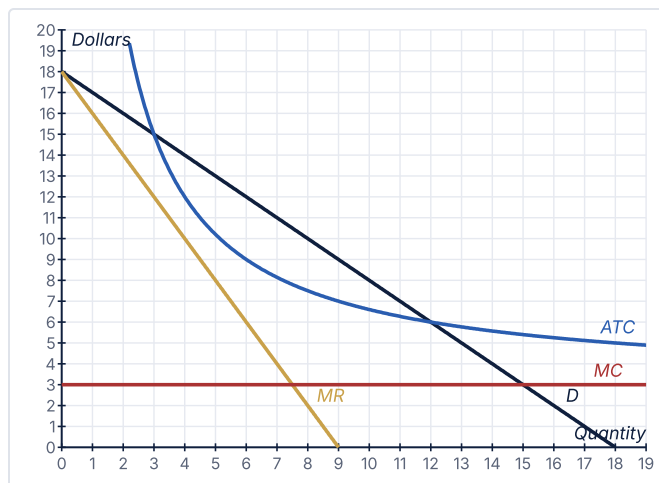
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QUESTION 4 Natural monopoly regulation

A local gas distributor is a natural monopoly. Market demand is $P = 18 - Q$, its marginal cost is constant at \$3, and its fixed cost is \$36, so $ATC = 3 + 36/Q$. The curves are shown in part (a).

13. (a) Find the unregulated quantity, price and economic profit.



14. (b) A regulator sets price equal to marginal cost. Find the quantity and the firm's profit or loss, and explain why this policy needs a subsidy.
15. (c) The regulator instead sets price equal to average total cost. Find the quantity and price, and calculate the deadweight loss.
16. (d) Compare cost-plus regulation with price-cap regulation in terms of incentives to reduce cost.

Answers Chapter 4: Answers and Explanations

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

4.1 Monopoly**SET A · CHECK YOUR UNDERSTANDING**

- MR = $100 - 10Q$, so MR at $Q = 6$ is $100 - 60 = \$40$, while the price at $Q = 6$ is $100 - 30 = \$70$. MR is lower because selling the sixth unit requires a lower price on all six units, so the firm loses revenue on the first five units while gaining the price of the sixth.
- (i) Government-created: patents are legal protection. (ii) Market-based: control of a scarce resource. (iii) Government-created: an exclusive franchise is a legal monopoly. (iv) Market-based: scale economies make a single firm cheapest, which is a natural monopoly.
- MR = $40 - 2Q = 10$ gives $Q = 15$ and $P = \$25$. Competition sets $P = MC$: $40 - Q = 10$, so $Q = 30$. $DWL = \frac{1}{2} \times (25 - 10) \times (30 - 15) = \frac{1}{2} \times 15 \times 15 = \$112.50$.
- TR = 90, 160, 210, 240, 250. Profit = TR - TC = 50, 90, 100, 70, 0. The maximum is \$100 at $Q = 3$ and $P = \$70$. Check with marginals: MR of unit 3 is 50 and MC is 40 (produce), but MR of unit 4 is 30 and MC is 60 (do not).
- On the inelastic part of demand, MR is negative. Since MC is always positive, $MR = MC$ cannot hold there. Cutting output would raise total revenue and also cut total cost, so profit rises until the firm is on the elastic part where MR is positive.
- Yes. It still sets $MR = MC$, and the price (\$9) covers AVC (\$7), so each unit contributes \$2 toward fixed cost. It makes a loss of \$2 per unit, which is smaller than the fixed-cost loss from shutting down. It would shut down only if price fell below AVC.

SET B · EXAM-STYLE MULTIPLE CHOICE

- B. MR = $80 - 8Q$, so at $Q = 5$ MR = \$40. The price is \$60 at that quantity (choice A), which is the tempting wrong answer because it confuses price with marginal revenue.
- D. MR = MC at $48 - 4Q = 16$ gives $Q = 8$, and $P = 48 - 16 = \$32$. ATC at 8 is $16 + 8 = \$24$, so profit = $(32 - 24) \times 8 = \$64$. The value \$128 uses $(P - MC) \times Q$, which ignores fixed cost.
- A. The firm sets $MR = MC$, but price is read off demand, which lies above MR. So $P > MR = MC$. Choice B describes perfect competition, where $MR = P$.
- E. Between Q_m and the competitive quantity, willingness to pay exceeds MC but those units are not produced. Profit (A) is a transfer from consumers to the firm, not a loss to society, so it is not the source of DWL.
- C. Fixed cost shifts ATC but not MC or MR, so $MR = MC$ gives the same Q and P . Profit falls by the amount of the increase. Choice A confuses a fixed cost with a marginal cost increase.
- B. A patent is legal protection granted by government. The mineral (A) and scale economies (C) are market-based barriers; brand (D) and price threats (E) are strategic.

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SET C · APPLY AND EXTEND

13. (a) 1 point: $MR = 30 - 2Q = 6$ gives $Q = 12$. 1 point: $P = 30 - 12 = \$18$. (b) 1 point: ATC at $12 = 6 + 8 = \$14$. 1 point: profit = $(18 - 14) \times 12 = \$48$. (c) 1 point: competitive quantity from $P = MC$ is $30 - Q = 6$, $Q = 24$. 1 point: $DWL = 1/2 \times (18 - 6) \times (24 - 12) = \$72$. (d) 1 point: yes, because barriers to entry prevent new firms from entering and competing the profit away; in a competitive market entry would drive price down to ATC .
14. (a) 1 point: with a ceiling the firm cannot charge more than \$12 and can sell any quantity up to the point where demand equals \$12 at that price, so each unit adds \$12 to revenue. That point is $Q = 18$ ($30 - Q = 12$). (b) 1 point: since $MR = 12 > MC = 6$ up to $Q = 18$, and beyond 18 MR is on the original curve, $30 - 2(18) = -6 < 6$, the firm produces $Q = 18$ at $P = \$12$. 1 point: $ATC = 6 + 96/18 = \$11.33$, so profit = $(12 - 11.33) \times 18 = \text{about } \$12$ ($TR\ 216 - TC\ 204$). (c) 1 point: output rises from 12 to 18 and price falls from \$18 to \$12, so consumers are better off. 1 point: DWL falls from \$72 to $1/2 \times (12 - 6) \times (24 - 18) = \$18$ and profit falls from \$48 to \$12.

4.2 Price Discrimination

SET A · CHECK YOUR UNDERSTANDING

- The firm needs (1) market power, (2) the ability to separate buyers with different willingness to pay or elasticity, and (3) a way to prevent resale. A perfectly competitive firm is a price taker facing a horizontal demand curve at the market price, so any attempt to charge more than the market price would lose all its customers.
- (i) Second degree: the price per unit depends on the quantity chosen. (ii) First degree (perfect): each buyer pays close to maximum willingness to pay. (iii) Third degree: buyers are split into groups with a different price for each group.
- (a) $MR = 30 - 2Q = 6$ gives $Q = 12$, $P = \$18$, profit = $12 \times 12 = \$144$. $DWL = 1/2 \times (18 - 6) \times (24 - 12) = \$72$. (b) The firm produces where $30 - Q = 6$, so $Q = 24$, profit = $1/2 \times 24 \times 24 = \$288$ and $DWL = 0$.
- Matinee customers (retirees, students, parents with small children) have more flexible schedules and more substitutes, so they respond strongly to price. Because their demand is more elastic, the $MR = MC$ rule gives a smaller markup over MC , so the profit-maximizing price is lower.
- Consumer surplus falls to zero because every buyer pays the maximum they would pay. Producer surplus rises to the whole area between demand and MC . Total surplus rises because output expands to the efficient quantity, and deadweight loss disappears.
- Only price-sensitive shoppers take the time to find and use coupons, so they pay a lower price while less price-sensitive shoppers pay full price, sorting buyers by elasticity. It works because the firm can separate groups by their willingness to spend effort, and coupons are hard to trade at scale, which limits resale.

SET B · EXAM-STYLE MULTIPLE CHOICE

- E. Profit before discrimination is not required, and in fact discrimination is meant to raise profit. Conditions A through D are the three requirements: market power, separable groups with different elasticities, and no resale.
- A. The firm produces where $D = MC$, which is the efficient quantity, so deadweight loss is zero; each buyer pays their maximum so consumer surplus is zero. Choice D keeps consumer surplus unchanged, but perfect discrimination transfers it all to the firm.
- C. The group with less elastic demand tolerates a bigger markup. Choice A reverses the elasticities. If the higher price reflected only higher cost, it would not be price discrimination.
- D. A higher MR in X means one more unit sold in X adds more revenue than one in Y, so shift sales toward X by lowering its price and cut sales in Y by raising its price, until MR is equal in both markets.
- C. Output goes to where $D = MC$, $Q = 16$, and profit is the triangle $1/2 \times 16 \times 16 = \$128$. Choices A and D describe the single-price outcome, and choice E treats the firm as a price taker.
- D. The per-unit price depends on how many units the buyer chooses, which is second degree (quantity-based). Part of a bulk discount can reflect lower packaging cost, but the economic definition is about price differing by quantity chosen.

SET C · APPLY AND EXTEND

13. (a) 1 point: $MR = 40 - 4Q = 10$, $Q = 7.5$. 1 point: $P = 40 - 15 = \$25$ and profit = $(25 - 10) \times 7.5 = \$112.50$. (b) 1 point: Q where $D = MC$: $40 - 2Q = 10$, $Q = 15$. 1 point: profit = $1/2 \times 30 \times 15 = \$225$. (c) 1 point: $DWL = 1/2 \times (25 - 10) \times (15 - 7.5) = \$56.25$. 1 point: $CS = 1/2 \times (40 - 25) \times 7.5 = \$56.25$. (d) 1 point: the firm gains (profit doubles); consumers lose all their surplus; society gains because deadweight loss disappears and output rises to the efficient level.
14. (a) 1 point: peak $MR = 24 - 4Q = 4$, $Q = 5$ and $P = \$14$. 1 point: locals $MR = 12 - 2Q = 4$, $Q = 4$ and $P = \$8$. (b) 1 point: peak profit $(14 - 4) \times 5 = 50$; locals $(8 - 4) \times 4 = 16$; total 66 thousand dollars. (c) 1 point: $|E| = (P/Q) \times (1/\text{slope})$: peak = $(14/5)/2 = 1.4$; locals = $(8/4)/1 = 2$. The more elastic locals get the lower price, consistent with $MR = P(1 - 1/|E|) = 4$ in both groups. (d) 1 point: resale violates the third condition; locals would buy at \$8 and resell near \$14, undercutting the resort, so the price gap cannot be maintained and the firm would drop back toward a single price.

4.3 Natural Monopoly and Regulation

SET A · CHECK YOUR UNDERSTANDING

- When ATC falls over all outputs the market can use, one firm producing everything has lower average cost than two firms each producing half. New entrants cannot match the incumbent's cost, and splitting the market raises cost. Examples: local water pipes, electricity distribution, rail track.
- $MR = 14 - 2Q = 2$ gives $Q = 6$, $P = \$8$. ATC at $6 = 2 + 4 = \$6$. Profit = $(8 - 6) \times 6 = \$12$.
- $P = MC$: $14 - Q = 2$, so $Q = 12$ and $P = \$2$. ATC at $12 = 2 + 2 = \$4$. Loss per unit = \$2, total \$24, which equals fixed cost. A lump-sum subsidy of \$24 would cover it.
- Under cost-plus the allowed price follows actual cost plus a normal return, so savings are passed to customers and the firm has little reason to cut cost (and may overinvest). Under a price cap the price is fixed for a period, so the firm keeps the profit from lower costs and has a stronger incentive to be efficient.

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5. One firm at $Q = 6$ has $ATC = 2 + 24/6 = \$6$. Two firms at $Q = 3$ have $ATC = 2 + 24/3 = \$10$ each. Average cost rises by \$4, so breaking up a natural monopoly wastes resources through duplicated fixed cost.
6. $P = ATC$ lets the firm earn a normal profit, so it stays in business without a subsidy, and it still gives a lower price and higher quantity than the unregulated outcome. Marginal-cost pricing is efficient but forces a loss, which needs taxpayer funding.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. E. Long-run average cost falls over the whole range of market demand, so one firm is the cheapest producer. Choices A and B describe legal monopolies; C describes resource-based monopoly.
8. B. $P = MC$ gives $Q = 12$ and $P = \$2$. ATC at 12 is \$4, so the loss is $\$2 \times 12 = \$24$, equal to the fixed cost. Choice C is the unregulated outcome.
9. C. Under a cap the firm keeps what it saves by cutting costs, which rewards efficiency. Choice A describes cost-plus regulation, which guarantees a normal return and weakens cost discipline.
10. A. If costs can be passed through in price, the firm has weak incentive to cut costs. Choice B is false: cost-plus covers average cost plus a normal return.
11. C. Where D crosses ATC the price is lower and quantity higher than at $MR = MC$, and profit is zero. It is not allocatively efficient (B) because P is still above MC , but DWL is smaller.
12. E. The Clayton Act (1914) addresses these practices; the Sherman Act (A) bans monopolization and conspiracies in restraint of trade but is not the law that specifically lists mergers, price discrimination and tied sales.

SET C · APPLY AND EXTEND

13. (a) 1 point: $MR = 24 - 2Q = 6$, $Q = 9$, $P = \$15$. 1 point: $ATC = 6 + 32/9 = \$9.56$, profit = $(15 - 9.56) \times 9 = \text{about } \$49$. (b) 1 point: $P = MC$ gives $Q = 18$, $P = \$6$. 1 point: $ATC = 6 + 32/18 = \$7.78$, so the loss is \$32 (fixed cost) and a \$32 subsidy is needed. (c) 1 point: $24 - Q = 6 + 32/Q$ gives $Q^2 - 18Q + 32 = 0$, $Q = 16$, $P = \$8$. 1 point: $DWL = 1/2 \times (8 - 6) \times (18 - 16) = \$2$. (d) 1 point: average-cost pricing, because it needs no subsidy, the firm breaks even, and the deadweight loss (\$2) is far below the unregulated \$40.50.
14. (a) 1 point: one firm at $Q = 9$ has $ATC = 6 + 32/9 = \$9.56$; two firms at 4.5 each have $ATC = 6 + 32/4.5 = \$13.11$. Average cost rises, so the split is productively inefficient. (b) 1 point: the cap makes $MR = \$8$ until demand reaches 8 at $Q = 16$, and $8 > MC$, so $Q = 16$ and $P = \$8$. 1 point: $ATC = 6 + 2 = \$8$, so profit is zero. (c) 1 point: new $ATC = 6 + 24/16 = \$7.50$ and profit = $0.50 \times 16 = \$8$. 1 point: the firm keeps the savings while the cap is fixed, so price caps reward cost reduction, unlike cost-plus regulation.

4.4 Monopolistic Competition

SET A · CHECK YOUR UNDERSTANDING

1. Many firms, differentiated products, free entry and exit, and a downward-sloping demand curve for each firm (some price control). Examples: restaurants, hair salons, clothing brands, coffee shops.
2. $MR = 20 - 5Q$ and $MC = 2 + Q$. Setting equal: $6Q = 18$, so $Q = 3$. $P = 20 - 7.5 = \$12.50$. $TR = 37.50$ and $TC = 18 + 6 + 4.5 = 28.50$, so profit = \$9.00.
3. Profit signals other entrepreneurs to enter with similar products. Each entrant takes customers from existing firms, so each firm's demand shifts left and becomes more elastic. Profit-maximizing output and price fall. Entry continues until the demand curve is tangent to ATC , where $P = ATC$ and economic profit is zero.
4. Excess capacity = $6 - 3 = 3$ units. Because the firm operates to the left of the minimum- ATC output, its average cost (\$9.50) exceeds the minimum (\$8). It is not productively efficient.
5. Advertising can shift demand to the right (more buyers at each price) and make demand less elastic (buyers care less about price). Both raise the profit-maximizing price and/or quantity and raise short-run profit. In the long run rivals respond and entry restores zero profit.
6. $MR = 8 - 3Q = 2 + Q$ gives $Q = 1.5$ and $P = \$5.75$. $ATC = 12 + 2 + 0.75 = \$14.75$, so the loss is $(14.75 - 5.75) \times 1.5 = \$13.50$. $AVC = 2 + 0.75 = \$2.75 < P$, so the firm produces rather than shuts down in the short run, expecting exit by others to raise its demand.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. The firm produces 3 units where $MR = MC$, while the minimum- ATC output is 6, so excess capacity is $6 - 3 = 3$. Choice A would be true only of a perfectly competitive firm.
8. E. $MR = MC$ at $Q = 4.5$, $P = \$13.25$, $ATC = \$8.25$, so profit = $\$5 \times 4.5 = \$22.50$. Choice A is the per-unit profit, and choice D is total revenue.
9. A. Profit attracts entrants offering close substitutes, so the demand for each existing firm falls until $P = ATC$. Choice C describes the adjustment to losses.
10. D. Branding makes buyers less price-sensitive and brings in more buyers. Rival firms and entry still exist, so advertising does not eliminate entry (E) and profit is competed away in the long run.
11. B. Many sellers, differentiated products and easy entry define monopolistic competition. It is not perfect competition (A) because the products are not identical and each firm has some price control.
12. E. The monopolistic competitor's tangency lies on the falling part of ATC , to the left of minimum ATC , so it has a higher ATC , a higher price and a lower output. Both have zero economic profit, which rules out D.

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SET C · APPLY AND EXTEND

13. (a) 1 point: $MR = MC: 20 - 5Q = 2 + Q$ gives $Q = 3$. 1 point: $P = 20 - 7.5 = \$12.50$. (b) 1 point: $ATC = 6 + 2 + 1.5 = \$9.50$, profit = $(12.50 - 9.50) \times 3 = \$9$. (c) 1 point: positive profit attracts entry of firms selling close substitutes. 1 point: demand shifts left and becomes more elastic (MR shifts left too). (d) 1 point: entry stops when the demand curve is tangent to ATC, so $P = ATC$ and profit is zero, at a lower quantity than before. 1 point: not allocatively efficient because $P > MC$; not productively efficient because output is below the minimum-ATC quantity (excess capacity).
14. (a) 1 point: $12 - 3Q = 2 + Q$, $Q = 2.5$, $P = \$8.25$. 1 point: $ATC = 7.2 + 2 + 1.25 = \$10.45$, so economic loss = $(10.45 - 8.25) \times 2.5 = \$5.50$. (b) 1 point: $AVC = 2 + 1.25 = \$3.25$, which is below $P = \$8.25$, so price covers variable cost and the firm should continue producing in the short run. (c) 1 point: losses cause exit; the remaining firms' demand shifts right until demand is tangent to ATC and economic profit is zero. (d) 1 point: a profit from advertising invites rivals to match the campaign or new firms to enter, shifting the firm's demand back left, and the cost of the advertising raises ATC, so long-run profit returns to zero.

4.5 Oligopoly and the Kinked Demand Curve

SET A · CHECK YOUR UNDERSTANDING

1. Few large firms, identical or differentiated products, high barriers to entry, and interdependence. Interdependence means each firm's profit depends on its rivals' choices, so a firm must predict how rivals will respond to a change in price or output before acting.
2. $CR4 = 40 + 20 + 15 + 10 = 85$. $HHI = 1,600 + 400 + 225 + 100 + 25 + 25 + 25 = 2,400$.
3. $MR = 60 - 2Q = 10$ gives $Q = 25$, $P = \$35$. Total profit = $25 \times 25 = \$625$, so each firm earns $\$312.50$.
4. If the firm raises price rivals do not follow, so buyers switch to rivals and quantity demanded falls a lot (elastic). If it cuts price rivals match the cut, so the firm gains little (inelastic). The firm therefore has little incentive to change price.
5. Examples: advertising, product design, warranties, free delivery, loyalty rewards. Price cuts are quickly matched and reduce profit for all firms, while non-price competition can win customers without starting a price war (though it can raise costs).
6. A member that secretly sells extra output at the high cartel price earns more than its agreed share, as long as others hold back. Every member faces this incentive, and when many cheat, price falls toward the competitive level. Cartels are also illegal in the U.S., so agreements cannot be enforced in court.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. E. Mutual interdependence among a few firms with barriers to entry defines oligopoly. Choice C describes monopolistic competition.
8. A. $HHI = 2,500 + 900 + 100 + 100 = 3,600$. Choice D squares only the largest share, and choice B is the HHI of a pure monopoly.
9. E. MC is still inside the MR gap, so $MR > MC$ up to $Q = 50$ and $MR < MC$ beyond it. Price and output remain at the kink. Choice A would apply only if MC rose above the top of the gap.
10. C. Rivals ignore a price rise (so the firm loses customers) and match a price cut (so the firm gains little). Choice D reverses this logic and would give a kink in the opposite direction.
11. B. The gain from cheating on the agreement is what destroys cartels. A small number of firms (A) and blocked entry (E) make collusion easier, not harder.
12. B. Merging two firms with shares a and b raises HHI by $2ab$, which is always positive. $CR4$ may or may not change depending on which firms merge, and the other choices are not implied by a merger.

SET C · APPLY AND EXTEND

13. (a) 1 point: above the kink rivals do not follow a price increase, so the firm loses many customers; below the kink rivals match price cuts, so quantity demanded rises only a little. (b) 1 point: $Q = 50$ and $P = \$10$. 1 point: MC passes through the vertical gap in MR, so $MR > MC$ just before $Q = 50$ and $MR < MC$ just after it. (c) 1 point: $MC1$ at $Q = 50$ is $\$7.50$, still within the gap ($\$4$ to $\$8$), so price and quantity do not change. (d) 1 point: the model does not explain how the kink price was originally set (and predicted price rigidity is not always observed in practice).
14. (a) 1 point: $MR = 60 - 2Q = 10$ gives $Q = 25$ and $P = \$35$. 1 point: total profit = $25 \times 25 = \$625$; each firm gets $\$312.50$. (b) 1 point: competition gives $P = MC = \$10$ and $Q = 50$, with zero profit, so the cartel's output is smaller, price higher and profit higher. (c) 1 point: $Q = 27.5$, $P = \$32.50$; the cheater earns $22.50 \times 15 = \$337.50$ and the other firm earns $22.50 \times 12.5 = \$281.25$. (d) 1 point: each member can gain by cheating, so the cartel tends to unravel and price falls toward the competitive level. 1 point: explicit price fixing violates the Sherman Act, so executives face fines and imprisonment, and agreements cannot be enforced in court.

4.6 Game Theory

SET A · CHECK YOUR UNDERSTANDING

1. A dominant strategy is the best choice for a player whatever the rival does. A Nash equilibrium is a combination of strategies in which each player's choice is a best response to the other's. Every dominant-strategy outcome is a Nash equilibrium, but a game can have a Nash equilibrium even when no player has a dominant strategy.
2. If B advertises, A earns 3 by advertising versus 1 by not; if B does not, A earns 7 versus 5. Advertising is dominant for A, and by symmetry for B. The Nash equilibrium is (Advertise, Advertise) with payoffs 3 and 3. Both would earn 5 if neither advertised, so it is a prisoner's dilemma.
3. Against Left, A prefers Up ($3 > 0$); against Right, A prefers Down ($2 > 1$). Against Up, B prefers Left ($2 > 1$); against Down, B prefers Right ($3 > 0$). No dominant strategies exist. Cells (Up, Left) and (Down, Right) are Nash equilibria, so there are two.
4. A prefers Top whether B plays Left ($4 > 3$) or Right ($2 > 1$), so Top is dominant for A. Knowing A plays Top, B compares 3 (Left) with 2 (Right) and plays Left. The Nash equilibrium is (Top, Left) with payoffs 4 and 3. B has no dominant strategy, since B would pick Right if A played Bottom.
5. Cooperating: $4 \times 10 = 40$. Cheating: $14 + 6 + 6 + 6 = 32$. Cooperation is better, since the one-time gain of 4 is smaller than the loss of 4 in each of the three later periods.

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6. Each firm earns more by cheating (producing more or cutting price) whatever the others do, so cheating is a dominant strategy. When all cheat, each earns less than if all had cooperated. This is a prisoner's dilemma. Cooperation could be sustained only if cheating can be detected and punished in later periods.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. B. Nash equilibrium requires mutual best responses. Choice A and E describe cooperative outcomes that may not be equilibria, as the prisoner's dilemma shows.
8. C. A prefers Small against Large ($2 > -2$) and Large against Small ($6 > 3$); B is symmetric. The cells (Large, Small) and (Small, Large) are mutual best responses. Choice B ignores the second equilibrium.
9. C. Dominance means the strategy is best whatever the rival does. A dominant strategy is not always part of an efficient outcome: in the prisoner's dilemma it leads to a worse result for both, and choice A reflects that confusion.
10. B. Punishment such as reverting to low prices in later periods makes cheating costly. Choice D is the one-period logic and E would cause cooperation to unravel by backward induction.
11. D. If the incumbent accommodates, the entrant gets 4 from entering versus 0. If the entrant enters, the incumbent gets 4 from accommodating versus 2 from fighting. So (Enter, Accommodate) is the Nash equilibrium; the threat to fight is not credible, which rules out B.
12. B. Low price is a dominant strategy for each firm, and the resulting equilibrium is worse for both than the cooperative cell, which defines a prisoner's dilemma. A cartel (A) would be the cooperative outcome the firms fail to maintain.

SET C · APPLY AND EXTEND

13. (a) 1 point: Advertise is dominant for A ($3 > 1$ and $7 > 5$) and for B by symmetry. (b) 1 point: Nash equilibrium is (Advertise, Advertise); 1 point: each earns 3 million. (c) 1 point: both would earn 5 million if neither advertised, so the dominant-strategy outcome leaves each worse off than another cell. (d) 1 point: if the firms interact repeatedly, a firm that advertises could be punished by rivals' advertising in later periods, which can make mutual restraint sustainable (for example tit-for-tat); this breaks down if the game has a known end or firms discount the future heavily.
14. (a) 1 point: Nash equilibrium is (Enter, Accommodate): given Accommodate the entrant prefers Enter ($4 > 0$), and given Enter the incumbent prefers Accommodate ($4 > 2$). (b) 1 point: if entry occurs, fighting pays the incumbent 2 but accommodating pays 4, so a rational incumbent would not carry out the threat and the entrant will ignore it. (c) 1 point: with Fight now paying the incumbent $5 > 4$ after entry, the incumbent's best response to Enter is Fight; the entrant's best response to Fight is Stay out ($0 > -3$). Given Stay out, the incumbent prefers Fight ($8 > 7$). The unique Nash equilibrium is (Stay out, Fight): the entrant stays out. 1 point: the capacity commitment made the threat credible and deters entry, so it acts as a strategic barrier to entry.

4.7 Multiple-Choice Practice: Imperfect Competition

SET A · CORE CONCEPTS

1. A. Selling an extra unit requires a lower price on every unit, so the added revenue is below the price. Choice B concerns cost, not revenue, and does not explain the gap between MR and P.
2. C. Falling long-run average cost over the whole range of demand makes one firm the cheapest producer. The patent (A) and legal prohibition (B) create legal monopolies, not natural ones.
3. E. Without a barrier to resale, low-price buyers would undercut the firm in the high-price group. A price taker (A) has no power to set different prices.
4. B. Differentiated products with free entry define the structure. Choice D describes perfect competition, where products are identical and firms are price takers.
5. D. Interdependence among a few large firms is the defining feature. Choice E is not required, since many oligopolies sell differentiated products.
6. C. Dominance means best against every rival action. Choice D describes a Nash equilibrium, which can exist without dominant strategies.
7. A. Entry drives demand down to tangency with ATC, so $P = ATC > MC$. Choice D describes perfect competition; the monopolistic competitor operates to the left of minimum ATC.

SET B · APPLICATIONS AND DATA

8. B. $MR = MC$ gives $Q = 10$ and $P = \$30$; competition sets $50 - 2Q = 10$, so $Q = 20$. $DWL = \frac{1}{2} \times (30 - 10) \times (20 - 10) = \$100$. Choice C (\$150) is the monopoly's profit, not the deadweight loss.
9. D. Set $12 - Q = 2 + 16/Q$, giving $Q^2 - 10Q + 16 = 0$, so $Q = 8$ (price $\$4 = ATC$). $Q = 5$ is the unregulated output where $MR = MC$, and $Q = 10$ is the marginal-cost-pricing output.
10. E. Output expands to where $D = MC$, $Q = 12$, and profit is the triangle $\frac{1}{2} \times 12 \times 12 = \$72$. The single-price profit is \$36 (choice A), found with $MR = MC$ at $Q = 6$ and $P = \$12$.
11. C. $HHI = 45^2 + 25^2 + 20^2 + 10^2 = 2,025 + 625 + 400 + 100 = 3,150$. A pure monopoly would give 10,000 (choice E), and the shares simply add to 100 (choice A).
12. A. Cutting is dominant for each firm ($9 > 6$ and $3 > 2$). The result is (Cut, Cut) with payoffs 3 and 3. (Hold, Hold) pays more but is not stable, because either firm gains by cutting.
13. B. MC_1 at $Q = 40$ (\$5.50) is still inside the vertical gap of MR, so $MR > MC$ just before 40 and $MR < MC$ just after. Choice A would require MC to rise above the top of the gap (\$6).
14. D. The ceiling makes $MR = \$20$ up to the quantity where demand equals 20 ($Q = 10$), and $20 > MC$, so the firm sells 10. Choice B (7.5) is the unregulated output; 15 is the competitive output, which would require a ceiling of \$10.

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SET C · EXAM-LEVEL STRETCH

15. E. MC becomes 20: $60 - 4Q = 20$ gives $Q = 10$ and $P = 60 - 20 = \$40$. Price rises by half the tax; choice D (\$44) wrongly assumes the full tax is passed on.
16. C. Profit attracts entrants offering close substitutes, reducing each firm's demand until $P = ATC$. Differentiation (A) gives market power but does not block entry.
17. A. Cooperating over T periods gives $8T$; cheating gives $12 + 5(T - 1)$. For $T = 2$ these are 16 and 17 (cheating wins), and for $T = 3$ they are 24 and 22 (cooperation wins). So the minimum is 3.
18. E. The cartel acts as a monopoly: $MR = 100 - 2Q = 20$, so $Q = 40$ and $P = \$60$, giving profit $= 40 \times 40 = \$1,600$. Choice A is each firm's share if they split equally.
19. B. For group B, $P \times (1 - 1/1.5) = 12$, so $P \times (1/3) = 12$ and $P = \$36$. Choice A (\$18) is group A's price, since $12/(1 - 1/3) = 18$. The less elastic group pays more.
20. D. Free entry removes profit in monopolistic competition, while downward-sloping demand keeps P above MC. Perfect competition has $P = MC$ (choice A), and monopoly with barriers can keep positive profit.

4.8 Free-Response Practice: Imperfect Competition**QUESTION 1 · MONOPOLY GRAPH AND CALCULATIONS**

1. (a) 1 point: sets $MR = MC$: $40 - 4Q = 8$, so $Q = 8$. 1 point: price is read from the demand curve at that quantity: $P = 40 - 16 = \$24$. (The price is above MR, which is only \$8 at $Q = 8$.)
2. (b) 1 point: ATC at 8 $= 8 + 60/8 = \$15.50$. 1 point: profit $= (24 - 15.50) \times 8 = \$68$ (check: $TR = 192$, $TC = 64 + 60 = 124$).
3. (c) 1 point: the competitive quantity sets $P = MC$: $40 - 2Q = 8$, $Q = 16$, so $DWL = 1/2 \times (24 - 8) \times (16 - 8) = \$64$. 1 point: it arises because at $Q = 8$ the price (marginal benefit) exceeds MC, so units between 8 and 16 that buyers value above their cost are not produced.
4. (d) 1 point: fixed cost does not change MC or MR, so quantity (8) and price (\$24) are unchanged. 1 point: profit falls by the \$20 increase to \$48.

QUESTION 2 · MONOPOLISTIC COMPETITION

5. (a) 1 point: $MR = MC$: $28 - 6Q = 4 + 2Q$ gives $Q = 3$. 1 point: $P = 28 - 9 = \$19$. 1 point: $ATC = 16/3 + 4 + 3 = \$12.33$, so profit $= (19 - 12.33) \times 3 = \$20$ (TR 57 minus TC 37).
6. (b) 1 point: positive profit attracts entry of new shops selling close substitutes. 1 point: the shop's demand shifts left and becomes more elastic, until demand is tangent to ATC and profit is zero.
7. (c) 1 point: $MR = 20 - 6Q = 4 + 2Q$ gives $Q = 2$ and $P = 20 - 6 = \$14$, equal to $ATC = 8 + 4 + 2 = \$14$, so profit is zero. 1 point: excess capacity = minimum- ATC output minus actual $= 4 - 2 = 2$ units.
8. (d) 1 point: not allocatively efficient because P (\$14) $>$ MC (\$8). 1 point: not productively efficient because the shop produces below the minimum- ATC output (ATC \$14 $>$ \$12). 1 point: benefit such as product variety, choice and innovation for consumers.

QUESTION 3 · GAME THEORY AND OLIGOPOLY

9. (a) 1 point: yes, Low fare is dominant for both. 1 point: for A, Low gives $55 > 40$ if B charges High and $25 > 15$ if B charges Low; B's payoffs are symmetric.
10. (b) 1 point: Nash equilibrium is (Low, Low). 1 point: each airline earns 25 million.
11. (c) 1 point: (High, High) gives the highest joint profit (80 million) but each airline has an incentive to cut its fare, whatever the rival does. 1 point: this is a prisoner's dilemma.
12. (d) 1 point: cooperating for three years gives $40 \times 3 = 120$; cheating first gives $55 + 25 + 25 = 105$. 1 point: cooperation pays when the game is expected to continue, because punishment (the low-fare outcome) costs more over time than the one-time gain from cheating; collusion is more likely to be sustained.

QUESTION 4 · NATURAL MONOPOLY REGULATION

13. (a) 1 point: $MR = 18 - 2Q = 3$ gives $Q = 7.5$ and $P = \$10.50$. 1 point: $ATC = 3 + 36/7.5 = \$7.80$, so profit $= (10.50 - 7.80) \times 7.5 = \$20.25$.
14. (b) 1 point: $P = MC$: $18 - Q = 3$ gives $Q = 15$ and $P = \$3$. 1 point: ATC at 15 $= \$5.40$, so the loss is $2.40 \times 15 = \$36$, equal to fixed cost. 1 point: since $P <$ ATC the firm loses money and would shut down in the long run unless a subsidy (at least \$36) covers the loss.
15. (c) 1 point: $18 - Q = 3 + 36/Q$ gives $Q^2 - 15Q + 36 = 0$, so $Q = 12$ and $P = \$6$ ($= ATC$, zero profit). 1 point: $DWL = 1/2 \times (6 - 3) \times (15 - 12) = \$4.50$.
16. (d) 1 point: under cost-plus the price follows cost, so the firm has weak incentive to reduce costs and may overspend. 1 point: under a price cap the firm keeps profit from cutting costs while the cap is in force, so incentives to be efficient are stronger.

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Chapter 5: Factor Markets.

6 sections with explanations and worked examples, then 92 practice problems. Answers and full explanations are at the end of the chapter.

5.1 Demand for Labor and Marginal Revenue Product

Learn why firms demand labor, how marginal revenue product sets the hiring decision, and what shifts labor demand and the market wage.

Firms do not hire workers because they like them. They hire workers because workers help produce goods that sell. That is why the demand for labor is a **derived demand**: it comes from the demand for the product the labor helps make. When customers want more pizza, pizzerias want more cooks. When customers lose interest in a product, the demand for the people who make it falls too.

Key terms: the hiring tools

Marginal product of labor (MPL): the extra output from one more worker, $MPL = \Delta Q / \Delta L$.

Marginal revenue product (MRP): the extra revenue from hiring one more worker, $MRP = MPL \times MR$. In a competitive product market $MR = P$, so $MRP = MPL \times P$ (also called value of marginal product).

Marginal factor cost (MFC): the extra cost of hiring one more worker, $MFC = \Delta TC / \Delta L$. A firm that is a wage taker has $MFC = \text{wage}$.

A firm's **demand curve for labor is its MRP curve**. Because of diminishing marginal returns, MPL falls as more workers are added to a fixed amount of capital, so MRP slopes downward. The firm compares the benefit of a worker (MRP) with the cost (MFC) and keeps hiring while the benefit is at least the cost.

Profit-maximizing hiring rule

Hire workers up to the quantity where $MRP = MFC$.

In a competitive labor market the firm is a wage taker, so $MFC = W$ and the rule becomes $MRP = W$.

If $MRP > MFC$, hire more. If $MRP < MFC$, hire fewer.

Notice how the rule parallels the output rule $MR = MC$. Hiring one more worker adds MRP to revenue and MFC to cost, so profit rises exactly when MRP exceeds MFC.

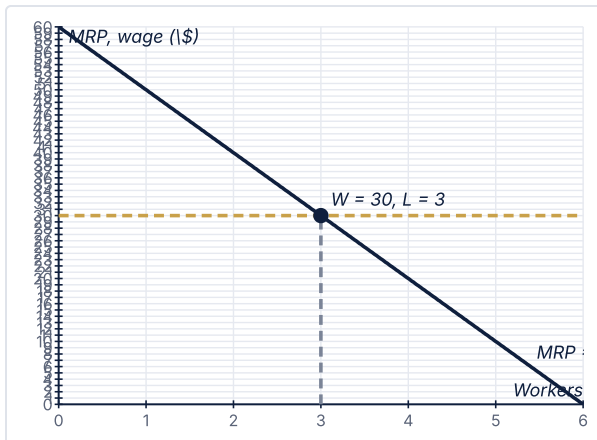
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EXAMPLE 1: HIRING IN A COMPETITIVE MARKET

A bakery sells loaves in a perfectly competitive market at \$5 per loaf. Total output per hour with 1 to 6 workers is 10, 18, 24, 28, 30, 30 loaves. The market wage is \$30 per hour. (a) Compute MPL and MRP for each worker. (b) How many workers should the bakery hire? (c) How many if the wage falls to \$20?

**SOLUTION**

(a) $MPL = 10, 8, 6, 4, 2, 0$. Since $P = \$5$, $MRP = 5 \times MPL = \$50, \$40, \$30, \$20, \$10, \$0$.

(b) Wage is \$30, so $MFC = \$30$. The third worker adds \$30 of revenue for \$30 of cost ($MRP = MFC$), while the fourth adds only \$20. Hire 3 workers.

(c) At $W = \$20$ the fourth worker still pays for himself ($MRP = \$20 = MFC$) and the fifth does not (\$10). Hire 4. A lower wage raises the quantity of labor demanded: a movement along the MRP curve.

What shifts labor demand? A change in the wage causes a movement along the MRP curve. Anything else that changes MRP at each quantity shifts the curve.

Shifter	Effect on MRP and labor demand
Price of the product (or demand for it)	Higher price raises MR and MRP, so demand shifts right. This is the derived-demand shifter.
Productivity of labor (training, better capital, technology)	Higher MPL raises MRP, so demand shifts right.
Price of a substitute input (such as robots)	Cheaper substitute: firms may switch away from labor (left), though a bigger scale of output can offset this.
Price of a complement input (such as delivery trucks)	Cheaper complement lowers costs and raises output, so labor demand shifts right.
Number of firms hiring	More employers in the market means a larger market demand for the labor.

Market wage in a competitive labor market. Summing every firm's MRP curve gives the market demand for labor. It meets market labor supply at the equilibrium wage. Each individual firm is too small to change that wage, so it takes the wage as given and hires up to $MRP = W$. The supply of labor to that one firm is a horizontal line at the market wage, which is why its MFC equals the wage.

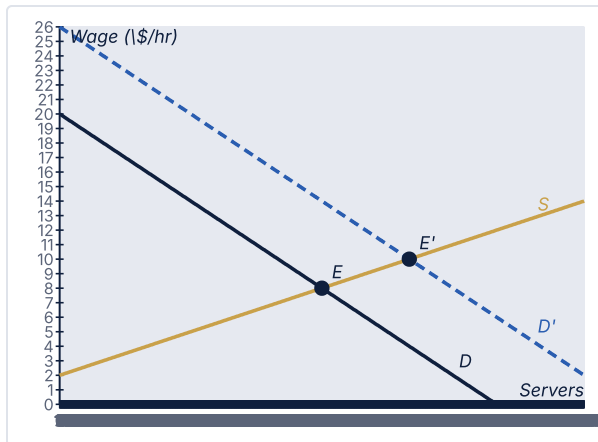
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EXAMPLE 2: MARKET EQUILIBRIUM AND A DEMAND SHIFT

In a local market for restaurant servers, labor demand is $W = 20 - 0.01L$ and labor supply is $W = 2 + 0.005L$, where L is the number of servers and W the hourly wage in dollars. Find equilibrium. Then a tourism boom raises demand to $W = 26 - 0.01L$. Find the new equilibrium.

**SOLUTION**

Set $D = S$: $20 - 0.01L = 2 + 0.005L$, so $18 = 0.015L$ and $L = 1,200$ servers. Then $W = 2 + 0.005(1,200) = \$8$ per hour.

After the boom: $26 - 0.01L = 2 + 0.005L$, so $24 = 0.015L$ and $L = 1,600$. $W = 2 + 0.005(1,600) = \$10$.

Derived demand: higher product demand raised MRP, shifting labor demand right. Both the wage and employment rose.

Imperfect product markets. A firm with market power in its product market must lower its price to sell more output, so MR is below P. Then $MRP = MPL \times MR$ falls faster as workers are added. Such a firm hires fewer workers than a competitive firm would at the same wage. Its labor market can still be competitive, so $MFC = W$.

EXAMPLE 3: A MONOPOLIST'S MRP

A monopolist hires workers at \$30 per hour. Output and the price it must charge are: 1 worker, 10 units at \$10; 2 workers, 18 at \$9; 3 workers, 24 at \$8; 4 workers, 28 at \$7; 5 workers, 30 at \$6. How many workers does it hire?

SOLUTION

Total revenue = $P \times Q$: \$100, \$162, \$192, \$196, \$180.

MRP is the change in TR from each added worker: \$100, \$62, \$30, \$4, -\$16.

Set $MRP = MFC = \$30$. The third worker adds \$30, the fourth only \$4. Hire 3 workers.

Check against competition: at the last price of \$8 and $MPL = 6$, a price taker would see the third worker's value as \$48, well above $MRP = \$30$. Market power cuts the benefit of labor.

Common mistakes

(1) Using MPL instead of MRP. A worker with $MPL = 10$ is not worth 10 dollars; multiply by marginal revenue. (2) Using P when the firm is a monopolist: MRP uses MR, not P. (3) Treating a wage change as a shift of the demand curve. It is a movement along MRP. (4) Forgetting that $MFC = \text{wage}$ only for a wage taker.

Practice**SET A Check Your Understanding**

Answer each item in a few sentences, showing any calculation.

1. Explain why the demand for labor is called a derived demand. Give one original example.
2. A price-taking firm sells output at \$3. Its fifth worker adds 8 units, and the wage is \$20. Calculate MRP and say whether the firm should hire the fifth worker.
3. A firm sells at \$2 per unit in a competitive market. Marginal products of workers 1 to 5 are 12, 10, 8, 6, 4. The wage is \$16. Find MRP for each worker and the profit-maximizing number of workers.

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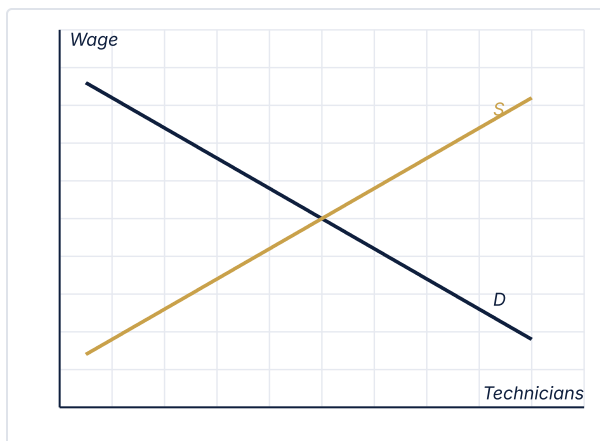
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4. State what happens to the demand for labor (shift right, shift left, or no shift) in each case: (i) the market price of the firm's product falls; (ii) workers complete a training program that raises MPL; (iii) the wage rises.
5. The price of robotic arms falls. Explain why the effect on a factory's demand for assembly workers is ambiguous.
6. Why is a single competitive firm's MFC for labor equal to the market wage, while its MRP curve slopes downward?

SET B Exam-Style Multiple Choice

Choose the best answer.

7. The demand for labor is called a derived demand because it depends on:
 - (A) the wage rate paid to the workers
 - (B) the number of workers willing to work
 - (C) the level of government spending on training
 - (D) the firm's marginal cost of capital
 - (E) the demand for the product that the labor helps produce
8. A perfectly competitive firm sells its output at \$6. Its last worker hired has a marginal product of 4 units, and the wage is \$30. To maximize profit the firm should:
 - (A) hire more workers, because the marginal product is positive
 - (B) hire fewer workers, because MRP of \$24 is below the wage
 - (C) hire the same number of workers, because MPL is above zero
 - (D) raise the price of its product
 - (E) pay a wage equal to the value of average product
9. A firm sells in a competitive market at \$4 per unit and pays \$20 per hour. Marginal products for workers 1 through 5 are 10, 8, 6, 4, 2. How many workers maximize profit?
 - (A) 1
 - (B) 2
 - (C) 3
 - (D) 4
 - (E) 5
10. Which of the following shifts a firm's labor demand curve to the right?
 - (A) A rise in the market price of the firm's output
 - (B) A rise in the wage rate
 - (C) A fall in the productivity of workers
 - (D) A fall in the price of the firm's product
 - (E) A decrease in the number of firms in the industry
11. The graph shows a competitive market for sound technicians, with demand D and supply S . If the demand for concerts rises, the new equilibrium wage and employment will be:



- (A) wage falls, employment rises
- (B) wage rises, employment falls
- (C) wage unchanged, employment rises
- (D) wage falls, employment unchanged
- (E) wage rises, employment rises

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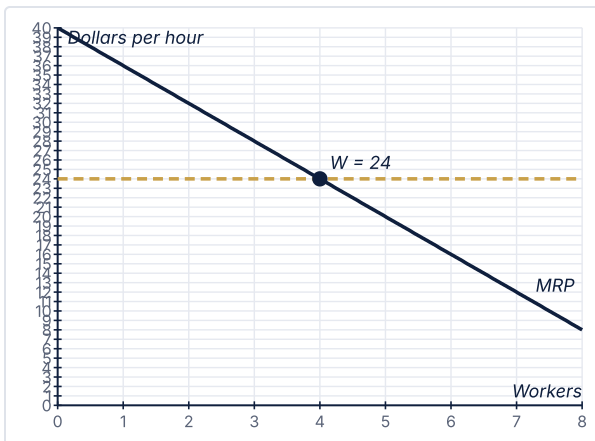
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12. A monopolist in its product market hires labor in a competitive labor market. Compared with a competitive firm facing the same wage and the same MPL, the monopolist's MRP is:
- (A) higher, because it earns economic profit
(B) the same, because MPL is identical
(C) lower, because MR is less than price
(D) higher, because it has no competitors
(E) zero, because it sets its own price

SET C Apply and Extend

Respond as you would on a free-response question.

13. The graph shows a price-taking landscaping firm's MRP curve for labor (\$ per hour). The market wage is \$24. (a) How many workers does the firm hire? (b) The firm buys new mowers that raise every worker's marginal product by 25 percent. Describe what happens to the MRP curve and explain how the number hired changes. Assume the wage stays at \$24. (c) At the original MRP curve, the wage falls to \$16. How many workers are hired, and is this a shift or a movement?



14. A diner is a price taker in the market for burgers and for cooks. The market for cooks is initially in equilibrium at \$12 per hour with 400 cooks employed. (a) Explain how a rise in demand for restaurant meals affects the market wage and employment of cooks, using a labor market graph. (b) Explain why the typical diner, as an individual employer, does not choose the wage. (c) State the hiring rule the diner follows.

5.2 Labor Supply and the Labor Market

Understand how workers choose between labor and leisure, what shifts labor supply, and how minimum wages and unions change wages and employment.

Workers supply labor only if the pay is worth more than the other uses of their time. Each person has a limited number of hours, so every hour of work is an hour of **leisure** given up. The wage is therefore the opportunity cost of leisure: at a wage of \$15 per hour, an hour of rest costs \$15 of forgone income.

Labor-leisure choice

A worker splits time between work (income) and leisure to maximize utility.

Opportunity cost of one hour of leisure = the hourly wage.

A higher wage has two opposing effects on hours worked: the **substitution effect** (leisure is costlier, so work more) and the **income effect** (the worker is richer and buys more leisure, so work less).

At low wages the substitution effect usually wins, so the individual labor supply curve slopes upward. At very high wages the income effect can dominate and hours fall, producing a **backward-bending labor supply curve**. For a whole market, the supply of labor is normally upward sloping: higher pay attracts people out of other jobs, school, and home production into this occupation.

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EXAMPLE 1: A WAGE INCREASE AND HOURS WORKED

Maya has 60 discretionary hours per week. At a wage of \$10 she works 30 hours. Her wage rises to \$15. (a) What is her opportunity cost of an hour of leisure before and after? (b) Her weekly income if she works 34 hours, 24 hours, or 18 hours? (c) Which effect dominates in each case?

SOLUTION

- (a) The opportunity cost of leisure equals the wage: \$10 before, \$15 after.
- (b) Old income: $30 \times \$10 = \$300$. New incomes at \$15: 34 hours gives \$510; 24 hours gives \$360; 18 hours gives \$270.
- (c) 34 hours: she works more, so the substitution effect dominates. 24 hours: she works less but still earns more than \$300, so the income effect dominates. 18 hours: she works much less and earns less than before; the income effect is very strong, a backward-bending case. Which happens depends on her preferences.

Shifters of labor supply. A wage change moves us along the supply curve (a change in quantity supplied). Other changes shift the whole curve.

Determinant	Shift in supply of labor
Number of qualified workers (immigration, population, retirement)	More workers shifts supply right; fewer shifts it left.
Wages in other occupations	A rise in wages elsewhere pulls workers away and shifts supply left.
Training and licensing requirements	Tougher requirements shift supply left; subsidized training shifts it right.
Non-wage job features (safety, flexibility, prestige)	More attractive job: shifts right. Less attractive: shifts left.
Preferences for leisure, taxes on labor income, benefits	Changes the wage at which workers will take the job.

Equilibrium. The labor market clears at the wage where quantity of labor demanded equals quantity supplied. A wage above equilibrium creates a surplus of labor (unemployment); a wage below it creates a shortage. Combining a demand shift with a supply shift: if both shift right, employment certainly rises and the wage change is ambiguous; if demand rises and supply falls, the wage certainly rises and employment is ambiguous.

Minimum wage in a competitive labor market

A binding minimum wage is a price floor set **above** the equilibrium wage.

It raises the wage, reduces the quantity of labor demanded, and increases the quantity supplied, so a surplus of labor (unemployment) appears.

Workers who keep jobs gain; workers who lose jobs and those who would now like a job lose out. A floor below equilibrium has no effect.

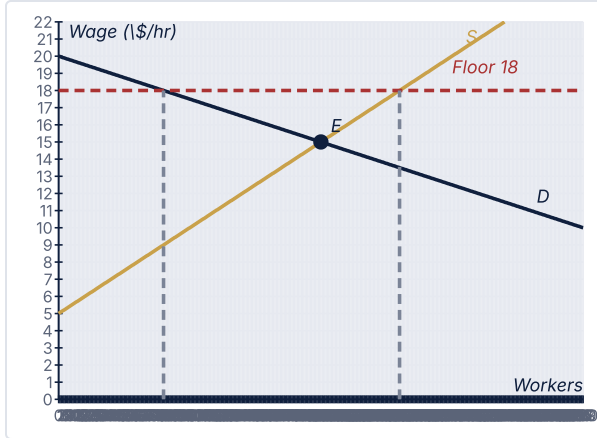
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EXAMPLE 2: MINIMUM WAGE

Demand for fast-food workers is $W = 20 - L/40$ and supply is $W = 5 + L/20$ (L in workers, W in dollars per hour). Find the equilibrium, then the effects of a \$18 minimum wage.

**SOLUTION**

Equilibrium: $20 - L/40 = 5 + L/20$ gives $15 = 3L/40$, so $L = 200$ and $W = \$15$.

At $W = \$18$: demand gives $18 = 20 - L/40$, so $L = 80$ employed. Supply gives $18 = 5 + L/20$, so 260 workers want jobs.

Unemployment (surplus) = $260 - 80 = 180$ workers. Employment fell by 120 from equilibrium.

Employed workers earn \$3 more per hour; the total wage bill changes from $\$15 \times 200 = \$3,000$ to $\$18 \times 80 = \$1,440$ per hour.

Unions. A labor union bargains collectively and can win a wage above the competitive level. Unions can also raise productivity, but in a competitive labor market a union wage above equilibrium reduces the quantity of labor demanded. The size of the job loss depends on how elastic labor demand is: when substitutes for the workers are easy to find, a wage hike costs many jobs. Craft unions may restrict entry (licensing, apprenticeships), shifting supply left.

EXAMPLE 3: A UNION WAGE

Labor demand and supply for bus drivers are shown. A union negotiates a wage of \$20. Find the equilibrium, the effect of the union wage on employment and unemployment, and the change in the total wage bill.

Wage	Quantity demanded	Quantity supplied
\$14	11,000	5,000
\$16	9,500	6,500
\$18	8,000	8,000
\$20	6,500	9,500

SOLUTION

Equilibrium: quantity demanded = quantity supplied at $W = \$18$ and $L = 8,000$.

At \$20 firms hire only 6,500, so employment falls by 1,500, while 9,500 drivers want work: 3,000 are unemployed.

Wage bill: $\$18 \times 8,000 = \$144,000$ per hour at equilibrium; $\$20 \times 6,500 = \$130,000$ under the union wage.

Insiders who keep jobs gain; 1,500 lost jobs and 1,500 additional job seekers are outsiders.

Exam tip

Always label the vertical axis as the wage. A minimum wage only matters if it lies above the equilibrium wage, and unemployment is the horizontal gap between quantity supplied and quantity demanded at the floor, not the distance to equilibrium. Never describe a wage change as a shift of supply or demand.

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Practice

SET A Check Your Understanding

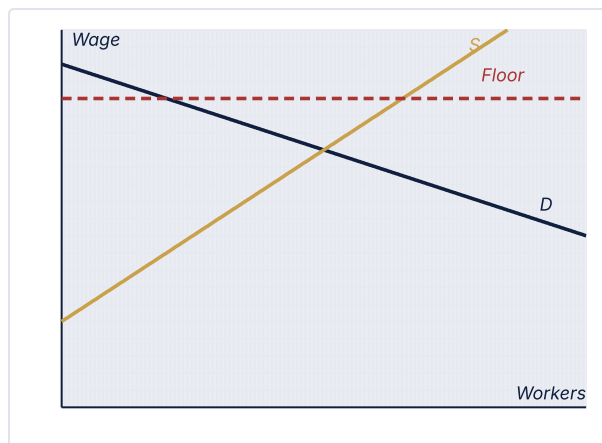
Answer each item in a few sentences, showing any calculation.

1. Explain the opportunity cost of leisure and use it to describe the substitution effect of a wage increase.
2. State whether the supply of labor for nurses shifts right, left, or not at all: (i) the state eases immigration rules for foreign-trained nurses; (ii) wages for pharmacists, a related occupation, rise sharply; (iii) hospitals increase the wage they pay.
3. Labor demand is $L_d = 600 - 20W$ and supply is $L_s = 10W$. Find the equilibrium wage and employment, then find unemployment if the government sets a minimum wage of \$24.
4. In the market above, what is the effect of a minimum wage of \$12?
5. Explain why the employment loss caused by a union wage increase is larger when labor demand is elastic.
6. Describe what a backward-bending labor supply curve means and why it happens.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. A worker reduces her weekly hours after receiving a large raise because she can now afford more time off. This behavior is best explained by the:
 - (A) substitution effect, because leisure became cheaper
 - (B) law of diminishing returns
 - (C) derived nature of labor demand
 - (D) price floor effect
 - (E) income effect, because higher earnings raise the demand for leisure
8. Which of the following would shift the supply of labor for registered dental hygienists to the right?
 - (A) Eased licensing requirements for the occupation
 - (B) A rise in the wage of dental hygienists
 - (C) Higher wages in other health occupations
 - (D) An increase in the number of retiring hygienists
 - (E) A decline in demand for dental services
9. The graph shows a competitive labor market with a minimum wage (dashed line). At the floor, quantity demanded is 80 and quantity supplied is 260. The number of unemployed workers is:



- (A) 80 (B) 120 (C) 180 (D) 260 (E) 340

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10. Using the table, if a union wins a wage of \$20, how many drivers want a job but cannot find one?

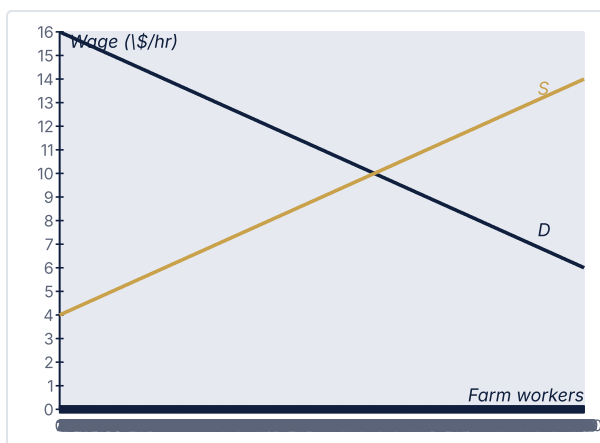
Wage	Qty demanded	Qty supplied
\$16	9,500	6,500
\$18	8,000	8,000
\$20	6,500	9,500

- (A) 1,500 (B) 3,000 (C) 6,500 (D) 8,000 (E) 9,500
11. A minimum wage is set below the equilibrium wage in a competitive labor market. The most likely result is that:
- (A) unemployment rises (B) employment falls
(C) the wage rises (D) supply of labor shifts right
(E) the wage and employment are unchanged
12. Which change would raise the equilibrium wage and reduce employment in a competitive labor market?
- (A) A leftward shift of labor supply (B) A rightward shift of labor demand
(C) A rightward shift of labor supply (D) A leftward shift of labor demand
(E) A rightward shift of both demand and supply

SET C Apply and Extend

Respond as you would on a free-response question.

13. The graph shows the competitive labor market for farm workers: demand $W = 16 - 0.01L$ and supply $W = 4 + 0.01L$ (W in dollars, L in workers). (a) Identify the equilibrium wage and employment. (b) The government imposes a minimum wage of \$13. Calculate the quantity demanded, quantity supplied, and unemployment. (c) Compare the total wage bill of farm workers before and after, and explain why the wage bill can fall.



14. A state tightens the licensing requirements for hair stylists, requiring much longer training. (a) Show the effect on the labor market for stylists with a correctly labeled graph. (b) State what happens to the equilibrium wage and employment. (c) Explain whether stylists who remain employed gain or lose, and who else is affected.

5.3 Monopsony and Other Factor Markets

See how a single buyer of labor sets wages and employment, and how the same marginal logic governs land, capital, and the mix of inputs.

A **monopsony** is a labor market with a single buyer, such as the only hospital or factory in a small town. Like a monopolist, the monopsonist has market power, but on the buying side. It faces the whole upward-sloping labor supply curve, so to attract more workers it must raise the wage.

The key point: if the firm must pay every worker the same wage, then raising the wage to hire one more worker raises the pay of all existing workers too. The extra cost of the next worker is the new wage plus the raises given to everyone else. So **marginal factor cost (MFC) is above the supply curve**, just as a monopolist's MR is below its demand curve.

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Monopsony rules

Supply of labor is the average factor cost (the wage). $MFC = \Delta TC / \Delta L$ lies **above** supply and rises faster.

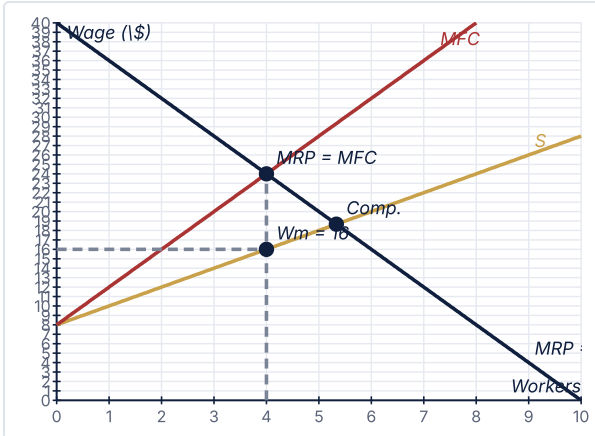
Hire where $MRP = MFC$.

Then read the wage **down from that quantity to the supply curve**. The wage is below MRP.

Compared with a competitive market: lower wage, lower employment, and a deadweight loss.

EXAMPLE 1: MONOPSONY VERSUS COMPETITION

A firm is the only employer in a town. It sells output in a competitive market, and its MRP is $40 - 4L$ (L in workers). Labor supply is $W = 8 + 2L$. (a) Find the monopsony MFC. (b) Find employment and the wage. (c) Compare with a competitive labor market.



SOLUTION

(a) Total labor cost = $W \times L = 8L + 2L^2$, so $MFC = 8 + 4L$, twice as steep as supply.

(b) $MRP = MFC$: $40 - 4L = 8 + 4L$ gives $L = 4$. The wage comes from supply: $W = 8 + 2(4) = \$16$. MRP at $L = 4$ is \$24, so each worker is paid \$8 less than the revenue he adds.

(c) Competitive: $MRP = S$: $40 - 4L = 8 + 2L$ gives $L = 5.33$ and $W = \$18.67$. So the monopsonist hires fewer workers (4 versus 5.33) and pays less (\$16 versus \$18.67).

Feature	Competitive labor market	Monopsony
Buyers of labor	Many, wage takers	One, wage maker
Supply facing each firm	Horizontal at the market wage	Upward-sloping market supply
MFC	Equals the wage	Above the wage (supply)
Hiring rule	$MRP = W$	$MRP = MFC$
Outcome	Wage = MRP	Wage < MRP, employment below competitive level

Minimum wage under monopsony. Suppose a floor is set between the monopsony wage and the competitive wage. The firm can no longer lower the wage to cut costs, so its MFC becomes flat at the floor up to the quantity workers supply at that wage. Employment can then **rise**.

EXAMPLE 2: A FLOOR ON A MONOPSONY WAGE

Use the monopsony in Example 1. A minimum wage of \$18 is imposed. Find employment. Then repeat for \$24.

SOLUTION

At \$18, workers supply: $18 = 8 + 2L$ gives $L = 5$. The firm values the 5th worker at $MRP = 40 - 20 = \$20$, above the \$18 MFC, so it hires all 5. Employment rises from 4 to 5 and the wage rises from \$16 to \$18.

At \$24, the firm hires where $MRP = 24$: $40 - 4L = 24$ gives $L = 4$. Workers supply 8 at this wage, so employment is 4 and there are 4 unemployed.

A floor helps up to the competitive wage (\$18.67); above it, employment falls, as in a competitive market.

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Other factor markets. The same $MRP = MFC$ logic applies to every input. **Land** has a fixed (perfectly inelastic) supply, so its price, **rent**, is set entirely by demand. A payment above what is needed to supply a factor is **economic rent**. **Physical capital** (machines) is rented at a price r ; a firm hires capital while $MRP_K \geq r$. **Financial capital** is borrowed at the interest rate: a firm invests when its expected return exceeds the interest rate. The factors earn wages (labor), rent (land), interest (capital), and profit (entrepreneurship).

Combining several inputs

Least-cost combination: $\frac{MP_L}{W} = \frac{MP_K}{r}$ (equal output per dollar on each input).

Profit-maximizing combination: $\frac{MRP_L}{W} = \frac{MRP_K}{r} = 1$.

If one ratio is higher, shift spending toward that input. If both exceed 1, expand.

EXAMPLE 3: USING TWO INPUTS

A firm sells output at \$2 each. Labor costs \$8 per hour with $MPL = 24$ units. Capital costs \$9 per hour with $MPK = 18$ units. (a) Is the firm minimizing cost? (b) Is it maximizing profit?

SOLUTION

(a) $MPL/W = 24/8 = 3$ units per dollar; $MPK/r = 18/9 = 2$. They differ, so the firm is not at least cost. It should use more labor and less capital: as it does, MPL falls and MPK rises until the ratios equalize.

(b) $MRPL = 2 \times 24 = \$48$ and $MRPK = 2 \times 18 = \$36$. $MRPL/W = 6$ and $MRPK/r = 4$. Both exceed 1, so the firm should also expand its use of both inputs until each ratio is 1.

Common mistakes

(1) Reading the monopsony wage off the MFC curve; it comes from the supply curve at the quantity where $MRP = MFC$. (2) Drawing MFC below supply. (3) Saying a minimum wage always reduces employment; under monopsony a floor between the monopsony and competitive wage can raise it. (4) Confusing equal ratios (cost minimization) with ratios equal to 1 (profit maximization).

Practice

SET A Check Your Understanding

Answer each item in a few sentences, showing any calculation.

1. Why does a monopsonist's marginal factor cost exceed the wage it pays?
2. A monopsonist pays wages of \$6, \$8, \$10, \$12 to hire 1, 2, 3, 4 workers (the same wage to all workers). MRP of the workers is \$20, \$18, \$16, \$14. Compute the total cost and MFC for each level of employment, then the profit-maximizing employment and wage.
3. A monopsonist faces $MRP = 22 - L$ and supply $W = 4 + L$. Find employment and the wage under monopsony and under competition. How large is the gap between MRP and the wage under monopsony?
4. A fixed 100 acres of farmland are available. Demand for farmland rises. What happens to rent and to the quantity of land used? Explain why.
5. A firm finds $MPL/W = 4$ and $MPK/r = 6$. What should it do to minimize the cost of a given output?
6. A firm may borrow at an interest rate of 8 percent to buy a machine that is expected to return 11 percent per year. Should it buy? Explain.

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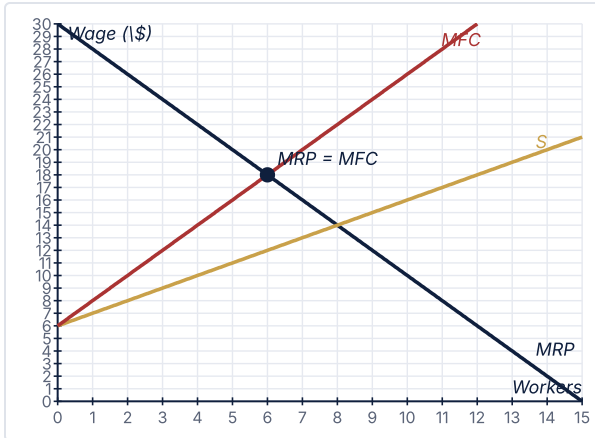
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. For a profit-maximizing monopsonist, the marginal factor cost curve:
- (A) lies above the labor supply curve (B) coincides with the labor supply curve
 (C) lies below the labor supply curve (D) is horizontal at the wage
 (E) is identical to the MRP curve
8. The graph shows a monopsony with MRP, S, and MFC. The wage the monopsonist pays is:



- (A) \$6 (B) \$12 (C) \$14 (D) \$18 (E) \$24
9. A minimum wage set between the monopsony wage and the competitive wage will most likely:
- (A) decrease employment and increase unemployment
 (B) decrease the wage and increase employment
 (C) have no effect on the labor market
 (D) increase both the wage and employment
 (E) reduce the wage and the MRP
10. The supply of land in an area is fixed. A rise in demand for the land will:
- (A) raise the quantity of land and leave rent unchanged
 (B) raise rent and the quantity of land
 (C) lower rent and raise the quantity of land
 (D) raise rent without changing the quantity of land
 (E) leave rent and quantity unchanged
11. A firm has $MPL = 30$, $W = \$6$, $MPK = 40$, $r = \$10$. To minimize cost, the firm should:
- (A) use more capital and less labor (B) use less labor only
 (C) use less of both inputs (D) use more of both inputs
 (E) use more labor and less capital
12. A competitive firm maximizes profit in the markets for labor and capital when:
- (A) $MPL = MPK$ (B) $W = r$ (C) $MRPL/W = MRPK/r = 1$
 (D) $MPL/W > MPK/r$ (E) $MRPL = MRPK$

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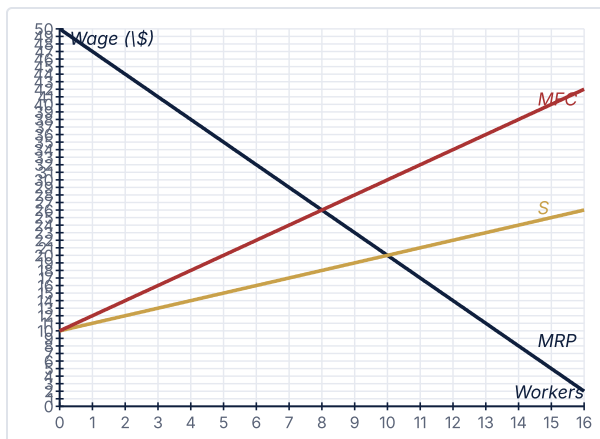
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SET C Apply and Extend

Respond as you would on a free-response question.

13. The graph shows the only employer in a rural town (a monopsony). $MRP = 50 - 3L$, supply $W = 10 + L$, and $MFC = 10 + 2L$. (a) What quantity of labor does the firm hire, and what wage does it pay? (b) What would the wage and employment be if the labor market were competitive? (c) The government imposes a minimum wage of \$20. What happens to employment? Explain.



14. A firm sells its product in a competitive market at \$5 per unit. Labor costs \$20 per hour and capital costs \$40 per hour. The marginal product of labor is 5 units and of capital is 10 units. (a) Compute MRP of each input. (b) Is the firm using the least-cost combination? Is it maximizing profit? Explain. (c) What should the firm do and what happens to marginal products as it does so?

5.4 Income Distribution, Poverty, and Inequality

Measure income inequality with quintiles, Lorenz curves, and the Gini coefficient, and evaluate taxes and transfers that redistribute income.

Factor markets determine who earns what: wages for labor, rent for land, interest for capital, and profit for entrepreneurs. Differences in the quantity and value of the resources people own produce differences in income. Two related questions follow. **Poverty** asks who cannot afford basic needs. **Income inequality** asks how unevenly income is spread across the whole population. A country can have little poverty but high inequality, or the reverse.

Why do incomes differ? Economists point to human capital (education and experience raise MRP), compensating differentials (dangerous or unpleasant jobs pay more), discrimination, union status, technology that rewards high skill, inheritance and ownership of wealth, and differences in family structure and hours worked. In labor markets, the wage reflects the worker's MRP and the supply of workers with that skill.

Measuring inequality

Quintiles divide households into five equal groups ranked by income; we compare each group's share of total income.

The **Lorenz curve** plots the cumulative share of households (horizontal axis) against the cumulative share of income (vertical axis). The 45-degree line is perfect equality.

The **Gini coefficient** = area between the line of equality and the Lorenz curve, divided by the whole area below the line of equality ($A/(A+B)$). It ranges from 0 (perfect equality) to 1 (one household has everything). A bigger bow means more inequality.

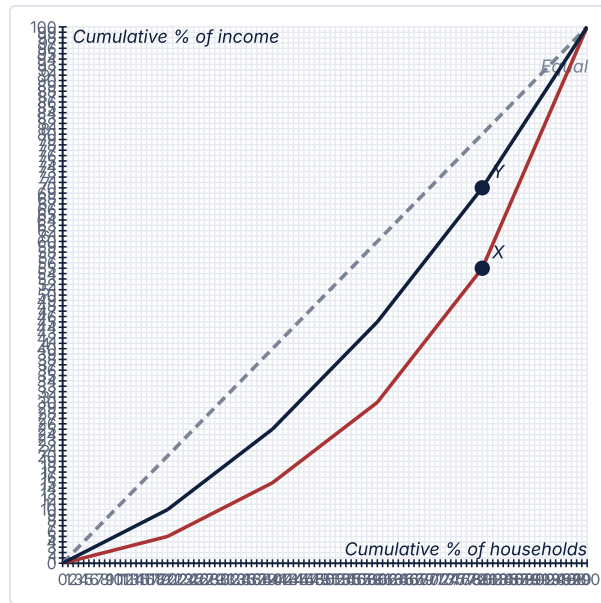
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EXAMPLE 1: BUILDING AND COMPARING LORENZ CURVES

Quintile income shares (lowest to highest) are: Country X: 5, 10, 15, 25, 45 percent. Country Y: 10, 15, 20, 25, 30 percent. (a) Find the cumulative shares and plot the Lorenz curves. (b) Which country is more unequal? (c) Estimate the Gini coefficients using $\text{Gini} = 1 - 2 \times (\text{area under the Lorenz curve})$.

**SOLUTION**

(a) Cumulative shares (adding as you go): X: 5, 15, 30, 55, 100. Y: 10, 25, 45, 70, 100. Plot at 20, 40, 60, 80, 100 percent of households.

(b) X's curve lies farther below the line of equality, so X is more unequal. In X the bottom 40 percent get 15 percent of income; in Y they get 25 percent.

(c) Area under X with trapezoids (each 0.2 wide): $0.2 \times [(0+0.05)/2 + (0.05+0.15)/2 + (0.15+0.30)/2 + (0.30+0.55)/2 + (0.55+1)/2] = 0.2 \times 1.55 = 0.31$. $\text{Gini}_X = 1 - 0.62 = 0.38$. For Y the area is 0.40 and $\text{Gini}_Y = 0.20$.

Tax structures. Compare taxes by the **average tax rate** = tax paid divided by income. A **progressive** tax takes a larger share of income as income rises (federal income tax). A **proportional** (flat) tax takes the same share. A **regressive** tax takes a smaller share as income rises (a sales tax, or a payroll tax that stops at an earnings cap). Progressive taxes narrow inequality; regressive ones widen it.

EXAMPLE 2: CLASSIFYING TAXES

Three taxes are levied on people earning \$20,000, \$50,000, and \$100,000. Tax A collects \$1,000, \$5,000, \$15,000. Tax B collects \$2,000, \$5,000, \$10,000. Tax C collects \$2,000, \$3,000, \$4,000. Classify each.

SOLUTION

Tax A: average rates 5%, 10%, 15%. The rate rises, so it is progressive.

Tax B: 10%, 10%, 10%. The rate is constant, so it is proportional.

Tax C: 10%, 6%, 4%. The rate falls even though the dollar amount rises, so it is regressive. The test is always the percentage of income, not the dollar amount.

Transfers and poverty. The **poverty line** is a fixed income threshold for a basic standard of living, and the **poverty rate** is the share of people below it. Governments use **transfer payments** (cash such as TANF and the earned income tax credit, and in-kind help such as SNAP food assistance and Medicaid) funded by progressive taxes, to redistribute income. A **poverty trap** occurs when benefits shrink as earnings rise, so working yields little net gain; if a family loses 50 cents of benefits for each dollar earned, it faces an effective marginal tax rate of 50 percent.

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EXAMPLE 3: REDISTRIBUTION AND THE GINI COEFFICIENT

A country's total income of \$1,000 billion is split by quintile: \$50, \$100, \$150, \$250, \$450 billion. A tax takes \$50 billion from the top quintile and gives it to the bottom quintile. Compute the Gini coefficient before and after.

SOLUTION

Before: shares 5, 10, 15, 25, 45 percent; cumulative 5, 15, 30, 55, 100. Gini = 0.38 (Example 1).
After: incomes \$100, \$100, \$150, \$250, \$400 billion, shares 10, 10, 15, 25, 40; cumulative 10, 20, 35, 60, 100.
Area under the new Lorenz curve = $0.2 \times [0.05 + 0.15 + 0.275 + 0.475 + 0.80] = 0.2 \times 1.75 = 0.35$, so Gini = $1 - 0.70 = 0.30$.
Inequality fell, and the Lorenz curve moved toward the line of equality.

Policy	How it reduces inequality	Possible efficiency cost
Progressive income tax	Takes a larger share from high earners	Lower after-tax reward for work and investment
Earned income tax credit	Raises pay of low-income workers and rewards work	Cost to taxpayers; phase-out creates high marginal rates
Cash/in-kind transfers	Raise incomes of poor households	Benefit reduction as earnings rise can discourage work
Education and training	Raises MRP of low-skill workers	Costly and slow to take effect

Equity versus efficiency

Efficiency means maximizing the size of the economic pie; equity concerns how fairly it is divided.
Redistribution can reduce incentives to work and invest (the 'leaky bucket'), so there is often a tradeoff.
Judging how much equity is worth is a normative question; the size of the tradeoff is positive.

Common mistakes

- (1) Plotting income shares instead of cumulative shares. (2) Calling a tax regressive because the dollar amount rises; look at the percentage of income. (3) Mixing poverty (below a fixed line) with inequality (the spread across everyone). (4) Putting the Lorenz curve above the 45-degree line; it must lie on or below it.

Practice

SET A Check Your Understanding

Answer each item in a few sentences, showing any calculation.

1. Distinguish poverty from income inequality, and give an example of a change that would lower poverty but leave inequality higher.
2. A country's quintile income shares are 6, 12, 18, 24, and 40 percent. Find the cumulative shares and estimate the Gini coefficient.
3. A worker earning \$30,000 pays \$3,000 in a tax, while a worker earning \$90,000 pays \$7,200. Compute the average tax rates and classify the tax.
4. A family receives \$500 per month in benefits, reduced by 50 cents for every dollar it earns. It takes a job earning \$600 per month. Find the change in net monthly income and the effective marginal tax rate. What problem does this illustrate?
5. Explain the tradeoff between equity and efficiency in designing a redistribution program.
6. Describe the Lorenz curve and Gini coefficient for a country with perfect equality and for one in which a single household earns all the income.

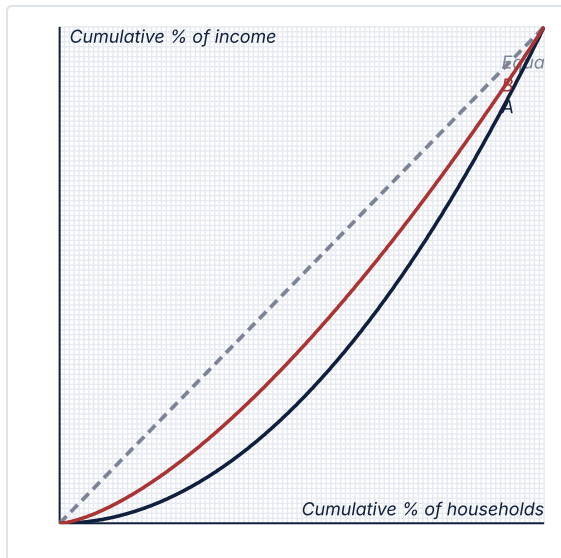
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. On a Lorenz curve diagram, the 45-degree line shows:
- (A) the actual distribution of income
 - (B) a perfectly unequal distribution
 - (C) a distribution where each fifth of households gets the same share of income as its share of households
 - (D) income inequality in the poorest country
 - (E) the poverty line
8. Quintile income shares in a country are 4, 9, 14, 23, and 50 percent. The cumulative share of income received by the bottom 60 percent of households is:
- (A) 14 percent
 - (B) 23 percent
 - (C) 13 percent
 - (D) 50 percent
 - (E) 27 percent
9. The graph shows Lorenz curves for countries A and B. Which statement is correct?



- (A) Country B has more income inequality than country A
 - (B) Country A has more income inequality than country B
 - (C) Both have the same Gini coefficient
 - (D) Country A has a Gini coefficient of 0
 - (E) Country B has no poverty
10. A person with a \$40,000 income pays \$4,000 in tax, and a person with an \$80,000 income pays \$12,000. The tax is:
- (A) regressive, because the dollar amount rises
 - (B) proportional, because both pay a tax
 - (C) progressive, because the second person pays less than twice the amount
 - (D) progressive, because the average tax rate rises from 10 percent to 15 percent
 - (E) regressive, because the average tax rate rises
11. Which of the following is an in-kind transfer?
- (A) A cash payment under TANF
 - (B) SNAP food assistance
 - (C) The earned income tax credit
 - (D) A wage subsidy
 - (E) A progressive income tax

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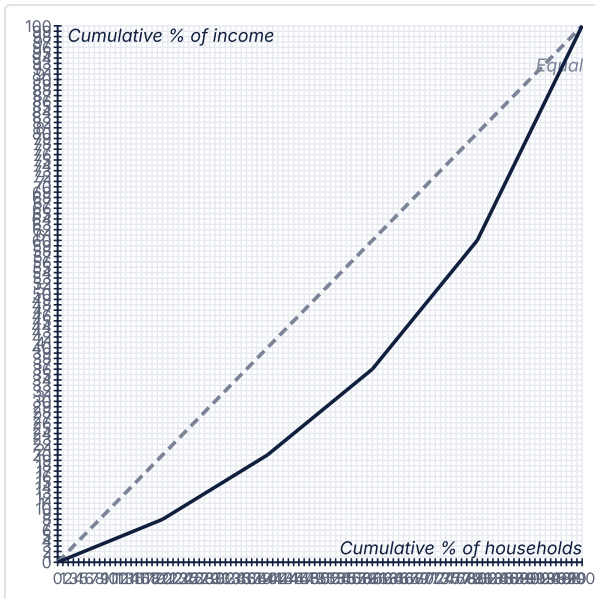
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12. The Gini coefficient of country M is 0.45 and of country N is 0.30. Compared with N, M has:
- (A) more equal income distribution
 - (B) a Lorenz curve closer to the line of equality
 - (C) a lower poverty rate
 - (D) a higher marginal tax rate
 - (E) a Lorenz curve farther below the line of equality

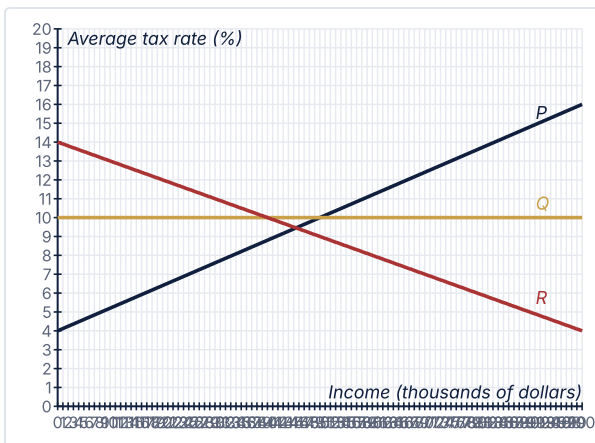
SET C Apply and Extend

Respond as you would on a free-response question.

13. A country's households, ranked from poorest to richest in fifths, receive 8, 12, 16, 24, and 40 percent of total income. The Lorenz curve is shown. (a) Calculate the cumulative income shares and identify the share going to the bottom 60 percent. (b) Estimate the Gini coefficient. (c) The government moves 5 percentage points of total income from the top fifth to the bottom fifth. Compute the new Gini coefficient and describe the change in the Lorenz curve. (d) Identify one efficiency cost of the policy.



14. The graph shows average tax rates (percent of income) at different income levels (thousands of dollars) for three taxes: P, Q, and R. (a) Classify each tax. (b) Which tax is most likely a sales tax on food, and why? (c) Explain how replacing tax P with tax R would affect the Lorenz curve and the equity-efficiency tradeoff.



5.5 Multiple-Choice Practice: Factor Markets

Twenty AP-style multiple-choice questions covering labor demand, labor supply, monopsony, other factor markets, and income distribution.

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Choose the best answer for each question. Explanations name the correct reasoning and the most tempting wrong choice. Use a calculator only where noted; most items need quick arithmetic.

SET A Core Concepts

Choose the best answer.

1. A rise in the price of pizza will most likely cause the demand for pizza cooks to:
(A) fall, because the wage rises
(B) fall, because pizza output falls
(C) shift right, because labor demand is derived from product demand
(D) remain unchanged, because the wage is unchanged
(E) shift left, because cooks become less productive
2. A competitive firm sells its output at \$5 per unit and pays a wage of \$35. Total output with 1, 2, 3, 4 workers is 12, 22, 30, 36 units. How many workers should it hire?
(A) 3 (B) 1 (C) 2 (D) 4 (E) 0
3. A worker's hours fall after her wage rises sharply. This is best explained by the:
(A) law of diminishing returns (B) derived demand for labor
(C) substitution effect (D) monopsony power of her employer
(E) income effect
4. A binding minimum wage in a competitive labor market will:
(A) raise employment because more workers want to work
(B) create a surplus of labor because quantity supplied exceeds quantity demanded
(C) shift the demand for labor to the left
(D) shift the supply of labor to the right
(E) lower the wage of workers who keep their jobs
5. A monopsonist maximizes profit by hiring labor until:
(A) the wage equals MRP
(B) the wage equals the marginal product of labor
(C) MRP equals the wage and the wage equals MFC
(D) MFC equals the wage minus MRP
(E) MRP equals MFC, and then it pays a wage below MRP
6. A Gini coefficient of 0 for an economy means:
(A) every household is in poverty
(B) all households have the same income
(C) one household has all the income
(D) the Lorenz curve lies below the horizontal axis
(E) the poverty rate is zero
7. A tax takes 12 percent of income from a person earning \$20,000 and 8 percent from a person earning \$80,000. This tax is:
(A) progressive (B) proportional
(C) regressive (D) lump-sum
(E) a tax with a falling dollar amount

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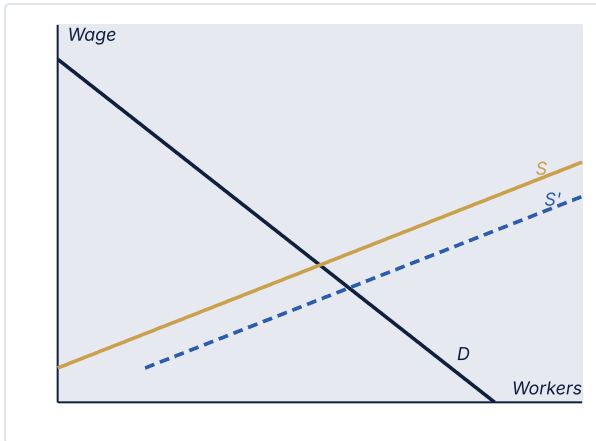
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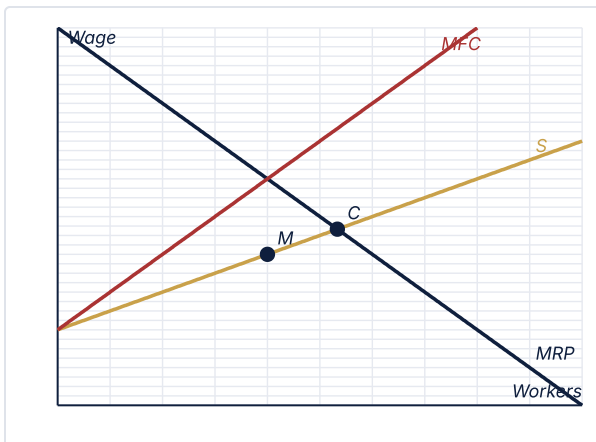
SET B Applications and Data

Choose the best answer; some items use graphs or tables.

8. A competitive firm sells output at \$6. Total output with 1 through 5 workers is 9, 16, 21, 24, 25 units. The market wage is \$24. The profit-maximizing number of workers is:
 (A) 1 (B) 2 (C) 5 (D) 3 (E) 4
9. The graph shows the labor market for warehouse workers. Supply shifts from S to S' because of an increase in immigration. The new equilibrium has:



- (A) a higher wage and lower employment
 (B) a higher wage and higher employment
 (C) a lower wage and lower employment
 (D) the same wage and higher employment
 (E) a lower wage and higher employment
10. The graph shows a monopsonist. M marks the quantity and wage it chooses; C marks the competitive outcome. Compared with competition, the monopsonist pays a:



- (A) lower wage and hires fewer workers
 (B) lower wage and hires more workers
 (C) higher wage and hires fewer workers
 (D) higher wage and hires more workers
 (E) lower wage but hires the same number of workers
11. A firm finds that $MPL = 20$ and $W = \$4$, while $MPK = 36$ and $r = \$9$. To minimize the cost of its output the firm should:
 (A) use more capital and less labor (B) use less of both inputs
 (C) use more labor and less capital (D) use more of both inputs
 (E) make no change

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12. Quintile shares of income (lowest to highest) are 5, 10, 15, 25, and 45 percent. What share of income goes to the bottom 80 percent of households?
- (A) 55 percent (B) 30 percent (C) 45 percent
(D) 25 percent (E) 15 percent
13. The table gives taxes paid at three income levels. The tax is:

Income	Tax paid
\$20,000	\$3,000
\$60,000	\$6,600
\$100,000	\$8,000

- (A) progressive (B) proportional (C) a lump-sum tax
(D) regressive (E) a tax on wealth
14. A union negotiates a wage above the equilibrium wage in a competitive labor market. The most likely effects are:
- (A) higher employment and a surplus of labor
(B) higher wage for union members and fewer jobs than at equilibrium
(C) a lower wage and unemployment
(D) a rightward shift of labor demand
(E) no effect on employment because demand is inelastic

SET C Exam-Level Stretch

Choose the best answer.

15. A firm sells in a competitive output market at \$3. For labor, $MPL = 10$ and $W = \$5$; for capital, $MPK = 16$ and $r = \$8$. Which statement is correct?
- (A) The firm should use more labor and less capital
(B) The firm should use more capital and less labor
(C) The firm should use less of both
(D) The firm is maximizing profit
(E) The firm is at least cost, but should hire more of both inputs
16. A single employer faces $MRP = 40 - 4L$ and labor supply $W = 8 + 2L$. A minimum wage of \$18 is imposed. Compared with no minimum wage ($L = 4$, $W = \$16$), employment:
- (A) falls to 3 (B) falls to 2 (C) rises to 5
(D) stays at 4 (E) rises to 8
17. Stricter licensing requirements reduce labor supply for electricians at the same time that a construction boom raises labor demand. The equilibrium wage and employment:
- (A) rise and fall (B) wage rises, employment is uncertain
(C) wage falls, employment rises (D) wage is uncertain, employment falls
(E) are both uncertain
18. A worker's hourly wage rises from \$10 to \$20, and her weekly hours fall from 40 to 30 (income rises from \$400 to \$600). This indicates that:
- (A) the income effect outweighs the substitution effect
(B) the substitution effect outweighs the income effect
(C) her labor supply is perfectly elastic
(D) she faces a binding price ceiling
(E) the demand for labor has shifted left

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19. A government raises taxes on the top quintile and uses the revenue to fund cash transfers to the bottom quintile. Which is the most likely result?
- (A) The Lorenz curve shifts down and the Gini coefficient rises
 - (B) The Lorenz curve is unchanged
 - (C) The Gini coefficient is unchanged because total income is unchanged
 - (D) The Lorenz curve shifts up toward the line of equality and the Gini coefficient falls
 - (E) The line of equality shifts up
20. Which of the following is a normative statement?
- (A) The top quintile received 51 percent of income in a certain year.
 - (B) A progressive tax has a rising average tax rate.
 - (C) A minimum wage above equilibrium creates a surplus of labor.
 - (D) Transfers may reduce work incentives for recipients.
 - (E) The government should reduce inequality even if output falls somewhat.

5.6 Free-Response Practice: Factor Markets

Four free-response questions on labor markets, monopsony, and income distribution.

Each question is scored by points for correct calculations, labeled graphs, and explanations. Show your work: on the real exam, a correct answer with no reasoning may earn no credit. Point values appear in the model answers.

QUESTION 1 Hiring labor in a competitive market

A bakery sells loaves in a perfectly competitive product market at \$4 per loaf and hires labor in a competitive labor market. Total loaves per hour with 1, 2, 3, 4, 5 workers are 14, 26, 36, 44, 50. The market wage is \$32 per hour.

1. (a) Calculate the marginal revenue product of each of the five workers.
2. (b) How many workers should the bakery hire at a wage of \$32? Explain using the hiring rule.
3. (c) The wage rises to \$40. How many workers does it hire now? Is this a shift or a movement along the labor demand curve?
4. (d) The wage returns to \$32, but the price of a loaf falls to \$3. How many workers are hired, and what happens to the bakery's labor demand curve?

QUESTION 2 A minimum wage in a competitive labor market

The market for dishwashers is perfectly competitive. Labor demand is $W = 24 - 0.02L$ and labor supply is $W = 6 + 0.01L$, where L is the number of workers and W is the hourly wage in dollars.

5. (a) Find the equilibrium wage and employment.
6. (b) The government sets a minimum wage of \$15. Calculate quantity demanded, quantity supplied, and unemployment.
7. (c) Compare the total wage payments to dishwashers before and after the minimum wage, and say what this suggests about the elasticity of labor demand.
8. (d) Explain how your analysis would differ if the dishwashers' employer were a monopsonist.

QUESTION 3 Monopsony and factor prices

The only employer in a rural town sells output in a competitive market. Its MRP of labor is $MRP = 60 - 4L$, and the labor supply curve is $W = 12 + 2L$, so its marginal factor cost is $MFC = 12 + 4L$ (L in workers, W in dollars per hour).

9. (a) Find the profit-maximizing quantity of labor and the wage the firm pays. Explain why the wage is not equal to MFC.
10. (b) How much less than MRP is each worker paid at that quantity?
11. (c) What wage and employment would occur if the labor market were competitive?
12. (d) A minimum wage of \$28 is imposed. What happens to employment compared with part (a)? Explain.

QUESTION 4 Income distribution and taxes

Country Z has the following shares of total income by household quintile (lowest to highest): 3, 8, 14, 23, and 52 percent.

13. (a) Compute the cumulative income shares and draw (or describe) the Lorenz curve. What share of income goes to the bottom 60 percent of households?
14. (b) Estimate the Gini coefficient.
15. (c) A tax-and-transfer program moves 4 percentage points of national income from the top quintile to the bottom quintile. Compute the new Gini coefficient.

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16. (d) An income tax takes \$3,000 from a person earning \$30,000, \$7,200 from a person earning \$60,000, and \$18,000 from a person earning \$120,000. Classify the tax and explain one possible efficiency cost of the redistribution.

Answers**Chapter 5: Answers and Explanations**

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

5.1 Demand for Labor and Marginal Revenue Product**SET A • CHECK YOUR UNDERSTANDING**

1. Firms hire labor only because customers buy what labor helps produce, so labor demand comes from product demand. Example: if more people buy electric bikes, bike makers need more assemblers and the demand for assemblers shifts right. If bike sales fall, the demand for assemblers falls.
2. $MRP = P \times MPL = 3 \times 8 = \$24$. Since MRP (\$24) exceeds the wage and MFC (\$20), the fifth worker adds \$4 more to revenue than to cost. The firm should hire that worker.
3. $MRP = 2 \times MPL = \$24, \$20, \$16, \$12, \$8$. The firm hires while $MRP \geq W$, so the third worker ($MRP = \$16 = W$) is the last hired. The answer is 3 workers. The fourth would add \$12 of revenue for \$16 of cost.
4. (i) Shifts left: lower P lowers MRP at every quantity. (ii) Shifts right: higher MPL raises MRP. (iii) No shift: a wage change moves the firm along its existing MRP curve and changes the quantity of labor demanded.
5. Cheaper robots are a substitute for labor, so firms may replace workers with robots (substitution effect, labor demand shifts left). But cheaper production lowers costs, so firms may expand output and hire more of everything (output effect, shift right). The net result depends on which effect is larger.
6. The firm is a tiny part of the market, so it can hire any number of workers at the going wage without moving it; its supply of labor is horizontal and $MFC = W$. Its MRP slopes downward because diminishing marginal returns make each added worker less productive, so MPL and MRP fall.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. E. Labor is wanted for the output it makes, so its demand derives from product demand. Choice A confuses cause with price: the wage moves you along the demand curve, not why the curve exists.
8. B. $MRP = 6 \times 4 = \$24$, below the \$30 MFC, so the last worker costs more than she adds. Choice A ignores that marginal product must be converted to revenue and compared with cost.
9. C. $MRP = \$40, \$32, \$24, \$16, \$8$. The third worker (\$24) still exceeds the \$20 wage, the fourth (\$16) does not. Choice D is tempting if you hire while MPL is positive, but it ignores cost.
10. A. A higher output price raises MRP at every quantity. Choice B is a movement along the curve, not a shift, and a lower price (D) shifts it left.
11. E. Higher demand for concerts raises output price and MRP, shifting D right along S, so both wage and employment rise. Choice C would require a perfectly elastic supply.
12. C. For the monopolist $MR < P$, so $MRP = MPL \times MR$ is smaller than $MPL \times P$. Choice B is wrong because the multiplier, MR, differs even though MPL is the same.

SET C • APPLY AND EXTEND

13. (a) 1 point: $MRP = \text{wage at } 40 - 4L = 24$, so $L = 4$ workers. (b) 1 point: higher MPL raises MRP at each quantity, so the MRP curve shifts right/up (each point is 25 percent higher: $MRP = 50 - 5L$). 1 point: at $W = 24$, $50 - 5L = 24$ gives $L = 5.2$, so the firm hires about 5 workers instead of 4 (MRP exceeds the wage for the fifth worker: $50 - 25 = 25 > 24$). (c) 1 point: at $W = 16$, $40 - 4L = 16$ gives $L = 6$. 1 point: it is a movement along the existing MRP curve (quantity demanded changes), not a shift.
14. (a) 1 point: labor demand (a derived demand) shifts right, with a correctly labeled graph showing W on the vertical axis, cooks on the horizontal, D1 to D2 along an upward-sloping S. 1 point: the equilibrium wage rises above \$12 and employment rises above 400. (b) 1 point: in a competitive labor market the diner is small relative to the market, so the market wage is set by market supply and demand and the diner faces a horizontal supply curve at that wage, $MFC = W$. (c) 1 point: hire cooks up to the point where $MRP = MFC (= W)$.

5.2 Labor Supply and the Labor Market**SET A • CHECK YOUR UNDERSTANDING**

1. Each hour of leisure forgoes one hour of wages, so leisure's opportunity cost equals the wage. When the wage rises, leisure becomes more expensive relative to work, so the worker substitutes toward work and supplies more hours. This substitution effect pushes the supply curve upward.
2. (i) Shifts right: more qualified workers are available at each wage. (ii) Shifts left: some nurses retrain or switch to the better-paying related occupation. (iii) No shift: a higher wage causes a movement along the supply curve to a larger quantity supplied.
3. Set $600 - 20W = 10W$, so $600 = 30W$, $W = \$20$ and $L = 200$. At \$24: quantity demanded = $600 - 480 = 120$, quantity supplied = 240, so unemployment is $240 - 120 = 120$ workers. Employment falls from 200 to 120.
4. A \$12 minimum is below the equilibrium wage of \$20, so it is not binding. Firms and workers already agree on \$20, so the wage, employment, and unemployment are unchanged.
5. If demand is elastic, a given percentage rise in the wage causes a larger percentage fall in the quantity demanded because firms can easily substitute capital or other workers. So employment drops more and the total wage bill for union members can fall. With inelastic demand, jobs are lost little, so union members gain more.
6. At high wage levels the income effect (the worker feels rich enough to buy more leisure) can outweigh the substitution effect, so hours supplied decrease when the wage rises further. Graphically the individual's supply curve bends back toward the vertical axis.

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SET B • EXAM-STYLE MULTIPLE CHOICE

7. E. The extra income lets her buy more of a normal good, leisure; that is the income effect. A is wrong because higher wages make leisure costlier, not cheaper.
8. A. Easier entry raises the number of qualified workers at each wage. B is a movement along the curve, and C shifts supply left by attracting workers elsewhere.
9. C. Unemployment is quantity supplied minus quantity demanded at the floor: $260 - 80 = 180$. B (120) is the fall in employment from the equilibrium of 200, a tempting but different measure.
10. B. At \$20, 9,500 supply and 6,500 demand: $9,500 - 6,500 = 3,000$ unemployed. A (1,500) is only the fall in employment from equilibrium ($8,000 - 6,500$).
11. E. A floor below equilibrium is non-binding, so nothing changes. A is wrong because unemployment arises only if the floor is above equilibrium.
12. A. Less labor supplied at each wage lifts the wage and cuts employment. D lowers the wage, and B raises both.

SET C • APPLY AND EXTEND

13. (a) 1 point: $16 - 0.01L = 4 + 0.01L$ gives $12 = 0.02L$, $L = 600$ and $W = \$10$. (b) 1 point: at \$13 quantity demanded = $(16 - 13)/0.01 = 300$. 1 point: quantity supplied = $(13 - 4)/0.01 = 900$. 1 point: unemployment = $900 - 300 = 600$. (c) 1 point: wage bill before = $10 \times 600 = \$6,000$ per hour; after = $13 \times 300 = \$3,900$. The bill falls because the percentage fall in employment (50 percent) outweighs the 30 percent wage gain, i.e. labor demand is elastic in this range.
14. (a) 1 point: graph with wage on the vertical axis, workers on the horizontal axis, downward-sloping D, and supply shifting left from S1 to S2. (b) 1 point: wage rises. 1 point: employment falls. (c) 1 point: stylists who stay employed earn a higher wage because supply is restricted. 1 point: consumers pay higher prices and lose access, and would-be stylists who cannot meet the requirements are shut out of the occupation.

5.3 Monopsony and Other Factor Markets**SET A • CHECK YOUR UNDERSTANDING**

1. To hire another worker the monopsonist must raise the wage, and under a single wage the raise applies to all current workers too. The marginal cost of the new worker is therefore his wage plus the raises for everyone else, so MFC lies above the supply curve (average cost).
2. Total cost = wage $\times$ workers: \$6, \$16, \$30, \$48. MFC = \$6, \$10, \$14, \$18. Hire while $MRP \geq MFC$: worker 3 has $MRP \$16 \geq \$14$, worker 4 has $\$14 < \$18$. Employment is 3 and the wage is \$10 (read from supply), not the \$14 MFC.
3. Monopsony: $MFC = 4 + 2L$; set $22 - L = 4 + 2L$, so $L = 6$ and $W = 4 + 6 = \$10$. Competition: $22 - L = 4 + L$ gives $L = 9$ and $W = \$13$. Under monopsony MRP at $L = 6$ is \$16, so the gap is $\$16 - \$10 = \$6$ per worker. Employment and wages are both lower.
4. Land supply is perfectly inelastic, so the quantity stays at 100 acres, and rent rises because the higher demand has to be rationed among users. The whole payment is economic rent, since the land would be supplied even at a lower price.
5. $MPL/W = 4$ is less than $MPK/r = 6$, so capital gives more output per dollar. The firm should use more capital and less labor. As it does, MPK falls and MPL rises until the ratios are equal.
6. Yes. The expected return of 11 percent exceeds the 8 percent cost of financing, so the machine adds more to revenue than it costs. The firm should keep investing until the marginal return falls to the interest rate.

SET B • EXAM-STYLE MULTIPLE CHOICE

7. A. Supply is the average cost of labor; because raising the wage applies to all workers, the cost of the marginal worker exceeds the average. D describes a competitive firm, whose MFC is the wage.
8. B. $MRP = MFC$ where $30 - 2L = 6 + 2L$, $L = 6$. The wage is read from supply: $6 + 6 = \$12$. The tempting answer D (\$18) is the MRP at that quantity, which is not the wage paid.
9. D. At such a floor the firm cannot cut the wage by hiring fewer workers, so it hires more. Choice A is the competitive-market result, which does not hold in this range.
10. D. Perfectly inelastic supply means more demand cannot increase quantity; competition among users bids rent up. B would need an upward-sloping supply.
11. E. $MPL/W = 5$ and $MPK/r = 4$, so labor gives more output per dollar. Choice A reverses the comparison.
12. C. Each ratio of MRP to input price must equal 1 so no input adds more revenue than cost. Choice D is a cost-minimization-type comparison, and equal ratios alone do not guarantee profit maximization.

SET C • APPLY AND EXTEND

13. (a) 1 point: $MRP = MFC$: $50 - 3L = 10 + 2L$ gives $L = 8$. 1 point: wage from supply = $10 + 8 = \$18$ (MRP there is \$26). (b) 1 point: competitive: $50 - 3L = 10 + L$ gives $L = 10$ and $W = \$20$. (c) 1 point: at \$20 workers supply 10 and the firm's MRP at 10 is $50 - 30 = \$20$, so it hires 10. Employment rises from 8 to 10 (and the wage from \$18 to \$20). 1 point: the floor makes MFC flat at \$20, removing the incentive to restrict hiring.
14. (a) 1 point: $MRPL = 5 \times 5 = \$25$; $MRPK = 5 \times 10 = \$50$. (b) 1 point: $MPL/W = 5/20 = 0.25$ and $MPK/r = 10/40 = 0.25$, equal, so the firm is at the least-cost combination. 1 point: $MRPL/W = 25/20 = 1.25$ and $MRPK/r = 50/40 = 1.25$, both above 1, so it is not maximizing profit. (c) 1 point: it should hire more of both inputs. 1 point: diminishing marginal returns reduce MPL and MPK as it expands, lowering the ratios until they equal 1.

5.4 Income Distribution, Poverty, and Inequality

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SET A · CHECK YOUR UNDERSTANDING

- Poverty is the condition of being below an income threshold needed for basic needs, while inequality is the spread of incomes across all households. If a boom lifts low incomes above the poverty line but raises top incomes even faster, the poverty rate falls while inequality rises.
- Cumulative shares: 6, 18, 36, 60, 100. Area under the Lorenz curve = $0.2 \times [(0+0.06)/2 + (0.06+0.18)/2 + (0.18+0.36)/2 + (0.36+0.60)/2 + (0.60+1)/2] = 0.2 \times 1.70 = 0.34$. Gini = $1 - 2(0.34) = 0.32$.
- Average rates: $3,000/30,000 = 10$ percent and $7,200/90,000 = 8$ percent. The rate falls as income rises, so the tax is regressive, even though the high earner pays more dollars.
- Benefits fall by $0.5 \times 600 = \$300$, so net income rises from \$500 to $600 + 200 = \$800$, a gain of only \$300. The effective marginal tax rate is $300/600 = 50$ percent. This is a poverty trap: high implicit tax rates give little reward for working.
- Redistribution through taxes and transfers improves equity (a fairer split) but can reduce the incentive of high earners to work and invest and of benefit recipients to earn income, so total output may shrink. Society must weigh how much efficiency to give up for greater equality, a normative judgment.
- With perfect equality the Lorenz curve is the 45-degree line and the Gini coefficient is 0. When one household has everything, the Lorenz curve runs along the horizontal axis and then jumps to 100 percent at the end, so the area between it and the line equals nearly the whole triangle and the Gini coefficient is about 1.

SET B · EXAM-STYLE MULTIPLE CHOICE

- C. At every point on the 45-degree line, the bottom x percent of households earn x percent of income. B is the opposite extreme and describes the horizontal-axis Lorenz curve.
- E. Cumulative share = $4 + 9 + 14 = 27$ percent. B (23) is a single quintile's share, and C (13) is the bottom 40 percent.
- B. Curve A bows farther below the line of equality than B, so A has the larger Gini coefficient and more inequality. Choice A reverses the comparison, and a Lorenz curve alone cannot reveal poverty.
- D. Average rates are 10 percent ($4,000/40,000$) and 15 percent ($12,000/80,000$): rising, so progressive. Option A confuses dollars with rates; option C is wrong in its reasoning because paying less than double is not the test.
- B. SNAP provides food benefits rather than cash. TANF and the EITC are delivered as cash payments.
- E. A higher Gini means greater inequality and a Lorenz curve farther from the 45-degree line. The Gini coefficient says nothing about the poverty rate, so C is wrong.

SET C · APPLY AND EXTEND

- (a) 1 point: cumulative shares 8, 20, 36, 60, 100; bottom 60 percent receive 36 percent. (b) 1 point: area = $0.2 \times [(0+0.08)/2 + (0.08+0.20)/2 + (0.20+0.36)/2 + (0.36+0.60)/2 + (0.60+1)/2] = 0.2 \times 1.74 = 0.348$, so Gini = $1 - 0.696 = 0.304$. (c) 1 point: new shares 13, 12, 16, 24, 35 give cumulative 13, 25, 41, 65, 100, area 0.388, Gini = 0.224. 1 point: the Lorenz curve moves up toward the 45-degree line. (d) 1 point: the higher tax on top incomes or the transfer benefit may reduce incentives to work or invest, lowering output.
- (a) 1 point: P is progressive (average rate rises from 4 to 16 percent); Q is proportional (10 percent throughout); R is regressive (falls from 14 to 4 percent). (b) 1 point: R. Low-income households spend a larger share of income on food, so the tax takes a larger percentage of their income. (c) 1 point: switching from P to R would raise the burden on lower incomes and cut it on higher incomes, so after-tax income would be less equal; the Lorenz curve would shift away from the 45-degree line and the Gini coefficient would rise. 1 point: this may improve efficiency by taxing high earners less and discouraging work less, but at the cost of equity.

5.5 Multiple-Choice Practice: Factor Markets**SET A · CORE CONCEPTS**

- C. Labor is wanted for the output it produces, so higher pizza prices raise MRP and shift labor demand right. A confuses a wage change with a shift in demand.
- A. MPL = 12, 10, 8, 6 and MRP = \$60, \$50, \$40, \$30. The third worker's \$40 still exceeds the \$35 wage; the fourth's \$30 does not. Choice D hires the worker whose MRP is below the wage.
- E. Greater income lets her buy more leisure, the income effect. C, the substitution effect, would predict she works more because leisure became costlier.
- B. At a wage above equilibrium, firms demand fewer workers and more people want to work, so there is a labor surplus. A is wrong because employment is determined by the smaller quantity demanded.
- E. The monopsonist hires where MRP = MFC and then pays the lower wage read from the supply curve. A is the competitive rule; for a monopsonist, MFC exceeds the wage.
- B. A Gini of 0 corresponds to the 45-degree line of equality. C describes a Gini near 1, and poverty status is separate from the distribution.
- C. The percentage of income paid falls as income rises, so the tax is regressive. E mentions the dollar amount, which is irrelevant: the test is the average tax rate.

SET B · APPLICATIONS AND DATA

- D. MPL = 9, 7, 5, 3, 1 so MRP = \$54, \$42, \$30, \$18, \$6. Hire through the third ($\$30 \geq \$24$); the fourth adds only \$18. E hires a worker costing more than she brings in.
- E. More workers at every wage shifts supply right, lowering the wage and raising employment. A and B require a leftward demand-side or supply change instead.
- A. At M the firm hires 4 at a wage of \$16; competition gives about 5.33 workers at \$18.67. The monopsonist restricts hiring along the supply curve so it can pay less. C reverses the result.

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11. C. $MPL/W = 5$ and $MPK/r = 4$, so each dollar buys more output from labor. A is the reverse. D is wrong because the ratios alone do not say the firm should expand.
12. A. Add the first four shares: $5 + 10 + 15 + 25 = 55$ percent. B is the bottom 60 percent, which is a trap if you include only three quintiles.
13. D. Average rates are 15, 11, and 8 percent, falling as income rises. A would need rising rates, and B constant rates.
14. B. The wage floor raises pay for those still employed but reduces the quantity of labor demanded. E is wrong because a wage above equilibrium reduces employment whatever the elasticity, only by different amounts.

SET C • EXAM-LEVEL STRETCH

15. E. $MPL/W = 2$ and $MPK/r = 2$, so cost is minimized. $MRPL = \$30$, so $MRPL/W = 6 > 1$ and $MRPK/r = 48/8 = 6 > 1$: each input adds more revenue than cost, so hire more of both. D confuses equal ratios with ratios equal to 1.
16. C. At \$18, 5 workers supply labor and MRP at $L = 5$ is \$20, above the wage, so the firm hires all 5. A applies the competitive-market intuition that a floor always cuts employment.
17. B. A rise in demand and a fall in supply both raise the wage, but demand pushes employment up while supply pushes it down. E is wrong because the wage direction is certain.
18. A. Hours fell while the wage rose, so she took part of her raise as extra leisure: the income effect dominates. B would require her hours to rise.
19. D. Taking from the top and giving to the bottom raises the bottom quintile's share of income, moving the Lorenz curve toward the 45-degree line and lowering the Gini. C ignores that the Gini measures distribution, not total income.
20. E. 'Should' signals a value judgment. D is a positive claim (it describes a possible effect) even though it concerns policy.

5.6 Free-Response Practice: Factor Markets

QUESTION 1 • HIRING LABOR IN A COMPETITIVE MARKET

1. (a) 1 point: $MPL = 14, 12, 10, 8, 6$. 1 point: $MRP = 4 \times MPL = \$56, \$48, \$40, \$32, \$24$.
2. (b) 1 point: the hiring rule is hire until $MRP = MFC$ (= wage for a wage taker). 1 point: MRP of the fourth worker is \$32, equal to the wage, so hire 4 workers; the fifth (\$24) adds less than she costs.
3. (c) 1 point: at \$40 the third worker ($MRP = \$40$) is the last hired, so 3 workers. 1 point: a movement along the existing MRP curve (a change in quantity of labor demanded), not a shift.
4. (d) 1 point: $MRP = 3 \times MPL = \$42, \$36, \$30, \$24, \$18$, so hire 2 workers (the second has $MRP \$36 \geq \$32$; the third, \$30, does not). 1 point: labor demand shifts left because a lower output price lowers MRP at each quantity.

QUESTION 2 • A MINIMUM WAGE IN A COMPETITIVE LABOR MARKET

5. (a) 1 point: $24 - 0.02L = 6 + 0.01L$ gives $L = 600$. 1 point: $W = 6 + 6 = \$12$.
6. (b) 1 point: quantity demanded = $(24 - 15)/0.02 = 450$. 1 point: quantity supplied = $(15 - 6)/0.01 = 900$. 1 point: unemployment = $900 - 450 = 450$.
7. (c) 1 point: before = $12 \times 600 = \$7,200$ per hour; after = $15 \times 450 = \$6,750$, a decrease. 1 point: the wage bill falls only if demand is elastic over this range (midpoint method: employment falls about 29 percent while the wage rises about 22 percent), so the minimum wage cost more in lost employment than it added in pay.
8. (d) 1 point: a monopsonist hires fewer workers than a competitive market and pays a wage below MRP. 1 point: a floor set between the monopsony wage and the competitive wage can raise both the wage and employment, because it removes the firm's incentive to restrict hiring along the supply curve.

QUESTION 3 • MONOPSONY AND FACTOR PRICES

9. (a) 1 point: $60 - 4L = 12 + 4L$ gives $L = 6$. 1 point: wage from supply = $12 + 12 = \$24$. 1 point: MFC (\$36) exceeds the wage because raising the wage to attract a worker also raises pay for all current workers.
10. (b) 1 point: MRP at $L = 6$ is $60 - 24 = \$36$, so each worker is paid \$12 less than MRP.
11. (c) 1 point: $60 - 4L = 12 + 2L$ gives $L = 8$ and $W = \$28$.
12. (d) 1 point: at \$28, workers supply 8 and MRP at $L = 8$ is \$28, so the firm hires 8: employment rises from 6 to 8. 1 point: the floor makes MFC flat at \$28, removing the gain from restricting employment, so wage and employment both rise.

QUESTION 4 • INCOME DISTRIBUTION AND TAXES

13. (a) 1 point: cumulative shares 3, 11, 25, 48, 100 plotted at 20, 40, 60, 80, 100 percent of households, below the 45-degree line. 1 point: the bottom 60 percent receive 25 percent.
14. (b) 1 point: area under the Lorenz curve = $0.2 \times [1.5 + 7 + 18 + 36.5 + 74]/100 = 0.274$. 1 point: Gini = $1 - 2(0.274) = 0.452$.
15. (c) 1 point: new shares 7, 8, 14, 23, 48, cumulative 7, 15, 29, 52, 100; area = $0.2 \times 153/100 = 0.306$; Gini = 0.388, lower than before.
16. (d) 1 point: average rates 10, 12, and 15 percent rise with income, so the tax is progressive. 1 point: higher marginal taxes on top earners and phased-out benefits for low earners can weaken incentives to work, save, and invest, shrinking total output (the equity-efficiency tradeoff).

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Chapter 6: Market Failure and the Role of Government.

7 sections with explanations and worked examples, then 106 practice problems. Answers and full explanations are at the end of the chapter.

6.1 Externalities

Learn how spillovers to third parties make private market quantities inefficient, and how to find the efficient quantity and deadweight loss on a graph.

Markets usually allocate resources well because buyers and sellers weigh their own benefits and costs. That logic breaks down when a transaction affects people who are not part of it. In this lesson you learn to spot those spillovers, draw them, and measure the efficiency loss they create.

Key definitions

Externality: a cost or benefit of a transaction that falls on a third party who is not buying or selling. A **negative externality** is an external cost; a **positive externality** is an external benefit.

Market failure: a situation in which the market, left alone, produces a quantity that is not allocatively efficient.

Marginal private cost (MPC): the cost to the producer of one more unit. **Marginal external cost (MEC):** the extra cost imposed on others. $MSC = MPC + MEC$.

Marginal private benefit (MPB): the benefit to the buyer of one more unit (the demand curve). **Marginal external benefit (MEB)** goes to others. $MSB = MPB + MEB$.

Efficiency rule. A quantity is allocatively efficient when marginal social benefit equals marginal social cost. A private market only looks at private numbers, so it settles where $MPB = MPC$. If an externality drives a wedge between private and social values, those two quantities differ.

Negative externalities. Think of a paper mill that dumps waste into a river. The mill pays for labor, wood, and electricity, but not for the damage to downstream fishers. Its supply curve is the MPC curve, which lies below the true MSC curve by the MEC. Buyers and the mill agree on a price at the intersection of demand and MPC, and the market produces **too much**. For the last units between the efficient quantity and the market quantity, MSC is greater than MSB, so each unit destroys value.

Positive externalities. Vaccination, education, and basic research benefit people other than the buyer. The buyer only counts MPB, so demand understates society's true willingness to pay. The MSB curve lies above demand by the MEB, and the market produces **too little**. For units between the market quantity and the efficient quantity, MSB is greater than MC, so society would gain from producing them.

Feature	Negative externality	Positive externality
Who is affected	Third party bears a cost	Third party gets a benefit
Curve that is missing from the market	MSC above supply (MPC)	MSB above demand (MPB)
Market quantity vs efficient	Market is higher (overproduction)	Market is lower (underproduction)
Examples	Pollution, noise, second-hand smoke, congestion	Education, vaccines, research, a neighbor's garden
Deadweight loss triangle	Between MSC and demand, from Q^* to Q_m	Between MSB and supply, from Q_m to Q^*

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Graph rules for externalities

Market quantity (Q_m): where demand (MPB) meets supply (MPC). Efficient quantity (Q^*): where MSB meets MSC.

Deadweight loss = area of the triangle between the MSB and MSC curves over the quantities between Q_m and Q^* . Its area is $\frac{1}{2} \times$ (external cost or benefit per unit) $\times$ (difference in quantities).

Constant per-unit externality means the social curve is parallel to the private curve.

EXAMPLE 1: NEGATIVE EXTERNALITY ON A GRAPH

Producing steel has $MPC = 2 + Q$ and demand is $P = 12 - Q$ (Q in thousands of tons, P in \$ per ton). Each ton also creates \$4 of pollution damage to neighbors. Find the market output, the efficient output, and the deadweight loss.



SOLUTION

Market: set $MPB = MPC$, so $12 - Q = 2 + Q$, giving $Q_m = 5$ thousand tons and $P = \$7$.

Social cost: $MSC = MPC + 4 = 6 + Q$.

Efficient: set $MSB = MSC$, so $12 - Q = 6 + Q$, giving $Q^* = 3$ thousand tons at a price of \$9.

Check at $Q_m = 5$: $MSC = \$11$ but $MSB = \$7$, a gap of \$4 on the last unit.

Deadweight loss = $\frac{1}{2} \times 4 \times (5 - 3) = \$4$ thousand. The market overproduces by 2 thousand tons.

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EXAMPLE 2: POSITIVE EXTERNALITY ON A GRAPH

A college course has private marginal benefit $P = 10 - Q$ and marginal cost $2 + Q$ (Q in thousands of enrollments). Each enrollment gives \$4 of benefit to the community. Find the market and efficient quantities and the deadweight loss.

**SOLUTION**

Market: $10 - Q = 2 + Q$, so $Q_m = 4$ and $P = \$6$.

Social benefit: $MSB = 10 - Q + 4 = 14 - Q$.

Efficient: $14 - Q = 2 + Q$, so $Q^* = 6$ thousand, where the marginal cost is \$8.

At $Q_m = 4$, $MSB = \$10$ and $MC = \$6$, so the 4-dollar gap shows an unrealized gain.

Deadweight loss $= \frac{1}{2} \times 4 \times (6 - 4) = \$4$ thousand. The market underproduces by 2 thousand enrollments.

EXAMPLE 3: READING A MARGINAL TABLE

The table gives marginal values for a good whose production spills \$3 of external cost on each unit. Find the market quantity, the efficient quantity, and the loss from overproduction (assume a unit is produced only if its marginal benefit is at least its marginal cost).

Q	MPB	MPC	MEC	MSC
1	14	3	3	6
2	12	4	3	7
3	10	5	3	8
4	8	6	3	9
5	6	7	3	10

SOLUTION

Market compares MPB with MPC: unit 4 has $8 \geq 6$ (produce); unit 5 has $6 < 7$ (stop). Market quantity = 4.

Efficient quantity compares MPB with MSC: unit 3 has $10 \geq 8$ (produce); unit 4 has $8 < 9$ (stop). Efficient quantity = 3.

The 4th unit is made because the producer ignores the \$3 of harm. It adds benefit 8 but social cost 9, so the net social loss is \$1.

Common mistakes

Do not shift supply or demand to the social curve in a market diagram: the market equilibrium stays on the private curves. Do not shade the full area between the curves; shade only the triangle between Q^* and Q_m . Remember that a negative externality leads to overproduction, and a positive one leads to underproduction. A price rise caused by a drought is not an externality because it works through market prices.

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Practice

SET A Check Your Understanding

Answer each question. Show your marginal reasoning or calculation.

1. Define externality and classify each as positive or negative: (a) a farmer's bees pollinate a neighbor's orchard, (b) a late-night party keeps the next apartment awake, (c) a person gets a flu shot, (d) a delivery truck adds to traffic jams.
2. A firm's marginal private cost is \$9 for a unit, and the unit creates \$5 of damage to neighbors. What is the marginal social cost of that unit? Explain whether the firm will count the \$5 when it chooses output.
3. Demand is $P = 20 - Q$, MPC is $4 + Q$, and each unit causes \$6 of external damage (Q in thousands). Find the market quantity, the efficient quantity, and the deadweight loss.
4. Explain, using marginal benefit and marginal cost, why a market with a negative externality produces too much.
5. Demand (MPB) is $P = 16 - Q$ and MC is $4 + Q$. Each unit gives \$2 of benefit to bystanders. Find the market quantity, the efficient quantity, and the deadweight loss.
6. For the 100th flu shot, the patient's private benefit is \$18, the external benefit is \$12, and the marginal cost is \$25. Will a private market supply it? Should society want it supplied? Explain.

SET B Exam-Style Multiple Choice

Choose the best answer.

7. The graph shows a market in which production generates a negative externality. What is the deadweight loss caused by the externality?



- (A) 9 (B) 3 (C) 6 (D) 12 (E) 18
8. Which of the following is an example of a positive externality?
 - (A) A drought raises the price of wheat
 - (B) A homeowner who plants flowers that neighbors enjoy seeing
 - (C) A student pays tuition to attend a university
 - (D) A factory pays a fine for dumping waste
 - (E) A buyer purchases a car at a lower price after bargaining
 9. At the market equilibrium for a good with a negative externality, which statement is true?
 - (A) Marginal private cost exceeds marginal private benefit
 - (B) Marginal social benefit exceeds marginal social cost
 - (C) Marginal social cost exceeds marginal social benefit
 - (D) Marginal external cost is zero
 - (E) Price is below marginal private cost

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10. The table shows marginal values for a good with a positive externality of \$3 per unit that is not included in MPB. Which quantity is allocatively efficient?

Q	MPB	MC
1	11	3
2	8	4
3	6	5
4	5	6
5	3	7

- (A) 2 (B) 3 (C) 5 (D) 4 (E) 6
11. Which statement about the deadweight loss from an externality is correct?
- (A) It equals total pollution damage
(B) It is zero whenever the market is in equilibrium
(C) It equals the entire area under the demand curve
(D) It exists only with a positive externality
(E) It equals the area between the MSB and MSC curves from the market quantity to the efficient quantity
12. A positive externality causes the market to produce a quantity that is
- (A) less than the efficient quantity because demand ignores external benefits
(B) more than the efficient quantity because supply ignores external costs
(C) equal to the efficient quantity because the price is correct
(D) less than the efficient quantity because supply is too high
(E) more than the efficient quantity because demand is too high

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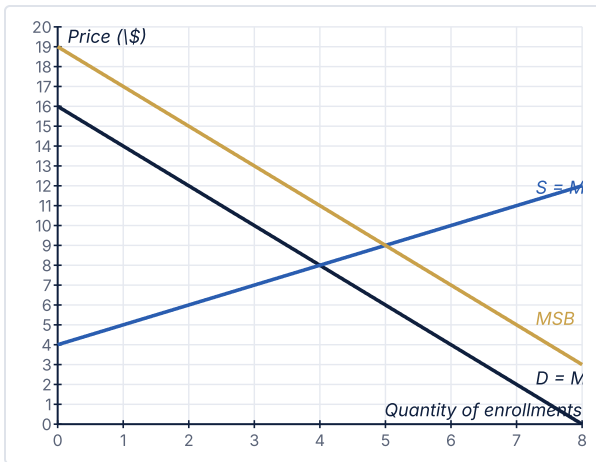
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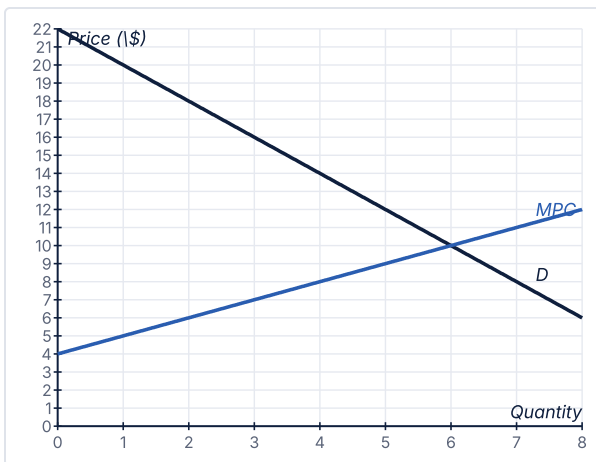
SET C Apply and Extend

Answer all parts. Show setup and labels.

13. The graph shows the market for a vaccination service. Each vaccination gives \$3 of benefit to people who are not vaccinated. (a) Find the market price and quantity. (b) Find the efficient quantity. (c) Calculate the deadweight loss. (d) Explain, in terms of marginal values, why the market fails.



14. A chemical plant sells at demand $P = 22 - 2Q$ and has $MPC = 4 + Q$ (shown). Pollution creates a constant external cost of \$6 per unit. (a) Find the market quantity and price. (b) Find the efficient quantity and compute the deadweight loss. (c) Suppose the external cost per unit rises to \$9. Without recomputing everything, say how the efficient quantity and the deadweight loss change, then verify with numbers. (d) State how the shapes of the curves would need to differ for the deadweight loss to be zero.

**6.2 Correcting Externalities**

Compare taxes, subsidies, tradable permits, regulation, and bargaining as ways to correct externalities, and calculate their effects.

If a market makes the wrong quantity because costs or benefits spill over to others, governments and private parties can try to make decision makers face the full social picture. This lesson covers the main tools, how to draw their effects, and how to compare them.

The policy toolkit

Pigouvian tax: a per-unit tax on a good with a negative externality, set equal to the marginal external cost at the efficient quantity. It raises the producer's cost from MPC to MSC.

Subsidy: a per-unit payment for a good with a positive externality, set equal to the marginal external benefit. It brings the buyer's or seller's side up to the social value.

Tradable permits (cap and trade): the government fixes total pollution, issues permits that add up to the cap, and lets firms trade them.

Regulation (command-and-control): legal limits or required technology, such as an emission standard or a ban.

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Taxing a negative externality. With a tax equal to the MEC, supply moves up by the tax and lies on the MSC curve. The market equilibrium now sits at the efficient quantity, and deadweight loss disappears. The tax makes the polluter pay a price for pollution, so the firm cuts output until the last unit's social cost equals its social benefit. The tax collects revenue, which can be used to repair the damage or lower other taxes.

Subsidizing a positive externality. A subsidy equal to the MEB moves the supply curve down (or demand up) so the market quantity rises to the efficient level. The government pays the subsidy, so the true price paid by consumers falls and the price received by producers rises. Subsidies for education, vaccines, and research are examples.

Tradable permits. Different firms can reduce pollution at very different costs. A trading system lets low-cost abaters cut a lot and sell their spare permits to high-cost firms. The cap fixes the total amount of pollution, and trading finds the cheapest way to meet it. A tax fixes the price of pollution instead and lets the quantity adjust.

Coase theorem and property rights. Ronald Coase argued that if property rights are clearly defined and the costs of bargaining (transaction costs) are low, the affected parties can negotiate to the efficient outcome without government help. Who holds the right affects who pays, not the efficient quantity. The idea fails when there are many parties, when it is hard to measure the harm, or when negotiators hold out. These are the usual situations for air pollution, which is why governments step in.

Tool	Strength	Weakness
Pigouvian tax	Cost-effective; raises revenue; gives a constant incentive to cut	Hard to measure MEC; the resulting quantity is uncertain
Subsidy	Raises output of beneficial goods	Costs taxpayers; may reward activity that would happen anyway
Tradable permits	Exact cap; cheapest abatement	Setting the cap; needs monitoring and a trading market
Standards or bans	Simple; predictable; direct	Ignores differences in abatement cost; no reward for doing better
Property rights and bargaining	No government cost	Fails with high transaction costs or many parties

Rules to remember

Efficient tax = MEC at Q^* (negative externality). Efficient subsidy = MEB at Q^* (positive externality).

Tax revenue = tax per unit $\times$ quantity after the tax. Subsidy cost = subsidy per unit $\times$ quantity after the subsidy.

Coase theorem: clear property rights + low transaction costs $\rightarrow$ bargaining reaches efficiency, whoever holds the right.

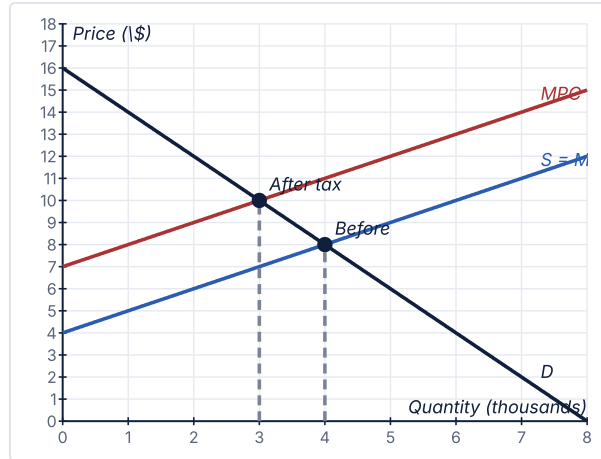
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EXAMPLE 1: A PIGOUVIAN TAX

Demand is $P = 16 - 2Q$, MPC is $4 + Q$ (Q in thousands of units), and each unit imposes \$3 of external cost. Find the tax that yields efficiency, the prices buyers pay and sellers keep, and the tax revenue.

**SOLUTION**

Without a tax: $16 - 2Q = 4 + Q$, so $Q_m = 4$ and $P = \$8$.

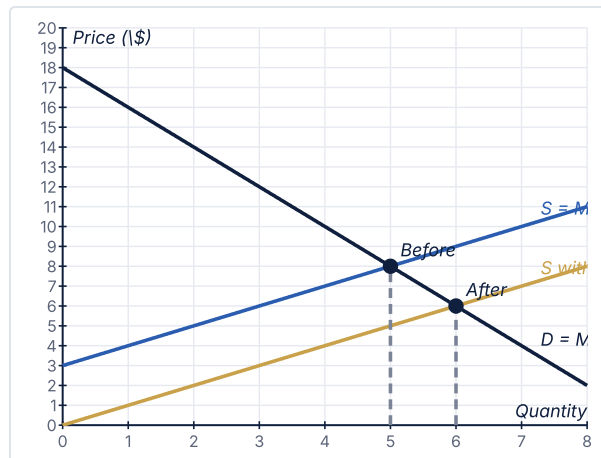
$MSC = 4 + Q + 3 = 7 + Q$. Setting $16 - 2Q = 7 + Q$ gives $Q^* = 3$ thousand.

Tax per unit equals MEC = \$3. At $Q = 3$, buyers pay $16 - 6 = \$10$; sellers keep $10 - 3 = \$7$ (equal to MPC at 3).

Tax revenue = $3 \times 3,000 = \$9,000$. The deadweight loss removed was $\frac{1}{2} \times 3 \times (4 - 3) = \$1.5$ thousand.

EXAMPLE 2: A SUBSIDY

Demand (MPB) is $P = 18 - 2Q$, marginal cost is $3 + Q$, and each unit gives \$3 of benefit to others. Find the efficient subsidy, the price buyers pay, and the cost to the government.

**SOLUTION**

Market: $18 - 2Q = 3 + Q$, so $Q_m = 5$ and $P = \$8$.

$MSB = 21 - 2Q$. Setting $21 - 2Q = 3 + Q$ gives $Q^* = 6$.

Subsidy per unit = MEB = \$3. Subsidized supply is $3 + Q - 3 = Q$, and $18 - 2Q = Q$ gives $Q = 6$.

Buyers pay $18 - 12 = \$6$; sellers get $6 + 3 = \$9$, which equals MC at 6.

Government cost = $3 \times 6 = \$18$.

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EXAMPLE 3: WHY TRADING CUTS COST

Two plants each emit 30 units. The city wants total emissions of 40. Plant A can cut up to 20 units at \$2 per unit; Plant B can cut up to 20 units at \$6 per unit. Compare an equal 10-unit cut for each with a permit system in which each plant gets 20 permits that can be traded.

SOLUTION

Equal cuts: A pays $10 \times 2 = \$20$ and B pays $10 \times 6 = \$60$, so the total cost is \$80.

Permits: each plant starts with 20 permits. A can cut 20 units (cost \$40) and emit only 10, so it has 10 spare permits.

B would otherwise pay \$6 per unit to cut, so it will buy A's 10 spare permits at any price from \$2 to \$6, say \$4. Then B emits 30 and A emits 10; total emissions are still 40.

Total abatement cost is just A's \$40, half the \$80 of equal cuts. A's net cost is $40 - 40 = \$0$ and B pays \$40 for permits instead of \$60 for abatement. A tax of \$4 per unit would give the same split.

Common mistakes

A tax is set at the marginal external cost at the efficient quantity, not at the market quantity, and it makes the price buyers pay higher but less than the full tax if sellers absorb part. Do not call a subsidy for a negative externality efficient. Remember that the Coase theorem needs low transaction costs and clear property rights; it does not say the government should never act.

Practice**SET A Check Your Understanding**

Answer each question. Show calculations.

1. Define a Pigouvian tax. A paper mill's pollution costs neighbors \$5 per ton. What per-ton tax is appropriate if the damage is constant? Explain why.
2. Demand is $P = 30 - Q$, MPC is $6 + Q$, and each unit has an external cost of \$8 (Q in thousands). Find the market quantity, the efficient tax, the quantity after the tax, the price buyers pay, and tax revenue.
3. Demand (MPB) is $P = 14 - Q$ and MC is $2 + Q$; each unit gives \$4 of external benefit. Find the efficient quantity, the per-unit subsidy, and total government spending.
4. A factory causes \$10,000 a year of damage to a fishing club. The factory can eliminate the damage for \$6,000 a year. Bargaining costs are zero. Describe the outcome (a) if the club holds the right to clean water and (b) if the factory holds the right to pollute.
5. A firm that emits 4 tons faces a pollution charge of \$50 per ton. Abating the 1st, 2nd, 3rd, and 4th tons costs \$20, \$40, \$60, and \$80. How many tons will it abate, and what is its total cost (abatement plus charges)?
6. Give one advantage of tradable permits over a uniform emission standard and one weakness of permits.

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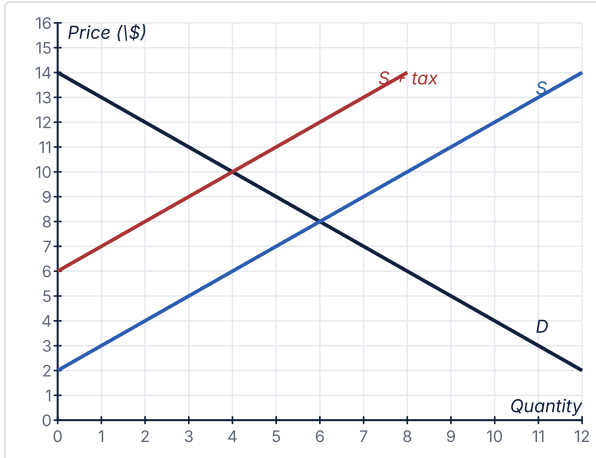
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. The graph shows a per-unit tax of \$4 on a good with a negative externality. How much revenue does the government collect?



- (A) 8 (B) 12 (C) 16 (D) 20 (E) 24
8. A Pigouvian tax achieves efficiency when it is set equal to
- (A) the marginal external cost at the efficient quantity
 - (B) the total damage from pollution
 - (C) the market price of the good
 - (D) the deadweight loss
 - (E) the producer's marginal private cost
9. According to the Coase theorem, private bargaining can reach an efficient outcome when
- (A) the government taxes the polluter
 - (B) the number of affected parties is large
 - (C) the externality is positive and not negative
 - (D) property rights are clearly defined and transaction costs are low
 - (E) the polluter has the legal right to pollute
10. Which feature most clearly favors a tradable permit system over a uniform emission standard?
- (A) It guarantees a lower cap than any other policy
 - (B) Firms with low abatement costs reduce more and sell permits to high-cost firms
 - (C) It removes the need for government monitoring
 - (D) It makes every firm cut by the same amount
 - (E) It eliminates the need to choose a cap
11. A per-unit subsidy equal to the marginal external benefit will
- (A) lower output to the efficient quantity
 - (B) leave output unchanged but lower prices
 - (C) create deadweight loss by raising output above the efficient quantity
 - (D) raise output only if demand is elastic
 - (E) raise output to the efficient quantity at a cost to taxpayers
12. Bargaining between the affected parties is LEAST likely to solve which problem?
- (A) Smog affecting millions of residents of a large city
 - (B) Noise from a bar that disturbs one neighbor
 - (C) A farm's runoff that hurts one downstream owner
 - (D) A shared hedge between two homeowners
 - (E) A dispute between two adjacent shop owners over a shared wall

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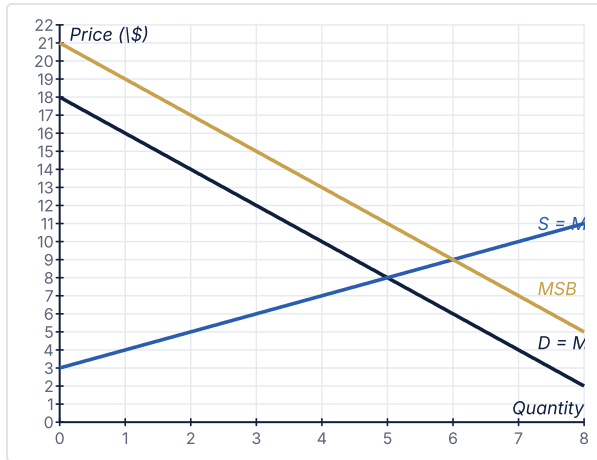
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SET C Apply and Extend

Answer all parts. Show your work.

13. The graph shows an immunization market. Each immunization gives \$3 of benefit to people who are not immunized. (a) Find the market quantity and the efficient quantity. (b) Find the per-unit subsidy that achieves the efficient quantity and the total cost to the government. (c) State the price consumers pay and the price sellers receive with the subsidy. (d) Explain why the subsidy is not simply a transfer with no efficiency effect.



14. A city has two plants that each emit 30 units. The goal is 40 units total. Plant X can cut up to 30 units at \$3 per unit; Plant Y can cut up to 30 units at \$9 per unit. (a) Compute the total abatement cost if the city requires both plants to cut 10 units. (b) Compute the lowest possible total abatement cost to reach 40 units and explain who cuts. (c) Describe how a permit system would reach the result in (b) and give a price range at which trade occurs. (d) Name one reason a regulator might still choose the uniform standard.

Plant	Emissions now	Cost per unit of cutting
X	30	\$3
Y	30	\$9

6.3 Public Goods and Common Resources

Classify goods by rivalry and excludability, find the efficient quantity of a public good, and analyze free riding and the tragedy of the commons.

Some goods are hard to sell because nobody can be stopped from using them. Others are open to all and get used up. This lesson explains the two characteristics that sort goods into types, why markets struggle with two of those types, and what can be done about it.

Two tests for every good

Excludable: the seller can prevent non-payers from using the good. **Nonexcludable:** it is impossible or very costly to keep non-payers out.

Rival: one person's use reduces what is left for others. **Nonrival:** one more user does not reduce anyone else's use.

A **public good** is nonexcludable and nonrival (national defense, a lighthouse, tornado sirens). A **common resource** is nonexcludable but rival (ocean fish, open grazing land, clean air).

	Rival	Nonrival
Excludable	Private good (pizza, shoes, a haircut)	Club or quasi-public good (cable TV, a toll road with no congestion, a theater seat before it fills)
Nonexcludable	Common resource (fish in the open sea, public pasture)	Pure public good (national defense, flood control, clean-air policy)

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The free-rider problem. Because no one can be excluded from a public good, each person would like to enjoy it without paying. A **free rider** benefits from a good without paying for it. If everyone reasons this way, buyers do not reveal their true willingness to pay, firms cannot collect revenue, and the private market provides too little or none. The result is underproduction even when the good's total benefit exceeds its cost.

How much is efficient? For a private good, the market demand curve is found by adding quantities at each price (horizontal summation). For a public good, everyone consumes the same quantity, so we add the marginal benefits at each quantity (**vertical summation**). The social marginal benefit curve is the sum of individual demand curves added vertically. The efficient quantity is where this sum equals marginal cost. Any single person, ignoring others, would buy where only their own marginal benefit equals marginal cost, which is a smaller quantity.

Efficient public good quantity

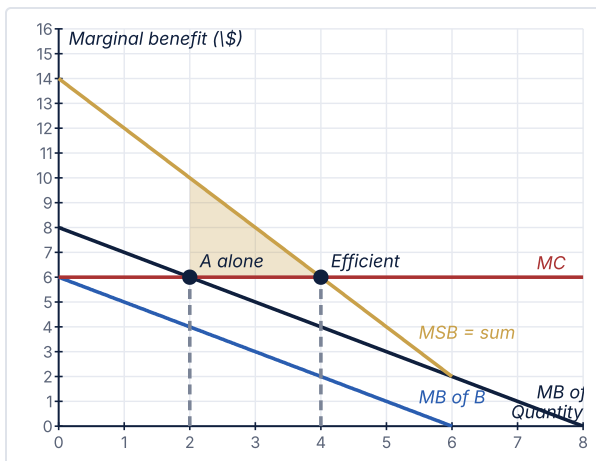
$$MSB = MB_1 + MB_2 + \dots \text{ at the same quantity } Q$$

$$\text{Efficient } Q^* \text{ solves } MSB = MC$$

An individual buying alone solves $MB_i = MC$, which gives a lower quantity, so the private market underprovides.

EXAMPLE 1: VERTICAL SUMMATION

Two neighbors value street lighting. Their marginal benefits (\$ per month) are $MB_A = 8 - Q$ and $MB_B = 6 - Q$, and the marginal cost is \$6 per light. How many lights are efficient, and how many would A buy alone?



SOLUTION

Add vertically for $Q \leq 6$: $MSB = (8 - Q) + (6 - Q) = 14 - 2Q$.

Set $MSB = MC$: $14 - 2Q = 6$, so $Q^* = 4$ lights. Check: $MB_A = 4$, $MB_B = 2$, total \$6 = MC.

A alone sets $8 - Q = 6$, so $Q = 2$ lights (if A expects B to free ride).

Deadweight loss from stopping at 2: at $Q = 2$, $MSB = \$10$ versus $MC = \$6$ (gap \$4), shrinking to 0 at $Q = 4$, so $DWL = \frac{1}{2} \times 4 \times 2 = \$4$.

Providing public goods. Because the market fails, three solutions are common. (1) **Government provision** paid by taxes, which forces every beneficiary to contribute. (2) **Indirect funding** such as advertising on broadcast media. (3) **Voluntary or social-pressure** funding such as neighborhood associations and charity drives. Government need not produce the good itself; it may pay private firms to do it.

Tragedy of the commons. With a common resource, each user gains the full benefit of taking more, while the cost (a smaller stock for everyone else) is spread across all users. Each user ignores that cost, so the resource is overused. This is a negative externality caused by missing property rights. Solutions include private ownership, tradable quotas, licenses or fees, seasons and catch limits, and community rules.

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EXAMPLE 2: AN OPEN-ACCESS FISHERY

Each boat costs \$750 per season. Fish sell for \$100 per ton. Compare the number of boats under open access (boats enter until the average catch per boat just covers cost) with the number that maximizes total profit.

Boats	Total catch (tons)	Average catch	Marginal catch
1	12	12	12
2	22	11	10
3	30	10	8
4	36	9	6
5	40	8	4
6	42	7	2

SOLUTION

A boat's cost equals $750/100 = 7.5$ tons of fish.

Open access: boats enter while the average catch is at least 7.5. Averages stay at or above 8 through the 5th boat and fall to 7 at the 6th, so 5 boats operate.

Efficient: add a boat only if the marginal catch is at least 7.5. The 3rd boat adds 8 (yes), the 4th adds 6 (no), so 3 boats.

Profit with 3 boats: $30 \times 100 - 3 \times 750 = \$750$. Profit with 5 boats: $40 \times 100 - 5 \times 750 = \$250$. Open access uses 2 extra boats and wastes profit because each boat ignores that it reduces others' catch.

Quasi-public goods. Many goods are not pure public goods yet have such large positive externalities that governments provide or subsidize them: education, vaccinations, parks, highways, and public libraries. They can be excluded or are partly rival, but private markets would supply too little of them. Their efficient quantity is found with the positive externality logic from earlier, using MSB above demand.

Common mistakes

Public goods are defined by rivalry and excludability, not by who produces them: a government-run college is not a public good, and a privately funded lighthouse could be. Use vertical summation for public goods and horizontal summation for private goods. Do not call the tragedy of the commons a public goods problem; it involves a rival resource.

Practice**SET A Check Your Understanding**

Answer each question. Show calculations.

1. Classify each as private good, public good, common resource, or club good, using rivalry and excludability: (a) a street light, (b) a monthly streaming subscription, (c) tuna in international waters, (d) an uncrowded toll bridge.
2. Define the free-rider problem and explain why a private firm would not provide a fireworks display that the whole town can see from their homes.
3. Two residents have marginal benefits for a flood levee of $MB_1 = 10 - Q$ and $MB_2 = 8 - Q$. The marginal cost is \$8. Find the efficient quantity and the quantity resident 1 would buy alone.
4. Each person can contribute \$10 to a project; each contribution creates \$16 of benefit shared equally by two people. Complete the payoffs: what does a person gain if both contribute, if only they contribute, if only the other contributes, and if neither does? What is the likely outcome?
5. Why do open-ocean fish tend to be overharvested, and name two policies that could reduce overfishing?
6. Explain why a vaccination is called a quasi-public good, and give one policy tool a government can use to bring about the efficient quantity.

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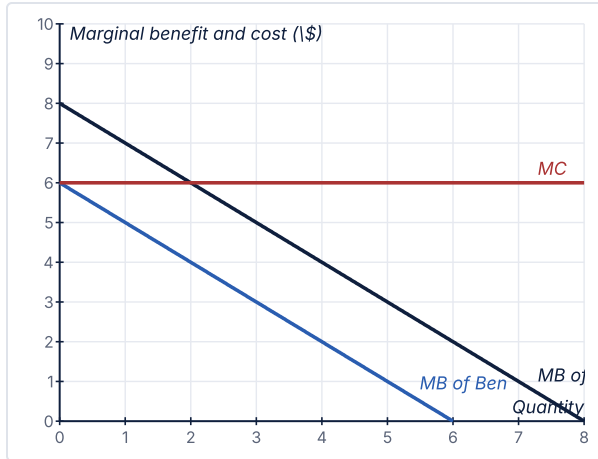
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SET B Exam-Style Multiple Choice

Choose the best answer.

7. Which of the following is the best example of a pure public good?
- (A) Tornado warning sirens in a town (B) A toll bridge
(C) Fish in the open ocean (D) A subscription streaming service
(E) A slice of pizza
8. The graph shows two people's marginal benefits for a public good and its marginal cost of \$6. What is the efficient quantity?



- (A) 2 (B) 3 (C) 4 (D) 6 (E) 8
9. The free-rider problem explains why private markets
- (A) produce too much of a good with external costs
(B) produce too little of a nonexcludable good
(C) cannot sell rival goods
(D) charge too high a price for club goods
(E) tend to overproduce public goods
10. Overfishing of a lake open to all anglers is an example of
- (A) a public good with free riders
(B) a positive externality
(C) an excludable private good
(D) a tragedy of the commons caused by missing property rights
(E) a natural monopoly
11. Which policy would most directly address the overuse of a common pasture?
- (A) Subsidize each cow
(B) Make the pasture a free public good with no limits
(C) Lower the price of cattle feed
(D) Remove all limits on herd size
(E) Issue a fixed number of tradable grazing permits
12. A town has 4 buyers of a public good. Each buyer's marginal benefit at the efficient quantity is \$3 and the marginal cost is \$12. This outcome is
- (A) efficient because the sum of marginal benefits equals marginal cost
(B) inefficient because each person's benefit is below cost
(C) inefficient because the good is rival
(D) efficient only if one person pays the whole cost
(E) impossible because the good is nonexcludable

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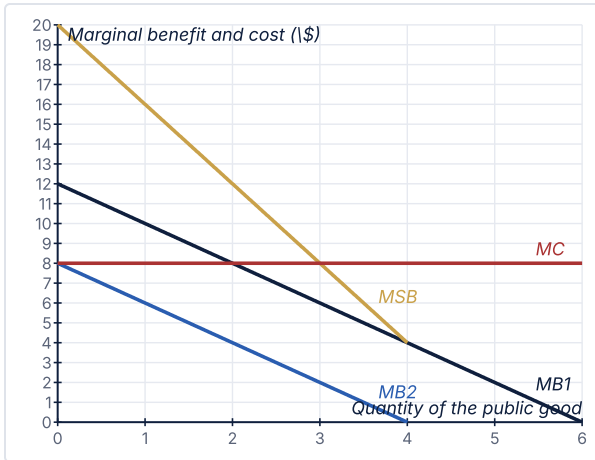
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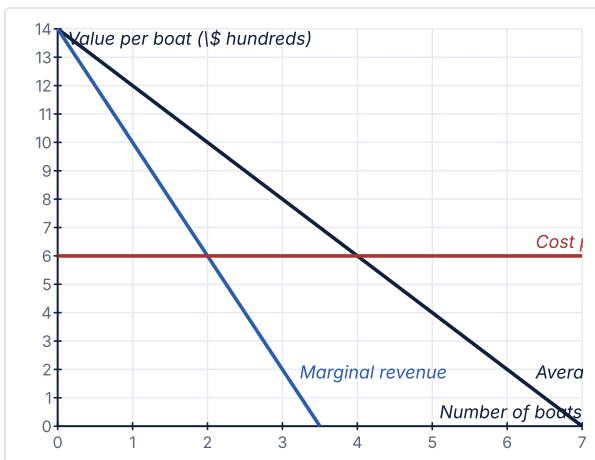
SET C Apply and Extend

Answer all parts. Show your work.

13. Two residents' marginal benefits for a public park (in \$ per unit) and the marginal cost are shown. (a) Find the efficient quantity. (b) Find the quantity resident 1 would pay for alone. (c) Calculate the deadweight loss from relying on resident 1 alone. (d) Explain the free-rider problem in this case and give one way to solve it.



14. An ocean fishery has average revenue per boat of $14 - 2N$ and marginal revenue $14 - 4N$ (in hundreds of dollars), and each boat costs 6 (see graph). (a) How many boats enter under open access and what is the total profit? (b) How many boats maximize total profit, and what is the profit? (c) Compute a per-boat license fee that would limit entry to the profit-maximizing number. (d) Explain why open access leads to overuse.

**6.4 Asymmetric Information and Other Failures**

Understand adverse selection, moral hazard, market power, and government failure, and weigh efficiency against equity.

Externalities and public goods are not the only ways markets or governments can go wrong. In this lesson you study situations where one side knows more than the other, where firms have market power, and where government decisions themselves are flawed, and you weigh efficiency against equity.

Asymmetric information

Asymmetric information: one party to a transaction knows more than the other about quality, risk, or behavior.

Adverse selection: before a deal, the party with hidden bad traits is more likely to take part (sick people buy insurance, owners of poor cars sell them). The average quality of participants falls.

Moral hazard: after a deal, a protected party takes more risk or less care because someone else bears the cost (a driver with full coverage parks carelessly).

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Adverse selection and insurance. Insurance works by pooling risk. A fair premium is the average expected claim of the group. If the insurer cannot tell low-risk from high-risk customers, it must charge one premium based on the average. Low-risk customers find that price too high and leave, so the remaining pool is riskier, claims rise, and the premium must rise again. This spiral can shrink or destroy a market. Remedies are screening (medical exams, driving records), group or mandatory coverage that pools everyone, warranties, and reputation.

Markets and governments both develop tools for hidden information. Sellers offer warranties and build reputations to signal quality. Lenders ask for collateral and credit checks. Employers use references and trial periods. Governments require disclosure, licensing, and mandatory participation in some insurance pools.

EXAMPLE 1: ADVERSE SELECTION

An insurer covers 100 people: 50 are low-risk with an expected claim of \$200 each and 50 are high-risk with an expected claim of \$600 each. It cannot tell them apart. A low-risk person is willing to pay at most \$250. What premium would the insurer need, and what happens?

SOLUTION

Average expected claim = $(50 \times 200 + 50 \times 600)/100 = \$400$, so a premium of \$400 breaks even if everyone buys.

Low-risk buyers will pay at most \$250, which is below \$400, so they refuse.

Only high-risk customers remain, with an expected claim of \$600. To break even the premium must rise to \$600.

The pool has been 'adversely selected'. The low-risk group who would gladly buy fair insurance at \$200 is left uninsured, an efficiency loss.

Moral hazard. Insurance changes behavior. To reduce moral hazard, insurers use **deductibles** (the amount the customer pays first), **copayments** (a flat fee per use), and **coinsurance** (a percentage share). These give the customer a stake in the outcome, but they also leave some risk uninsured.

EXAMPLE 2: COST SHARING

A policy has a \$500 deductible and 80% coinsurance (the insurer pays 80% of covered costs above the deductible). Repairs cost \$10,000. How much does each party pay?

SOLUTION

Amount above the deductible: $10,000 - 500 = \$9,500$.

Insurer pays $0.80 \times 9,500 = \$7,600$.

Policyholder pays $500 + 0.20 \times 9,500 = 500 + 1,900 = \$2,400$. Check: $7,600 + 2,400 = 10,000$.

The \$2,400 share gives the owner a reason to take care, which reduces moral hazard.

Market power. A firm with market power (monopoly) restricts output and charges a price above marginal cost. Some mutually beneficial trades do not occur, creating deadweight loss. Remedies include antitrust law, price regulation, and public ownership, but each has problems.

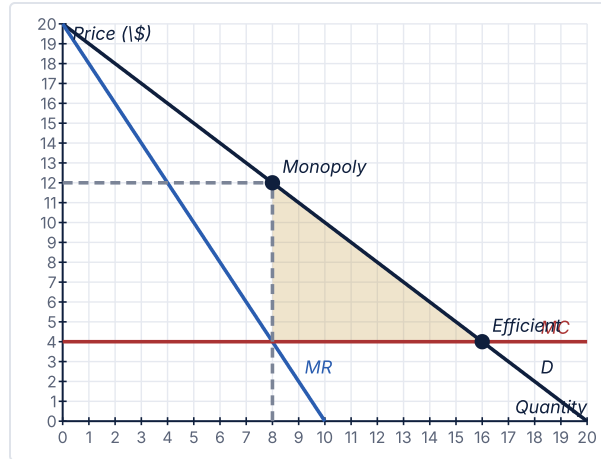
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EXAMPLE 3: MARKET POWER AS MARKET FAILURE

A monopolist faces $D: P = 20 - Q$ with constant $MC = \$4$. Find its profit-maximizing output and price, the efficient output, and the deadweight loss.

**SOLUTION**

$MR = 20 - 2Q$. Set $MR = MC$: $20 - 2Q = 4$, so $Q_m = 8$ and $P = 20 - 8 = \$12$.

Efficient output sets $P = MC$: $20 - Q = 4$, so $Q^* = 16$.

Deadweight loss is the triangle between D and MC from 8 to 16: $\frac{1}{2} \times (12 - 4) \times (16 - 8) = \$32$.

Failure	Source of the problem	Typical remedy
Externality	Third-party costs or benefits ignored	Tax, subsidy, permits, bargaining
Public good	Nonexcludable and nonrival, so free riding	Government provision paid by taxes
Asymmetric information	Hidden traits or hidden actions	Screening, cost sharing, warranties, disclosure
Market power	Output restricted, price above MC	Antitrust, regulation
Government failure	Poor incentives for officials and voters	Transparency, rules, competition

Government failure and public choice. Public choice theory applies economics to political behavior. A voter's single vote rarely decides an election, so a voter may remain **rationally ignorant** (not gather information because its cost exceeds the expected benefit). Policies with concentrated benefits and dispersed costs attract lobbying by **special interest groups**, which can win subsidies or protection that cost society more than they bring. Legislators may trade votes (**logrolling**) and fund projects in their own districts (**pork-barrel spending**). Firms may spend resources to gain favors (**rent-seeking**). These problems show that government intervention does not automatically fix a market failure.

Efficiency versus equity

Efficiency asks whether the total surplus is as large as possible; equity asks whether the distribution of results is fair.

Markets can be efficient yet produce very unequal outcomes. Redistribution can raise equity but may reduce incentives to work and invest.

Judgments about fairness are normative, so economics shows the tradeoff but does not tell society which balance to choose.

Exam tip

Do not mix up the two information problems: adverse selection happens before the deal because of hidden traits, and moral hazard happens after the deal because of hidden actions. For market power, the key checks are $MR = MC$ for output and $P = MC$ for efficient output.

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Practice

SET A Check Your Understanding

Answer each question. Show calculations.

- Classify as adverse selection or moral hazard: (a) a driver with full collision coverage stops checking mirrors when backing out, (b) the people most likely to need surgery are the ones who purchase the most generous health plan.
- An insurer has 40 low-risk customers with expected claims of \$100 and 60 high-risk customers with expected claims of \$500. (a) What uniform premium breaks even? (b) If low-risk customers leave, what premium is now needed?
- A policy has a \$1,000 deductible, and the insurer pays 70% of costs above the deductible. For an \$8,000 loss, how much does each side pay, and why does this reduce moral hazard?
- A monopolist faces $D: P = 30 - Q$ and $MC = \$6$. Find the monopoly quantity and price, the efficient quantity, and the deadweight loss.
- A subsidy gives each of 10 firms \$5 million, and the cost is \$1.60 collected from each of 50 million taxpayers. Compute the total benefit and cost, and use public choice ideas to explain why the subsidy may pass.
- Explain the tradeoff between efficiency and equity using a progressive income tax as an example.

SET B Exam-Style Multiple Choice

Choose the best answer.

- A used-car seller knows the true quality of the car; the buyer does not. Because buyers fear getting a bad car, they offer low prices, and owners of good cars withdraw from the market. This is best described as
 (A) adverse selection (B) moral hazard (C) a positive externality
 (D) a public good problem (E) rational ignorance
- Which of the following is the best example of moral hazard?
 (A) A sick person buys more health insurance than a healthy person
 (B) After buying fire insurance, a store owner stops maintaining the sprinklers
 (C) A seller hides the mileage of a used car
 (D) A voter decides not to read about candidates
 (E) A monopolist raises its price
- Which feature of an insurance policy reduces moral hazard?
 (A) A lower premium for everyone (B) Full coverage of all costs
 (C) A deductible (D) Covering only the healthiest customers
 (E) A guaranteed payout without a claim
- The graph shows a monopolist with constant marginal cost. What is the deadweight loss from monopoly?



- (A) 25 (B) 100 (C) 150 (D) 50 (E) 200

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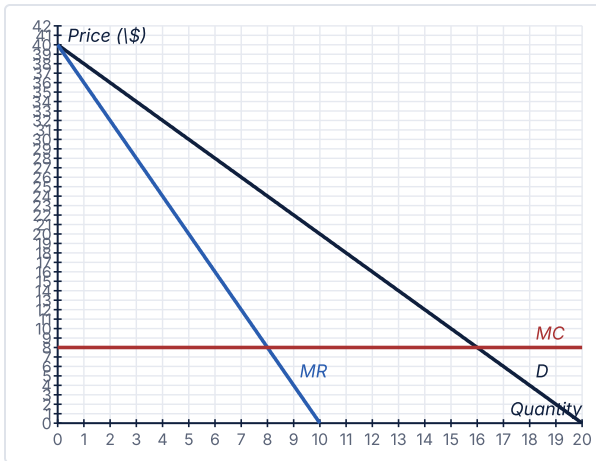
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11. Voters remain uninformed about a minor budget item because the cost of learning about it exceeds the expected benefit of their single vote. This behavior is called
 (A) logrolling (B) adverse selection (C) rent-seeking
 (D) a free-rider subsidy (E) rational ignorance
12. Which statement about government intervention in markets is most consistent with public choice theory?
 (A) Policies with concentrated benefits and widely spread costs are likely to be adopted even if they are inefficient
 (B) Government always corrects market failures at no cost
 (C) Voters are fully informed about every policy
 (D) Politicians ignore organized groups
 (E) Government failure cannot occur

SET C Apply and Extend

Answer all parts. Show your work.

13. A monopolist faces the demand, marginal revenue, and constant marginal cost shown. (a) Find the profit-maximizing quantity and price. (b) Find the efficient quantity and the deadweight loss. (c) Suppose the regulator imposes a price ceiling of \$8, equal to MC. What quantity is sold and what is the deadweight loss? (d) Explain one reason regulation might still be imperfect.



14. A health insurer has 1,000 potential customers: 600 low-risk with expected annual costs of \$1,000 and 400 high-risk with expected annual costs of \$4,000. A low-risk person will pay at most \$1,500 for the plan. (a) Compute the break-even premium if all buy. (b) Who stays in the pool at that premium? (c) What premium would be needed next, and what is the outcome? (d) Name one policy that could prevent the problem and explain how it works.

Group	People	Expected cost	Maximum willing to pay
Low-risk	600	\$1,000	\$1,500
High-risk	400	\$4,000	more than \$4,000

6.5 Taxation, Equity, and Government Policy Choices

Compare tax structures, fairness principles, and the efficiency cost of taxes, then apply the whole chapter to policy choices.

Governments need revenue and often want a fairer distribution of income. Every tax changes incentives, though, so economists ask two questions: who bears the tax, and how much output and surplus is lost? This lesson also pulls the whole chapter together for policy choices.

Tax structures

Progressive tax: the average tax rate rises as income rises (the federal income tax). **Proportional (flat) tax:** the same rate at all incomes. **Regressive tax:** the average rate falls as income rises (a sales tax on necessities).

Average tax rate = $\frac{\text{tax paid}}{\text{income}}$. **Marginal tax rate** = $\frac{\text{change in tax}}{\text{change in income}}$, the rate on the next dollar earned.

Tax incidence: who actually bears the burden, regardless of who writes the check.

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Principles of fairness. The **benefit principle** says people should pay in proportion to the benefits they receive from government spending; fuel taxes that pay for roads and user fees at parks are examples. The **ability-to-pay principle** says people with greater capacity should pay more, which supports progressive taxes. These principles can conflict, and judging which is fair is a normative decision.

EXAMPLE 1: CLASSIFYING A TAX

A tax takes 10% of the first \$20,000 of income and 20% of income above \$20,000. Compute the tax, average rate, and marginal rate for incomes of \$20,000, \$50,000, and \$100,000. Then classify the tax.

SOLUTION

Income \$20,000: tax = $0.10 \times 20,000 = \$2,000$, average 10%, marginal rate of the next dollar 20%.

Income \$50,000: tax = $2,000 + 0.20 \times 30,000 = \$8,000$, average $8,000/50,000 = 16\%$, marginal 20%.

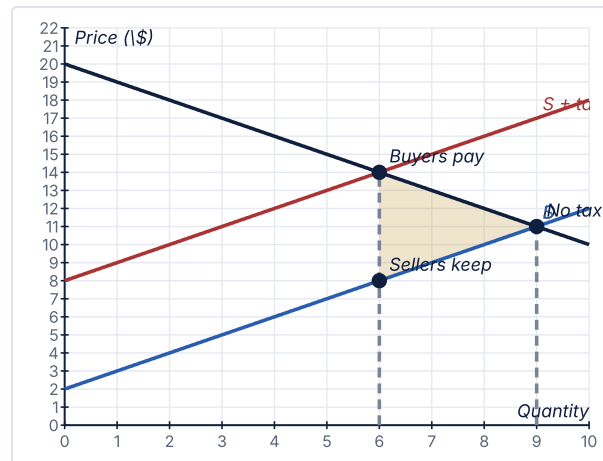
Income \$100,000: tax = $2,000 + 0.20 \times 80,000 = \$18,000$, average 18%, marginal 20%.

The average rate rises (10%, 16%, 18%) with income, so the tax is progressive. The marginal rate is not the same thing as the average rate.

Efficiency cost of taxes. A per-unit tax drives a wedge between what buyers pay and what sellers receive. Some trades that were worth making no longer occur, producing **deadweight loss** equal to the triangle between demand and supply over the lost quantity. Three facts help: (1) the burden is shared according to elasticity, and the more inelastic side bears more; (2) the more elastic the demand or supply, the larger the quantity change and the larger the deadweight loss; (3) deadweight loss rises faster than the tax rate, roughly with the square of the tax. A tax on a good with a negative externality is different: it can reduce the deadweight loss.

EXAMPLE 2: EXCISE TAX AND DEADWEIGHT LOSS

Demand is $P = 20 - Q$ and supply is $P = 2 + Q$. A tax of \$6 per unit is collected from sellers. Find the quantity, prices paid and received, revenue, deadweight loss, and who bears the tax.



SOLUTION

Before the tax: $20 - Q = 2 + Q$ gives $Q = 9$, $P = \$11$.

With the tax, supply becomes $P = 8 + Q$: $20 - Q = 8 + Q$ gives $Q = 6$. Buyers pay $20 - 6 = \$14$ and sellers keep $14 - 6 = \$8$.

Revenue = $6 \times 6 = \$36$. Deadweight loss = $\frac{1}{2} \times 6 \times (9 - 6) = \$9$.

Buyers pay \$3 more than before ($14 - 11$) and sellers receive \$3 less ($11 - 8$). The burden is split equally because the demand and supply curves have equal slopes.

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EXAMPLE 3: DOUBLING THE TAX

Using the same market, what happens to revenue and deadweight loss if the tax doubles to \$12 per unit?

SOLUTION

New supply: $P = 14 + Q$. Then $20 - Q = 14 + Q$ gives $Q = 3$.

Revenue = $12 \times 3 = \$36$, the same as with the \$6 tax.

Deadweight loss = $\frac{1}{2} \times 12 \times (9 - 3) = \$36$, four times the \$9 from before.

Doubling the tax quadrupled the efficiency loss while revenue did not grow. Low taxes on broad bases are usually more efficient than high taxes on narrow ones.

Policy goal	Tool	Efficiency effect	Equity concern
Cut pollution	Pigouvian tax or permits	Improves efficiency	May burden low-income households
Fund a public good	Broad tax	Some deadweight loss	Choose tax by benefit or ability to pay
Reduce inequality	Progressive tax and transfers	May reduce work incentives	Improves fairness of outcomes
Encourage a positive externality	Subsidy	Improves efficiency	Costs taxpayers

Integrated case studies. (1) A fuel tax serves as a Pigouvian tax on pollution and a benefit-principle tax for roads, but it is regressive because poor households spend more of their income on fuel; returning revenue to households can offset that. (2) A tradable permit system and a carbon tax both internalize the cost, but the first fixes quantity and the second fixes price. (3) Subsidies for vaccination correct an externality but must be funded by taxes that carry their own deadweight loss. For each policy, ask: what is the market failure, what is the efficiency gain, who pays, and could government failure make the cure worse?

Policy checklist

Identify the failure (externality, public good, information, market power).

Compute the efficient quantity and the gain.

List who gains, who pays, and any deadweight loss from financing it.

Compare efficiency and equity, and consider whether officials have the information and incentives to implement it.

Common mistakes

Do not confuse average and marginal tax rates: a person in a 20% marginal bracket does not pay 20% on all income. The legal payer of a tax does not decide who bears it; elasticity does. Do not say all taxes create deadweight loss: a Pigouvian tax on a negative externality can remove it.

Practice**SET A Check Your Understanding**

Answer each question. Show calculations.

- Classify each tax as progressive, proportional, or regressive: (a) a flat 8% on all income, (b) a tax of 10% on income up to \$30,000 and 25% above, (c) a \$200 yearly vehicle fee paid by all drivers.
- A tax is 10% on the first \$20,000 and 20% on income above. Find the tax, average rate, and marginal rate for an income of \$40,000.
- A 5% sales tax applies to all spending. Household A earns \$20,000 and spends \$18,000; household B earns \$100,000 and spends \$50,000. Compare tax as a share of income and classify the tax.
- A town charges park users a \$5 entry fee to pay for park upkeep. Which tax principle does this fit? How would a progressive property tax for the same purpose differ?
- Demand is $P = 16 - Q$ and supply is $P = 4 + Q$. A tax of \$4 per unit is placed on sellers. Find the quantity, buyer price, seller price, revenue, and deadweight loss.
- In the market of the previous question, what happens to deadweight loss and revenue if the tax is raised to \$8? What does this show about high tax rates?

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A tax is regressive if
 (A) the average tax rate falls as income rises
 (B) the marginal tax rate rises with income
 (C) the tax is paid only by high-income households
 (D) it takes a constant percentage of income
 (E) it collects revenue from producers instead of consumers
8. A gasoline tax used to pay for highways best illustrates
 (A) the ability-to-pay principle
 (B) the benefit principle
 (C) a progressive tax
 (D) a subsidy for a positive externality
 (E) rent-seeking
9. The graph shows a \$4 per-unit tax. What is the deadweight loss?



- (A) 2 (B) 8 (C) 4 (D) 12 (E) 24
10. A tax on a good will mostly be borne by consumers when
 (A) supply is relatively inelastic
 (B) the tax is legally placed on sellers
 (C) demand is relatively elastic
 (D) demand is relatively inelastic
 (E) the tax rate is low
11. Which tax is most likely to improve efficiency?
 (A) A tax on a good with an elastic demand
 (B) A tax on a good with no externality
 (C) A high tax on a necessity
 (D) A tax on a good with a positive externality
 (E) A per-unit tax on a good whose production causes pollution
12. If a tax rate is doubled in a competitive market, deadweight loss will
 (A) rise by about four times
 (B) double
 (C) stay the same
 (D) fall by half
 (E) rise by one-half

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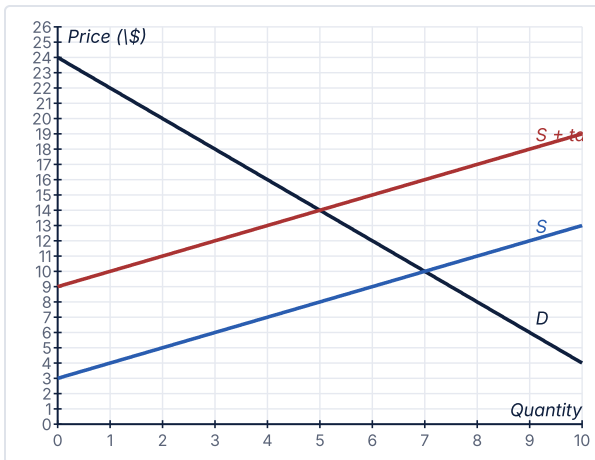
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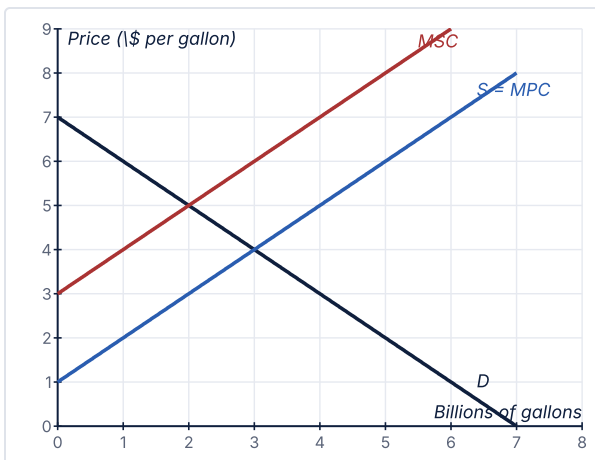
SET C Apply and Extend

Answer all parts. Show your work.

13. The graph shows a market with a \$6 per-unit tax on sellers. (a) Find the pre-tax equilibrium. (b) Find the quantity, the price buyers pay, and the price sellers keep after the tax. (c) Calculate tax revenue and deadweight loss. (d) Which side bears more of the burden, and why?



14. Gasoline has a marginal external cost of \$2 per gallon (graph). (a) Find the market quantity, the efficient quantity, and the deadweight loss. (b) Find the Pigouvian tax, the price consumers pay, and the revenue. (c) Low-income households spend a larger share of income on gasoline. Explain the equity concern and propose a way to address it without removing the incentive. (d) Compare this tax with a general tax on a good with no externality.

**6.6 Multiple-Choice Practice: Market Failure and the Role of Government**

Twenty AP-style multiple-choice questions on externalities, policy responses, public goods, information problems, and taxes.

Choose the best answer to each question. Read the explanation for every item, including the ones you got right, to see why the best wrong choice fails.

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SET A Core Concepts

Choose the best answer.

- Which of the following is a positive externality?
 - A student pays tuition to a private university
 - A factory's output is reduced by a new tax
 - A homeowner repaints her house, and the whole street's property values rise
 - A buyer bargains for a lower price on a car
 - A bakery raises its prices after flour becomes more expensive
- The graph shows a market with a negative externality. To reach the efficient output, production should fall by how many units from the market level?



- (A) 2 (B) 1 (C) 3 (D) 5 (E) 7
- A Pigouvian tax on a good with a negative externality is efficient when it equals
 - the total external damage
 - the deadweight loss per unit
 - the equilibrium price before the tax
 - the producer's marginal private cost
 - the marginal external cost at the efficient quantity
 - A good that is nonrival and nonexcludable is best classified as
 - a private good
 - a public good
 - a common resource
 - a club good that charges fees
 - a good with only negative externalities
 - The free-rider problem leads private markets to
 - provide more than the efficient amount of a public good
 - charge firms too low a price for public goods
 - create a tragedy of the commons for every public good
 - provide less than the efficient amount of a public good
 - ignore all external costs
 - An insurer sets one premium for all customers based on the average risk. Low-risk customers drop out, raising the average risk of the remaining pool. This process is
 - adverse selection
 - moral hazard
 - rational ignorance
 - logrolling
 - a positive externality

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7. The table shows taxes paid at three incomes. This tax is best described as

Income	Tax paid
\$20,000	\$2,000
\$40,000	\$6,000
\$80,000	\$20,000

- (A) regressive
- (B) proportional
- (C) a head tax
- (D) progressive
- (E) a benefit-based tax

SET B Applications and Data

Choose the best answer.

8. The graph shows a good with an external benefit. What is the deadweight loss caused by the externality?



- (A) 3
- (B) 6
- (C) 9
- (D) 12
- (E) 18

9. A firm can reduce emissions at the marginal abatement costs shown. It faces a pollution tax of \$35 per ton. How many tons will it abate?

Ton abated	1st	2nd	3rd	4th	5th
Marginal abatement cost	\$10	\$20	\$30	\$40	\$50

- (A) 1 ton
- (B) 2 tons
- (C) 4 tons
- (D) 5 tons
- (E) 3 tons

10. Firm A can cut pollution for \$2 per unit and Firm B for \$7 per unit. Under tradable permits, which outcome is most likely?

- (A) Firm B cuts a lot and sells permits to Firm A
- (B) Both firms cut by the same amount
- (C) Firm A cuts a lot and sells permits to Firm B at a price between \$ 2 and \$ 7
- (D) Neither firm trades because permits raise cost
- (E) Firm A buys permits from Firm B at \$ 9

11. Marginal benefits of a public good are shown. If the marginal cost is \$12 per unit, what is the efficient quantity?

Q	MB of A	MB of B
1	9	6
2	7	5
3	5	4
4	3	3

- (A) 2
- (B) 1
- (C) 3
- (D) 4
- (E) 0

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12. Fish sell for \$50 per ton and each boat costs \$900 per season. The table gives total catch. Under open access, boats enter until average revenue per boat equals cost. How many more boats operate than the number that maximizes total profit?

Boats	1	2	3	4
Total catch (tons)	20	36	48	56

- (A) 0 (B) 2 (C) 3 (D) 1 (E) 4
13. A policy has a \$200 deductible and 50% coinsurance above it. For a \$1,000 loss, how much does the insurer pay?
- (A) \$ 500 (B) \$ 400 (C) \$ 600 (D) \$ 800 (E) \$ 200
14. A monopolist faces $D: P = 30 - Q$ with $MC = \$6$. What is the deadweight loss?



- (A) 36 (B) 144 (C) 72 (D) 216 (E) 288

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SET C Exam-Level Stretch

Choose the best answer.

15. A factory's smoke damages a nearby laundry by \$5,000 per year. The factory can install a filter for \$3,000 per year. Bargaining is costless and property rights are clear. According to the Coase theorem, the filter will be installed
- (A) only if the laundry holds the right to clean air
 (B) only if the factory holds the right to pollute
 (C) only if the government taxes the smoke
 (D) only if the laundry's damage were smaller than the filter cost
 (E) regardless of which party holds the property right
16. Demand is $P = 20 - Q$ and supply is $P = 2 + Q$. A per-unit tax on sellers is raised from \$6 to \$12. What happens to tax revenue and deadweight loss?
- (A) Revenue doubles and deadweight loss doubles
 (B) Revenue doubles and deadweight loss is unchanged
 (C) Revenue is unchanged and deadweight loss rises fourfold
 (D) Revenue is unchanged and deadweight loss is unchanged
 (E) Revenue falls to zero and deadweight loss doubles
17. The graph shows a good with an external benefit of \$4 per unit. What is the total cost to the government of a per-unit subsidy that achieves the efficient quantity?



- (A) \$32 (B) \$16 (C) \$24 (D) \$40 (E) \$48
18. A good has the marginal values below, and the external cost rises with output. A single per-unit Pigouvian tax is set to reach the efficient quantity. What should the tax be?

Q	MPB	MPC	MEC
1	20	4	2
2	17	6	4
3	14	8	6
4	11	10	8
5	8	12	10

- (A) \$2 (B) \$4 (C) \$8 (D) \$6 (E) \$10

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19. A tariff-like subsidy gives \$5 million to each of 10 firms. It is paid for by 50 million taxpayers at \$1.60 each. Which concept best explains why it may pass despite a net loss to society?
- (A) Taxpayers have perfect information
 - (B) Concentrated benefits and dispersed costs favor special-interest lobbying
 - (C) The subsidy corrects a positive externality
 - (D) Adverse selection among firms
 - (E) The free-rider problem in the market for lobbying is absent
20. An insurer has 60 low-risk customers with expected claims of \$300 and 40 high-risk customers with expected claims of \$800. Low-risk customers will pay at most \$400. It cannot tell the groups apart. Which describes the eventual market outcome?
- (A) Everyone buys at \$ 500 forever
 - (B) Only low-risk customers buy at \$ 300
 - (C) Only high-risk customers buy and the premium falls to \$ 400
 - (D) Insurance premiums stay at \$ 500 because of moral hazard
 - (E) Only high-risk customers buy, and the premium rises to \$ 800

6.7 Free-Response Practice: Market Failure and the Role of Government

Four free-response questions covering externalities, public goods, information problems, and taxes.

Each question is worth about 5 to 6 points. Points are earned for correct graph readings, calculations with units, and explanations that name the economic reasoning (marginal social cost, free riding, adverse selection, and so on). Show every setup, because partial credit is given for correct work.

QUESTION 1 Negative externality and a tax

A chemical plant sells fertilizer in a competitive market. The graph shows demand, the plant industry's marginal private cost (supply), and marginal social cost. Quantity is in thousands of tons and price is in dollars per ton. The plant's pollution imposes an external cost of \$6 per ton.

1. (a) Find the market equilibrium quantity and price.



2. (b) Find the allocatively efficient quantity and calculate the deadweight loss caused by the externality.
3. (c) Identify a per-unit tax that would lead to the efficient quantity. Calculate the price buyers pay, the price sellers keep, and tax revenue.
4. (d) Explain why the market quantity is greater than the efficient quantity.

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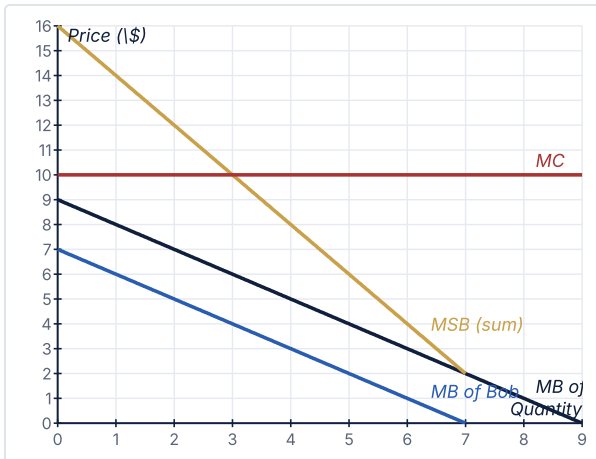
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QUESTION 2 Public good provision

Ann and Bob are the only two residents of a small island. Their marginal benefits from additional hours of coastal patrol per week are shown on the graph in dollars. Each hour has a marginal cost of \$10.

5. (a) Is coastal patrol a public good? Define the two characteristics that make a good a public good and apply them.



6. (b) Find the efficient number of hours.
 7. (c) Explain why neither Ann nor Bob would hire any patrol hours on their own, and name the problem.
 8. (d) Describe one way the island could achieve the efficient quantity.

QUESTION 3 Asymmetric information in insurance

An auto insurer has 200 potential customers: 150 safe drivers with an expected annual claim of \$400 and 50 risky drivers with an expected annual claim of \$1,600. The insurer cannot tell them apart. A safe driver will pay at most \$600 for the policy.

9. (a) Compute the premium at which the insurer breaks even if all 200 customers buy.
 10. (b) Will safe drivers buy at that premium? What premium would the insurer need to charge after the safe drivers leave?
 11. (c) Identify the market failure and explain why it occurs.
 12. (d) After the policy is sold, insured drivers begin driving more carelessly. Name this problem and describe one feature of a policy that reduces it.

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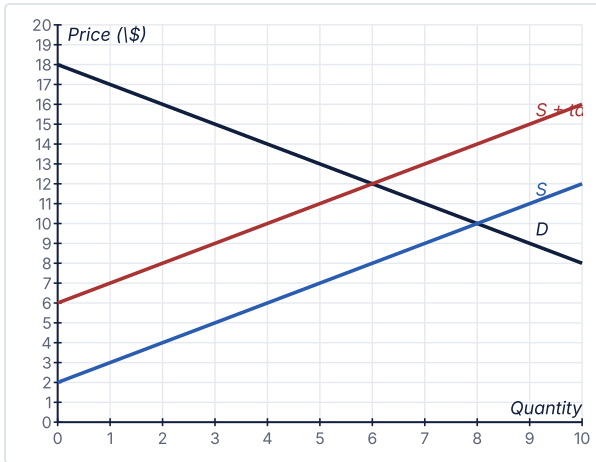
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QUESTION 4 Tax incidence, efficiency, and equity

The graph shows the market for a good before and after a \$4 per-unit tax collected from sellers. Quantity is in thousands and price is in dollars.

13. (a) Find the equilibrium quantity before the tax and after the tax, and the prices paid by buyers and received by sellers after the tax.



14. (b) Calculate tax revenue and the deadweight loss of the tax.
 15. (c) Suppose that the good causes a \$4 external cost per unit. Explain how your answer to (b) changes in terms of efficiency.
 16. (d) A 5% sales tax is paid by Household A (income \$20,000, spending \$16,000) and Household B (income \$80,000, spending \$40,000). Calculate the tax as a share of income for each and classify the tax.

Answers Chapter 6: Answers and Explanations

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

6.1 Externalities**SET A · CHECK YOUR UNDERSTANDING**

1. An externality is an effect of a transaction on a third party who is outside it. (a) is positive because the orchard owner gains pollination for free. (b) is negative because the neighbor bears noise. (c) is positive because other people are less likely to catch the flu. (d) is negative because other drivers lose time.
2. $MSC = MPC + MEC = 9 + 5 = \$14$. The firm does not count the \$5 because it does not pay it; the cost falls on neighbors. The firm therefore decides using a cost that is too low, which leads it to supply more than is efficient.
3. Market: $20 - Q = 4 + Q$, so $Q = 8$ and $P = \$12$. $MSC = 10 + Q$, so efficient output solves $20 - Q = 10 + Q$, giving $Q^* = 5$. Deadweight loss = $(1/2)(6)(8 - 5) = \$9$ thousand. The market overproduces by 3 thousand units.
4. The market keeps producing until $MPB = MPC$. At that quantity MSC is above MPC by the external cost, so MSC exceeds MSB . The last units therefore cost society more than they benefit it. Efficiency requires cutting output back to where $MSB = MSC$.
5. Market: $16 - Q = 4 + Q$, so $Q = 6$ and $P = \$10$. $MSB = 18 - Q$, so $18 - Q = 4 + Q$ gives $Q^* = 7$. Deadweight loss = $(1/2)(2)(7 - 6) = \$1$ (in whatever units Q is measured). The market underproduces by 1 unit.
6. The buyer values the shot at \$18, below the \$25 cost, so a private market will not supply the 100th shot. Its marginal social benefit is $18 + 12 = \$30$, which exceeds the \$25 cost, so it should be supplied. This is underproduction caused by a positive externality, and the net social gain forgone is \$5.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. A. Market output is 6 ($14 - x = 2 + x$) and efficient output is 3 ($14 - x = 8 + x$). The external cost per unit is 6, so $DWL = (1/2)(6)(6 - 3) = 9$. Choice 18 is the full rectangle-style product 6×3 , which forgets the one-half.
8. B. The neighbors benefit without paying, which is the definition of a positive externality. The drought case is a price change that works through the market, and the tuition and bargaining cases only involve the buyer and seller.
9. C. At the market equilibrium $MPB = MPC$, but $MSC = MPC + MEC$ is higher, so MSC is greater than MSB and output is too high. The second choice is wrong because MPB equals MPC at equilibrium, and the third describes a positive externality.
10. D. Compare $MSB = MPB + 3$ with MC . Unit 4: $5 + 3 = 8 \geq 6$ (produce). Unit 5: $3 + 3 = 6 < 7$ (stop). So the efficient quantity is 4. The market quantity (MPB vs MC) is 3, which is the tempting wrong answer.
11. E. DWL is the triangle of net social value lost on units that should not be (or should be) produced. Total damage is larger because it includes the damage on units that are worth producing. A market can be in equilibrium and still inefficient.

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12. A. Demand reflects only the buyer's MPB, so willingness to pay is understated relative to MSB and the market quantity is too low. The second choice describes a negative externality.

SET C · APPLY AND EXTEND

13. (a) $16 - 2Q = 4 + Q$ gives $Q = 4$ and $P = \$8$ (1 point). (b) $MSB = 19 - 2Q$; setting $19 - 2Q = 4 + Q$ gives $Q^* = 5$ (1 point). (c) $DWL = (1/2)(3)(5 - 4) = \$1.50$ (1 point). (d) At $Q = 4$ the MSB is \$11 but the MC is \$8, so the 5th unit adds more benefit to society than it costs; buyers ignore the \$3 external benefit, so the market underproduces (1 point).
14. (a) $22 - 2Q = 4 + Q$ gives $Q = 6$ and $P = \$10$ (1 point). (b) $MSC = 10 + Q$; $22 - 2Q = 10 + Q$ gives $Q^* = 4$. $DWL = (1/2)(6)(6 - 4) = \$6$ (2 points). (c) A larger external cost lowers the efficient quantity and raises DWL because the wedge is taller and the quantity gap is wider: $MSC = 13 + Q$ gives $Q^* = 3$, $DWL = (1/2)(9)(6 - 3) = \$13.50$ (2 points). (d) DWL is zero only if the external cost is zero, so MSC coincides with MPC and the market quantity is already efficient (1 point).

6.2 Correcting Externalities

SET A · CHECK YOUR UNDERSTANDING

1. A Pigouvian tax is a per-unit tax equal to the marginal external cost. With constant damage the tax should be \$5, because that adds the neighbors' cost to the mill's own cost and makes MPC plus the tax equal MSC. The mill then produces the efficient quantity.
2. Market: $30 - Q = 6 + Q$ gives $Q = 12$ and $P = \$18$. $MSC = 14 + Q$, so $30 - Q = 14 + Q$ gives $Q^* = 8$. The tax is \$8 per unit. Buyers pay $30 - 8 = \$22$ and sellers keep $22 - 8 = \$14$. Revenue is $8 \times 8 = \$64$ thousand.
3. Market: $14 - Q = 2 + Q$ gives $Q = 6$. $MSB = 18 - Q$, so $18 - Q = 2 + Q$ gives $Q^* = 8$. The subsidy equals MEB, \$4 per unit. Spending is $4 \times 8 = \$32$. Buyers pay $14 - 8 = \$6$ and sellers receive $6 + 4 = \$10$, which equals MC at 8.
4. (a) The factory must either pay \$10,000 in damages or spend \$6,000 to abate, so it abates. (b) The club would pay the factory up to \$10,000 to stop and the factory accepts anything above \$6,000, so abatement happens again. Efficiency is the same in both cases (the cheaper fix is chosen), but who pays differs. This illustrates the Coase theorem.
5. It abates a ton whenever the abatement cost is below the \$50 charge, so it abates the first two tons ($20 + 40 = \$60$). It pays the charge on the 2 remaining tons, \$100. Total cost is \$160. Abating a third ton would cost \$60 to save \$50, which raises total cost to \$170.
6. Permits let the firms with the lowest abatement cost do most of the cutting, so the cap is met at lower total cost; a uniform standard forces equal cuts regardless of cost. A weakness is that regulators must choose the cap and monitor emissions, and permit prices can swing widely. If the cap is set too high, the policy does little.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. After the tax, $14 - x = 6 + x$ gives $x = 4$. Revenue = $4 \times 4 = 16$. The choice 24 uses the pre-tax quantity of 6, which is wrong because the tax reduces the quantity sold.
8. A. The tax makes the producer's cost equal to marginal social cost. Total damage is bigger than the per-unit external cost and would cut output too far.
9. D. Efficiency needs clear rights and cheap bargaining; it does not matter which side holds the right. A large number of affected parties raises transaction costs and weakens the theorem.
10. B. Trading shifts abatement to the firms that can do it cheaply, so the cap is met at the lowest total cost. The government still sets the cap and monitors, which is why the other choices fail.
11. E. For a positive externality, the subsidy lifts the market quantity to Q^* where $MSB = MC$. Raising quantity beyond Q^* would only happen with a subsidy larger than MEB.
12. A. With millions of victims, organizing and negotiating is extremely costly and every person is tempted to hold out or free ride, so the Coase conditions fail. The other cases involve few parties and low transaction costs.

SET C · APPLY AND EXTEND

13. (a) $18 - 2Q = 3 + Q$ gives $Q = 5$; $21 - 2Q = 3 + Q$ gives $Q^* = 6$ (1 point). (b) Subsidy = MEB = \$3 per unit; cost = $3 \times 6 = \$18$ (1 point). (c) Consumers pay $18 - 12 = \$6$; sellers receive $6 + 3 = \$9 = MC$ at 6 (1 point). (d) It raises the quantity to where $MSB = MC$, eliminating the deadweight loss of $(1/2)(3)(1) = \$1.50$ from underproduction (1 point).
14. (a) X pays $10 \times 3 = \$30$ and Y pays $10 \times 9 = \$90$, total \$120 (1 point). (b) The need is 20 units of cuts. All of it should come from X: $20 \times 3 = \$60$ (1 point). (c) Give each plant 20 permits; X cuts to 10 and sells 10 permits to Y, which then emits 30. Trade occurs at any price between \$3 (X's cost) and \$9 (Y's cost); total emissions stay at 40 (2 points). (d) A uniform standard is easy to monitor and enforce and does not need a market, or it may be chosen when local hot spots of pollution matter (1 point).

6.3 Public Goods and Common Resources

SET A · CHECK YOUR UNDERSTANDING

1. (a) Public good: nobody can be excluded and one person's light does not reduce another's. (b) Club good: access can be blocked for non-payers, and extra users do not reduce others' viewing. (c) Common resource: it cannot be restricted, but a fish caught is unavailable to others. (d) Club good: tolls exclude, but one more car does not hinder others until it gets crowded.
2. A free rider enjoys a good without paying for it. Anyone can watch the fireworks without a ticket (nonexcludable), so most residents would prefer others to pay. The firm cannot collect enough revenue to cover costs, and the display is not provided even though the total benefit to residents may exceed its cost.
3. $MSB = (10 - Q) + (8 - Q) = 18 - 2Q$. Setting $18 - 2Q = 8$ gives $Q^* = 5$. Resident 1 alone sets $10 - Q = 8$, so $Q = 2$. The market underprovides by 3 units because resident 1 ignores resident 2's benefit.

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4. Both contribute: total benefit is 32, so each receives 16 and pays 10, a net gain of +6. Only I contribute: total benefit 16 is split, so I receive 8 and pay 10, net -2 (the other gets +8 free). Only the other contributes: I get +8 free. Neither: 0. Not contributing is better for each person whatever the other does, so neither contributes even though both would gain +6 by cooperating.
5. The fish are rival but nonexcludable, so each boat ignores the effect of its catch on the stock available to others. This is a missing-property-rights externality. Tradable catch quotas or limited licenses give owners an interest in the future stock; seasonal closures or a per-boat fee can also cut effort.
6. A vaccination is excludable and rival, so it is not a pure public good, but it gives large external benefits by lowering the spread of disease. Because buyers ignore those benefits, the market quantity is too low. A per-unit subsidy equal to the marginal external benefit (or direct government provision) raises the quantity to the efficient level.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. A. Everyone in earshot hears the siren (nonexcludable) and one more listener does not reduce another's use (nonrival). Open-ocean fish are rival, and the toll bridge and subscription are excludable.
8. C. Add the curves vertically: $(8 - Q) + (6 - Q) = 14 - 2Q$, which equals 6 at $Q = 4$. Quantity 2 is what Ana would buy alone, where her MB equals MC.
9. B. Because non-payers cannot be excluded, consumers hide their willingness to pay and firms cannot collect revenue, so output is below the efficient level. The first choice is a negative externality problem, not free riding.
10. D. The lake is a common resource: nonexcludable and rival. Each angler ignores the cost imposed on others. A public good would be nonrival, which fish are not.
11. E. Tradable permits cap total grazing and give users a stake in the pasture's future, which addresses the missing property rights. A subsidy per cow would encourage even more grazing.
12. A. For a public good, the relevant benefit is the vertical sum: $4 \times 3 = 12 = MC$. A buyer's own benefit being lower than cost does not signal inefficiency.

SET C · APPLY AND EXTEND

13. (a) $MSB = (12 - 2Q) + (8 - 2Q) = 20 - 4Q$; $20 - 4Q = 8$ gives $Q^* = 3$ (1 point). (b) $12 - 2Q = 8$ gives $Q = 2$ (1 point). (c) At $Q = 2$, $MSB = 12$ and $MC = 8$, a gap of \$4 that falls to 0 at $Q = 3$: $DWL = (1/2)(4)(1) = \$2$ (1 point). (d) Resident 2 can enjoy the park paid for by resident 1 and has no reason to contribute, so the market stops short of Q^* . Taxes that make both contribute (or a membership rule) solve it (1 point).
14. (a) Boats enter until $AR = \text{cost}$: $14 - 2N = 6$ gives $N = 4$; profit = $4 \times (6 - 6) = 0$ (1 point). (b) Set $MR = \text{cost}$: $14 - 4N = 6$ gives $N = 2$; revenue per boat is $14 - 4 = 10$, profit = $2 \times (10 - 6) = 8$ hundred = \$800 (1 point). (c) At $N = 2$, $AR - \text{cost} = 4$, so a fee of 4 hundred (\$400) per boat makes a third boat unprofitable (1 point). (d) Each boat considers its own average revenue and ignores that it lowers the catch for others, a negative externality of missing property rights (1 point).

6.4 Asymmetric Information and Other Failures

SET A · CHECK YOUR UNDERSTANDING

1. (a) Moral hazard: the behavior changes after the driver is insured because the insurer bears the cost. (b) Adverse selection: risk differences exist before the contract and the riskiest customers are most eager to buy. Both come from asymmetric information.
2. (a) $(40 \times 100 + 60 \times 500)/100 = (4,000 + 30,000)/100 = \$340$. (b) With only the high-risk group left the expected claim is \$500, so the premium must rise to \$500. This spiral is adverse selection.
3. Above the deductible: $8,000 - 1,000 = 7,000$. The insurer pays $0.70 \times 7,000 = \$4,900$. The customer pays $1,000 + 0.30 \times 7,000 = \$3,100$ (check $4,900 + 3,100 = 8,000$). Because the customer pays part of every loss, there is a reason to take care.
4. $MR = 30 - 2Q = 6$ gives $Q = 12$ and $P = \$18$. Efficiency requires $P = MC$: $30 - Q = 6$, so $Q^* = 24$. $DWL = (1/2)(18 - 6)(24 - 12) = \$72$. The monopolist restricts output because selling more would lower the price on all units.
5. Benefit to firms: $10 \times \$5 \text{ million} = \$50 \text{ million}$. Cost: $50 \text{ million} \times \$1.60 = \$80 \text{ million}$, so society loses \$30 million. Each firm gains a lot and will lobby hard; each taxpayer loses \$1.60, too little to gather information or organize. This is concentrated benefits and dispersed costs.
6. A progressive tax raises revenue from higher incomes and finances transfers, which makes the distribution of income more equal. It can lower the reward for extra work or investment, which may shrink total output and surplus. The tradeoff means society must choose how much equity to buy at the cost of some efficiency; that choice is normative.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. A. Hidden quality before the sale drives good sellers out and lowers average quality. Moral hazard involves behavior after a contract.
8. B. The owner changes behavior because insurance shifts the cost of fire. The sick person example is adverse selection, which occurs before the contract.
9. C. A deductible makes the insured pay the first part of each loss, creating a reason to be careful. Full coverage increases moral hazard.
10. D. $MR = MC$: $24 - 2Q = 4$ gives $Q = 10$ and $P = 14$. Efficiency ($P = MC$) gives $Q = 20$. $DWL = (1/2)(14 - 4)(20 - 10) = 50$. The choice 100 forgets the one-half.
11. E. Rational ignorance is the choice not to become informed when the cost exceeds the benefit. Logrolling is vote trading, and rent-seeking is spending to win favors.
12. A. Small groups with a big stake lobby effectively, while each taxpayer has little reason to resist. The other statements assume perfect government.

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SET C · APPLY AND EXTEND

13. (a) $MR = MC: 40 - 4Q = 8$ gives $Q = 8$ and $P = 40 - 16 = \$24$ (1 point). (b) $P = MC: 40 - 2Q = 8$ gives $Q^* = 16$; $DWL = (1/2)(24 - 8)(16 - 8) = \$64$ (1 point). (c) At a ceiling of \$8 the firm sells 16 units, where MC meets demand, so DWL falls to 0 (1 point). (d) The regulator may not know the firm's true marginal cost (asymmetric information), may be influenced by the firm, or the ceiling may be below cost in the long run (1 point).
14. (a) $(600 \times 1,000 + 400 \times 4,000)/1,000 = (600,000 + 1,600,000)/1,000 = \$2,200$ (1 point). (b) Low-risk customers will pay at most \$1,500, below \$2,200, so they leave; only the high-risk 400 remain (1 point). (c) The premium must rise to \$4,000, so only high-risk people buy and the market for low-risk insurance disappears (adverse selection) (1 point). (d) A mandate that everyone buy (or a large group plan) keeps low-risk people in the pool so the average cost is not driven up (1 point).

6.5 Taxation, Equity, and Government Policy Choices

SET A · CHECK YOUR UNDERSTANDING

1. (a) Proportional: the rate is 8% at every income. (b) Progressive: the average rate rises with income as more income falls in the higher bracket. (c) Regressive: the same \$200 is a larger share of a low income than of a high income.
2. $\text{Tax} = 0.10 \times 20,000 + 0.20 \times 20,000 = 2,000 + 4,000 = \$6,000$. Average rate $= 6,000/40,000 = 15\%$. The marginal rate is 20% because the next dollar falls in the upper bracket.
3. A pays $0.05 \times 18,000 = \$900$, which is 4.5% of income. B pays $0.05 \times 50,000 = \$2,500$, which is 2.5% of income. The share falls as income rises, so the tax is regressive even though the sales tax rate is the same.
4. The entry fee follows the benefit principle because those who use the park pay for it. A progressive property tax follows the ability-to-pay principle: the cost is spread by wealth regardless of use. The first is more efficient in matching payment to use; the second may be fairer to low-income families.
5. Before: $16 - Q = 4 + Q$ gives $Q = 6$, $P = \$10$. After: supply is $8 + Q$, so $16 - Q = 8 + Q$ gives $Q = 4$. Buyers pay $16 - 4 = \$12$ and sellers keep $12 - 4 = \$8$. Revenue $= 4 \times 4 = \$16$; $DWL = (1/2)(4)(6 - 4) = \$4$.
6. Supply becomes $12 + Q$, so $16 - Q = 12 + Q$ gives $Q = 2$. Revenue $= 8 \times 2 = \$16$, unchanged. $DWL = (1/2)(8)(6 - 2) = \$16$, four times higher. Doubling the tax quadruples the efficiency loss and here brings no additional revenue.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. A. Regressive means the share of income paid falls as income rises. A constant percentage is proportional and rising shares are progressive.
9. C. Before the tax $Q = 8$ ($18 - x = 2 + x$); after the tax $Q = 6$ ($18 - x = 6 + x$). $DWL = (1/2)(4)(8 - 6) = 4$. The value 24 is tax revenue, 4×6 .
11. E. A tax equal to the external cost moves output toward the efficient level. Taxes on goods without externalities or on goods with positive externalities create or worsen deadweight loss.
8. B. Drivers who use roads pay for them. Fuel taxes are also somewhat regressive, so they do not follow ability to pay.
10. D. The side with fewer alternatives (the less elastic side) bears more of the tax. Who is legally billed does not determine incidence.
12. A. DWL is the area of a triangle whose height (the tax) and base (the drop in quantity) both double, so it grows about fourfold.

SET C · APPLY AND EXTEND

13. (a) $24 - 2Q = 3 + Q$ gives $Q = 7$ and $P = \$10$ (1 point). (b) $24 - 2Q = 9 + Q$ gives $Q = 5$; buyers pay $24 - 10 = \$14$, sellers keep $14 - 6 = \$8$ (1 point). (c) Revenue $= 6 \times 5 = \$30$; $DWL = (1/2)(6)(7 - 5) = \$6$ (1 point). (d) Buyers pay \$4 more than before while sellers receive \$2 less, so buyers bear two-thirds; demand is steeper (less elastic) than supply (1 point).
14. (a) $7 - Q = 1 + Q$ gives $Q = 3$, $P = \$4$. $MSC = 3 + Q$; $7 - Q = 3 + Q$ gives $Q^* = 2$. $DWL = (1/2)(2)(3 - 2) = \$1$ billion (1 point). (b) Tax $= \$2$; buyers pay $7 - 2 = \$5$, sellers keep \$3; revenue $= 2 \times 2 = \$4$ billion (1 point). (c) The tax is regressive; rebating the revenue as equal per-household payments keeps the price signal but returns money to poor households (1 point). (d) A tax on a good with no externality only creates deadweight loss, while this tax removes the loss caused by the externality (1 point).

6.6 Multiple-Choice Practice: Market Failure and the Role of Government

SET A · CORE CONCEPTS

1. C. Neighbors gain without paying, which is a spillover benefit. The price rise from flour costs works through the market, so it is not an externality.
3. E. The tax adds the external cost to the producer's private cost so that MPC plus tax equals MSC. Total damage would overshoot, because the tax is per unit.
5. D. People who cannot be excluded have no reason to pay, so revenue is too small and output is too low. The tragedy of the commons involves rival resources, not public goods.
7. D. Average rates are 10%, 15%, and 25%, which rise with income. A proportional tax would have the same rate at every income.
2. A. Market output is 5 ($12 - x = 2 + x$) and the efficient output is 3 ($12 - x = 6 + x$), so it falls by 2. Choice 3 is the efficient quantity itself, not the reduction.
4. B. Both nonexcludability and nonrivalry define a public good. A common resource is nonexcludable but rival.
6. A. The riskier customers select into the pool because of hidden information before the contract. Moral hazard describes behavior change after getting insurance.

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SET B · APPLICATIONS AND DATA

8. B. Market output is 5 ($20 - 2x = 5 + x$) and efficient output is 7 ($26 - 2x = 5 + x$). The gap between MSB and MC at 5 is 6, so $DWL = (1/2)(6)(7 - 5) = 6$. Choice 12 forgets the one-half.
9. E. The firm abates a ton whenever the abatement cost is below the \$35 tax: \$10, \$20, and \$30 qualify, but \$40 does not. Four tons is wrong because avoiding a \$35 tax at a cost of \$40 would raise its costs.
10. C. Trade benefits both firms when the price is between their abatement costs, and total emissions stay at the cap. Equal cuts are what a uniform standard would require.
11. A. Add the benefits vertically: 15 at $Q = 1$, 12 at $Q = 2$, 9 at $Q = 3$. The sum equals MC at $Q = 2$. $Q = 3$ is wrong because its combined benefit of 9 is less than its cost of 12.
12. D. Open access: revenue per boat is 1,000, 900, 800, 700, so 2 boats enter. The profit-maximizing number adds boats only if marginal revenue is at least 900; marginal revenues are 1,000, 800, 600, 400, so just 1 boat. The difference is 1, and answering 2 mistakes the open-access count for the difference.
13. B. Above the deductible: $1,000 - 200 = 800$; the insurer pays half, \$400. Choice \$500 applies 50% to the entire loss and ignores the deductible.
14. C. $MR = 30 - 2Q = 6$ gives $Q = 12$ and $P = 18$; efficiency gives $Q = 24$. $DWL = (1/2)(18 - 6)(24 - 12) = 72$. The 144 forgets the one-half.

SET C · EXAM-LEVEL STRETCH

15. E. The filter is the cheaper fix, so bargaining leads to it either way; the right only decides who pays (the factory directly, or the laundry paying the factory between \$3,000 and \$5,000). The second choice is wrong because the factory would pollute only if the filter cost more than the damage.
16. C. With a \$6 tax $Q = 6$ and revenue is 36; with a \$12 tax $Q = 3$ and revenue is again 36. $DWL = (1/2)(6)(3) = 9$ versus $(1/2)(12)(6) = 36$. Revenue does not double because the quantity falls.
17. A. The efficient subsidy is the external benefit, \$4. Efficient output solves $18 - x = 2 + x$, so $x = 8$, and cost = $4 \times 8 = \$32$. Choice \$24 uses the market quantity of 6, but the subsidy is paid on every unit at the new quantity.
18. D. Market quantity is 4 ($MPB_{11} \geq MPC_{10}$). Efficient quantity is 3, because $MPB_{14} \geq MSC_{14}$ but unit 4 has $MPB_{11} < MSC_{18}$. The tax equals MEC at the efficient quantity, \$6. Using the MEC at the market quantity (\$8) would cut output too far.
19. B. The firms gain \$50 million and have strong reason to lobby, while taxpayers lose a total of \$80 million but only \$1.60 each and are rationally ignorant. The externality explanation is wrong because the question gives no spillover.
20. E. The average claim is $(60 \times 300 + 40 \times 800)/100 = \$500$. Low-risk customers will pay only \$400, so they leave, and the premium must rise to \$800 for the remaining group. Moral hazard is about behavior after purchase and does not explain this.

6.7 Free-Response Practice: Market Failure and the Role of Government**QUESTION 1 · NEGATIVE EXTERNALITY AND A TAX**

1. (a) Set $20 - 2Q = 2 + Q$, so $Q = 6$ thousand tons and $P = \$8$. 1 point: correct quantity. 1 point: correct price.
2. (b) $MSC = 8 + Q$; $20 - 2Q = 8 + Q$ gives $Q^* = 4$ thousand tons. 1 point: $Q^* = 4$. $DWL = (1/2)(6)(6 - 4) = \$6$ thousand. 1 point: correct DWL with the one-half and the 2-thousand difference.
3. (c) Tax = \$6 per ton, equal to the marginal external cost. 1 point. Buyers pay $20 - 8 = \$12$; sellers keep $12 - 6 = \$6$, which equals MPC at 4. 1 point for both prices. Revenue = $6 \times 4 = \$24$ thousand. 1 point.
4. (d) The plant ignores the external cost, so it supplies where $MPB = MPC$. At that quantity MSC (\$14 at $Q = 6$) exceeds the marginal benefit (\$8), so the last units reduce total surplus. 1 point: private cost omits the external cost. 1 point: compares MSC with MSB at the market quantity.

QUESTION 2 · PUBLIC GOOD PROVISION

5. (a) Yes. 1 point: nonexcludable, because no one on the island can be kept from the protection. 1 point: nonrival, because Ann's protection does not reduce Bob's.
6. (b) Add benefits vertically: $MSB = (9 - Q) + (7 - Q) = 16 - 2Q$. Setting $16 - 2Q = 10$ gives $Q^* = 3$ hours. 1 point: vertical summation. 1 point: $Q^* = 3$.
7. (c) Ann's own marginal benefit for the first hour is \$9 and Bob's is \$7, each below the \$10 cost, so neither would buy even though the combined benefit of the first hour is \$16. 1 point: compares each individual MB with MC. 1 point: names free riding (each hopes the other pays) or the underprovision problem.
8. (d) Residents could vote to tax themselves to fund 3 hours, with the cost shared (for example, \$10 each hour split by benefit), or sign a binding agreement. 1 point: a mechanism that makes both contribute.

QUESTION 3 · ASYMMETRIC INFORMATION IN INSURANCE

9. (a) Expected claims = $150 \times 400 + 50 \times 1,600 = 60,000 + 80,000 = \$140,000$. Average = $140,000/200 = \$700$. 1 point: correct total. 1 point: \$700.
10. (b) No, because \$700 exceeds the \$600 maximum they will pay. 1 point. The remaining pool is the risky drivers only, so the premium must rise to \$1,600. 1 point.
11. (c) Adverse selection from asymmetric information: customers know their own risk but the insurer does not, so the insurer prices at the average and the low-risk customers leave. 1 point: adverse selection. 1 point: explanation tying hidden information to the departure of low-risk customers.
12. (d) Moral hazard (hidden action after the contract). 1 point. A deductible, copayment, or coinsurance makes the driver pay part of any loss and restores some incentive for care. 1 point.

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QUESTION 4 · TAX INCIDENCE, EFFICIENCY, AND EQUITY

13. (a) Before: $18 - Q = 2 + Q$ gives $Q = 8$ and $P = \$10$. After: $18 - Q = 6 + Q$ gives $Q = 6$. Buyers pay $18 - 6 = \$12$; sellers keep $12 - 4 = \$8$. 1 point: both quantities. 1 point: both prices.
14. (b) Revenue = $4 \times 6 = \$24$ thousand. 1 point. DWL = $(1/2)(4)(8 - 6) = \$4$ thousand. 1 point.
15. (c) The supply curve plus the tax is exactly the marginal social cost curve ($6 + Q$), so the tax moves output from 8 to the efficient 6. 1 point. The \$4 triangle is not a loss relative to the efficient outcome; it is the deadweight loss of the externality that the tax removes, so efficiency improves. 1 point.
16. (d) A pays $0.05 \times 16,000 = \$800$, which is 4% of income. B pays $0.05 \times 40,000 = \$2,000$, which is 2.5% of income. 1 point: both shares. The share falls as income rises, so the tax is regressive. 1 point.

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Chapter 7: Deep Dives and Extra Practice.

2 sections with explanations and worked examples, then 34 practice problems. Answers and full explanations are at the end of the chapter.

7.1 Taxes, Subsidies and Price Ceilings on Firm Decisions

Learn to tell policies that move a firm's marginal cost from those that only change fixed cost, and use that to predict output, price and profit for competitive firms and monopolies.

A firm's profit-maximizing rule never changes: produce where marginal revenue equals marginal cost. So the question for any government intervention is simple: **does it change the firm's marginal cost or marginal revenue, or only its fixed costs?** Policies that move the margin change output and price. Policies that only move fixed costs change profit but not (in the short run) output. This lesson applies that one idea to taxes, subsidies and price ceilings for both competitive and monopoly firms.

Which curves move?

Per-unit tax t : MC, AVC and ATC all shift up by t (the firm pays t on every unit, so the cost of the next unit rises by t). Output falls.

Lump-sum tax (or license fee): only ATC shifts up, because it adds to fixed cost. MC and AVC do not move, so the short-run output decision does not change.

Per-unit subsidy s : MC, AVC and ATC all shift down by s . Output rises.

Lump-sum subsidy: only ATC shifts down. Output does not change in the short run.

Competitive firm, short run. A price taker produces where $P = MC$ as long as $P \geq AVC$. A per-unit tax raises MC by t , so at the same market price the firm moves back along its new MC curve and produces less. The shutdown price also rises: the firm now needs $P \geq \min AVC + t$ to keep operating. A lump-sum tax leaves MC and AVC alone, so the firm produces the same quantity, earns less profit, and shuts down at the same price. In the long run, though, a lump-sum tax can push a firm's economic profit below zero and trigger exit, because it raises ATC at every output.

Monopoly. A monopolist also produces where $MR = MC$, then reads the price from demand. A per-unit tax shifts MC up. With a linear demand curve and constant MC, the monopolist passes on exactly **half** of the tax in a higher price (because MR is twice as steep as demand). A lump-sum tax changes neither output nor price in the short run. It simply reduces profit by the amount of the tax, which is why economists call a lump-sum tax non-distortionary.

Policy	Curves that shift	Output (SR)	Profit effect
Per-unit tax	MC, AVC, ATC up by t	Falls	Falls (lower output and the tax paid)
Lump-sum tax	ATC up only	Unchanged	Falls by the full amount
Per-unit subsidy	MC, AVC, ATC down by s	Rises	Rises
Lump-sum subsidy	ATC down only	Unchanged	Rises by the amount
Price ceiling on monopoly (above MC)	MR becomes flat at the ceiling	Can rise	Falls

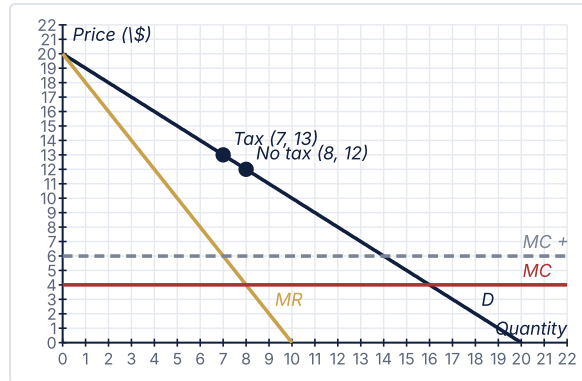
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EXAMPLE 1: A TAX ON A MONOPOLIST

A monopolist faces $P = 20 - Q$ with constant $MC = \$4$ and no fixed cost. (a) Find output, price and profit with no tax. (b) A per-unit tax of \$2 is imposed. Find output, price, profit after the tax and tax revenue. (c) Instead the government imposes a lump-sum tax equal to the tax revenue in (b). Find output, price and profit.

**SOLUTION**

(a) $MR = 20 - 2Q = 4$, so $Q = 8$ and $P = \$12$. Profit = $(12 - 4) \times 8 = \$64$.

(b) The tax raises MC to \$6. $MR = 20 - 2Q = 6$ gives $Q = 7$ and $P = 20 - 7 = \$13$. The price rose by \$1, which is half of the \$2 tax. Profit = $(13 - 6) \times 7 = \$49$. Tax revenue = $2 \times 7 = \$14$.

(c) A lump-sum tax of \$14 does not change MC , so Q stays 8 and P stays \$12. Profit = $64 - 14 = \$50$.

The firm keeps \$1 more profit under the lump-sum tax, and consumers get a lower price (\$12 instead of \$13) and more output (8 instead of 7). The government collects the same \$14 either way, so the per-unit tax distorts the market more.

Competitive firm, subsidy. A subsidy is a negative tax. A per-unit subsidy lowers MC by s , so the firm expands output along its MC curve; a lump-sum subsidy raises profit only. Subsidies can also keep firms in business that would otherwise shut down, because the effective shutdown price falls to $\min AVC - s$.

Price ceiling on a monopoly. A binding ceiling set below the monopoly price has a surprising effect: it can **increase** output. Under a ceiling at P_c , the firm cannot charge more than P_c on any unit, so the price it receives is flat at P_c until the quantity where demand meets the ceiling. Over that range, marginal revenue equals P_c (each extra unit sells at the same price), so the firm expands until MC rises to P_c or demand ends. Beyond that point the original demand and MR apply, and MR falls sharply, so output stops there.

Ceiling on a monopoly with constant MC

Ceiling above the monopoly price: no effect.

Ceiling between MC and the monopoly price: output rises to the quantity where demand meets the ceiling, price falls, profit falls.

Ceiling equal to MC : the efficient quantity, with zero deadweight loss (profit equals zero here because no fixed cost).

Ceiling below MC : the firm supplies nothing, a shortage results, and the firm eventually exits.

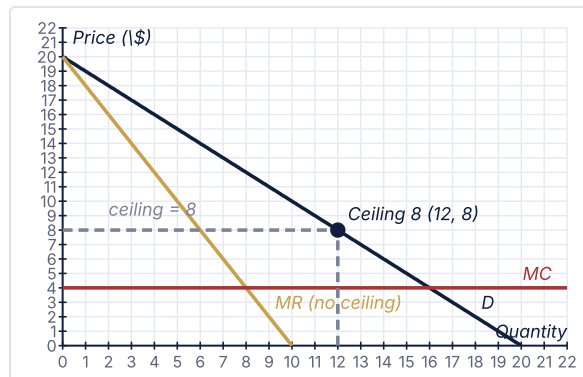
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EXAMPLE 2: CEILINGS ON A MONOPOLY

The monopolist in Example 1 ($P = 20 - Q$, $MC = \$4$, no fixed cost) faces a price ceiling. Find output, price and profit for ceilings of (a) \$8, (b) \$4 and (c) \$2.

**SOLUTION**

Unregulated: $Q = 8$, $P = \$12$, profit = \$64.

(a) At a \$8 ceiling demand reaches the ceiling at $Q = 12$ ($20 - 12 = 8$). For Q up to 12, $MR = \$8$, which exceeds $MC = \$4$, so the firm expands to $Q = 12$. Beyond 12 the price must follow demand below \$8, and MR is negative, so it stops. $Q = 12$, $P = \$8$, profit = $(8 - 4) \times 12 = \$48$. Output rose from 8 to 12 and price fell by \$4.

(b) At a \$4 ceiling demand reaches the ceiling at $Q = 16$. $P = MC$, so output is the efficient 16 and $DWL = 0$. Profit = $(4 - 4) \times 16 = 0$.

(c) A ceiling of \$2 is below MC . The firm loses \$2 on each unit and supplies nothing. Buyers want 18 units, so there is a shortage of 18.

Notice the contrast with a competitive market. A binding ceiling on a competitive market creates a shortage and a deadweight loss because it reduces quantity supplied. A ceiling on a monopoly can move the market toward the efficient quantity, because the monopolist was withholding output to keep the price high. This is the logic of regulating a natural monopoly at the fair-return or socially optimal price.

Common mistakes

1) Shifting MC for a lump-sum tax. Only ATC moves. 2) Saying a per-unit tax raises price by the full tax for a monopolist. It raises price by less (half, with linear demand and constant MC). 3) Forgetting that tax paid reduces profit: profit = $TR - TC - \text{tax revenue paid}$. 4) Drawing the ceiling on a monopoly graph as a horizontal line for all quantities: the firm's effective demand is flat only up to the quantity where demand meets the ceiling. 5) Saying a binding ceiling must cause a shortage; against a monopoly it does not, as long as the ceiling is at or above MC .

Practice**SET A Check Your Understanding**

Answer each item. Show your work on calculations.

1. Explain why a per-unit tax shifts both MC and ATC upward for a perfectly competitive firm, but a lump-sum tax shifts only ATC . State the effect of each on short-run output.
2. A monopolist faces $P = 30 - Q$ with $MC = \$6$ and no fixed cost. Find the profit-maximizing quantity and price before and after a per-unit tax of \$4. What share of the tax is passed on to buyers?
3. For the same monopolist, a lump-sum tax of \$30 replaces the per-unit tax. Find quantity, price and profit, and explain why price does not change.
4. A competitive firm has $MC = 2q$ and faces a price of \$12. Find its output, then its output after a per-unit subsidy of \$4.
5. A competitive firm's minimum AVC is \$8. A per-unit tax of \$3 is imposed. What is the new shutdown price, and why?
6. A monopolist faces $P = 26 - Q$ with $MC = \$6$ and no fixed cost. Compare the unregulated outcome with a price ceiling of \$10: find quantity, price and profit for each, and explain why output rose.

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SET B Exam-Style Multiple Choice

Choose the best answer.

7. A lump-sum tax is imposed on a profit-maximizing monopolist. In the short run the firm will
(A) raise its price and reduce output
(B) reduce output but leave price unchanged
(C) leave price and output unchanged and earn lower profit
(D) lower its price and raise output
(E) shut down immediately
8. A per-unit tax is imposed on a perfectly competitive firm. Which of the following curves shift upward by the amount of the tax?
(A) MC, AVC and ATC (B) ATC only (C) MC only
(D) AFC only (E) MR
9. A perfectly competitive firm receives a per-unit subsidy. Holding the market price constant, the firm will
(A) produce the same output but earn a higher profit
(B) reduce output because average cost fell
(C) shut down because the subsidy lowers revenue
(D) produce less because MC rose
(E) increase output because MC shifted down
10. A monopolist faces a linear demand curve and constant marginal cost. A per-unit tax of \$6 is imposed. The price paid by consumers will most likely rise by
(A) \$0 (B) \$3 (C) \$6 (D) \$12 (E) \$9
11. A monopolist currently charges a price above MC. The government imposes a price ceiling between MC and the monopoly price. Compared with no ceiling, the monopolist will
(A) supply nothing (B) produce less and charge more
(C) produce the same output at a lower price (D) produce more and earn a larger profit
(E) produce more and earn a smaller profit
12. A competitive firm earns zero economic profit. A lump-sum tax is imposed, with no change in the market price. In the long run the firm will
(A) exit the industry (B) raise output along its MC curve
(C) raise price (D) stay in the industry and earn zero profit
(E) shift its MC curve down

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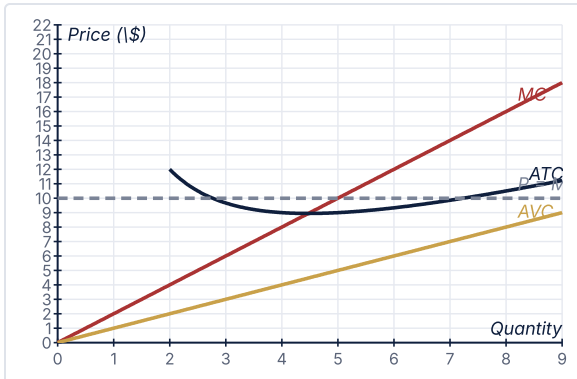
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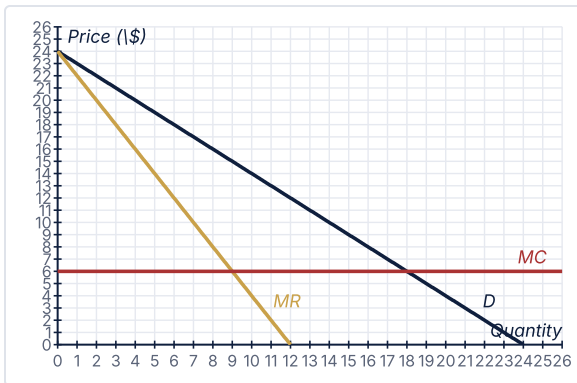
SET C Apply and Extend

Answer fully with graphs and calculations, as on a free-response question.

13. A perfectly competitive firm has $TC = 20 + q^2$, so $MC = 2q$, $AVC = q$ and $ATC = 20/q + q$ (curves shown). The market price is \$10. (a) Find the firm's output and economic profit. (b) A per-unit tax of \$2 is imposed. Find the new output and economic profit (remember to subtract the tax paid). (c) Instead, a lump-sum tax of \$8 is imposed. Find output and profit. (d) Compare (b) and (c) for output, profit and the government's revenue, and state what will happen in the long run.



14. A monopolist faces $P = 24 - Q$ and $MC = \$6$ with no fixed cost (curves shown). (a) Find the unregulated quantity, price and profit. (b) A price ceiling of \$12 is imposed. Find quantity, price and profit. (c) The regulator instead sets the ceiling at \$6. Find quantity, profit and deadweight loss. (d) Explain why a ceiling lowers the quantity in a competitive market but can raise it for a monopoly.

**7.2 Mixed Review: Multiple Choice**

Twenty questions that mix topics from every unit, so you practice switching between ideas as you must on the real exam. Set A tests core concepts, Set B uses graphs, tables and calculations, and Set C is exam-level stretch. Each answer explains the right choice and why the best distractor fails.

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SET A Core Concepts

Choose the best answer.

1. When the price of tea rises by 10 percent, the quantity of coffee demanded rises by 4 percent. The cross-price elasticity of demand of coffee with respect to the price of tea is
(A) -0.4, so the goods are substitutes (B) +0.4, so the goods are complements
(C) -0.4, so the goods are complements (D) +0.4, so the goods are substitutes
(E) +2.5, so the goods are substitutes
2. Country X can produce either 6 cars or 12 tons of wheat per worker-year. Country Y can produce either 2 cars or 8 tons of wheat. Which price of one car, in tons of wheat, would allow both countries to gain from trade?
(A) 1 ton (B) 2 tons (C) 3 tons (D) 4 tons (E) 5 tons
3. Consumer income rises and, at the same time, a new technology lowers the cost of producing a normal good. In the market for that good, equilibrium
(A) quantity rises and the price change is ambiguous
(B) price rises and the quantity change is ambiguous
(C) price falls and quantity falls
(D) price and quantity both certainly rise
(E) price rises and quantity falls
4. Which statement best explains why private markets tend to underprovide national defense?
(A) Defense is rival in consumption, so extra users crowd out others
(B) The marginal cost of serving an additional citizen is very high
(C) Defense creates a negative externality that firms ignore
(D) Defense is always produced by a profit-maximizing monopoly
(E) Non-payers cannot be excluded, so people free ride and private firms cannot cover their costs
5. At its current output, a perfectly competitive firm faces a price of \$9, with AVC of \$10 and ATC of \$12. In the short run the firm should
(A) continue producing to cover part of its fixed cost
(B) expand output to earn a profit
(C) continue producing because price exceeds marginal cost
(D) exit the industry permanently
(E) shut down and lose only its fixed cost
6. An owner leaves a job paying \$50,000 a year to open her own shop. In the first year revenue is \$300,000 and explicit costs are \$260,000. Her economic profit is
(A) -\$10,000 (B) \$40,000 (C) \$0 (D) -\$50,000 (E) \$90,000
7. The supply of a good is perfectly elastic and demand is downward sloping. A per-unit tax is placed on sellers of the good. Who bears the burden of the tax?
(A) Producers bear all of it
(B) Consumers bear all of it
(C) Consumers and producers split it equally
(D) Producers bear all of it because they are legally taxed
(E) No one, because quantity falls to zero

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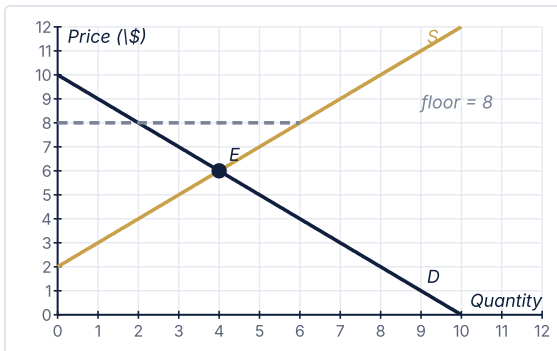
SET B Applications and Data

Choose the best answer.

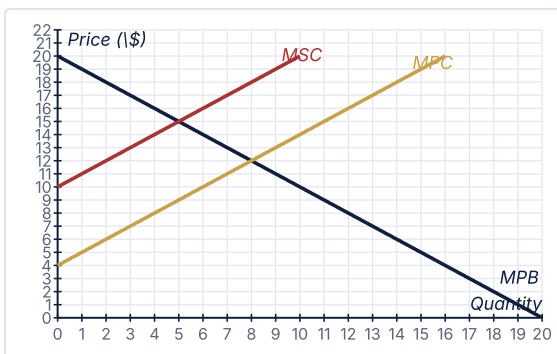
8. A competitive firm sells its output at \$4 per unit and hires labor at a wage of \$30. The table shows its total product. How many workers should it hire to maximize profit?

Workers	Total product
1	10
2	18
3	24
4	28
5	30

- (A) 1 worker (B) 2 workers (C) 3 workers (D) 4 workers (E) 5 workers
9. In the market shown, the government sets a price floor of \$8. The result is



- (A) a shortage of 4 units
 (B) a surplus of 2 units
 (C) a surplus of 4 units
 (D) a surplus of 6 units
 (E) no effect because the floor is above the equilibrium quantity
10. A monopolist faces the demand curve $P = 60 - 3Q$ and has $MC = \$12$ at all outputs. At the profit-maximizing output, ATC is \$30. Economic profit is
- (A) \$6 (B) \$24 (C) \$48 (D) \$192 (E) \$288
11. The graph shows a good whose production creates an external cost of \$6 per unit. The deadweight loss from producing the market quantity is



- (A) \$3 (B) \$6 (C) \$9 (D) \$18 (E) \$27

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12. Two firms simultaneously choose whether to advertise. Payoffs are profits in millions of dollars, listed as (Firm A, Firm B). Which statement is correct?

	B: Advertise	B: Do not advertise
A: Advertise	(4, 4)	(9, 2)
A: Do not advertise	(2, 9)	(7, 7)

- (A) The Nash equilibrium is (Do not advertise, Do not advertise) because it gives the highest joint profit
 (B) Firm A has a dominant strategy but Firm B does not
 (C) There is no Nash equilibrium because no firm is satisfied
 (D) Advertising is a dominant strategy for each firm, the Nash equilibrium is (Advertise, Advertise), and both would earn more if neither advertised
 (E) The Nash equilibrium is (Advertise, Advertise), and it maximizes joint profit
13. The domestic price of a good is \$7 with an import quota of 20 units, and the world price is \$4. If the government gives the import licenses free to foreign exporters, the quota creates
- (A) tariff revenue of \$ 60 for the domestic government
 (B) a gain of \$ 60 for domestic consumers
 (C) a gain of \$ 140 for the government
 (D) no transfer, because the quota does not affect the price
 (E) a gain of \$ 60 for the foreign license holders
14. The table shows the total cost of a firm. Its average variable cost at 5 units of output is

Output	Total cost
0	\$50
4	\$130
5	\$170

- (A) \$ 10 (B) \$ 24 (C) \$ 34 (D) \$ 40 (E) \$ 50

SET C Exam-Level Stretch

Choose the best answer.

15. A single employer faces labor supply $W = 10 + 2L$ and has $MRP = 58 - 2L$ (W in dollars, L in workers). The wage it pays is
 (A) \$ 18 (B) \$ 22 (C) \$ 26 (D) \$ 42 (E) \$ 58
16. A monopolistically competitive firm is earning positive economic profit. In the long run, the demand curve facing each existing firm will
 (A) shift left and become more elastic as new firms enter with close substitutes
 (B) shift right and become less elastic
 (C) shift left and become less elastic
 (D) stay the same while the ATC curve shifts down
 (E) shift left until price equals marginal cost
17. An oligopolist faces a kinked demand curve with a vertical gap in its marginal revenue curve. If the firm's marginal cost rises but stays within the gap, the firm's price and output will
 (A) not change (B) both fall
 (C) both rise (D) price rise and output fall
 (E) price fall and output rise
18. Demand falls in a perfectly competitive increasing-cost industry that was in long-run equilibrium. After all adjustments, compared with the original equilibrium, the price is
 (A) unchanged and the quantity is lower (B) lower and the quantity is lower
 (C) higher and the quantity is lower (D) lower and the quantity is higher
 (E) unchanged and the quantity is unchanged

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19. A competitive firm sells its output at \$3 per unit and pays a wage of \$20. The last worker hired added 8 units of output. To maximize profit the firm should
- (A) hire fewer workers, because MP is below the wage
 - (B) keep its labor force the same
 - (C) hire fewer workers, because the wage exceeds the price
 - (D) raise its price to cover the wage
 - (E) hire more labor, because $MRP = \$24$ exceeds the wage
20. A firm with $MC = \$10$ sells the same product in two markets. At the optimum, the absolute value of price elasticity is 5 in Market A and 2 in Market B. Using $MR = P(1 - 1/|E|)$, the price in Market B is
- (A) \$12.50 (B) \$15 (C) \$17.50 (D) \$20 (E) \$25

Answers**Chapter 7: Answers and Explanations**

Answers for every practice problem, numbered to match. Read the explanation even when your answer is correct.

7.1 Taxes, Subsidies and Price Ceilings on Firm Decisions**SET A · CHECK YOUR UNDERSTANDING**

1. A per-unit tax is paid on every unit, so producing one more unit costs t extra: MC , AVC and ATC all rise by t , and the firm moves back along MC to a smaller quantity. A lump-sum tax is a fixed amount that does not depend on output, so it raises only fixed and average total cost. MC does not change, so the short-run quantity does not change; only profit falls.
2. Before: $MR = 30 - 2Q = 6$, so $Q = 12$ and $P = \$18$. After the tax $MC = \$10$: $30 - 2Q = 10$, so $Q = 10$ and $P = \$20$. The price rose by \$2, which is half of the \$4 tax, so buyers bear half and the monopolist absorbs the other half.
3. MC stays at \$6, so $Q = 12$ and $P = \$18$ are unchanged. Profit before the tax is $(18 - 6) \times 12 = \$144$, so after the tax it is $144 - 30 = \$114$. Price does not change because the monopolist's best output depends only on $MR = MC$, and a lump-sum tax moves neither curve.
4. With $P = MC$: $2q = 12$ gives $q = 6$. The subsidy lowers MC to $2q - 4$: $2q - 4 = 12$ gives $q = 8$. Output rises from 6 to 8 because each unit now costs \$4 less at the margin.
5. New shutdown price = $8 + 3 = \$11$. The tax adds \$3 to the average variable cost of every unit, so the firm needs a price at least \$3 higher to cover its variable costs including the tax. Below \$11 the firm minimizes loss by producing nothing.
6. Unregulated: $MR = 26 - 2Q = 6$, so $Q = 10$ and $P = \$16$, profit = $(16 - 6) \times 10 = \$100$. With a \$10 ceiling demand meets the ceiling at $Q = 16$. $MR = \$10$ up to $Q = 16$, which exceeds $MC = \$6$, so the firm produces 16 at \$10: profit = $(10 - 6) \times 16 = \$64$. Output rose because the ceiling removes the monopolist's gain from restricting output: it can no longer raise the price by selling less.

SET B · EXAM-STYLE MULTIPLE CHOICE

7. C. A lump-sum tax raises fixed cost only. MC and MR do not change, so $MR = MC$ gives the same output and price. Choice A describes a per-unit tax, which raises MC .
8. A. The tax is paid on every unit, so it adds to marginal, average variable and average total cost alike. Choice B describes a lump-sum tax. Market price (and MR for the firm) does not change.
9. E. The subsidy lowers MC at every output, so $P = MC$ occurs at a larger quantity. Choice A describes a lump-sum subsidy.
10. B. With linear demand and constant MC , MR has twice the slope of demand, so the monopolist raises price by half of the increase in MC . A full \$6 pass-through is not what a monopolist facing linear demand does; it absorbs half.
11. E. Below the original price the firm's marginal revenue is the flat ceiling price up to the quantity where demand meets it, so it expands output while profit falls. Choice D is wrong because a binding ceiling cannot raise profit above the unconstrained maximum.
12. A. The lump-sum tax raises ATC above the price at every output, so the firm earns a loss and exits. Its MC curve is unchanged, which is why choice B cannot be the response. As firms exit, market price rises until the remaining firms again break even.

SET C · APPLY AND EXTEND

13. (a) 1 point: $P = MC$ gives $2q = 10$, so $q = 5$. 1 point: $TR = 50$, $TC = 20 + 25 = 45$, profit = \$5. (b) 1 point: MC rises to $2q + 2 = 10$, so $q = 4$. 1 point: $TR = 40$, $TC = 20 + 16 = 36$, tax paid = $2 \times 4 = 8$, profit = $40 - 36 - 8 = -\$4$ (a loss; $AVC + \text{tax at } q = 4$ is $4 + 2 = 6$, below 10, so the firm still operates in the short run). (c) 1 point: MC is unchanged, so $q = 5$; profit = $5 - 8 = -\$3$. (d) 1 point: the per-unit tax reduces output (4 vs 5) and the lump-sum tax does not; both raise \$8 in revenue, but the firm loses more under the per-unit tax. 1 point: in the long run, with losses, firms exit, supply falls and price rises until economic profit returns to zero.
14. (a) 1 point: $MR = 24 - 2Q = 6$, so $Q = 9$ and $P = \$15$. 1 point: profit = $(15 - 6) \times 9 = \$81$. (b) 1 point: demand meets the \$12 ceiling at $Q = 12$. $MR = \$12 > MC = \$6$ up to $Q = 12$, so $Q = 12$, $P = \$12$. 1 point: profit = $(12 - 6) \times 12 = \$72$. (c) 1 point: demand meets \$6 at $Q = 18$, so $Q = 18$, profit = 0 and $DWL = 0$ (compared with the unregulated DWL of $1/2 \times (15 - 6) \times (18 - 9) = \$40.50$). (d) 1 point: in a competitive market the ceiling lowers the price firms receive below the market-clearing price, so quantity supplied falls. 1 point: a monopolist restricts output to keep the price high; a ceiling removes that benefit, because selling more units no longer pushes the price down, so output rises until MC reaches the ceiling.

7.2 Mixed Review: Multiple Choice

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SET A · CORE CONCEPTS

1. D. Cross-price elasticity is the percentage change in quantity of coffee divided by the percentage change in the price of tea: $4/10 = +0.4$. A positive sign means substitutes. Choice E inverts the ratio.
2. C. Country X gives up 2 tons of wheat per car and Country Y gives up 4, so trade must occur at a price between 2 and 4. At 2 or 4 one country gains nothing, and 1 or 5 would make one country worse off than producing the car itself.
3. A. Demand shifts right (normal good) and supply shifts right (lower cost), so quantity rises for sure. The price effect depends on which shift is larger. Choice B is wrong because it makes the price effect certain when it is not.
4. E. Defense is nonexcludable and nonrival: everyone benefits whether or not they pay, so each person has an incentive to free ride and a private seller cannot collect revenue. Choice A is wrong because defense is nonrival, and the marginal cost of an extra user is close to zero (choice B).
5. E. Price is below AVC, so each unit sold loses money even before fixed costs. Producing nothing limits the loss to fixed cost. Choice A is the rule when P is between AVC and ATC. Permanent exit (D) is a long-run decision, not a short-run one.
6. A. Accounting profit is $300,000 - 260,000 = \$40,000$. Economic profit also subtracts the implicit cost of the forgone salary: $40,000 - 50,000 = -\$10,000$. Choice B ignores implicit costs. Choice E adds the forgone salary instead of subtracting it.
7. B. With perfectly elastic supply, sellers will not accept any lower net price, so the whole tax is added to the price buyers pay. Who the law taxes does not determine who bears the burden (choices A and D).

SET B · APPLICATIONS AND DATA

8. B. $MRP = \text{price} \times MP$ gives 40, 32, 24, 16, 8 for workers 1 through 5. Hire while MRP is at least the wage of \$30: workers 1 and 2 qualify, worker 3 (24) does not. Choice E would hire everyone, which ignores that marginal product falls.
9. C. At \$8, quantity demanded is 2 and quantity supplied is 6, so there is a surplus of 4. Choice E is wrong because the floor is above the equilibrium price of \$6, so it binds. Choice B is only the gap's quantity demanded side (2), not the gap.
10. C. $MR = 60 - 6Q = 12$ gives $Q = 8$ and $P = 60 - 24 = \$36$. Profit = $(P - ATC) \times Q = (36 - 30) \times 8 = \$48$. Choice D computes $(P - MC) \times Q$, ignoring fixed cost, and choice E is total revenue.
11. C. The market quantity is 8 ($20 - Q = 4 + Q$). The efficient quantity is 5 ($20 - Q = 10 + Q$, with $MSC = MPC + 6$). The deadweight loss is the triangle $\frac{1}{2} \times 6 \times (8 - 5) = \$9$. Choice D (\$18) forgets the one-half.
12. D. Whatever B does, A earns more by advertising ($4 > 2$ and $9 > 7$), and the same holds for B, so (Advertise, Advertise) = (4, 4) is the Nash equilibrium. Both would get 7 if neither advertised, the prisoners' dilemma. Choice A fails because (7, 7) is not stable: each firm gains by deviating.
13. E. Each imported unit can be bought at \$4 and sold at \$7, so the license holders capture $(7 - 4) \times 20 = \$60$ of quota rent, and the rent leaves the country. With a tariff, the government would collect the revenue (choice A). The quota does raise the domestic price, so choice D is wrong.
14. B. Fixed cost is TC at zero output, \$50, so variable cost at 5 units is $170 - 50 = \$120$ and $AVC = 120/5 = \$24$. Choice C (\$34) is ATC, choice D (\$40) is the marginal cost of the fifth unit, and choice E is fixed cost.

SET C · EXAM-LEVEL STRETCH

15. C. $MFC = 10 + 4L$. Setting $MRP = MFC$: $58 - 2L = 10 + 4L$ gives $L = 8$. The wage comes from the supply curve: $10 + 16 = \$26$. Choice D (\$42) is the MRP and MFC at $L = 8$, not the wage.
16. A. Profit attracts entry, and new differentiated products take customers from existing firms, so each firm's demand falls and becomes more elastic until it is tangent to ATC (zero economic profit). Choice E is wrong: price stays above MC because the demand curve slopes downward.
17. A. $MR = MC$ still occurs at the kink quantity as long as MC cuts through the vertical gap, so the profit-maximizing price and quantity do not change. This is why prices are sticky in the model. Choice D is what a firm with a smooth MR curve would do.
18. B. Falling demand causes exit. In an increasing-cost industry the shrinking industry bids down input prices, shifting each firm's cost curves down, so the long-run price ends lower than before. Choice A describes a constant-cost industry.
19. E. $MRP = P \times MP = 3 \times 8 = \$24$, which is greater than the \$20 wage, so the last worker adds more to revenue than to cost; hire more until MRP falls to the wage. Choice A compares physical output to a dollar wage, a units mistake.
20. D. In Market B, $P(1 - 1/2) = 10$, so $P = \$20$. In Market A, $P(1 - 1/5) = 10$, so $P = \$12.50$. The less elastic market (B) pays the higher price. Choice A is the price in the elastic market.

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E1 Practice Exam 1

A full-length AP Microeconomics practice exam: 60 multiple-choice questions and 3 free-response questions, with explained answers and scoring points.

Section I has 60 multiple-choice questions (suggested time 70 minutes, two-thirds of the score). Choose the best answer for each question; there is no penalty for guessing. Section II has 3 free-response questions (suggested time 60 minutes, one-third of the score): one long question worth 10 points and two short questions worth 4 points each. Read each stem, label graphs fully, and show calculations. Explanations and scoring points follow each part. To estimate your score, multiply your free-response raw points by 30/18 and add your multiple-choice total for a composite out of 90; roughly 60 or more is in the range of a 5, 48 to 59 a 4, 37 to 47 a 3, and 27 to 36 a 2 (a rough guide, not an official conversion).

Section	Questions	Suggested time	Weight	Raw points
I Multiple choice	60	70 min	66.7%	60
II FRQ 1 (long)	5 parts	25 min	16.7%	10
II FRQ 2 (short)	4 parts	12 min	8.3%	4
II FRQ 3 (short)	4 parts	13 min	8.3%	4

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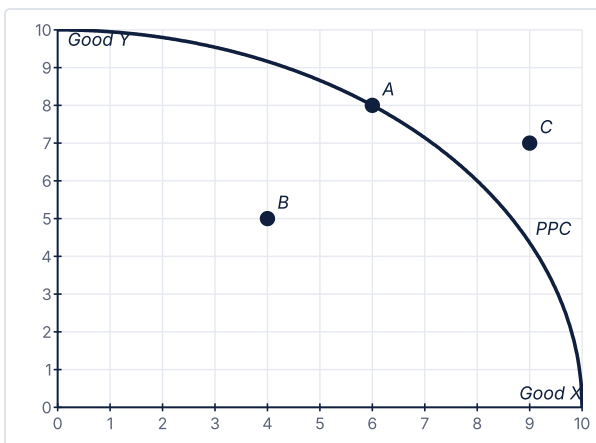
SECTION I, PART A Multiple Choice: Questions 1-20

Choose the best answer. Questions that refer to a table or graph use the data shown.

1. Two countries can each devote all resources to wheat or cloth. If all resources go to one good, Country A can make 100 tons of wheat or 50 bolts of cloth, and Country B can make 60 tons of wheat or 40 bolts of cloth. Assume constant opportunity costs. Which statement is correct?

Country	Wheat (tons)	Cloth (bolts)
A	100	50
B	60	40

- (A) Country A has the comparative advantage in cloth because 50 bolts is more than 40 bolts.
 (B) Country A has the comparative advantage in both goods because it can produce more of each.
 (C) Country B has the comparative advantage in wheat because its total output is smaller.
 (D) Neither country can gain from trade because Country A is better at producing both goods.
 (E) Country A has the comparative advantage in wheat, and Country B has the comparative advantage in cloth.
2. The production possibilities curve below shows the maximum combinations of two goods an economy can produce with its current resources and technology. Which statement about the labeled points is correct?



- (A) Point C shows economic growth that has already occurred.
 (B) Point A is unattainable because it lies on the boundary of the curve.
 (C) Point B is efficient because the economy can always produce inside its curve.
 (D) Point B is attainable but inefficient because some resources are unemployed or misallocated.
 (E) Point C is attainable if the economy trades off some of Good X for Good Y.
3. A technological advance doubles the output per worker in the shirt industry only; technology in the computer industry is unchanged. On a PPC with shirts on the horizontal axis and computers on the vertical axis, the curve will
- (A) become a straight line because opportunity cost is now constant.
 (B) stay in place, because only the economy's resources can move the curve.
 (C) shift outward in a parallel way along both axes.
 (D) shift outward along the shirts axis only, leaving the computers intercept unchanged.
 (E) shift inward along the shirts axis.
4. Country X needs 2 hours of labor to make a shirt and 4 hours to make a bag. Country Y needs 3 hours to make a shirt and 9 hours to make a bag. If X exports bags to Y, which price of one bag, measured in shirts, would make both countries better off?
- (A) 1.5 shirts (B) 2 shirts (C) 2.5 shirts
 (D) 3 shirts (E) 4 shirts
5. A student values extra study time as shown. Each hour of study costs her \$10 of forgone wages. Total benefit (in dollars of value) is 20 for 1 hour, 36 for 2, 48 for 3, 56 for 4, and 60 for 5 hours. To maximize net benefit she should study
- (A) 1 hour (B) 2 hours (C) 3 hours (D) 4 hours (E) 5 hours

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6. In the circular flow model, which transaction takes place in the factor (resource) market?
- Firms sell output to the government.
 - Households pay firms for goods and services.
 - Households receive goods and services in exchange for spending.
 - Firms pay households for finished products.
 - Firms pay wages to households in exchange for labor.
7. A student considers one year of college. Tuition is \$10,000, books cost \$1,000, and room and board cost \$8,000, which she would pay whether or not she attends. If she does not attend, she would earn \$25,000 working full time. The opportunity cost of attending is
- \$11,000
 - \$25,000
 - \$35,000
 - \$36,000
 - \$44,000
8. Which of the following is a normative statement?
- Demand for sugary drinks is more elastic than demand for water.
 - Sugary drink sales fell 8 percent after the tax was introduced.
 - A tax on sugary drinks will reduce the quantity of sugary drinks purchased.
 - The government should raise taxes on sugary drinks to improve public health.
 - A tax raises the price consumers pay.
9. Coffee and tea are substitutes. If the price of tea rises sharply, which of the following will occur in the market for coffee?
- The quantity demanded of coffee rises along an unchanged demand curve.
 - Demand for coffee decreases, lowering the equilibrium price and quantity.
 - Only the equilibrium price rises; the equilibrium quantity is unchanged.
 - Supply of coffee increases, lowering the equilibrium price.
 - Demand for coffee increases, raising the equilibrium price and quantity.
10. Wages rise for pizza cooks. In the market for pizza, what happens to the equilibrium price and quantity?
- Price and quantity both fall.
 - Price rises and quantity is unchanged.
 - Price falls and quantity rises.
 - Price rises and quantity falls.
 - Price and quantity both rise.
11. The graph shows a competitive market. If the government sets a price ceiling at \$4, the resulting shortage is



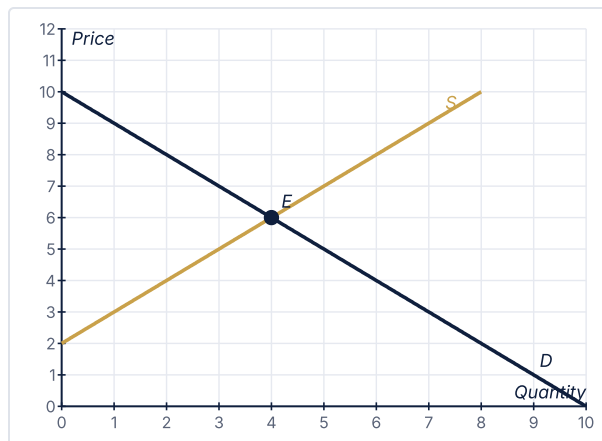
- 2 units
- 4 units
- 6 units
- 8 units
- 10 units

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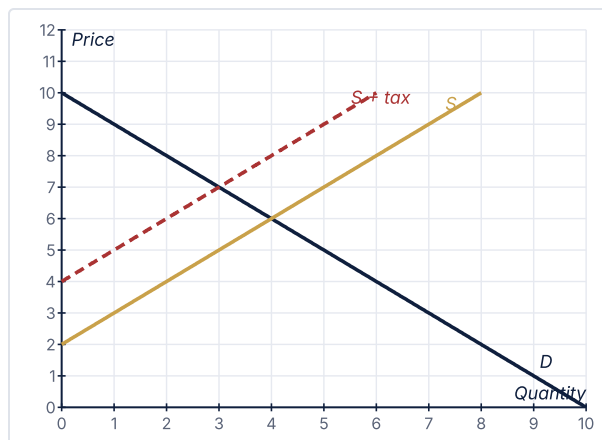
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12. In the market shown, with no government intervention, the total surplus (consumer surplus plus producer surplus) is



- (A) 8 (B) 12 (C) 16 (D) 20 (E) 32
13. When the price of a product rises from \$8 to \$12, the quantity demanded falls from 120 units to 80 units. Using the midpoint method, the price elasticity of demand is
 (A) 0.25 (B) 0.50 (C) 1.00 (D) 1.50 (E) 2.00
14. The price elasticity of demand for a product is 2.5. If the seller lowers the price, total revenue will
 (A) decrease, because the seller receives less on each unit.
 (B) increase, because the percent increase in quantity demanded exceeds the percent decrease in price.
 (C) increase, because demand is inelastic.
 (D) decrease, because demand is elastic.
 (E) remain unchanged, because price and quantity move in opposite directions.
15. When the price of good X rises 10 percent, the quantity demanded of good Y falls 5 percent. The cross-price elasticity of demand and the relationship between X and Y are
 (A) -0.5; complements (B) -2.0; complements (C) -0.5; substitutes
 (D) +2.0; substitutes (E) +0.5; substitutes
16. When a household's income rises 5 percent, its purchases of bus rides fall 3 percent. The income elasticity of demand for bus rides and the type of good are
 (A) +0.6; normal good (B) +1.67; luxury good (C) -1.67; inferior good
 (D) -0.6; inferior good (E) -0.6; complement
17. A per-unit tax of \$2 is collected from sellers in the market shown (supply shifts up by \$2). Tax revenue collected by the government is



- (A) 2 (B) 4 (C) 6 (D) 8 (E) 12

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18. A per-unit tax is placed on sellers of a good. The consumer's share of the tax burden will be larger if
 (A) the good has many close substitutes.
 (B) the tax is a fixed percent of price.
 (C) the tax is collected from buyers rather than sellers.
 (D) demand is less elastic than supply.
 (E) demand is more elastic than supply.
19. Which of the following is most likely to make the price elasticity of supply of a product greater?
 (A) Firms are operating at full capacity.
 (B) The product cannot be stored.
 (C) Production requires highly specialized inputs.
 (D) The input needed is in fixed supply.
 (E) Producers have a longer time to adjust production.
20. Both the demand for and the supply of a product increase. What is the effect on equilibrium price and quantity?
 (A) Quantity decreases; the change in price is indeterminate.
 (B) Price decreases; the change in quantity is indeterminate.
 (C) Price and quantity both increase.
 (D) Price increases; the change in quantity is indeterminate.
 (E) Quantity increases; the change in price is indeterminate.

SECTION I, PART B Multiple Choice: Questions 21-40

Choose the best answer. Questions that refer to a table or graph use the data shown.

21. The graph shows a domestic market for a good. If the country opens to trade and the world price is \$3 (below the domestic equilibrium price), the country will import



- (A) 2 units (B) 4 units (C) 6 units (D) 8 units (E) 10 units
22. The table shows total output as a firm adds workers to a fixed amount of capital. Diminishing marginal returns to labor begin with the
- | Workers | 1 | 2 | 3 | 4 | 5 |
|--------------|----|----|----|----|----|
| Total output | 10 | 24 | 36 | 44 | 48 |
- (A) 1st worker (B) 2nd worker (C) 3rd worker
 (D) 4th worker (E) 5th worker
23. The table shows a firm's total cost. The average variable cost at 4 units of output is

Output	0	1	2	3	4
Total cost	\$100	\$150	\$190	\$240	\$300

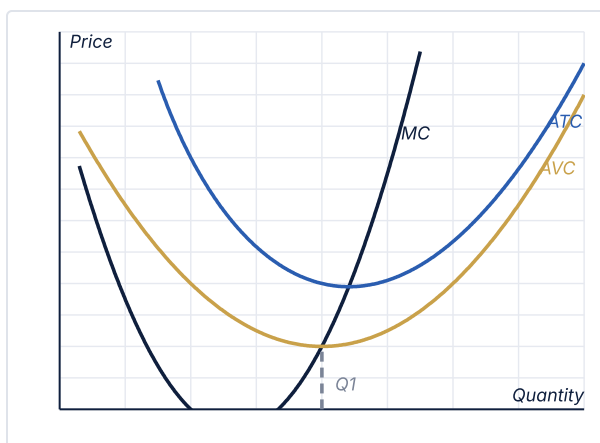
- (A) \$ 25 (B) \$ 50 (C) \$ 60 (D) \$ 75 (E) \$ 200

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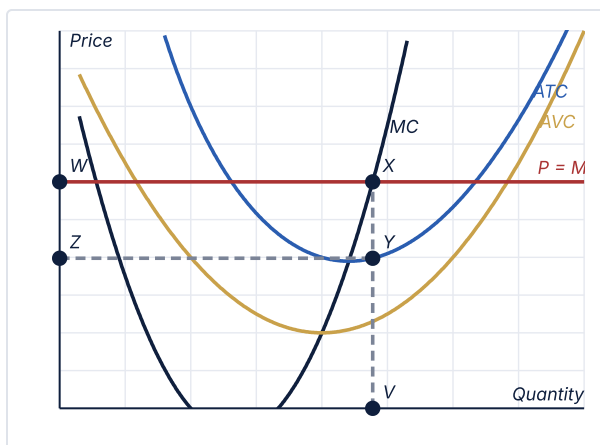
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24. The graph shows a firm's marginal cost (MC), average variable cost (AVC), and average total cost (ATC). At output Q_1 , where MC crosses AVC, which statement is true?



- (A) AVC is at its minimum and ATC is still falling.
 (B) AVC is rising because MC is above it.
 (C) Both AVC and ATC are at their minimum values.
 (D) ATC is at its minimum and AVC is still falling.
 (E) MC is below ATC, so ATC must be rising.
25. A perfectly competitive firm faces a market price of \$12. Its marginal cost is \$4, \$6, \$8, \$10, \$12, and \$14 for the 1st through 6th units, and its average total cost at 5 units is \$11. The firm's economic profit at its profit-maximizing output is
 (A) \$0 (B) \$5 (C) \$25 (D) \$55 (E) \$60
26. A perfectly competitive firm has a market price of \$9. Its average variable cost at the profit-maximizing output is \$7 and its average total cost is \$10. In the short run the firm should
 (A) raise its price to cover average total cost.
 (B) continue to produce, because price exceeds average variable cost.
 (C) shut down, because it is earning negative economic profit.
 (D) shut down, because price is less than average total cost.
 (E) produce more to reach the minimum of average total cost.
27. The graph shows a perfectly competitive firm in the short run at market price P . At the profit-maximizing quantity, economic profit is represented by the area



- (A) rectangle W-X-Y-Z
 (B) rectangle with corners Z, Y, V and the origin
 (C) rectangle with corners W, X, V and the origin
 (D) the triangle under MC up to Q^*
 (E) rectangle between the ATC and AVC curves at Q^*

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28. A perfectly competitive, constant-cost industry is in long-run equilibrium when demand for its product increases. After all long-run adjustments, compared with the original equilibrium
- (A) the price is higher and firms earn positive economic profit.
 - (B) the price is unchanged, industry output is unchanged, and firms earn profit.
 - (C) the price is higher, industry output is higher, and the number of firms is unchanged.
 - (D) the price is lower, industry output is higher, and there are more firms.
 - (E) the price is unchanged, industry output is higher, and there are more firms.
29. In long-run equilibrium, a perfectly competitive firm is
- (A) neither allocatively nor productively efficient.
 - (B) productively efficient but not allocatively efficient.
 - (C) earning positive economic profit because it is efficient.
 - (D) both allocatively efficient ($P = MC$) and productively efficient ($P = \text{minimum ATC}$).
 - (E) allocatively efficient but not productively efficient.
30. In the short run, firms in a perfectly competitive industry are earning economic losses, with price below ATC but above AVC. What will happen in the long run?
- (A) Firms exit, market supply decreases, and price rises until economic profit is zero.
 - (B) Firms raise prices to cover their losses.
 - (C) Firms shut down immediately, and price is unchanged.
 - (D) Firms enter, market supply increases, and price falls.
 - (E) Firms stay in the industry indefinitely because P exceeds AVC.
31. The table shows a firm's long-run average total cost at various output levels. Which statement is correct?

Output	100	200	300	400
LRATC	\$12	\$9	\$9	\$11

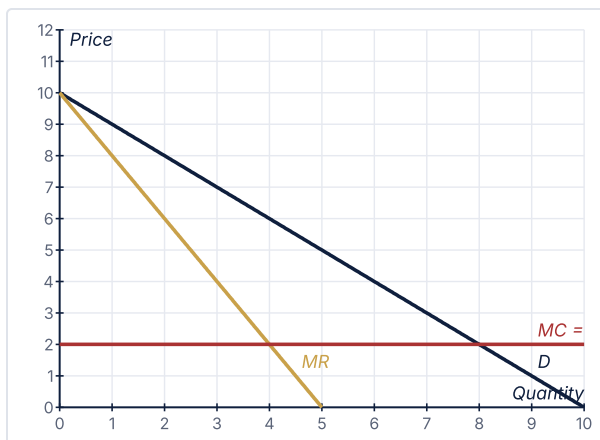
- (A) There are diseconomies of scale from 100 to 300 units.
 - (B) There are economies of scale from 200 to 300 units.
 - (C) There are constant returns to scale from 300 to 400 units.
 - (D) There are diseconomies of scale from 100 to 200 units and economies of scale from 300 to 400 units.
 - (E) There are economies of scale from 100 to 200 units and diseconomies of scale from 300 to 400 units.
32. A self-employed owner earns \$500,000 in revenue, pays \$380,000 in explicit costs, and could earn \$90,000 working for another firm. Her economic profit is
- (A) \$ 30,000
 - (B) \$ 90,000
 - (C) \$ 120,000
 - (D) \$ 410,000
 - (E) \$ 470,000
33. A perfectly competitive firm must pay a fixed annual license fee that does not depend on how much it produces. In the short run the fee will
- (A) leave the profit-maximizing output unchanged and reduce profit by the amount of the fee.
 - (B) shift the firm's supply curve to the left.
 - (C) shift the marginal cost curve upward.
 - (D) increase output, to spread the fixed cost.
 - (E) reduce output, because average total cost rises.
34. A firm's average total cost is \$20 at 10 units. The marginal cost of the 11th unit is \$15. At 11 units, average total cost will
- (A) rise, because marginal cost is positive.
 - (B) fall, because marginal cost is below average total cost.
 - (C) equal \$ 15.
 - (D) rise, because fixed cost must be spread over more units.
 - (E) stay at \$ 20 because the 11th unit costs less.

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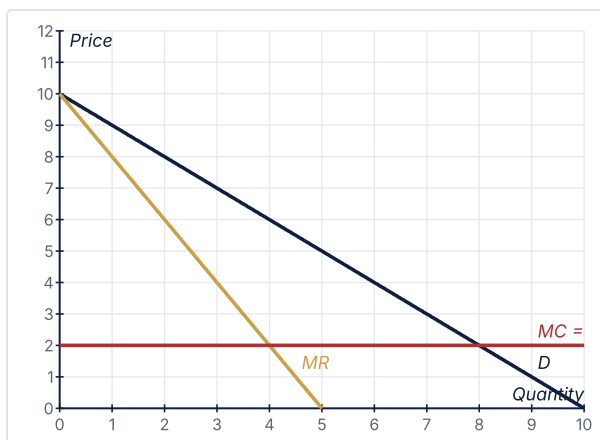
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35. The wage that a competitive firm pays its workers rises. Which of the following correctly describes the firm's short-run cost curves?
- (A) Only AFC shifts up.
 - (B) Only ATC shifts up.
 - (C) Only MC shifts up.
 - (D) MC, AVC, ATC, and AFC all shift up.
 - (E) MC, AVC, and ATC all shift up, while average fixed cost is unchanged.
36. The graph shows a profit-maximizing monopolist. The monopolist will produce and charge



- (A) $Q = 4$ and $P = \$2$
 - (B) $Q = 5$ and $P = \$5$
 - (C) $Q = 4$ and $P = \$6$
 - (D) $Q = 8$ and $P = \$2$
 - (E) $Q = 8$ and $P = \$6$
37. In the same market, $MC = ATC = \$2$ at every output. The deadweight loss caused by the monopoly (compared with the perfectly competitive outcome) is



- (A) 4
 - (B) 8
 - (C) 12
 - (D) 16
 - (E) 32
38. For a single-price monopolist, marginal revenue is less than price because
- (A) to sell an additional unit the firm must lower the price on all units it sells.
 - (B) the firm's costs rise as it expands output.
 - (C) consumers receive consumer surplus on each unit.
 - (D) the firm is a price taker.
 - (E) the firm faces a perfectly elastic demand curve.

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39. A monopolist that practices perfect (first-degree) price discrimination will
- (A) charge each consumer the average total cost.
 - (B) produce less than a single-price monopolist.
 - (C) earn zero economic profit.
 - (D) produce the same quantity as a single-price monopolist.
 - (E) produce where demand equals marginal cost and capture all consumer surplus.
40. A natural monopoly's average total cost is falling and its marginal cost is below ATC at every relevant output. If a regulator requires a price equal to marginal cost, the firm will
- (A) produce less than the efficient quantity and earn a profit.
 - (B) shut down in the long run only if demand is elastic.
 - (C) produce the efficient quantity and earn zero economic profit.
 - (D) produce the efficient quantity but suffer an economic loss.
 - (E) produce where $MR = MC$ and earn a profit.

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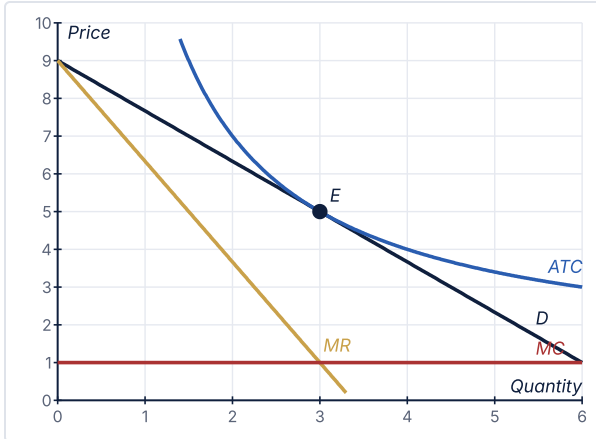
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SECTION I, PART C Multiple Choice: Questions 41-60

Choose the best answer. Questions that refer to a table or graph use the data shown.

41. The graph shows a monopolistically competitive firm in long-run equilibrium. Which statement correctly describes the firm?



- (A) It produces at the minimum of ATC, so it is productively efficient.
 (B) It produces where price equals marginal cost, so it is allocatively efficient.
 (C) It earns economic losses, which will cause exit.
 (D) It earns positive economic profit, which attracts entry.
 (E) It earns zero economic profit, charges a price above marginal cost, and has excess capacity.
42. Two firms choose whether to advertise. Payoffs (Firm 1, Firm 2) in millions of dollars are shown. The Nash equilibrium of this one-shot game is

	Firm 2 advertises	Firm 2 does not
Firm 1 advertises	4, 4	9, 1
Firm 1 does not	1, 9	6, 6

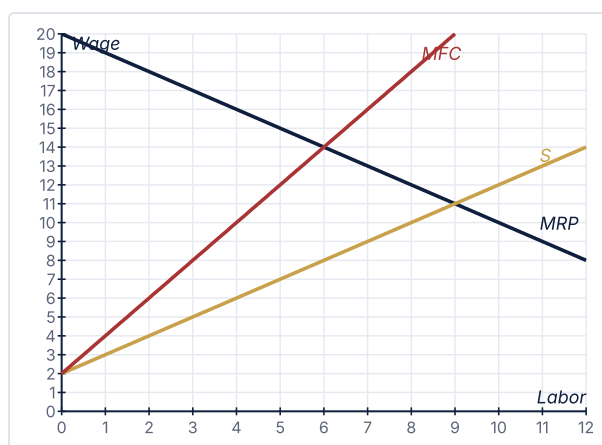
- (A) Firm 2 advertises and Firm 1 does not.
 (B) there is no Nash equilibrium.
 (C) neither firm advertises, with payoffs of 6 and 6.
 (D) Firm 1 advertises and Firm 2 does not.
 (E) both firms advertise, with payoffs of 4 and 4.
43. A cartel of oligopolists agrees to restrict output and share monopoly profit. The agreement is difficult to maintain mainly because
- (A) average total cost rises when output is restricted.
 (B) the members' demand curves are perfectly elastic.
 (C) each member can raise its own profit by secretly producing more than its quota.
 (D) the cartel has no market power.
 (E) consumers will refuse to buy at the higher price.
44. The market shares of the eight firms in an industry are 30, 25, 15, 10, 8, 5, 4, and 3 percent. The four-firm concentration ratio is
- (A) 30 percent (B) 55 percent (C) 70 percent
 (D) 80 percent (E) 88 percent
45. An industry has many firms selling differentiated products, each firm faces a downward-sloping demand curve, and entry and exit are easy. This is
- (A) oligopoly (B) monopolistic competition (C) monopoly
 (D) perfect competition (E) natural monopoly

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46. A monopolist can earn positive economic profit in the long run, but a perfectly competitive firm cannot, because
- (A) barriers to entry prevent new firms from competing the profit away.
 - (B) the competitive firm sets price above marginal cost.
 - (C) the monopolist produces at the minimum of ATC.
 - (D) the monopolist faces a horizontal demand curve.
 - (E) the monopolist has lower costs of production.
47. A perfectly competitive firm sells its output for \$3 per unit and pays a wage of \$15. The marginal product of the 1st through 5th workers is 10, 8, 6, 4, and 2 units. To maximize profit the firm should hire
- (A) 1 worker
 - (B) 2 workers
 - (C) 3 workers
 - (D) 4 workers
 - (E) 5 workers
48. The price of a firm's output rises. Other things equal, the firm's demand for labor will
- (A) increase, because marginal revenue product rises at every quantity of labor.
 - (B) decrease, because workers become less productive.
 - (C) be unchanged, because the wage rate has not changed.
 - (D) increase only if the wage falls.
 - (E) decrease, because labor becomes more expensive.
49. The graph shows a labor market with a single employer (monopsony). MRP is the firm's labor demand, S is labor supply, and MFC is marginal factor cost. The wage the monopolist pays is



- (A) \$6
 - (B) \$8
 - (C) \$11
 - (D) \$14
 - (E) \$16
50. A firm's marginal product of labor is 12 and the wage is \$4. Its marginal product of capital is 10 and the price of capital is \$2. To minimize cost for a given output, the firm should
- (A) use more capital and less labor.
 - (B) keep the current mix.
 - (C) use more of both inputs.
 - (D) use less of both inputs.
 - (E) use more labor and less capital.
51. Which of the following would increase the supply of labor in a competitive labor market?
- (A) An increase in the working-age population
 - (B) A decrease in the number of firms hiring
 - (C) An increase in worker productivity
 - (D) An increase in the price of the product workers make
 - (E) A rise in the market wage

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52. In a competitive labor market, labor demand is $MRP = 20 - L$ and labor supply is $W = 2 + L$. A legal minimum wage of \$14 is imposed. The resulting unemployment is



- (A) 3 units of labor (B) 6 units of labor (C) 9 units of labor
(D) 12 units of labor (E) 18 units of labor
53. A firm is the only seller of its product and a competitive buyer of labor. Compared with a competitive seller with the same marginal product of labor, this firm's marginal revenue product of labor is
- (A) higher, because it can set its price.
(B) lower, because wages are higher.
(C) the same, because the marginal product is the same.
(D) higher, because it has no competition.
(E) lower, because marginal revenue is less than price.
54. The graph shows a market with a negative externality. D is demand, MPC is the private marginal cost, and MSC is the marginal social cost. A per-unit tax that would lead to the efficient quantity is



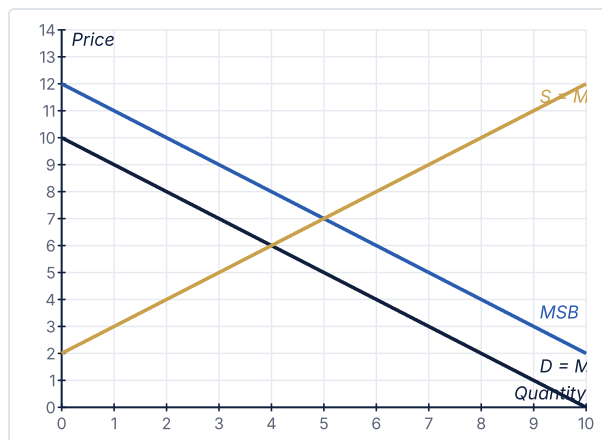
- (A) \$1 (B) \$2 (C) \$3 (D) \$4 (E) \$6
55. Which of the following is a pure public good?
- (A) A toll road (B) Fish in an open ocean (C) Books in a library
(D) National defense (E) A movie theater seat
56. Tradable pollution permits can reduce pollution at lower total cost than a uniform emission standard because
- (A) firms that can cut pollution cheaply do so and sell permits to firms for which abatement is costly.
(B) the government sets a price for each permit that equals the marginal cost.
(C) permits eliminate all pollution.
(D) firms are no longer responsible for damage.
(E) every firm must cut pollution by the same amount.

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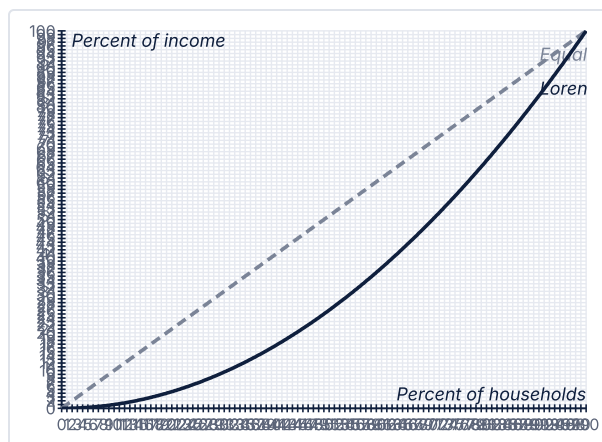
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57. Overfishing of an open ocean fishery occurs because each fisher
 (A) can exclude other fishers.
 (B) values the fish less than society does.
 (C) receives a subsidy equal to the external cost.
 (D) bears only the private cost of fishing and ignores the cost imposed on others through depleting the stock.
 (E) faces rising marginal revenue.
58. The graph shows a market for a good with a positive externality. D is the private marginal benefit, MSB is the marginal social benefit, and S is the marginal cost. The efficient quantity is



- (A) 3 (B) 4 (C) 5 (D) 6 (E) 8
59. The graph shows a Lorenz curve for an economy, with percent of households on the horizontal axis and cumulative percent of income on the vertical axis. The curve is $y = x^2 / 100$. The Gini coefficient is approximately



- (A) 0.17 (B) 0.25 (C) 0.33 (D) 0.50 (E) 0.67
60. A person earning \$40,000 pays 10 percent on the first \$20,000 of income and 20 percent on every dollar above that. Her average tax rate and marginal tax rate are
- (A) 20 percent and 20 percent (B) 15 percent and 20 percent
 (C) 15 percent and 15 percent (D) 10 percent and 20 percent
 (E) 15 percent and 10 percent

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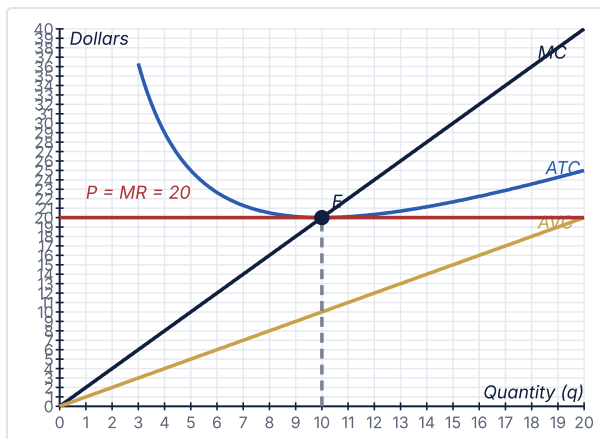
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QUESTION 1 Perfect Competition: Short Run and Long Run (10 points)

A perfectly competitive firm operates in a constant-cost industry in long-run equilibrium. Its total cost is $TC = 100 + q$ squared, so its marginal cost is $MC = 2q$, its average variable cost is $AVC = q$, and its average total cost is $ATC = 100/q + q$. The graph shows its cost curves and the market price of \$20.

61. (a) At the market price of \$20, determine the firm's profit-maximizing quantity and its economic profit. Show your work.



62. (b) Market demand increases, and in the short run the price rises to \$30. Calculate the firm's new profit-maximizing quantity and its economic profit.
63. (c) Explain what happens in the long run to the number of firms, the market price, and each firm's quantity after the demand increase in part (b).
64. (d) Return to the original long-run equilibrium at \$20. The government now imposes a tax of \$4 on each unit the firm produces, so MC becomes $2q + 4$. If the market price is still \$20 in the short run, calculate the firm's quantity and economic profit.
65. (e) Explain what happens in the long run to the market price and the number of firms after the tax. State the new long-run price.

QUESTION 2 Negative Externality (4 points)

A paper mill dumps waste in a river. The market for paper is perfectly competitive. The graph shows demand (D), the private marginal cost curve that is the market supply ($S = MPC$), and the marginal social cost (MSC), which includes \$4 of external cost per unit.

66. (a) Identify the market equilibrium quantity and price.



67. (b) Identify the efficient (socially optimal) quantity and explain why it is efficient.
68. (c) What per-unit tax would cause the market to produce the efficient quantity?
69. (d) Calculate the deadweight loss of the unregulated market.

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QUESTION 3 Comparative Advantage and Trade (4 points)

Two countries, Alta and Beta, use one worker-day to produce either bushels of grain or bolts of cloth. Opportunity costs are constant. The table shows output per worker-day.

70. (a) Which country has an absolute advantage in producing grain, and which in producing cloth?

Country	Grain (bushels)	Cloth (bolts)
Alta	12	6
Beta	4	4

71. (b) Calculate the opportunity cost of producing one bolt of cloth in each country.
 72. (c) Which country has the comparative advantage in cloth? Explain.
 73. (d) Give one price for one bolt of cloth, in bushels of grain, at which both countries would gain from trade.

Key Practice Exam 1: Answers and Explanations

Complete solutions. Free-response keys show the scoring breakdown.

E1 Practice Exam 1**SECTION I, PART A · MULTIPLE CHOICE: QUESTIONS 1-20**

- E. Opportunity cost of 1 bolt of cloth is 2 tons of wheat in A ($100/50$) and 1.5 tons in B ($60/40$), so B has the lower cost in cloth. In wheat, A gives up 0.5 bolt per ton and B gives up 0.67, so A has the comparative advantage in wheat. The claim that no trade is possible confuses absolute advantage with comparative advantage; absolute advantage in both goods does not rule out gains from trade.
- D. Points inside the curve (B) can be produced, but the economy is not using all resources fully or efficiently. Point C lies outside the curve, so it cannot be reached with current resources; it would require growth. Reaching C by trading off goods fails because moving along the curve changes the mix but cannot reach an unattainable point.
- D. If all resources go to computers, the shirt technology is irrelevant, so the vertical intercept stays the same. The maximum number of shirts rises, so the horizontal intercept moves out. A parallel shift would require improvement in both industries.
- C. Producing a bag costs X 2 shirts ($4 \text{ hours} / 2$) and costs Y 3 shirts ($9 / 3$). X gains by selling a bag for more than 2 shirts and Y gains by paying less than 3, so any price strictly between 2 and 3, such as 2.5, helps both. At exactly 2 or 3 one country gains nothing.
- C. Marginal benefit of each hour is 20, 16, 12, 8, and 4. She should keep studying while marginal benefit is at least marginal cost of 10, which holds through the third hour ($12 \geq 10$) but not the fourth ($8 < 10$).
- E. In the factor market households sell labor, land, and capital, and firms are the buyers; wages, rent, and interest flow to households as income. Households paying firms for goods describes the product market, where roles are reversed.
- D. Opportunity cost counts only costs that depend on the choice: tuition \$10,000 + books \$1,000 + forgone wages \$25,000 = \$36,000. Room and board is incurred either way, so including it gives the tempting \$44,000.
- D. A normative statement expresses a value judgment about what ought to be, signaled by 'should'. All the others can be tested against evidence, even if they might be false.
- E. A higher price of a substitute shifts the demand curve for coffee right, and equilibrium price and quantity both rise. A rise in quantity demanded along an unchanged curve is a movement along the curve, which only a change in coffee's own price can cause.
- D. Higher wages raise the cost of production, so supply decreases (shifts left). With demand unchanged, the price rises and the equilibrium quantity falls. Both falling would require demand to fall.
- B. At \$4 quantity demanded is 6 ($10 - P$) and quantity supplied is 2 ($P - 2$), so the shortage is $6 - 2 = 4$. Quantity demanded alone (6) is the usual tempting error.
- C. Equilibrium is at $Q = 4$ and $P = 6$. Consumer surplus is $\frac{1}{2} \times 4 \times (10 - 6) = 8$ and producer surplus is $\frac{1}{2} \times 4 \times (6 - 2) = 8$, so total surplus is 16. Choice A counts only one side.
- C. Percent change in quantity = $40/100 = 40$ percent; percent change in price = $4/10 = 40$ percent. The ratio is 1.0, unit elastic. Using the starting values instead gives a different, incorrect ratio (33 percent / 50 percent).
- B. When demand is elastic ($E_d > 1$) price and total revenue move in opposite directions, so a price cut raises revenue. Saying revenue falls because the seller gets less per unit ignores the larger gain in quantity.
- A. Cross elasticity = $\% \text{ change in Qd of Y} / \% \text{ change in price of X} = -5/10 = -0.5$. A negative sign means the goods are complements. Reversing the ratio (-2.0) is a common slip.
- D. Income elasticity = $-3/5 = -0.6$. A negative value means demand falls as income rises, so bus rides are an inferior good for this household.
- C. The new equilibrium is where $10 - Q = 4 + Q$, so $Q = 3$ and the buyer pays 7. Revenue = tax per unit $\times$ quantity = $2 \times 3 = 6$. Using the old quantity of 4 gives the tempting 8.
- D. The side of the market with the less elastic curve cannot easily switch away and so bears more of the tax. Legal collection does not change who bears the economic burden, and many close substitutes would make demand more elastic, shifting the burden to sellers.
- E. Over a longer time firms can build capacity and change inputs, so quantity supplied responds more to price. The other choices describe constraints that make supply less responsive.

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20. E. Both shifts push equilibrium quantity up, but increased demand raises price while increased supply lowers it, so the net effect on price depends on the size of the shifts.

SECTION I, PART B · MULTIPLE CHOICE: QUESTIONS 21-40

21. C. At \$3 domestic buyers want 7 units ($10 - 3$) and domestic producers supply 1 unit ($3 - 2$), so imports fill the gap of 6. The shortage at a price ceiling is calculated the same way, but here the gap is filled by imports.
22. C. Marginal product is 10, 14, 12, 8, 4. It rises through the 2nd worker and first falls with the 3rd worker, so diminishing marginal returns begin there. The 4th worker is where total product is still rising but more slowly than earlier, which is not the definition.
23. B. Fixed cost is \$100 (cost at zero output), so variable cost at 4 units is $300 - 100 = \$200$ and $AVC = 200 / 4 = \$50$. \$75 is average total cost and \$60 is marginal cost of the 4th unit.
24. A. MC cuts AVC at the minimum of AVC. Because average fixed cost keeps falling, ATC reaches its minimum at a higher output, so at Q1 ATC is still falling (MC is below ATC). Saying ATC is at its minimum is wrong because MC is still below ATC at Q1.
25. B. The firm produces until price equals marginal cost, which occurs at 5 units ($MC = \$12$). Profit = $(P - ATC) \times Q = (12 - 11) \times 5 = \$5$. Total revenue is \$60 and total cost is \$55, so \$60 and \$55 are the tempting but incomplete amounts.
26. B. The firm loses \$1 per unit relative to total cost, but producing covers all variable cost and contributes \$2 per unit toward fixed cost. Shutting down would lose all the fixed cost. The firm is a price taker, so raising the price is not possible for a price taker.
27. A. Profit per unit is $P - ATC$ at Q^* , which is the height from point Z (on ATC) up to W (on the price line). Multiplying by Q^* gives rectangle WXYZ. The rectangle ending at V is total revenue and the one with Z and Y is total cost.
28. E. Higher price creates profit, which attracts entry; supply shifts right until price falls back to the original minimum ATC. Output rises because firms are added. Long-run supply is horizontal in a constant-cost industry, so price cannot stay higher.
29. D. Free entry forces price down to the minimum of ATC (productive efficiency) and the firm sets $P = MC$ (allocative efficiency). Economic profit is zero in the long run, which rules out the claim of positive economic profit.
30. A. Persistent economic losses push some firms out. As supply falls, the price rises until the remaining firms earn zero economic profit. Price exceeding AVC explains short-run operation, not long-run survival.
31. E. Economies of scale occur where LRATC falls as output rises (12 to 9 between 100 and 200) and diseconomies where it rises (9 to 11 between 300 and 400). Between 200 and 300 LRATC is constant, so there are constant returns to scale there.
32. A. Economic profit = revenue - explicit costs - implicit costs = $500,000 - 380,000 - 90,000 = \$30,000$. Accounting profit is \$120,000 because it ignores the implicit cost of her time.
33. A. A fixed cost adds to ATC and total cost but not to marginal cost, so the $P = MC$ output does not change. Only profit falls. A per-unit tax, in contrast, would shift MC up.
34. B. When MC is below ATC, producing another unit pulls the average down: total cost = $200 + 15 = 215$, and $215 / 11$ is about \$19.55. The spreading of fixed cost is real, but it is already included in the new average.
35. E. Labor is a variable input in the short run, so higher wages raise the cost of each additional unit and the average variable and total costs. Fixed cost is unaffected, so AFC does not change.
36. C. The monopolist produces where $MR = MC$ ($10 - 2Q = 2$, so $Q = 4$) and then reads the price from the demand curve ($P = 10 - 4 = \$6$). $Q = 8$ with $P = \$2$ is the perfectly competitive outcome, and $Q = 4$ with $P = \$2$ uses the MC value as the price.
37. B. The efficient output is where $P = MC$ ($Q = 8$); the monopoly output is 4. The loss is the triangle $\frac{1}{2} \times (8 - 4) \times (6 - 2) = 8$. The value 16 is the monopolist's profit, $(6 - 2) \times 4$, not the deadweight loss.
38. A. The price cut needed to sell one more unit applies to the units that could have been sold at the higher price too, so the revenue gained is less than the new price. Costs are irrelevant to the MR-versus-price gap.
39. E. Charging each buyer their maximum willingness to pay means MR equals price, so the firm produces until $D = MC$, which is the efficient quantity, and consumer surplus becomes producer surplus.
40. D. At $P = MC$ the quantity is allocatively efficient, but since $MC < ATC$ the price is below average cost and the firm loses money, so regulators often use a fair-return price ($P = ATC$) or a subsidy.

SECTION I, PART C · MULTIPLE CHOICE: QUESTIONS 41-60

41. E. Demand is tangent to ATC at $Q = 3$, so $P = ATC = \$5$ and profit is zero. Because MC is only \$1, $P > MC$ (not allocatively efficient). The tangency is on the falling part of ATC, so output is below the minimum-ATC level (excess capacity).
42. E. Advertising is a dominant strategy for each firm: Firm 1 earns $4 > 1$ if Firm 2 advertises and $9 > 6$ if it does not (and symmetrically for Firm 2). Both advertise even though (6, 6) would leave them both better off, which is the prisoner's dilemma.
43. C. At the cartel price each member's marginal revenue exceeds its marginal cost, so cheating is profitable for the individual even though collective cheating erodes the cartel price.
44. D. Add the four largest shares: $30 + 25 + 15 + 10 = 80$ percent. The value 88 percent is the five-firm ratio.
45. B. Many sellers with free entry and product differentiation define monopolistic competition. Perfect competition has identical products and a horizontal demand curve; oligopoly has few firms and barriers.
46. A. Profit signals entry in a competitive market, which lowers the price until profit is zero. A monopoly's barriers keep entrants out, so the profit persists.
47. C. Marginal revenue product is price times MP: \$30, \$24, \$18, \$12, and \$6. Hire while MRP is at least the wage of \$15: the 3rd worker adds \$18, the 4th only \$12, so hire 3.
48. A. Labor demand is derived demand: $MRP = MP \times P$, so a higher output price raises MRP and shifts labor demand right at every wage.
49. B. Hire where $MRP = MFC$ ($20 - L = 2 + 2L$), so $L = 6$. The wage is read from the supply curve at $L = 6$: $2 + 6 = \$8$. The MRP at that quantity is \$14, which is not the wage, and \$11 is the competitive wage.

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50. A. MPL per dollar is $12 / 4 = 3$ and MPK per dollar is $10 / 2 = 5$. Capital gives more output per dollar, so the firm substitutes toward capital until the ratios are equal.
51. A. More available workers shifts labor supply right. Higher product price and higher productivity shift labor demand, and a higher wage causes a movement along the supply curve.
52. B. At \$14 firms demand 6 units ($20 - 14$) and workers supply 12 units ($14 - 2$), so $12 - 6 = 6$ workers are unemployed. The equilibrium employment is 9 at a wage of \$11, and the minimum wage cuts employment to 6.
53. E. MRP equals MP times MR. A monopolist's MR is below price, so each worker adds less revenue and the firm hires fewer workers.
54. B. A corrective tax equals the marginal external cost, the vertical gap between MSC and MPC, which is \$2. The tax shifts the private supply curve up to MSC, and the market quantity falls from 4 to the efficient 3.
55. D. Public goods are nonrival and nonexcludable: defense protects everyone and one more person's protection does not reduce anyone else's. Fish are rival and nonexcludable (a common resource).
56. A. Trading directs abatement to the firms with the lowest marginal abatement cost while the total allowed pollution stays fixed by the number of permits.
57. D. Fish are rival but nonexcludable, so each fisher's marginal private cost is less than the marginal social cost, which results in overuse (the tragedy of the commons).
58. C. The efficient quantity is where $MSB = MC$: $12 - Q = 2 + Q$, so $Q = 5$. The market produces only 4, where private $D = S$, so the good is under-produced. A per-unit subsidy of \$2 would restore efficiency.
59. C. The Gini coefficient is the area between the line of equality and the Lorenz curve divided by the whole area under the line. The area under the Lorenz curve is $1/3$ of the square, so the area between is $1/2 - 1/3 = 1/6$ and $Gini = (1/6) / (1/2) = 1/3$. The 0.17 value forgets to divide by $1/2$.
60. B. Tax = $2,000 + 4,000 = \$6,000$, so the average rate is $6,000 / 40,000 = 15$ percent. The marginal rate is the rate on the last dollar, 20 percent. Because the average rate rises with income, the tax is progressive.

QUESTION 1 · PERFECT COMPETITION: SHORT RUN AND LONG RUN (10 POINTS)

61. 2 points. 1 point: sets $P = MC$, $20 = 2q$, so $q = 10$. 1 point: economic profit = $TR - TC = 20(10) - (100 + 100) = 200 - 200 = \$0$ (equivalently, $P = ATC = 100/10 + 10 = \$20$). The graph shows MC crossing the price line at the minimum of ATC, so the firm earns zero economic profit, as expected in long-run equilibrium.
62. 2 points. 1 point: $30 = 2q$ gives $q = 15$. 1 point: $TR = 30(15) = \$450$ and $TC = 100 + 15^2 = \$325$, so economic profit = $\$125$ (or $ATC = 100/15 + 15 = \text{about } \$21.67$ and profit = $(30 - 21.67)(15) = \text{about } \$125$). Model graph: horizontal price line at \$30 meets MC at $q = 15$, above ATC, with a profit rectangle between P and ATC.
63. 2 points. 1 point: the positive economic profit attracts entry of new firms, so the number of firms rises and market supply shifts right. 1 point: price falls back to \$20 (the minimum of ATC), where each firm again produces 10 units and earns zero economic profit; market output is higher only because there are more firms.
64. 2 points. 1 point: set $P = MC$, $20 = 2q + 4$, so $q = 8$. 1 point: $TR = 20(8) = \$160$; $TC = 100 + 64 + 4(8) = \$196$; economic profit = $-\$36$ (a loss). The firm still produces because $P = \$20$ exceeds its AVC of $8 + 4 = \$12$ at $q = 8$. Model graph: MC and ATC both shift up, and the \$20 price line now lies below the new ATC at $q = 8$.
65. 2 points. 1 point: the loss causes firms to exit, market supply decreases, and the price rises until the remaining firms earn zero economic profit, so the number of firms falls. 1 point: the new minimum ATC is $100/10 + 10 + 4 = \$24$ at $q = 10$, so the long-run price is \$24 (consumers bear the whole per-unit tax in the long run in a constant-cost industry).

QUESTION 2 · NEGATIVE EXTERNALITY (4 POINTS)

66. 1 point: the market equilibrium is where $D = S$: $20 - Q = 4 + Q$, so $Q = 8$ and the price is \$12.
67. 1 point: the efficient quantity is where D (marginal social benefit) equals MSC: $20 - Q = 8 + Q$, so $Q = 6$ (at a price of \$14). It is efficient because at $Q = 6$ the value of the last unit equals its full cost to society; beyond that, units cost society more than buyers value them.
68. 1 point: a tax equal to the marginal external cost, \$4 per unit, shifts the private supply curve up to MSC, so the market quantity falls to 6.
69. 1 point: at $Q = 8$ MSC is \$16 and D is \$12, a gap of \$4. The loss is a triangle with base $8 - 6 = 2$ and height \$4, so $DWL = 1/2 \times 2 \times 4 = \$4$.

QUESTION 3 · COMPARATIVE ADVANTAGE AND TRADE (4 POINTS)

70. 1 point: Alta has the absolute advantage in both goods, because it produces more grain ($12 > 4$) and more cloth ($6 > 4$) per worker-day.
71. 1 point: Alta gives up $12/6 = 2$ bushels per bolt; Beta gives up $4/4 = 1$ bushel per bolt.
72. 1 point: Beta has the comparative advantage in cloth because it has the lower opportunity cost (1 bushel versus 2). Alta therefore has the comparative advantage in grain (opportunity cost of 0.5 bolt versus 1 bolt for Beta).
73. 1 point: any price strictly between 1 and 2 bushels per bolt, for example 1.5 bushels. Beta (the cloth exporter) gains by receiving more than its cost of 1, and Alta gains by paying less than its own cost of 2.

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Appendix: Reference.

Formulas, graph gallery, glossary, and a skills checklist for last-minute review.

R.1 Formula Sheet and Graph Gallery

Every formula you need with notes on when to use it, plus the standard graphs and how each behaves.

Use this reference to check formulas and graph conventions while you study. Each formula is paired with a note about when it applies. Always label every graph, show your formula, and include units.

Before you calculate

Identify the market structure: price taker ($MR = P$) or price maker (MR below P).

Identify the time frame: short run (a fixed input exists) or long run (all inputs variable).

Choose the right comparison: marginal for decisions, average for profit per unit, total for overall profit.

Check whether the problem asks for absolute values (elasticity classification) or signed values (income and cross elasticity).

Quantity	Formula and meaning	When to use / notes
Opportunity cost	Value of the best alternative given up. For a two-good PPC: units of Y given up per unit of X gained.	Unit 1; comparative advantage (lower opportunity cost wins)
Price elasticity of demand	%change in Q demanded divided by %change in P (absolute value). Midpoint: change divided by average of the two values.	Elastic above 1, unit elastic at 1, inelastic below 1
Total revenue	$P \times Q$	Total revenue test: raise price with inelastic demand and TR rises
Income elasticity	%change in Q divided by %change in income	Positive: normal; above 1: luxury; negative: inferior
Cross-price elasticity	%change in Q of X divided by %change in P of Y	Positive: substitutes; negative: complements
Price elasticity of supply	%change in Q supplied divided by %change in P	Larger when firms can raise output easily, especially over a longer time
Consumer surplus	Willingness to pay minus price paid; area below demand and above price	Triangle: one-half $\times$ base $\times$ height
Producer surplus	Price received minus minimum acceptable price; area above supply and below price	Triangle or trapezoid
Deadweight loss	Lost total surplus on units not traded (or traded but should not be)	Triangle between the two relevant curves
Tax incidence	Buyers' share = new price paid minus original price; sellers' share = original price minus new price received	More inelastic side bears more of the tax
Utility maximization	$MU_x/P_x = MU_y/P_y$ (marginal utility per dollar equal across goods)	Unit 1 or 2 consumer-choice questions
Total, fixed, variable cost	$TC = FC + VC$	FC does not change with output
Average costs	$ATC = TC/Q$; $AVC = VC/Q$; $AFC = FC/Q$; $ATC = AVC + AFC$	$ATC - AVC = AFC$ at any Q
Marginal cost	Change in TC (or VC) divided by change in Q	Crosses ATC and AVC at their minimums
Marginal product	Change in total output divided by change in labor (or any input)	Falls when diminishing returns set in

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Quantity	Formula and meaning	When to use / notes
Profit	$TR - TC = (P - ATC) \times Q$	Accounting profit subtracts only explicit costs
Profit-maximizing rule	Produce where $MR = MC$	For price takers $MR = P$; for monopoly MR is below P
Shutdown rule	Shut down in the short run if $P < \text{minimum AVC}$	Exit in the long run if $P < ATC$
Marginal revenue (monopoly)	$MR = \text{change in } TR / \text{change in } Q$; for linear demand MR has the same intercept and twice the slope	$MR < P$ because the price cut applies to all units
Concentration (HHI)	Sum of squared market shares (in percent) of the firms in the market	Higher HHI means more concentrated
Marginal revenue product	$MRP = MPL \times MR$ (= $MPL \times P$ if a price taker in the product market)	Labor demand curve for a competitive hirer
Hiring rule	Hire until $MRP = \text{wage (MRC)}$; with monopsony, hire until $MRP = MFC$	Monopsony hires fewer workers and pays less than competition
Least-cost hiring	$MPL/\text{wage} = MPK/\text{rental rate}$ across inputs	Use more of the input with higher MP per dollar
Gini coefficient	Area between Lorenz curve and equality line divided by area under the equality line	0 equality to 1 total inequality
Externality optimum	Efficient Q where marginal social benefit = marginal social cost	Pigouvian tax equals the marginal external cost at the optimum
Terms of trade	A price per unit lying between the two countries' opportunity costs	Both gain when it is between them

Rules to remember about the formulas

Marginal cost below average cost pulls the average down; marginal cost above average pulls it up. That is why MC crosses ATC and AVC at their lowest points.

Profit-maximizing output never depends on fixed cost in the short run: only MR and MC matter.

Allocative efficiency: $P = MC$. Productive efficiency: production at minimum ATC . Perfect competition in the long run achieves both; monopoly and monopolistic competition achieve neither.

The table below lists the graphs the exam can ask you to draw, how each curve behaves, and what to mark. Compare each pair when studying: many point losses come from confusing two similar graphs, such as monopoly and monopolistic competition, or a price ceiling and a price floor.

Graph	Shape and key curves	What to mark or calculate
Market (S and D)	D down, S up; E at the intersection	Shift for determinants; movement along for own price
Price ceiling	Horizontal line below equilibrium	Shortage = $Q_d - Q_s$, DWL triangle
Price floor	Horizontal line above equilibrium	Surplus = $Q_s - Q_d$, DWL triangle
Tax on sellers	S shifts up by the tax; wedge between buyer price and seller price	Revenue = tax $\times$ new Q ; DWL from lost units
Subsidy	S shifts down (or D up) by the subsidy	Quantity rises; deadweight loss from overproduction
Tariff or quota	Domestic price rises above world price; imports fall	Domestic producers gain, consumers lose, net loss
PPC	Bowed out for increasing opportunity cost; straight line for constant	Inside inefficient, outside unattainable
Competitive firm, short run	$P = MR = D$ horizontal; MC cuts ATC and AVC at minimums	Q^* where $P = MC$; profit is rectangle $(P - ATC) \times Q^*$

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Graph	Shape and key curves	What to mark or calculate
Competitive market and firm, long run	Entry or exit shifts S until $P = \text{minimum ATC}$	Zero economic profit; productive and allocative efficiency
Monopoly	D down, MR below D, MC and ATC	QM at $MR = MC$, PM on D; DWL triangle
Natural monopoly	ATC falls over the relevant range	Fair-return price ($P = ATC$) vs socially optimal ($P = MC$) with a loss
Price discrimination	Separate D and MR for each group or perfect	Perfect: $P = D$, no DWL, all surplus to seller
Monopolistic competition	D down, tangent to ATC in long run	Excess capacity; P above MC
Oligopoly and games	Payoff matrix; kinked demand	Nash equilibrium; dominant strategy
Labor market	D = MRP down, S up; firm sees horizontal wage	W^* and L^* ; $MRP = W$
Monopsony	MFC above labor supply	Hires where $MRP = MFC$; wage from supply
Negative externality	MSC above MPC (supply)	Market overproduces; Pigouvian tax = external cost
Positive externality	MSB above D	Market underproduces; subsidy
Public good	Free-rider problem; D is the vertical sum for social demand	Government provision
Lorenz curve	Bowed below the diagonal	Gini rises as the bow deepens

Shift versus movement

A change in the good's own price moves you along a curve (change in quantity demanded or supplied).

Changes in tastes, income, prices of related goods, expectations, or number of buyers shift demand.

Changes in input prices, technology, taxes, subsidies, expectations, or number of sellers shift supply.

Changes in the price of a related input or in wages shift cost curves; a fixed-cost change shifts only ATC.

Quick equilibrium effects. If demand increases and supply is unchanged, both price and quantity rise. If supply increases and demand is unchanged, price falls and quantity rises. If both shift in the same direction (both increase), quantity rises and the price change is ambiguous. If demand rises and supply falls, price rises and the quantity change is ambiguous. Always state which result is ambiguous and why.

Market structure	Number of firms	Product	Entry	Demand facing firm	Price vs MC	Long-run profit
Perfect competition	Many	Identical	Free	Horizontal	$P = MC$	Zero
Monopoly	One	Unique, no close substitutes	Blocked	Market demand	P above MC	Positive possible
Monopolistic competition	Many	Differentiated	Free	Downward sloping	P above MC	Zero
Oligopoly	Few	Identical or differentiated	Barriers	Depends on rivals	P above MC	Positive possible

R.2 Glossary and Skills Checklist

Key terms with plain definitions, and a unit-by-unit checklist to find your weak spots.

Use the glossary to test yourself: cover the definition, state it, and then use the term in a graph or sentence. The checklist below should be completed with an honest rating of green, yellow, or red for each skill, and revisit the reds first.

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Term	Definition
Absolute advantage	Ability to produce more of a good with the same resources
Accounting profit	Total revenue minus explicit costs
Allocative efficiency	Output where price equals marginal cost, so resources go to their most valued uses
Asymmetric information	One side of a transaction knows more than the other
Average fixed cost (AFC)	Fixed cost divided by output; falls continually
Average total cost (ATC)	Total cost divided by output
Average variable cost (AVC)	Variable cost divided by output
Barriers to entry	Obstacles such as patents, control of resources, scale, or licenses that keep new firms out
Capital	Human-made goods used to produce other goods
Cartel	Group of firms that coordinate output or price to act like a monopoly
Ceteris paribus	Holding all other things equal while examining one change
Coase theorem	If property rights are clear and bargaining is cheap, parties can resolve externalities privately
Comparative advantage	Ability to produce a good at a lower opportunity cost
Complements	Goods used together; a price rise for one lowers demand for the other
Constant returns to scale	Long-run average cost is unchanged as output expands
Consumer surplus	Difference between willingness to pay and price paid
Cross-price elasticity	Responsiveness of the quantity of one good to the price of another
Deadweight loss	Loss of total surplus when output differs from the efficient quantity
Demand	Relationship between price and the quantity consumers are willing and able to buy
Diminishing marginal returns	Added output from each additional unit of a variable input eventually falls
Diseconomies of scale	Long-run average cost rises as output grows
Dominant strategy	Action that is best for a player no matter what rivals do
Economic profit	Total revenue minus explicit and implicit costs
Economies of scale	Long-run average cost falls as output grows
Elastic	Elasticity greater than 1 in absolute value
Equilibrium	Price at which quantity demanded equals quantity supplied
Excess capacity	Producing below the output that minimizes ATC, as in monopolistic competition
Explicit costs	Out-of-pocket payments for inputs
Externality	Cost or benefit to third parties not reflected in market price
Factor market	Market for inputs such as labor, capital, and land
Fixed cost	Cost that does not vary with output in the short run
Free rider	Person who benefits from a good without paying
Game theory	Study of strategic decisions among interdependent players
Gini coefficient	Measure of inequality from 0 (equal) to 1
Herfindahl-Hirschman Index	Sum of squared market shares, used to measure concentration
Implicit costs	Opportunity costs of resources the firm already owns
Income elasticity	Responsiveness of quantity to a change in income
Inelastic	Elasticity less than 1 in absolute value
Inferior good	Good whose demand falls when income rises

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Term	Definition
Law of demand	Price and quantity demanded move in opposite directions, ceteris paribus
Law of supply	Price and quantity supplied move in the same direction
Lorenz curve	Graph of cumulative income share against cumulative population share
Marginal cost	Added cost of one more unit
Marginal product	Added output from one more unit of an input
Marginal revenue	Added revenue from selling one more unit
Marginal revenue product	Added revenue from employing one more unit of a resource
Marginal social benefit	Benefit to society of one more unit, including external benefits
Marginal social cost	Cost to society of one more unit, including external costs
Market failure	A market outcome that is not efficient, such as externalities or public goods
Monopolistic competition	Many firms, differentiated products, free entry
Monopoly	One seller with barriers to entry and no close substitutes
Monopsony	A market with a single buyer of labor or another input
Nash equilibrium	Outcome in which no player gains by changing strategy alone
Natural monopoly	Industry where one firm can supply the market at lower cost than two or more
Negative externality	Cost imposed on third parties
Normal good	Good whose demand rises with income
Oligopoly	Few interdependent firms
Opportunity cost	Value of the next best alternative forgone
Perfect competition	Many sellers, identical product, price takers, free entry and exit
Pigouvian tax	Tax equal to the marginal external cost
Positive externality	Benefit received by third parties
Price ceiling	Legal maximum price
Price discrimination	Charging different prices to different customers for the same good, not based on cost
Price floor	Legal minimum price
Price taker	Firm that cannot influence market price
Producer surplus	Difference between price received and the minimum acceptable price
Production possibilities curve	Combinations of two goods that can be produced with fixed resources
Productive efficiency	Producing at minimum average total cost
Public good	Nonrival and nonexcludable good
Quota	Limit on the quantity of imports
Rival	Consumption by one person reduces availability to others
Scarcity	Unlimited wants exceed limited resources
Shutdown point	Price at minimum AVC; below it a firm stops producing in the short run
Subsidy	Payment that lowers a producer's or consumer's cost
Substitutes	Goods used in place of each other; a price rise for one raises demand for the other
Sunk cost	Cost already paid and not recoverable; ignored in decisions
Supply	Relationship between price and quantity producers will sell
Tariff	Tax on imports

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Term	Definition
Terms of trade	Exchange ratio between two traded goods
Total revenue test	Rule linking price changes and total revenue to elasticity
Variable cost	Cost that varies with output

Skills checklist: rate each as green, yellow, or red

Green: I can do it without notes under time pressure.

Yellow: I can do it with notes or after a hint.

Red: I miss it or avoid it. Do five practice problems on every red item.

Unit 1: Basic economic concepts

- ◆ I can: define scarcity and opportunity cost and compute opportunity cost from a table or PPC.
- ◆ I can: draw and interpret a PPC with shifts, efficiency, and increasing costs.
- ◆ I can: identify absolute and comparative advantage and set terms of trade.
- ◆ I can: explain marginal analysis and sunk costs in decision making.

Unit 2: Supply and demand

- ◆ I can: draw and shift supply and demand and predict P and Q for single and double shifts.
- ◆ I can: calculate elasticities and apply the total revenue test and tax incidence.
- ◆ I can: show price ceilings, floors, taxes, and subsidies with surplus and deadweight loss.
- ◆ I can: analyze tariffs and quotas and the gains from trade.

Unit 3: Production, cost, and perfect competition

- ◆ I can: calculate marginal product, average and marginal costs from tables.
- ◆ I can: draw cost curves and explain their relationships and diminishing returns.
- ◆ I can: find profit-maximizing output, profit, shutdown, and long-run entry and exit.
- ◆ I can: explain productive and allocative efficiency; economies of scale.

Unit 4: Imperfect competition

- ◆ I can: derive MR from linear demand; find monopoly price, quantity, profit, DWL.
- ◆ I can: analyze price discrimination and natural monopoly regulation.
- ◆ I can: compare long-run outcomes in monopolistic competition.
- ◆ I can: use payoff matrices to find dominant strategies and Nash equilibria; interpret HHI.

Unit 5: Factor markets

- ◆ I can: derive labor demand from MRP; apply the hiring rule.
- ◆ I can: show wage and employment changes from shifts in labor demand and supply.
- ◆ I can: analyze monopsony and minimum wage; apply least-cost hiring rule.

Unit 6: Market failure and the role of government

- ◆ I can: draw externalities and compute the efficient quantity and corrective policy.
- ◆ I can: classify public goods, private goods, common resources, and club goods.
- ◆ I can: explain taxes, subsidies, and regulation; interpret Lorenz curves and the Gini coefficient.
- ◆ I can: discuss progressive, regressive, and proportional taxes.

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