Profit Maximization by a Perfectly Competitive Firm

A perfectly competitive firm will maximize its total profit by producing the output level at which marginal revenue equals marginal cost. You need to understand how economists find these two important "marginal" measures.

Part A: Revenue Measures of a Perfectly Competitive Firm

A perfectly competitive firm is a "price taker." This means it has no control over price and will charge the market-determined price for its product. In fact, because it is such a small participant in the market, a perfectly competitive firm can sell all the output it wants at the market price. It does not have to reduce its price to sell additional units. This makes the revenue measures of a perfectly competitive firm easy to calculate and to graph.

1. Assume the market for yo-yos is perfectly competitive and that the market price currently is $17 per box of yo-yos. Complete Table 3-6.1, which has the three revenue measures of a typical firm in this market. Put the MR values at the new output level. For example, when the firm increases output from four to five units, its total revenue increases by $17, so put "+$17" in the MR column for Q = 5.

Table 3-6.1
Revenue Measures of a Perfectly Competitive Firm

| (1) Output (Q) [boxes of yo-yos]	(2) Price (P) [per box]	(3) Total revenue TR = P × Q	(4) Marginal revenue MR = ΔTR/ΔQ	(5) Average revenue AR = TR/Q
0	$17		–	–
1	$17			
2	$17			$17
3	$17	$51		
4	$17			
5	$17		+$17	
6	$17			
7	$17			$17
8	$17	$136		
9	$17			
10	$17			

2. What happens to the value of MR as more output is sold? Why?

3. What is the relationship between MR and AR at every output level? Why?

4. What happens to the value of TR each time the firm sells one more unit of its good? Why?

5. Why is P equal to $17 at every level of Q?

6. What is the relationship between P, MR, and AR? Why?

7. Plot the firm's total revenue data in Figure 3-6.1.

Figure 3-6.1
**Total Revenue Function of a Perfectly Competitive Firm**
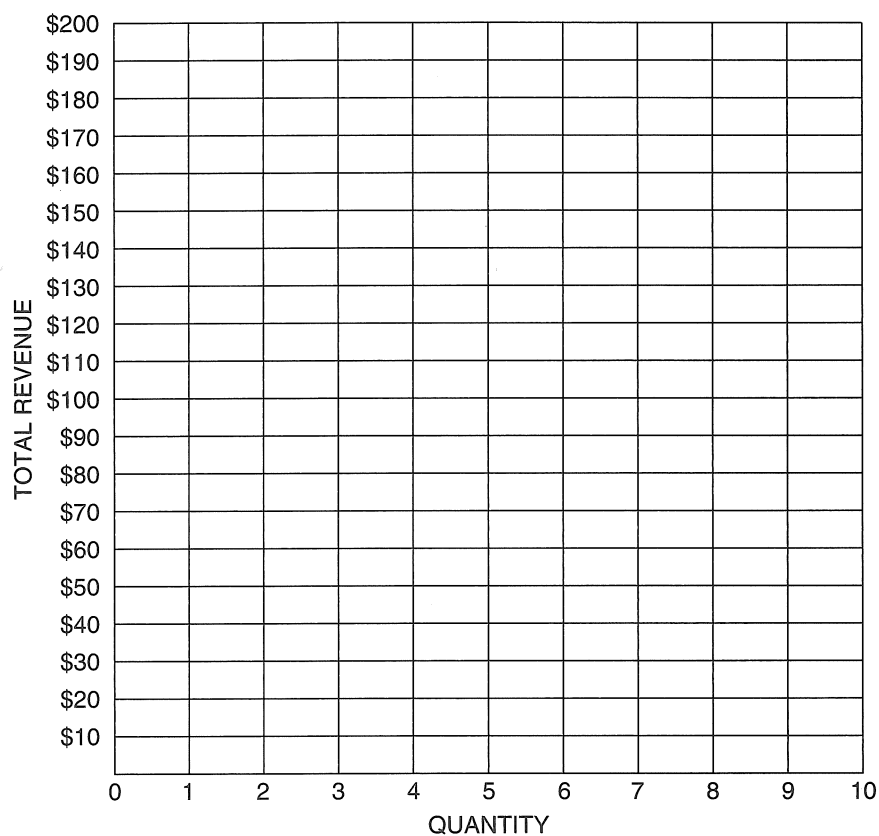
8. The slope of the total revenue function is ΔTR/ΔQ. What economic function does this ratio represent? Why is the TR curve a straight line?

9. If the market price increases, what will happen to the slope of the firm's TR curve? Will the TR curve still begin at the origin?

10. Plot the firm's marginal revenue, average revenue, and demand data in Figure 3-6.2.

Figure 3-6.2

Marginal Revenue, Average Revenue, and Demand Functions of a Perfectly Competitive Firm
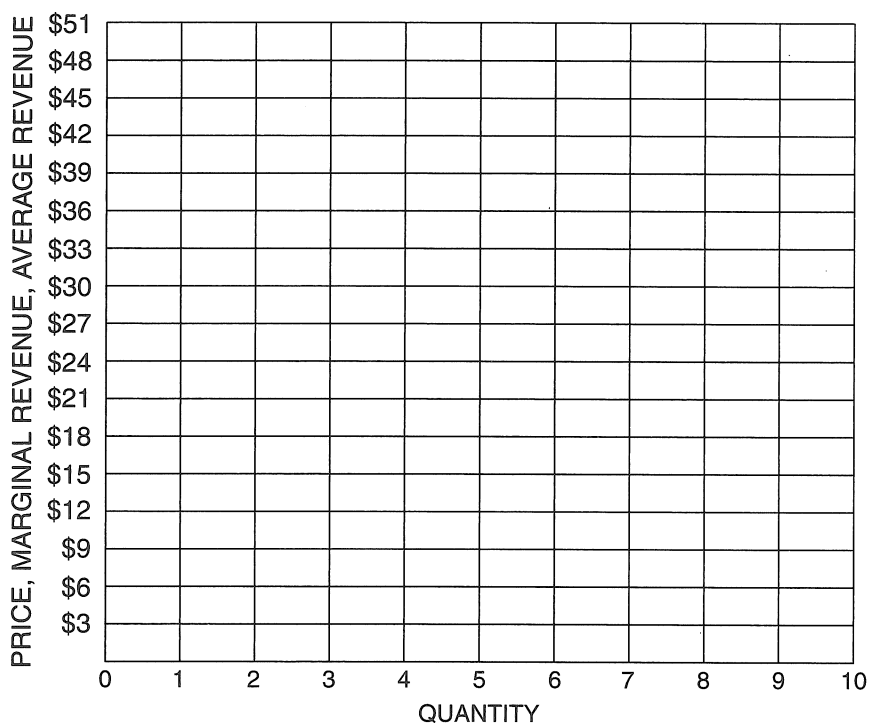
11. Does the demand curve D represent the firm's demand for something, such as inputs?

12. Why is the demand function horizontal?

13. What would happen to the quantity demanded of the firm's product if it increased the price above the market price of $17? What does this tell you about the price elasticity of demand for the firm's product?

14. Would you recommend that this firm lower its price below the market price of $17? Why?

15. What do you note about the relationship between price and marginal revenue for a perfectly competitive firm? What about between price and average revenue?

Part B: Cost Measures of a Perfectly Competitive Firm

The short-run cost curves of a perfectly competitive firm give you values of the various cost measures at different output levels.

16. Complete Table 3-6.2, which has the seven cost measures of a typical firm in this market. Put the MC values at the new output level. For example, when the firm increases output from four to five units, its total cost increases by $4, so put "+$4" in the MC column for Q = 5. Some of the cost values are provided for you.

Table 3-6.2
Cost Measures of a Perfectly Competitive Firm

(1) Output (Q) [boxes]	(2) Total fixed cost (TFC)	(3) Total variable cost (TVC)	(4) Total cost (TC)	(5) Marginal cost (MC) = ΔTC/ΔQ	(6) Average fixed cost (AFC) = TFC/Q	(7) Average variable cost (AVC) = TVC/Q	(8) Average total cost (ATC) = TC/Q
0			$40.00	–	–	–	–
1		$10.00					
2	$40.00			+$6.00			
3						$7.00	
4							$16.50
5		$30.00		+$4.00			
6						$6.00	
7			$85.50		$5.71		
8	$40.00						$12.00
9		$72.00					
10				+$18.00			

17. What happens to the value of AFC as Q rises? Why?

18. What happens to the value of AVC as Q increases? Why?

19. What happens to the value of MC as Q increases? Is this trend related to the marginal physical productivity of the firm's variable resources? Explain.

20. Is the value of MC the same whether it is computed as a change in TC or as a change in TVC? Why?

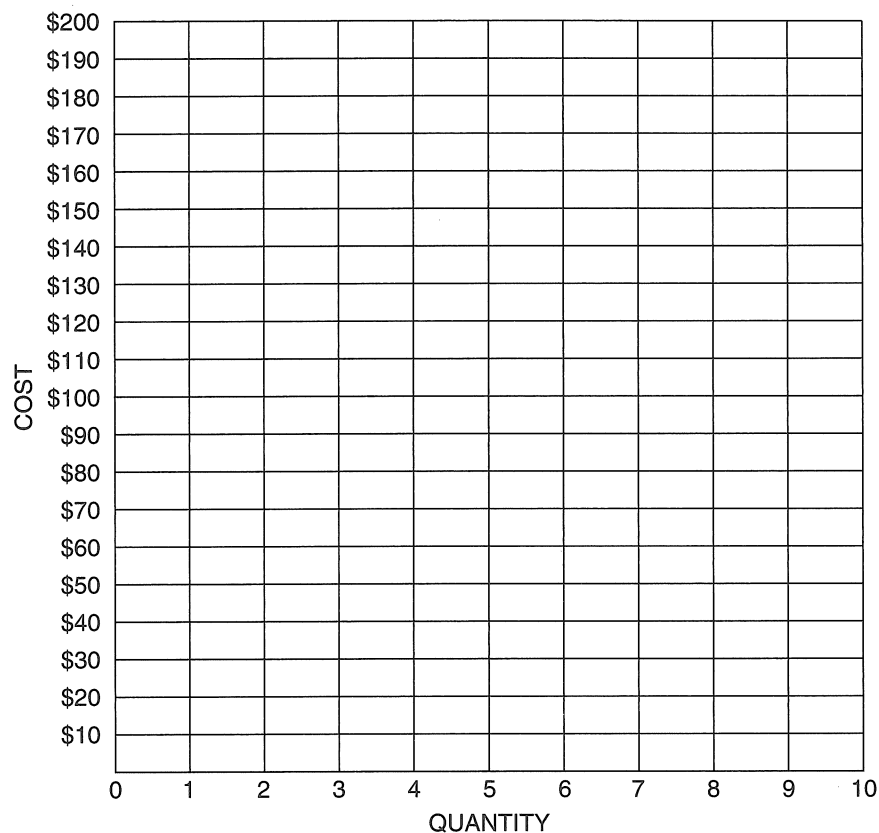21. Why does the value of TVC continue to get larger as the firm produces more Q?

22. The slope of the TC curve is $\Delta TC/\Delta Q$. Do you recognize this ratio as the expression of some other important economic function?

23. Plot the firm's TC, TVC, and TFC data in Figure 3-6.3.

Figure 3-6.3
**TC, TVC, and TFC Functions of a Perfectly Competitive Firm**

24. What does the vertical gap between the TC and TVC represent? What happens to the size of this gap as the firm increases its level of production?

25. Why does the TC cost curve not begin at the origin?

26. Why does the TVC curve have the same slope as the TC curve?

27. Plot the firm's ATC, AVC, AFC, and MC data in Figure 3-6.4. Connect the MC values with a dotted line in your graph.

Figure 3-6.4
ATC, AVC, AFC, and MC Functions of a Perfectly Competitive Firm
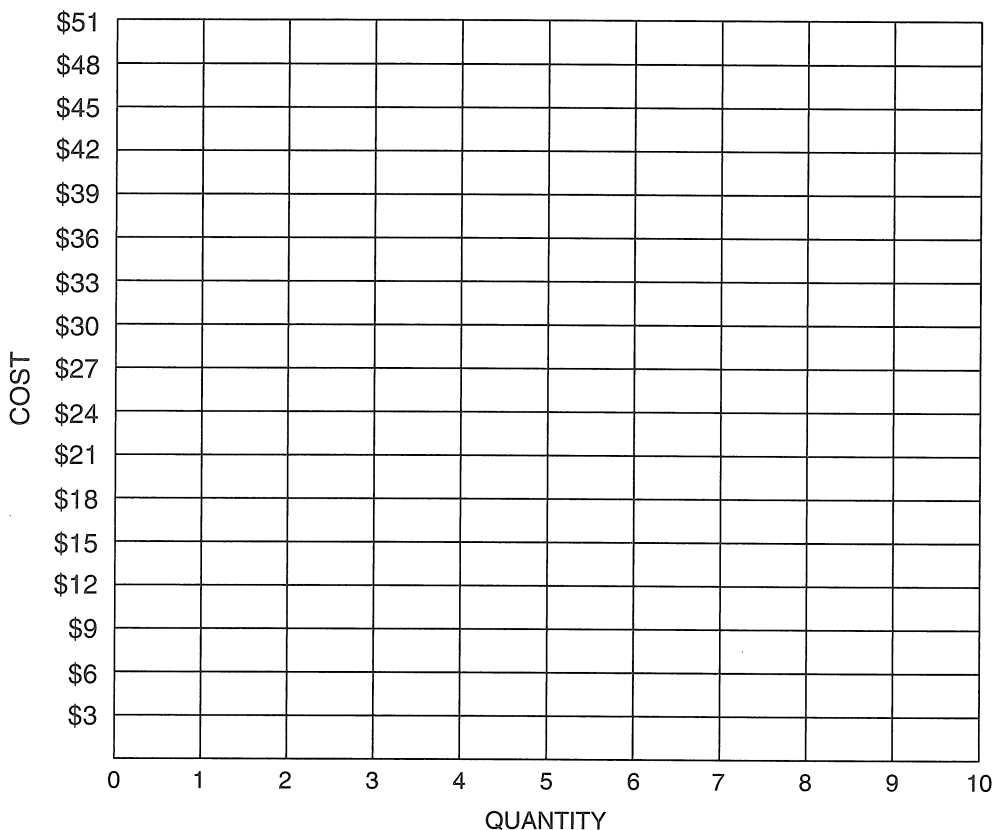
28. Why does the vertical gap between the ATC and AVC curves get smaller as the firm increases its Q?

29. At what unique point does the MC curve intersect both the AVC curve and the ATC curve? Why?

30. Between Q = 6 and Q = 8, AVC is rising while ATC is falling. How can this be?

Part C: Profit Maximization by a Perfectly Competitive Firm

Now that you have mastered the revenue and cost terms for a perfectly competitive firm, you can bring them together to determine how many units of output the firm should produce to maximize its total profit.

31. Complete Table 3-6.3 using your data from Tables 3-6.1 and 3-6.2. Some data have been entered for you.

Table 3-6.3
A Perfectly Competitive Firm Maximizes Total Profit

Q	TR	TC	TΠ	MR	MC	MΠ
0		$40.00	−$40.00	–	–	–
1					+$10.00	
2	$34.00			+$17.00		
3			−$10.00			+$12.00
4		$66.00			+$5.00	
5				+$17.00		
6	$102.00					+$11.00
7			$33.50			
8		$96.00			+$10.50	
9				+$17.00		+$1.00
10	$170.00					

32. The value of TΠ is greatest at Q = _____ units. The maximum TΠ = $_____.

33. The firm should produce each unit for which MR > MC. The last unit with MR > MC is the _____ unit, which has MΠ = $_____.

34. Should the firm produce the tenth unit of Q? Why?

35. MΠ has its greatest value at Q = _____ units. Should this be the Q level the firm decides to produce? Why?

36. Go back to Figure 3-6.3 and draw the firm's TR function. (You can get it from Figure 3-6.1). Label the function "TR."

37. What do we call the vertical gap between the TR and TC curves?

38. We saw in Table 3-6.3 that this firm should produce Q = _____ units to maximize its TΠ. Indicate the part of Figure 3-6.3 that represents this maximum TΠ.

39. Go back to Figure 3-6.4 and draw the firm's D, MR, and AR functions at the current market price of $17. (You can get these from Figure 3-6.2). Label the functions.

40. The last unit of output for which MR > MC is the _____ unit. This is the last unit the firm should produce in order to maximize its TΠ.

41. What does the vertical gap between the MR and MC curves represent?

Part D: When Is a Firm's Best Just Not Good Enough?

You proved this firm can earn a positive total profit if the market price is $17. But what if the market price drops? Since a perfectly competitive firm is a price taker, it will have to sell its product at the lower market price, which will reduce its total profit.

42. Assuming all its costs are unchanged, what will happen to the perfectly competitive firm if the market price drops to $10? In Figure 3-6.4, draw a new "$D_1 = MR_1$" line at the price of $10.

    (A) Based on a comparison of MR and MC, the firm's optimal Q level is _____ units.

    (B) Its TR will be (*greater than / equal to / less than*) its TC at this Q level.

    (C) Its TR will be (*greater than / equal to / less than*) its TVC.

    (D) What should the firm do? Choose one of these decisions:

        (1) It should produce its optimal Q even though it will make a loss.

        (2) It should shut down and produce no Q this period.

43. Assuming all its costs are unchanged, what will happen to the perfectly competitive firm if the market price drops to $5? In Figure 3-6.4, draw a new "$D_2 = MR_2$" line at the price of $5.

    (A) Based on a comparison of MR and MC, the firm's optimal Q level is _____ units.

    (B) Its TR will be (*greater than / equal to / less than*) its TC at this Q level.

    (C) Its TR will be (*greater than / equal to / less than*) its TVC.

    (D) What should the firm do? Choose one of these decisions:

        (1) It should produce its optimal Q even though it will make a loss.

        (2) It should shut down and produce no Q this period.

Note: Even though economists chant, "Produce where MR = MC," in a discrete case with a limited number of Q levels being considered, there might not be a level of Q where MR = MC. In such a case, the firm should produce units for which MR > MC and stop before it produces units for which MR < MC. That's what you did in this example.

44. A puzzle for you! Economists say a perfectly competitive firm can sell at the Q it wants at the going market price. So why doesn't a single firm decide to produce all the Q that is demanded in the market?

Short-Run Equilibrium and Short-Run Supply in Perfect Competition

The word "equilibrium" refers to being in a state of rest or balance. You know the meaning of this term in the context of a competitive market: the equilibrium price is the one at which the quantity demanded is equal to the quantity supplied. Neither the buyers nor the sellers have reason to move from this spot, unless factors cause the demand or supply curve to shift.

Part A: Short-Run Equilibrium for a Perfectly Competitive Firm

A perfectly competitive firm is in a *short-run equilibrium* position when it produces the output level Q^* at which marginal revenue (MR) is equal to marginal cost (MC). The firm will stay at this output level unless something causes a change in its MR curve or MC curve. In its short-run equilibrium position, the firm could be in any of four profit scenarios as shown in Table 3-7.1.

1. In the last column, circle what you feel the firm should do in each of these cases—produce or shut down.

Table 3-7.1
Four Possible Total Profit Positions of a Firm in Short-Run Equilibrium

Total profit (TΠ) at Q* where MR = MC	Total revenue (TR) compared to total cost (TC) and total variable cost (TVC) at Q*	What should the firm do?
1. TΠ > $0	TR > TC	*Produce Q* / shut down*
2. TΠ = $0	TR = TC	*Produce Q* / shut down*
3. TΠ < $0	TVC < TR < TC	*Produce Q* / shut down*
4. TΠ < $0	TR < TVC < TC	*Produce Q* / shut down*

Note: You will see in Activity 3-8 how a perfectly competitive firm moves from a position of short-run equilibrium to one of long-run equilibrium where it must break even (total profit = $0).

Part B: Short-Run Supply Curve of a Perfectly Competitive Firm

A market supply curve tells you how many units of a good or service producers will provide at different prices, other things being constant. The typical market supply curve is upward sloping because producers will put more units on the market at a higher price. A perfectly competitive firm also has a supply curve that is upward sloping. The basis of its short-run supply curve is its marginal cost curve as shown in the following exercise. Table 3-7.2 has information about some of the daily cost functions of the Fiasco Company, which sells its product in a perfectly competitive market.

   2. Fill in the missing cost values in Table 3-7.2.

Table 3-7.2
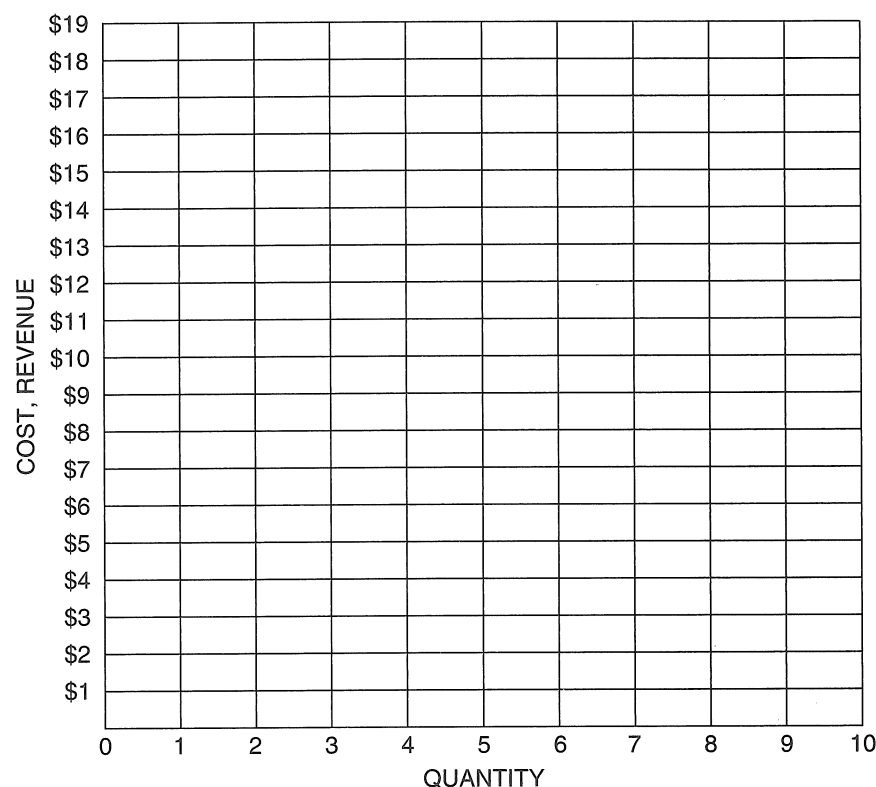### Cost Functions of a Perfectly Competitive Firm

Q	TC	TVC	MC	Average total cost (ATC)	Average variable cost (AVC)
0	$12.00		–	–	–
1		$4.00		$16.00	
2			+$3.00	$9.50	$3.50
3	$21.00				
4		$12.00			
5					$3.60
6			+$9.00		
7	$49.00				
8		$49.00	+$12.00		$6.13
9	$75.00			$8.33	
10				$9.10	

3. In Figure 3-7.1, plot and label the ATC, AVC, and MC curves of the firm. Plot the MC values at the higher of the two output levels. For example, when the firm increases output from 5 units to 6 units, its TC increases by $9, so plot the MC = $9 value at Q = 6. Use a dotted line to draw the MC curve.

Figure 3-7.1
Cost Curves of the Fiasco Company

How many units of Q should the firm produce to maximize its total profit? Given its cost functions, the answer depends on the market price that the perfectly competitive firm must charge for its product. Consider these four possible market prices: $15.00, $11.00, $5.50, and $2.50.

4. In Figure 3-7.1, draw the appropriate marginal revenue curve for each of these prices (P) and label them as follows: MR_1 (for P = $15.00), MR_2 (for P = $11.00), MR_3 (for P = $5.50), and MR_4 (for P = $2.50).

5. Using Figure 3-7.1 and Table 3-7.2, complete Table 3-7.3 and determine how many units of Q the firm should produce at each of the four market prices.

Table 3-7.3

Optimal Output Level for the Fiasco Firm at Different Market Prices

(1) P	(2) Q* (units)	(3) TR	(4) TVC	(5) TFC	(6) TΠ
$15.00					
$11.00					
$5.50					
$2.50					

6. What rule did you use to determine the Q level that would maximize the firm's TΠ if P were $15.00? Why?

7. Did you use this same rule to find the profit-maximizing Q level at P of $11.00? Why?

8. Should the firm shut down if P is $5.50? What if P is $2.50? Explain.

9. Complete Table 3-7.4, which is the supply schedule for the Fiasco Firm. It shows how many units the firm will provide to the market at different prices.

Table 3-7.4
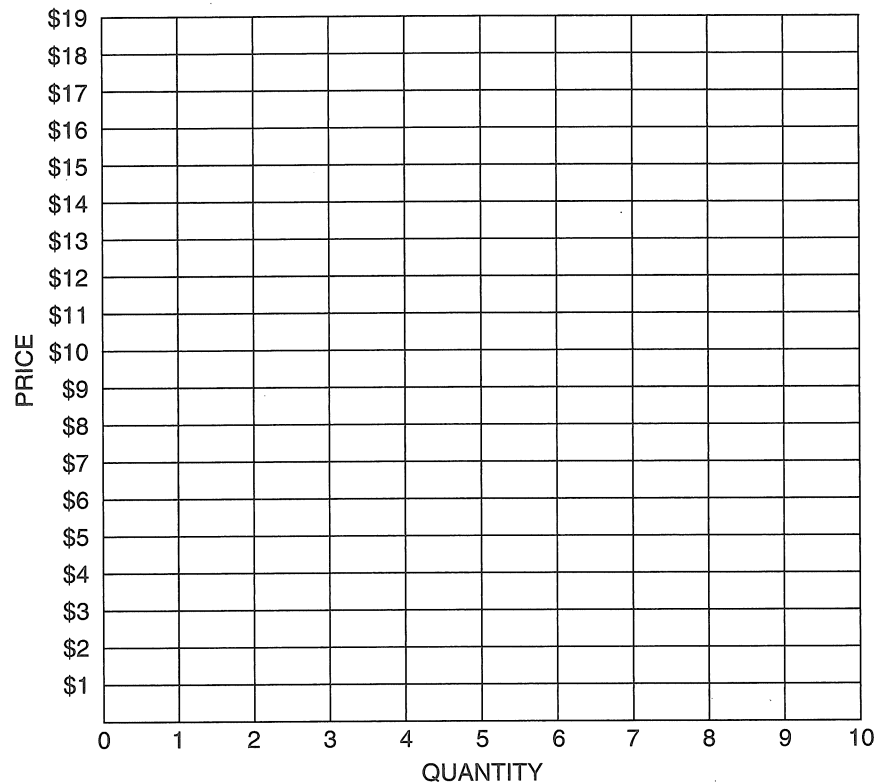
Supply Schedule for the Fiasco Firm

P	Q supplied (units)
$15.00	
$11.00	
$5.50	
$2.50	

10. Plot the supply curve of the Fiasco Firm in Figure 3-7.2. Label the curve as "S."

Figure 3-7.2
Supply Curve of the Fiasco Firm

11. To create the supply curve of this perfectly competitive firm, you used two important rules of profit maximization:

(A) The firm's optimal Q level is the one where _____ = _____.

(B) The firm should shut down if at its best Q level, _____ < _____.

12. In general, the supply curve of a perfectly competitive firm is that part of its _____ cost curve that lies above its _____ cost curve. Refer back to Figure 3-7.1 to see where you went at each of the four prices to find the best Q level for the firm.

13. What is the connection between a perfectly competitive firm having diminishing marginal productivity and its short-run supply curve being upward sloping?

Part C : Short-Run Supply Curve of a Perfectly Competitive Industry

The industry (or market) supply curve tells you how many units will be supplied by all firms at each possible price. To get the industry supply, you add the quantity supplied by each firm at each price. Economists call this *adding horizontally* because you add the quantity supplied (measured on the horizontal axis) at each price. Assume the Fiasco Firm is a typical firm in a perfectly competitive industry with 800 firms.

14. Complete Table 3-7.5. Refer to Table 3-7.4 for how many units a typical firm supplies at each price.

Table 3-7.5

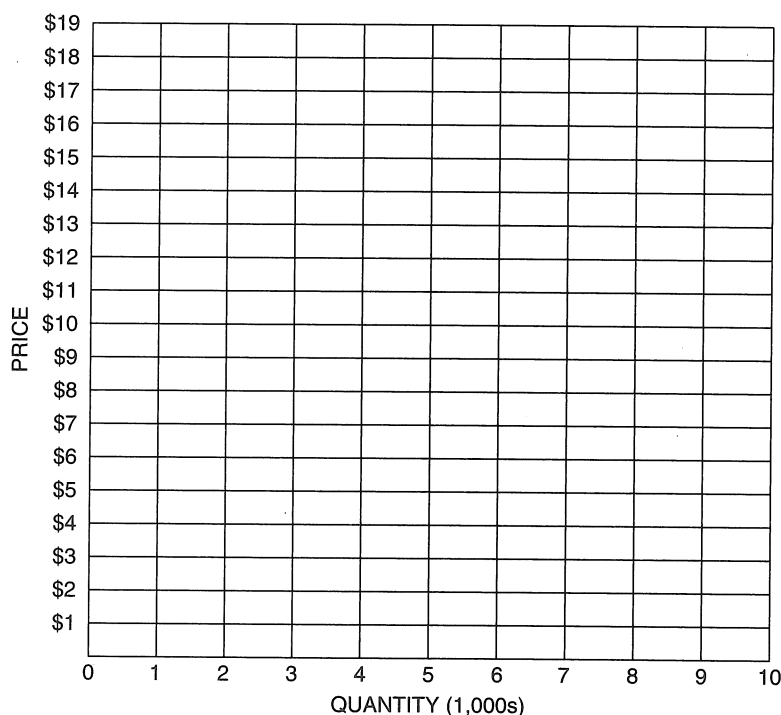### Supply Schedule for the Industry (800 firms)

P	Q supplied (units)
$15.00	
$11.00	
$5.50	
$2.50	

15. Plot the data from Table 3-7.5 in Figure 3-7.3. Is the market supply curve upward sloping? Why?

Figure 3-7.3

Market Supply Curve

Long-Run Equilibrium and Long-Run Supply in Perfect Competition

A firm is in a *short-run equilibrium (SRE)* position when it maximizes its total profit by producing the output level where marginal revenue equals marginal cost: MR = MC. When firms in short-run equilibrium in a perfectly competitive market are earning positive total profits, other firms will enter the market. If firms are making a loss in their short-run equilibrium position, over time some of the firms will exit the market. Eventually the perfectly competitive market reaches a *long-run equilibrium* (LRE) where all of the firms in the industry are earning zero total profits, based on the current market demand. Firms in other industries thus have no incentive to enter this market. And firms in this market have no incentive to leave it because they are earning their normal profit. An industry's *long-run supply* (LRS) curve is the set of LREs where each LRE is based on a different level of market demand. The shape of the LRS curve depends on how the production costs of firms change as the industry expands. The three cases to consider are *constant-cost*, *increasing-cost*, and *decreasing-cost industries*.

Part A: Movement from Short-Run Equilibrium to Long-Run Equilibrium

Table 3-8.1 presents some cost data for a typical firm in the perfectly competitive market for bricks. These cost data are shown in Figure 3-8.1.
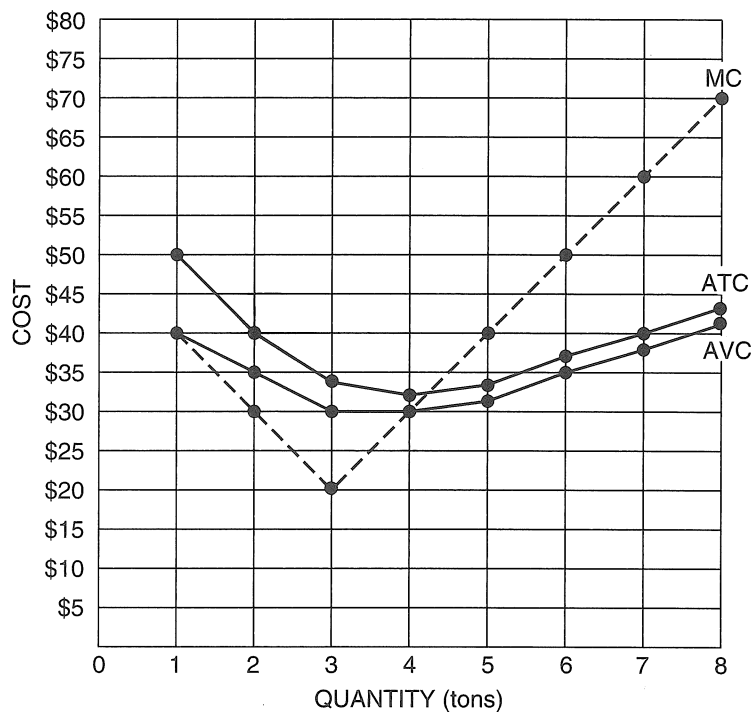
Table 3-8.1
Cost Data for a Typical Perfectly Competitive Firm

Output (Q) (tons)	Average total cost (ATC)	Average variable cost (AVC)	MC
0	–	–	–
1	$50.00	$40.00	+$40.00
2	$40.00	$35.00	+$30.00
3	$33.33	$30.00	+$20.00
4	$32.50	$30.00	+$30.00
5	$34.00	$32.00	+$40.00
6	$36.67	$35.00	+$50.00
7	$40.00	$38.57	+$60.00
8	$43.75	$42.50	+$70.00

Figure 3-8.1
Cost Functions of a Typical Firm

1. Complete Table 3-8.2, which shows how many units a firm will make available at different prices. Assume a firm cannot produce fractions of a unit.

Table 3-8.2
Supply Schedule of a Typical Firm

Price (P)	Quantity supplied (Q_s) (tons)
$70	
$60	
$50	
$40	
$30	
$20	
$10	

2. Assume there are 1,000 firms in the brick industry. Complete Table 3-8.3, which shows the market supply schedule. Information about the market demand schedule is included in Table 3-8.3.

Table 3-8.3
Market Supply and Demand Schedules

P	Q_s (tons)	Quantity demanded (Q_d) (tons)
$70		2,000
$60		3,000
$50		4,000
$40		5,000
$30		6,000
$20		7,000
$10		8,000

3. Figure 3-8.2 shows the market demand curve D_1. Draw the market supply curve S_1 from Table 3-8.3. What is the equilibrium price of bricks? What is the equilibrium quantity? Label the SRE intersection of D_1 and S_1 as "SRE."

Figure 3-8.2
The Market for Bricks
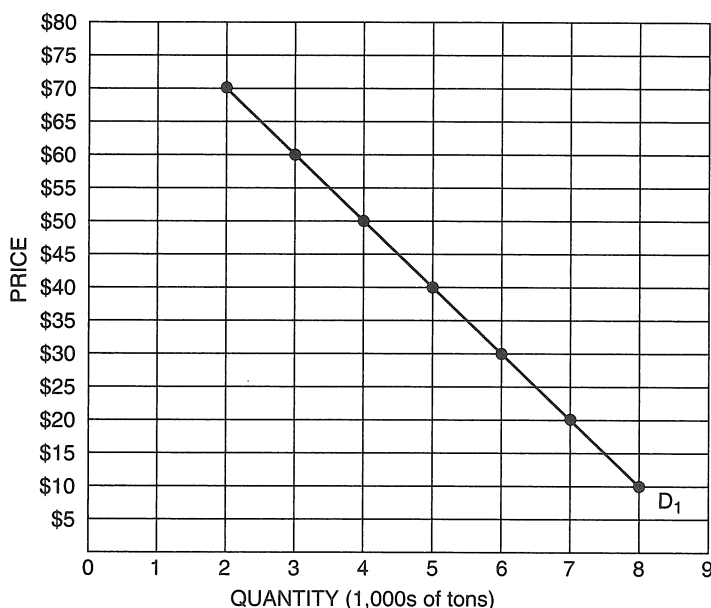
4. In Figure 3-8.1, draw the marginal revenue (MR$_1$), average revenue (AR$_1$), and demand (D$_1$) curves of a firm at the equilibrium price. How many units will the firm produce to maximize its total profit? (Assume the firm cannot produce fractions of a unit.) Does this number agree with your work in Table 3-8.2?

5. What is the value of the firm's average profit? What is the value of its total profit? In Figure 3-8.1, shade in the area representing its total profit.

6. Is the industry in a position of LRE? How do you know?

7. Why will other firms want to enter this industry? Assume the cost curves of a typical firm in the industry do not change as new firms enter.

8. As more firms enter the industry, the market supply curve shifts to the (*right / left*), which makes the market price (*increase / decrease*).

9. The industry is in a position of LRE when all firms break even based on the current level of market demand D$_1$. What is the LRE price? Why?

10. In Figure 3-8.2, draw the new market S curve (label it S$_2$) that will result in this LRE price. Do not change the existing market demand curve D$_1$. Label the LRE point as "LRE."

11. In Figure 3-8.1, draw the firm's MR_2, AR_2, and D_2 curves at the LRE price. How many units will the typical firm produce at this price? What is the total profit of a firm in this LRE position?

12. If all firms in the market earn $0 in economic profit, will other firms still want to enter the market? Will some firms want to exit the market? Why?
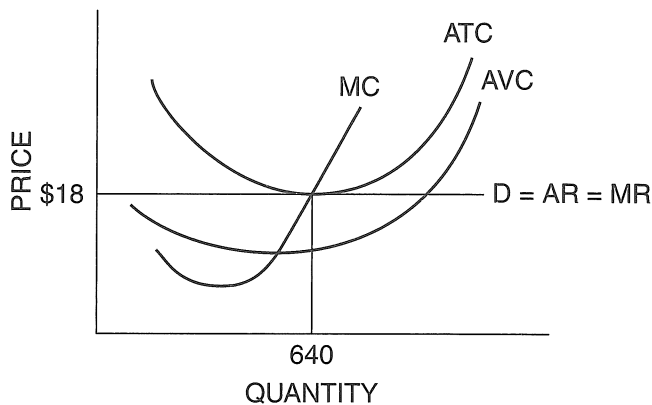
Part B: Long-Run Equilibrium for a Perfectly Competitive Firm

Let's leave the brick market and move to some other perfectly competitive market. Figure 3-8.3 shows a perfectly competitive firm in LRE, selling 640 units at a price of $18.

Figure 3-8.3
A Perfectly Competitive Firm in Long-Run Equilibrium

13. What does it mean for a firm to be productively efficient? Is this firm productively efficient? How do you know?

14. What does it mean for a firm to be allocatively efficient? Is this firm allocatively efficient? How do you know?

Part C: Long-Run Supply for a Perfectly Competitive Industry

The industry shown in Figure 3-8.4 is in LRE at point A with supply curve S_1 and demand curve D_1. The market price is $20, and the equilibrium quantity is 500 units. Now the demand for the industry's product increases to D_2. The price increases to $27 and quantity increases to 620 units. Because this boost in the market price results in positive total profits for firms in the industry, point B is considered a *short-run equilibrium (SRE)*. How the industry moves to its new LRE in response to this increase in demand depends on whether it is a constant-cost, increasing-cost, or decreasing-cost industry.

Figure 3-8.4
A Perfectly Competitive Industry
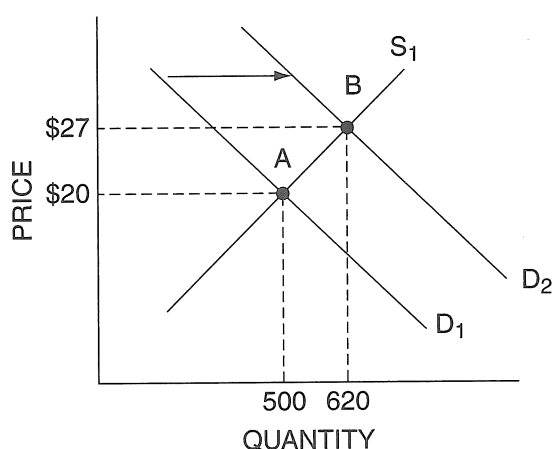
15. Assume the industry is a constant-cost industry. Explain how the industry moves to its new LRE. Show changes in supply and/or demand in Figure 3-8.4 and indicate the new LRE as point C.

16. Is the new LRE price greater than, equal to, or less than $20? Why?

17. The industry's LRS curve is the collection of LREs where each LRE is based on a different market demand curve. Draw a line connecting point A and point C, and label this line as "LRS." Is the LRS curve of a constant-cost industry upward sloping, horizontal, or downward sloping? What does this tell you about how price and quantity change as the industry expands in response to increases in demand?

18. Now assume the industry is an increasing-cost industry. In Figure 3-8.5, the industry is in LRE at point A. When demand increases to D_2, the industry moves to SRE at point B, where firms enjoy positive total profit. Explain how the industry moves to its new LRE. Show changes in supply and/or demand in Figure 3-8.5 and indicate the new LRE as point C.

Figure 3-8.5
A Perfectly Competitive Industry
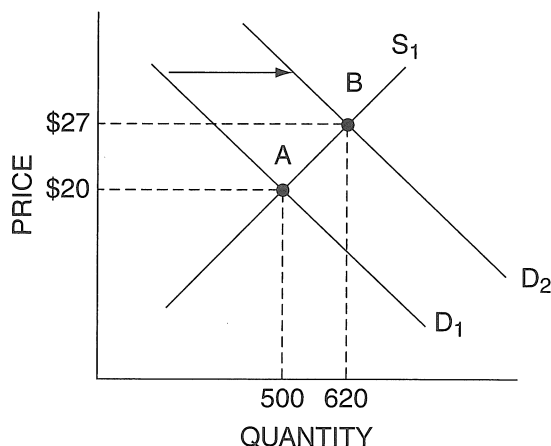
19. Is the new LRE price greater than, equal to, or less than $20? Why?

20. Draw a line connecting point A and point C, and label this line as "LRS" for long-run supply. Is the LRS curve of an increasing-cost industry upward sloping, horizontal, or downward sloping? What does this tell you about how price and quantity change as the industry expands in response to increases in demand?

21. If the industry were a decreasing-cost industry, what would happen to the market price and quantity as the industry expanded? What would be the shape of the industry LRS curve?

Graphing Perfect Competition

Figures 3-9.1 through 3-9.6 show side-by-side graphs of perfectly competitive industries and firms. Each pair of graphs illustrates the specific situation that is given.

(A) For the industry's graph, draw the supply (S) and demand (D) curves. Indicate by P* and Q* the equilibrium price and quantity.

(B) For the firm's graph, draw the average total cost (ATC), average variable cost (AVC), average revenue (AR), and demand (D) curves. Indicate by P* and Q* the firm's optimal price and output.

(C) Explain the reasoning for your graphs in each situation.

1. A firm earning positive total profit in the short run.

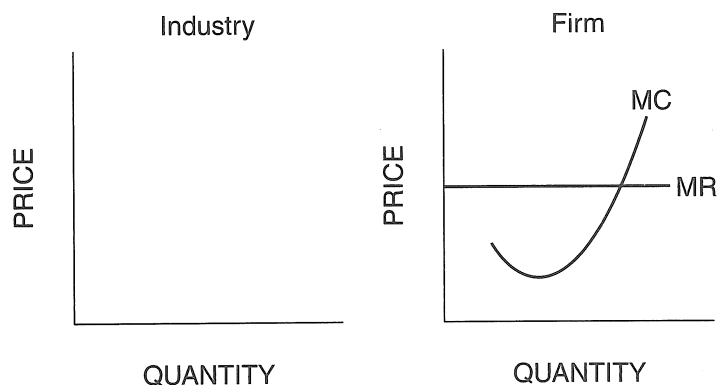Figure 3-9.1
Short-Run Economic Profit
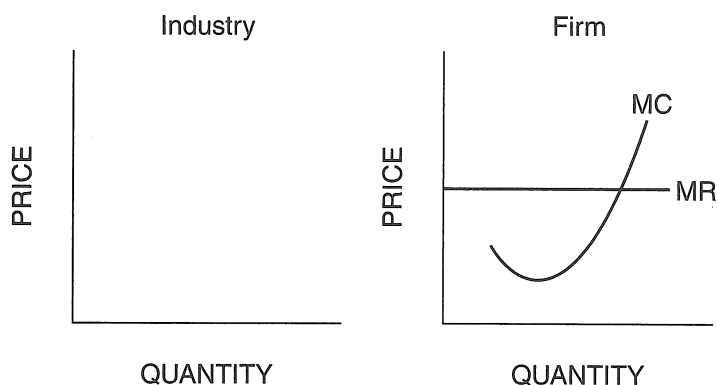
Explanation:

2. A firm operating with an economic loss but not wanting to shut down in the short run.

Figure 3-9.2
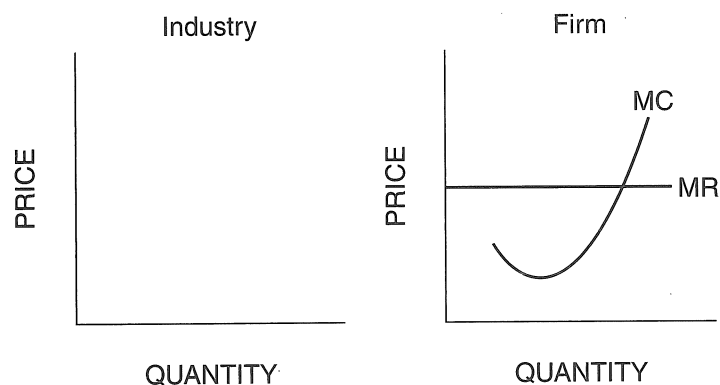**Short-Run Economic Loss but Not Shutting Down**

Explanation:

3. A firm in a classic shutdown position in the short run.

Figure 3-9.3
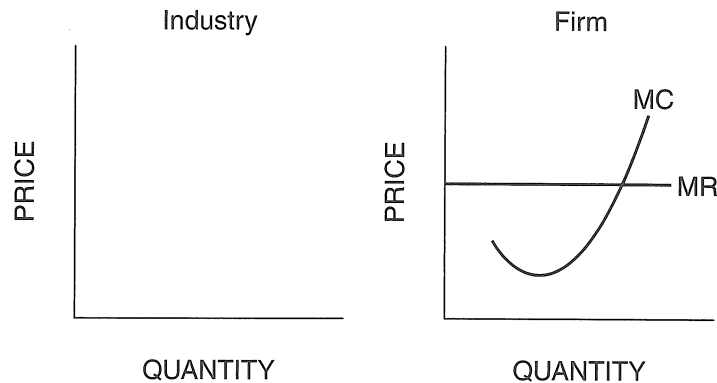**Classic Shutdown Position**

Explanation:

4. LRE for a firm and the industry.

Figure 3-9.4
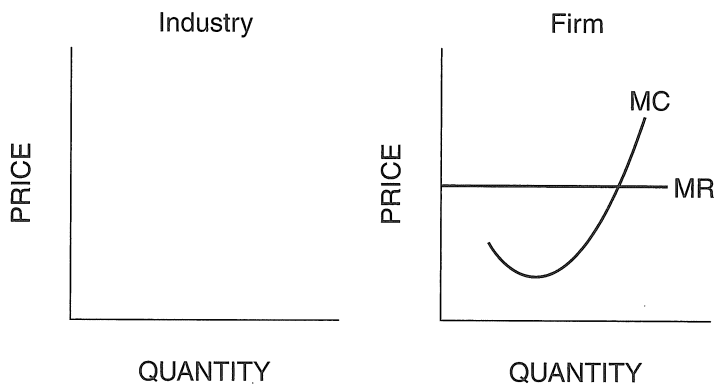**Long-Run Equilibrium**

Explanation:

5. Illustrate how economic profits will disappear in the long run.

Figure 3-9.5
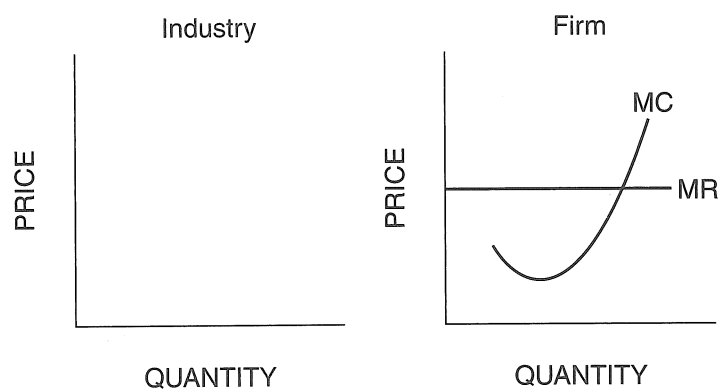**From Short-Run Profit to Long-Run Equilibrium**

Explanation:

6. Illustrate how economic losses will disappear in the long run.

Figure 3-9.6
From Short-Run Loss to Long-Run Equilibrium

Explanation:

The Revenue Functions of a Monopoly

At the opposite end of the market spectrum from perfect competition is monopoly. A monopoly exists when only one firm sells the good or service. This means the monopolist faces the market demand curve since it has no competition from other firms. If the monopolist wants to sell more of its product, it will have to lower its price. As a result, the price (P) at which an extra unit of output (Q) is sold will be greater than the marginal revenue (MR) from that unit.

Student Alert: **P is greater than MR for a monopolist.**

1. Table 3-10.1 has information about the demand and revenue functions of the Moonglow Monopoly Company. Complete the table. Assume the monopoly charges each buyer the same P (i.e., there is no price discrimination). Enter the MR values at the higher of the two Q levels. For example, since total revenue (TR) increases by $37.50 when the firm increases Q from two to three units, put "+$37.50" in the MR column for Q = 3.

Table 3-10.1
The Moonglow Monopoly Company

Q	P	TR	MR	Average revenue (AR)
0	$100.00		–	–
1				$87.50
2		$150.00		
3	$62.50		+$37.50	
4				$50.00
5		$187.50		
6	$25.00			
7			–$62.50	
8		$0.00		

2. Draw the demand (D), AR, and MR curves in Figure 3-10.1. Plot the MR values at the higher of the two Q levels.

Figure 3-10.1
Monopoly's Demand, Average Revenue, and Marginal Revenue Curves
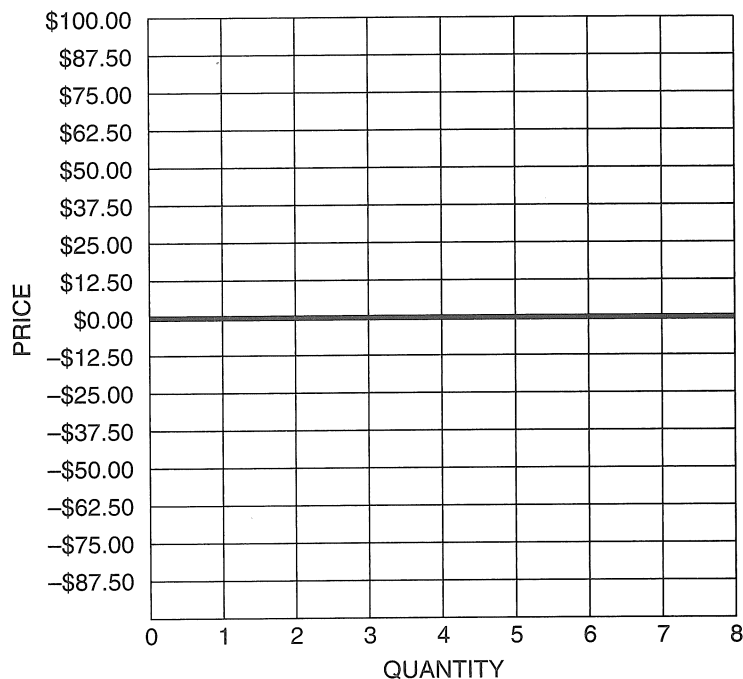
3. Plot the firm's TR curve in Figure 3-10.2.

Figure 3-10.2
Monopoly's Total Revenue Curve

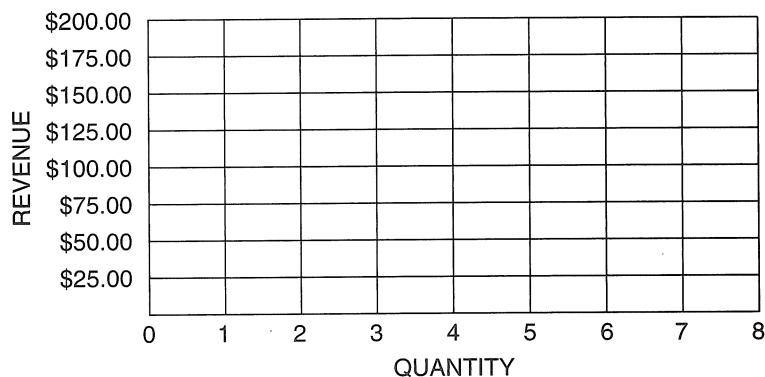4. We see in Table 3-10.1 that the price at which the firm can sell three units is $62.50. Yet the MR from the third unit is only $37.50. How do you explain this difference?

5. Why does the vertical gap between the firm's D curve and MR curve get larger as the firm sells more output?

Table 3-10.1 is an example of a *discrete* case because it has a small number of observations (output varies from zero to eight units). Figure 3-10.3 is an example of a *continuous* case because it is based on a large number of observations. Answer Questions 6–8 based on Figure 3-10.3.

Figure 3-10.3
A Continuous Example of a Monopoly's Revenue Curves
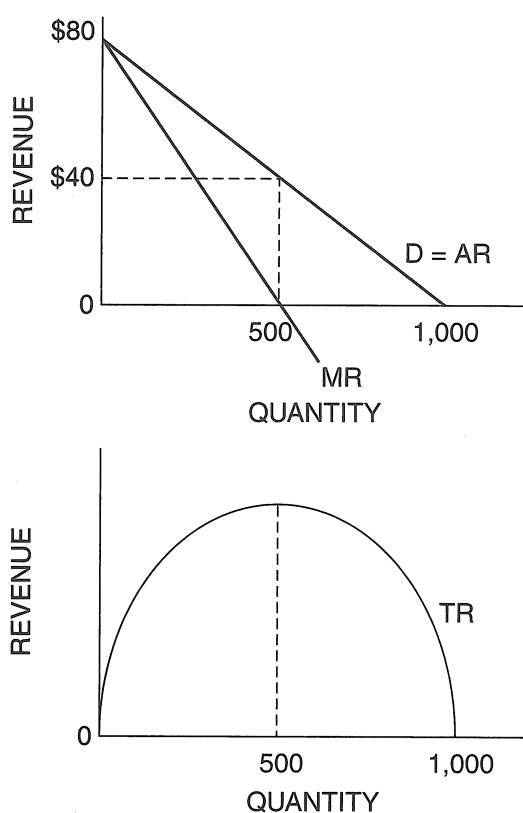
6. Indicate clearly in the top graph of Figure 3-10.3 the elastic, unitary elastic, and inelastic portions of the D curve. Explain your answer.

7. Marginal revenue is found using the ratio $MR = \Delta TR/\Delta Q$. This is also the formula for the slope of the TR curve. Thus, MR = slope of the TR curve.

   (A) Over what range of output is the slope of the TR curve positive? Over what range of output is the firm's MR positive?

   (B) Over what range of output is the firm's MR negative? Over what range of output is the slope of the TR curve negative?

   (C) Over what range of output is the slope of the TR curve equal to zero? Over what range of output is the firm's MR equal to zero?

8. What is the maximum dollar value of TR this firm can receive?

Bonus Question!

9. When the Galaxy Firm lowers its price from $60 to $57, the number of units it sells increases from 36 to 39. What is the value of MR? How should you interpret this value?

Profit Maximization by a Monopoly

The profit-maximizing monopolist works with the same key rules as any firm:

1. The optimal output level (Q*) is the one where marginal revenue equals marginal cost (MR = MC).

2. The optimal price (P*) is found on the demand curve at output Q*.

3. The firm should shut down if at Q* it finds its total revenue is less than its total variable cost (TR < TVC).

   Because price (P) and MR were equal for a perfectly competitive firm, that firm could also find its Q* by setting P = MC. But that is not the case for a monopoly since P and MR will be different. The monopolist will find its profit-maximizing output (Q) where MR = MC, not where P = MC. This activity shows how a monopolist finds the output at which it will maximize its total profit and the price it should charge for that output.

Part A: Determining the Optimal Output and Price for a Monopoly

Table 3-11.1 provides some revenue, cost, and profit data for a monopoly.

1. Complete Table 3-11.1. Enter the MR and MC values at the higher of the two output levels. For example, the MR value of $300 is placed at Q = 4 rather than at Q = 3.

   Be sure to distinguish between total profit (TΠ), average profit (AΠ), and marginal profit (MΠ):

   (A) TΠ = TR – TC = (Q) (AΠ)

   (B) AΠ = AR – ATC = TΠ/Q

   (C) MΠ = MR – MC = ΔTΠ/ΔQ

Table 3-11.1
Revenue, Cost, and Profit Values for a Monopoly

Q	P	TR	TC	TΠ	AR	ATC	AΠ	MR	MC	MΠ
0	$1,350		$100		–	–	–	–	–	–
1				$300	$1,200	$900			+$800	
2		$2,100	$1,600				$250			+$200
3	$900			$600						
4					$750		$150	+$300		
5	$600		$2,800							–$400
6		$2,700				$600			+$800	

2. In Figure 3-11.1, draw the monopolist's D, AR, MR, ATC, and AVC curves using the data from Table 3-11.1. Plot the MR and MC values at the higher of the two output levels rather than at the midpoint between the two levels. Use dotted lines for the MR and MC curves in your graph. Label each curve.

Figure 3-11.1
Revenue and Cost Curves of a Monopolist
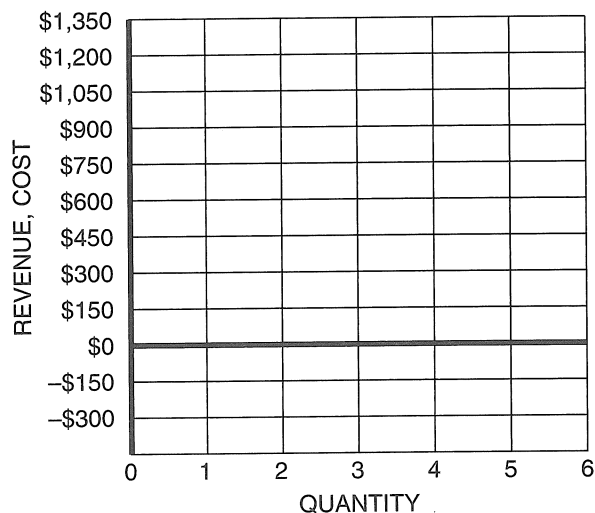
3. To maximize its total profit, this monopolist should produce _____ units.

4. What price should the monopolist charge for each of these units?

5. What is the total profit this firm will earn? _____ Shade in the total profit area in Figure 3-11.1.

Part B: Other Monopoly Examples

6. Suppose a monopolist can sell an extra unit of its good at a price of $50 and the MR of that unit is $44. If the MC of producing the extra unit is $46, the firm's total profit would (*increase / decrease*) by _____ if the firm sells that unit. Should the firm produce this additional unit of output? Explain your answer.

7. Figure 3-11.2 shows the MR and MC curves of a monopolist. Economists claim that the firm will maximize its total profit by producing 800 units where MR = MC. Show your understanding of this rule by circling the correct answer in each cell of Table 3-11.2.

Figure 3-11.2
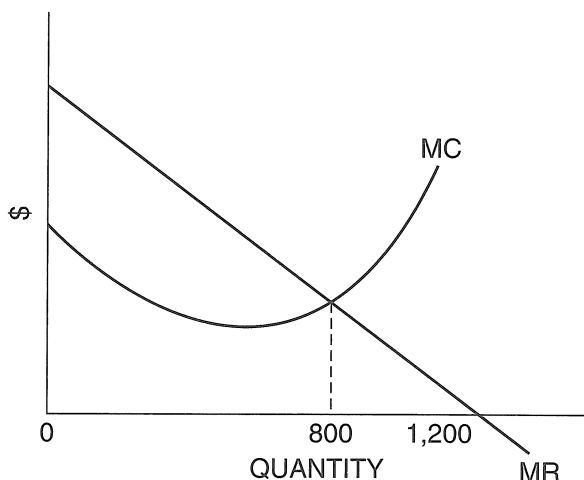
Table 3-11.2
The Logic behind the "MR = MC" Rule

Units of Q	For each extra unit of output in this range:		
1–799	MR is (> / = / <) MC.	MΠ is (> / = / <) $0.	TΠ will (*rise / fall / not change*).
800	MR is (> / = / <) MC.	MΠ is (> / = / <) $0.	TΠ will (*rise / fall / not change*).
801–1200	MR is (> / = / <) MC.	MΠ is (> / = / <) $0.	TΠ will (*rise / fall / not change*).

8. The firm illustrated in Figure 3-11.2 will maximize its total revenue if it produces 1,200 units. So why does it not want to produce those units between 800 and 1,200?

9. The monopolist's profit-maximizing output level will be in the (*elastic / unitary elastic / inelastic*) range of its demand curve. Explain.

Equilibrium in a Monopolistic Market

Part A: Equilibrium in a Perfectly Competitive Market

Consider Figure 3-12.1, which shows a perfectly competitive market. The market supply curve S is the horizontal summation of the marginal cost (MC) curves of all the firms in the market. Use Figure 3-12.1 to answer the questions that follow the graph.

Figure 3-12.1
Equilibrium in a Perfectly Competitive Market
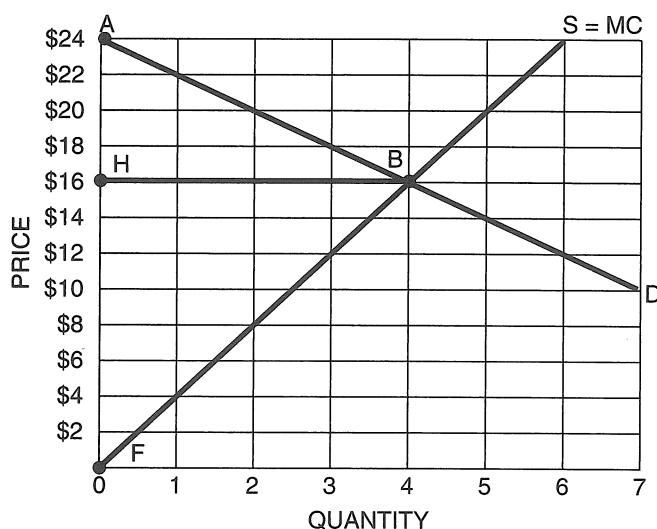
1. What is the equilibrium quantity in the market?

2. What is the equilibrium price?

3. What area of the graph represents consumer surplus in the market? Calculate the dollar value of consumer surplus.

4. What area of the graph represents producer surplus in the market? Calculate the dollar value of producer surplus.

5. What area of the graph represents total surplus (also called social welfare or total welfare)? Calculate the dollar value of total surplus.

Part B: Equilibrium in a Monopolistic Market

Now consider the same demand and cost curves, but assume the market is a monopoly. Because the monopoly faces the downward sloping market demand curve, it must reduce its price to sell more output, which means price will be greater than marginal revenue (MR). We add the firm's MR curve below its demand curve in Figure 3-12.2, as well as the monopolist's MC curve. Use Figure 3-12.2 to answer the questions that follow the graph.

Figure 3-12.2
Equilibrium in a Monopolistic Market
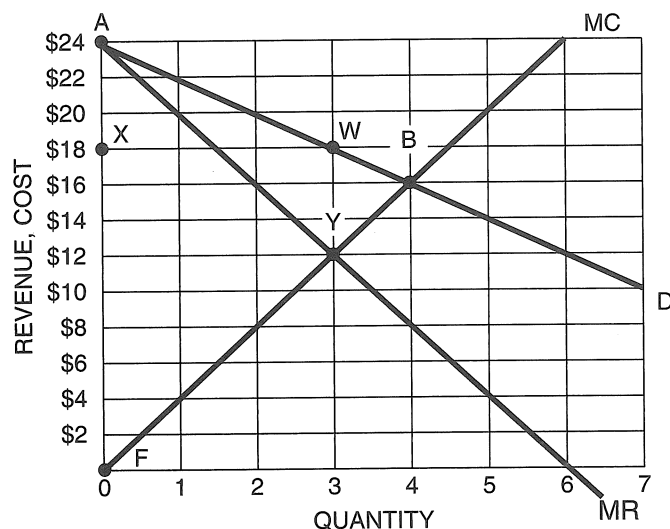
6. What output level will the monopolist produce? Why?

7. What price will the monopolist charge for this output? Why?

8. What area of the graph represents consumer surplus in the market? Calculate the dollar value of consumer surplus.

9. What area of the graph represents producer surplus? Calculate the dollar value of producer surplus.

10. What area of the graph represents total surplus? Calculate the dollar value of total surplus.

Part C: Comparing Equilibrium in the Two Markets

11. How do the price and output of a monopolist differ from those in the perfectly competitive market?

12. What is the dollar value of the portion of consumer surplus in the competitive market that is transferred to the firm's producer surplus in the monopoly situation?

13. How does a monopoly affect consumer surplus? Is this good or bad from the perspective of consumers?

14. What area of Figure 3-12.2 represents the deadweight loss resulting from the market being a monopoly? Calculate the dollar value of the deadweight loss.

Price Discrimination

When producers have market power and sell a good or service that cannot be resold, the possibility of price discrimination arises. *Price discrimination* exists when a producer charges different prices to different customers for the same item, for reasons other than differences in cost. The seller needs to be able to divide the total market for the good into separate submarkets, each with a different demand for the good. There also must be no possibility of resale of the product between the submarkets; otherwise the different submarkets will collapse into a single market.

Part A: Regular Monopoly with No Price Discrimination

Pat's Patriotic Tattoos is the only tattoo parlor in town. Pat provides only one tattoo—the American flag. There are 10 consumers in town who are willing to buy one tattoo, and they vary in their willingness to pay. One consumer is willing to pay $20 for a tattoo, another is willing to pay $18, and so forth, down to the tenth consumer who is willing to pay only $2. Table 3-13.1 shows the demand schedule for Pat's flag tattoo.

1. Complete Table 3-13.1 assuming the firm can only charge one price for its service. (There is no price discrimination yet.) If Pat wants to sell three units, she will sell all three units at a price of $16, so her TR is $48. Put each MR value at the higher of the two output levels.

Table 3-13.1
Demand Schedule for Pat's Tattoo

Price	Quantity	Total revenue (TR)	Marginal revenue (MR)
$20	1		+$20
$18	2		
$16	3	$48	
$14	4		
$12	5		+$4
$10	6		
$8	7		
$6	8		
$4	9	$36	−$12
$2	10		

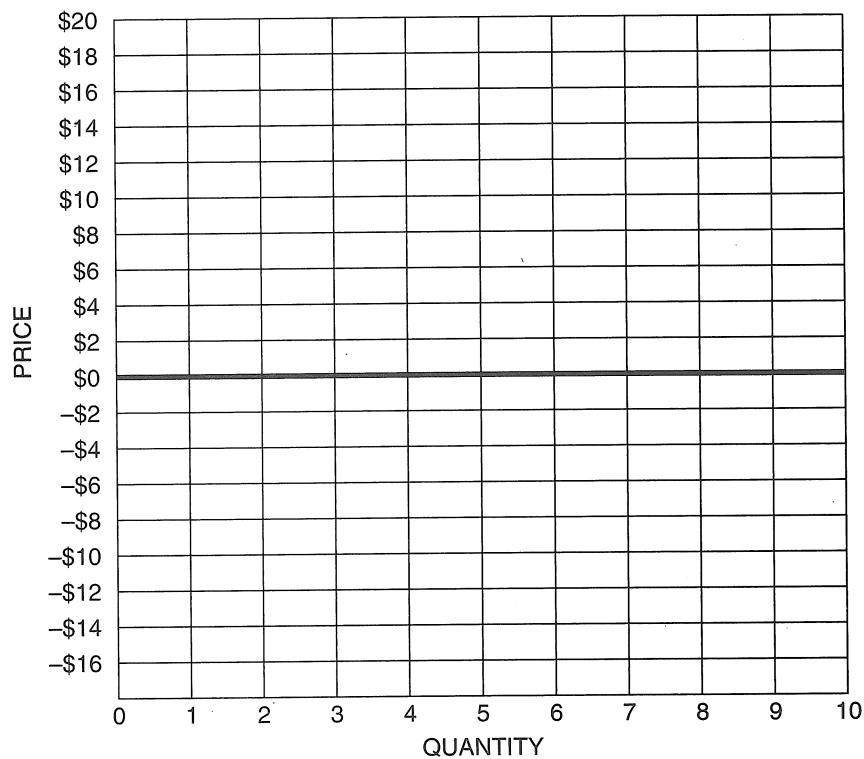2. What is the total consumer surplus if Pat sells three units at a price of $16?

3. What is the total consumer surplus if she sells five units at a price of $12?

4. In Figure 3-13.1, draw the demand curve for Pat's tattoos.

Figure 3-13.1
Demand for Pat's Tattoos

Part B: Perfect Price Discrimination (Also Called First-Degree Price Discrimination)

Perfect price discrimination is a monopolist's dream because it means that the firm can charge each individual consumer the highest price that he or she is willing to pay for the firm's product. As we will see in this activity, perfect price discrimination eliminates all consumer surplus and increases the monopolist's total profit above what it would if the firm sold all output at one price. For the questions in this section, assume that Pat's average total cost and marginal cost are constant and equal to $8 (ATC = MC = $8).

5. In Figure 3-13.1, draw the firm's ATC=MC curves as a horizontal line at $8.

6. If this were a perfectly competitive market, the MC curve would represent the supply of the product. If Pat produces the perfectly competitive quantity and charges the perfectly competitive price:

   (A) How many tattoos will she supply? Why?

   (B) What price will she charge for each tattoo? Why?

   (C) What is the amount of consumer surplus? Why?

7. If Pat produces the monopoly quantity and charges the monopoly price:

   (A) Draw her marginal revenue (MR) curve in Figure 3-13.1.

   (B) How many tattoos will she supply? Why?

   (C) What price will she charge for each tattoo? Why?

   (D) What is the amount of consumer surplus? Why?

---

8. Now assume Pat knows the tastes and preferences of all consumers and the conditions necessary for first-degree price discrimination apply.

   (A) Does the MR curve for the non-discriminating monopolist still apply? Why?

   (B) How many tattoos will she supply? Why?

   (C) Complete Table 3-13.2, which shows what price she will charge each individual consumer for her/his tattoo.

Table 3-13.2
Prices Charged by a Perfectly Discriminating Monopsonist

Consumer	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Price										

   (D) What is the amount of consumer surplus?

9. In Table 3-13.3, show Pat's total profit under each of the three market structures. Remember our assumption that ATC = MC = $8.

Table 3-13.3
Profit in Each Market Structure

Type of market	Pat's total profit
Perfect competition	
Regular monopoly	
Perfect price discrimination monopoly	

10. How does the total profit of the perfectly discriminating monopolist compare to the consumer surplus that existed in the perfectly competitive market? [See Question 6 (C).] Why?

11. Is the total profit for a regular monopolist different from the total profit of a monopolist that is able to practice perfect price discrimination? Why?

12. Is the output the same for perfect competition and perfect price discrimination? Why?

13. Is there a deadweight loss resulting from the non-discriminating monopolist? What about from the monopolist with first-degree price discrimination?

14. If an orange sells in Nebraska for $1.00 and the same quality orange sells in Florida for only $0.50, is this clear evidence of price discrimination? Why?

15. What is an example of price discrimination that works in favor of students?
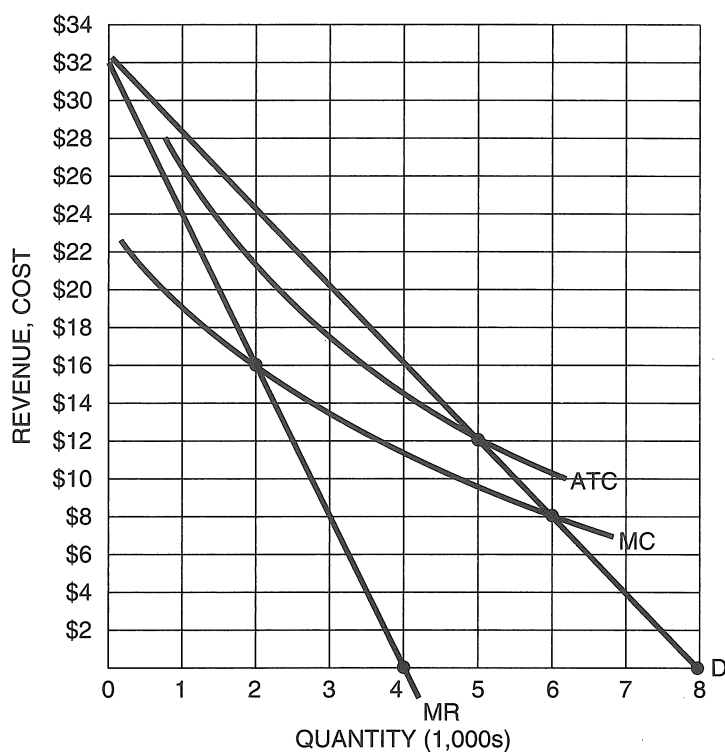
Regulating a Monopoly

There are some firms that have decreasing marginal costs over a large range of output. As long as marginal cost (MC) is below average total cost (ATC), the firm also will experience decreasing ATC. Such firms are called *natural monopolies* and are often regulated by a governmental agency that allows the firm to be the only provider of the service. This is an attempt to take advantage of the low average total cost of the firm. This activity lets you explore several regulation plans and their effects on the firm and the market.

Suppose you are the manager of a local natural monopoly. Figure 3-14.1 illustrates the revenue and cost functions of your monopoly.

Figure 3-14.1
Revenue and Cost Functions

1. Complete Table 3-14.1, which examines three possible pricing plans for the monopoly.

Table 3-14.1
Three Pricing Regulation Plans

	Output (Q)	Price (P)	Total revenue (TR)	Total cost (TC)	Average profit (AΠ)	Total profit (TΠ)
Unregulated monopoly						
Fair return pricing						
Socially optimal pricing						

2. In Figure 3-14.1, shade in the area representing your firm's total profit under each of the three regulation plans.

3. As the manager of this firm, which of the three regulation plans would you prefer? Why?

4. As the manager of the firm, which plan would you totally oppose? Why? What could the government do to make this plan acceptable to you?

5. Which plan would society like to see the government agency apply to your firm? Why?

6. Under the fair return pricing plan, does your firm earn an economic profit? Does it earn a normal profit?

7. Each of the three plans has its own rule for deciding how many units of output your firm will provide. State those rules.

Comparing Perfect Competition and Monopoly

The productivity and cost curves of a firm are the same regardless of the degree of competition the firm faces in the product market. The shapes of the productivity and cost curves depend on the productivity of resources and the prices the firm pays to acquire those resources. It is on the revenue side of the firm that we find the impact of the type of product market in which the firm sells its good or service.
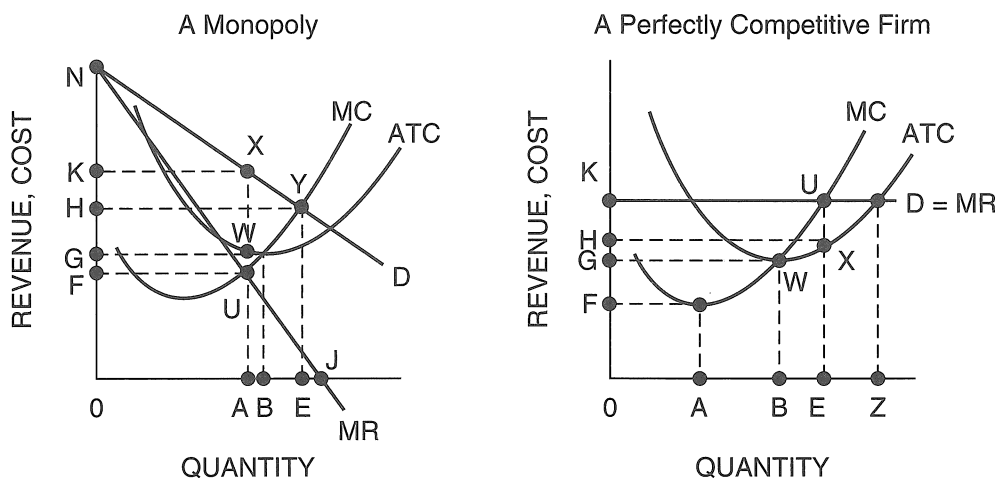
Part A: A Comparison of Firms

Answer the following questions based on Figure 3-15.1, which shows the revenue and cost functions of a monopoly and a perfectly competitive firm. Assume the monopoly will charge only one price for output (i.e., it does not price discriminate).

Figure 3-15.1
Revenue and Cost Functions for a Monopoly and a Perfectly Competitive Firm

Note: The values of coordinates are not the same in both graphs. For example, the value of 0K is greater in the monopoly graph than is the value of 0K in the graph of the competitive firm.

1. The monopoly will maximize its total profit by producing _____ units of output.

   (A) 0A   (B) 0B   (C) 0E   (D) 0J

2. The perfectly competitive firm will maximize its total profit by producing _____ units of output.

   (A) 0A   (B) 0B   (C) 0E   (D) 0Z

3. The profit-maximizing price for the monopoly is

   (A) 0F.   (B) 0G.   (C) 0H.   (D) 0K.

4. The profit-maximizing price for the perfectly competitive firm is

   (A) 0F.   (B) 0G.   (C) 0H.   (D) 0K.

5. The maximum total profit of the monopoly is shown by the coordinates

   (A) AX.   (B) UX.   (C) GWXK.   (D) 0AXK.

6. The maximum total profit of the perfectly competitive firm is shown by the coordinates

   (A) EU.   (B) UX.   (C) 0EUK.   (D) HXUK.

7. The maximum average profit of the perfectly competitive firm is at output

   (A) 0A.   (B) 0B.   (C) 0E.   (D) 0Z.

8. The marginal profit of the monopoly is $0 at output

   (A) 0A.   (B) 0B.   (C) 0E.   (D) 0J.

9. The marginal profit of the perfectly competitive firm is $0 at output

   (A) 0A.   (B) 0B.   (C) 0E.   (D) 0Z.

10. The marginal profit of the perfectly competitive firm is maximized at output

    (A) 0A.   (B) 0B.   (C) 0E.   (D) 0Z.

11. At output 0A, the total cost of the monopoly is shown by the coordinates

    (A) AU.   (B) AW.   (C) 0AUF.   (D) 0AWG.

12. The monopolist will maximize its total revenue at output

    (A) 0A.   (B) 0B.   (C) 0E.   (D) 0J.

13. What price will the perfectly competitive firm charge when it is in long-run equilibrium?

    (A) 0F   (B) 0G   (C) 0H   (D) 0K

14. What area represents consumer surplus when the monopoly maximizes its total profit?

    (A) KXN   (B) 0AXN   (C) GWXN   (D) HYN

15. The profit-maximizing output of the monopoly is _____ the output society would like the firm to produce.

    (A) greater than   (B) equal to   (C) less than

16. The profit-maximizing output of the perfectly competitive firm is _____ the output society would like the firm to produce.

    (A) greater than   (B) equal to   (C) less than

17. Is the perfectly competitive firm in a position of long-run equilibrium?

    (A) Yes   (B) No   (C) We need more information.

---

18. Which firm will operate at the minimum point of its ATC curve in long-run equilibrium?

   (A) Only the perfectly competitive firm

   (B) Only the monopolistic firm

   (C) Both firms

   (D) Neither firm

Part B: A Comparison of Markets

Figure 3-15.2 shows a perfectly competitive market with demand curve D and supply curve S. The equilibrium output is Q_2, and the equilibrium price is 0F. If the market were to become a monopoly, the firm would restrict output to some smaller output such as Q_1. Answer the questions below Figure 3-15.2.

Figure 3-15.2
Comparing Perfect Competition and Monopoly
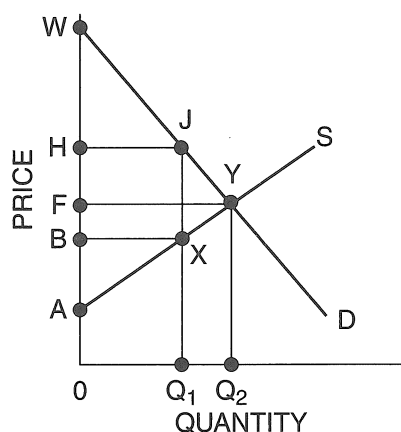
19. Complete Table 3-15.1 with the coordinates of the variables under each type of market.

Table 3-15.1
Comparing Perfect Competition and Monopoly

Market type	Consumer surplus	Producer surplus	Total surplus*
Perfect competition			
Monopoly			
*Total surplus is also called total welfare and social welfare.			

20. Explain what the triangle JXY represents.

Monopolistic Competition

Monopolistic competition is an appropriate name for this important market structure. There is competition because there is a large number of firms producing similar but not identical products. Each firm has some monopoly power over price because its product is different from others with which it is competing. Each monopolistically competitive firm faces a downward sloping demand (D) curve so it has to reduce its price to have consumers buy more of its product. This means it has a downward sloping marginal revenue (MR) curve that lies below its D curve. In fact, the revenue graph of a monopolistically competitive firm looks like the revenue graph of a monopoly.

A monopolistically competitive firm is similar to a perfectly competitive firm because while it can earn a positive total profit in its short-run equilibrium, it will break even in its long-run equilibrium. It is different from a monopoly in this regard because a monopoly can maintain a positive total profit in the long run as long as it has barriers to entry that prevent other firms from coming into the market.

Part A: Short-Run Equilibrium of a Monopolistically Competitive Firm

A monopolistically competitive firm is in short-run equilibrium when it produces the output where marginal revenue equals marginal cost (MR = MC). Its optimal price is found on its demand curve at this output level. Like other firms, the firm will shut down if at its best output level, its total revenue is less than its total variable cost. Figure 3-16.1 shows a monopolistically competitive firm in short-run equilibrium with an output of 600 units per period. Answer the questions that follow the graph.

Figure 3-16.1
A Monopolistically Competitive Firm in Short-Run Equilibrium
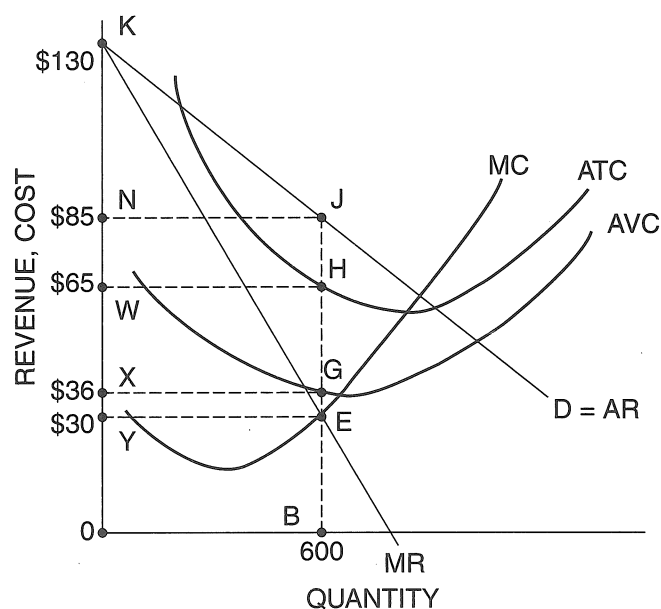
1. What price will the firm charge for its profit-maximizing output?

2. What are the dollar values and coordinates of these items at the output of 600 units?

   (A) Total revenue

   (B) Total cost

   (C) Total profit

   (D) Average profit

   (E) Marginal profit

3. What is the value of the firm's total fixed cost at 600 units? What is the value of its total fixed cost at 0 units?

4. Should this firm shut down? Why?

5. On the horizontal axis, indicate by Q_1 the output level society would like this firm to produce. Why does the firm not want to produce Q_1?

6. On the horizontal axis, indicate by Q_2 the output level at which this firm would maximize its total revenue. Why does the firm not want to produce Q_2?

7. What are the dollar value and the coordinates of consumer surplus when the firm maximizes its total profit?

Part B: Movement from Short-Run Equilibrium to Long-Run Equilibrium

If firms in a monopolistically competitive market are earning positive economic profits, other firms have an incentive to enter this market. As they do so, each firm's share of the total market demand gets smaller and smaller. This means the demand curve facing a monopolistically competitive firm shifts to the left. This process continues until all firms remaining in the industry break even. Outside firms then will no longer have an incentive to enter the market, and existing firms will have no reason to leave because they are receiving their normal profit. Figure 3-16.2 shows the demand and average total cost curves for a typical firm in the monopolistically competitive market for sport shirts.

Figure 3-16.2

Movement of a Monopolistically Competitive Firm to Long-Run Equilibrium
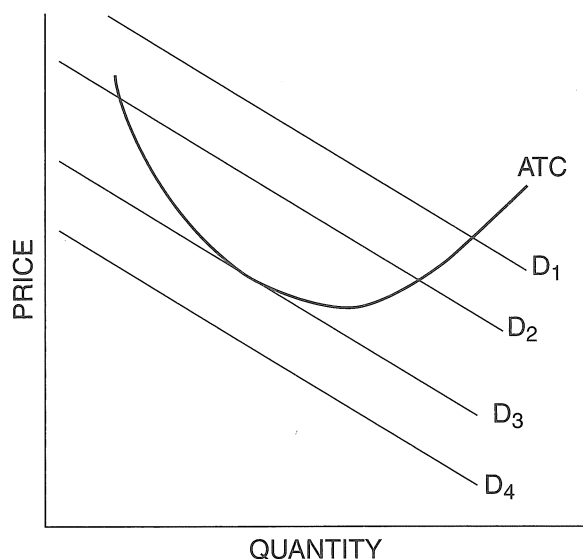
8. If the demand curve for this firm is D_1, is the firm earning positive total profit? If so, will other firms enter the market? What will this do to this firm's share of the market demand?

9. If this firm's demand decreases from D_1 to D_2, will the firm earn a positive total profit? What will happen to this firm's share of the market demand?

10. Assume the demand facing the firm drops from D_2 to D_4. Will it earn a positive total profit? If some other firms in the industry are in a similar situation, what will happen to the number of firms in the industry? What will happen to this firm's share of the market demand?

11. Suppose this firm's demand shifts from D_4 to D_3. Is this firm making a positive total profit or a loss? If this is the condition for other firms as well, will firms enter or leave the market?
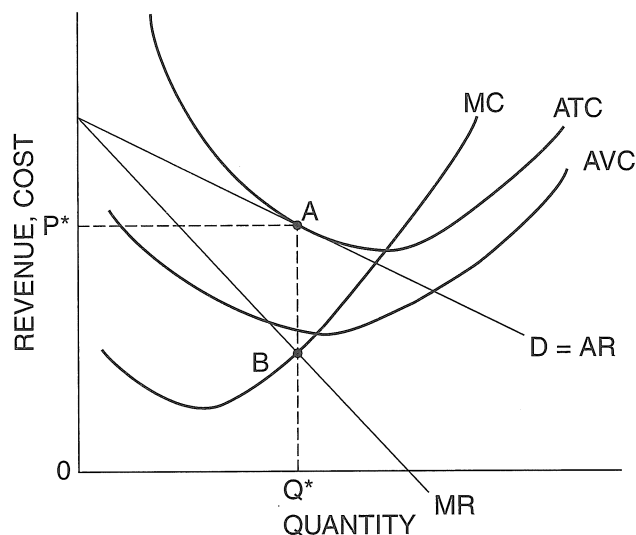
Part C: Evaluation of a Monopolistically Competitive Firm in Long-Run Equilibrium

When a monopolistically competitive firm is in long-run equilibrium, it will break even or earn $0 in total economic profit. Because it is receiving its normal profit, it is doing as well with its resources here as it would in its best alternative. Thus, the firm has no incentive to leave the industry. Figure 3-16.3 illustrates a monopolistically competitive firm in long-run equilibrium with quantity Q* and price P*.

Figure 3-16.3
A Monopolistically Competitive Firm in Long-Run Equilibrium

12. If you were asked to draw a graph of a monopolistically competitive firm in a position of long-run equilibrium, there are two conditions you must show with your graph at the profit-maximizing output.

   (A) At Q*, the firm's average revenue (or price) must be (*greater than / equal to / less than*) its average total cost. This is shown by drawing the demand curve tangent to the ATC curve at point A.

   (B) At Q*, the firm's marginal revenue must be (*greater than / equal to / less than*) its marginal cost. This is shown by drawing your MR curve through the MC curve at Q* at point B.

13. Is a monopolistically competitive firm productively efficient when it is in long-run equilibrium? Explain.

14. Is a monopolistically competitive firm allocatively efficient when it is in long-run equilibrium? Explain.

15. Is the demand curve facing a monopolistically competitive firm more or less elastic than the demand curve facing a monopoly? Why?

16. What are the characteristics of a monopolistically competitive market? What are two examples of such a market?

Game Theory

Strategic thinking is the art of outdoing an adversary, knowing that the adversary is trying to do the same to you. Dixit and Nalebuff*

Game theory is used to explain how two or more players make decisions or choose actions when their actions (or strategies) affect each participant. Each player determines his or her best response to the possible actions of every other player. According to game theory, a player's choice of strategy depends on the strategy the player thinks other players will choose. In some cases, these strategies reinforce each other, but in other cases they do not. When the chosen strategies reinforce each other, the game achieves what is called a *Nash Equilibrium*. The Nash Equilibrium is named after John F. Nash, Jr., who was co-winner of the 1994 Nobel Prize in Economics for his work in this area and the subject of the 2001 movie, *A Beautiful Mind*.

Game theory provides insights into how business and government decisions are made and has numerous real-world applications. For example, game theory has helped economists analyze antitrust policy, tariff wars, and auctioning behavior. This lesson is an introduction to the basic elements of game theory. As you do the math, think about the implications of the results.

Part A: The Basic Elements of Game Theory

The three basic elements of a game are

(A) the players,

(B) the strategies available to each player,

(C) the payoffs each player receives.

These three elements are summarized in a table called a *payoff matrix*. A payoff matrix describes the payoffs to each player for combinations of given strategies. Here is an example of a payoff matrix:

		Coke	
		Advertise	Don't Advertise
Pepsi	Advertise	80, 80	120, 45
	Don't Advertise	45, 120	100, 100

The first number in each square refers to the payoff for the row (horizontal) player, here Pepsi. The second number in each square refers to the payoff for the column (vertical) player, here Coke. The numbers represent the profit (in $ millions) for Pepsi and Coke.

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*Avinash K. Dixit and Barry J. Nalebuff, *Thinking Strategically: The Competitive Edge in Business, Politics, and Everyday Life* (New York: W.W. Norton, 1991), p. 409.

In this game:

   (A) The players are Pepsi and Coke.

   (B) Here are the strategies available to each player:

      ■ Pepsi, as the row player, can choose either Advertise or Don't Advertise.

      ■ Coke, as the column player, can choose either Advertise or Don't Advertise.

   (C) The payoffs each player receives:

      ■ If Pepsi chooses Advertise and Coke chooses Advertise, Pepsi earns 80 and Coke earns 80.

      ■ If Pepsi chooses Advertise and Coke chooses Don't Advertise, Pepsi earns 120 and Coke earns 45.

      ■ If Pepsi chooses Don't Advertise and Coke chooses Advertise, Pepsi earns 45 and Coke earns 120.

      ■ If Pepsi chooses Don't Advertise and Coke chooses Don't Advertise, Pepsi earns 100 and Coke earns 100.

In some games, one or more players can have a *dominant strategy*. A dominant strategy is the best strategy for a player regardless of the strategy chosen by the other player.

1. To see if Pepsi has a dominant strategy, answer these questions based on the information in the payoff matrix.

   (A) If Coke decides to advertise, Pepsi's best strategy would be (*Advertise / Don't Advertise*).

   (B) If Coke decides not to advertise, Pepsi's best strategy would be (*Advertise / Don't Advertise*).

   (C) Is Pepsi's best strategy the same regardless of whether Coke advertises or doesn't advertise? Does this mean Pepsi has a dominant strategy?

2. To see if Coke has a dominant strategy, answer these questions based on the information in the payoff matrix.

   (A) If Pepsi decides to advertise, Coke's best strategy would be (*Advertise / Don't Advertise*).

   (B) If Pepsi decides not to advertise, Coke's best strategy would be (*Advertise / Don't Advertise*).

   (C) Is Coke's best strategy the same regardless of whether Pepsi advertises or doesn't advertise? Does this mean Coke has a dominant strategy?

3. Do the profit values in the payoff matrix make sense? Why would Pepsi's profit be much higher than Coke's profit when Pepsi advertises and Coke does not? Why could both companies' profit be higher if they both don't advertise compared to if they both do advertise?

A *dominated strategy* yields a lower payoff than at least one other strategy. In this game, the dominated strategy for Pepsi is Don't Advertise; it is dominated by Advertise. Regardless of the strategy selected by Coke, Pepsi gains more by choosing Advertise. If Pepsi chooses Don't Advertise, the payoff is 45, while a strategy of Advertise has a payoff of 80. Since 45 is less than 80, the dominated strategy is Don't Advertise.

The dominated strategy for Coke is Don't Advertise; it is dominated by Advertise. If Coke chooses Don't Advertise, Coke receives 45 if Pepsi chooses Advertise and 100 if Pepsi chooses Don't Advertise. Since 45 is less than 100, the dominated strategy for Coke is Don't Advertise.

A *Nash Equilibrium* exists when each player is doing his/her best, given what the other player is doing. It is a combination of strategies for each player, such that each chooses his/her best response to the other's strategy choice. In this game, the Nash Equilibrium is both players deciding to Advertise. Although in this example both Coke and Pepsi select the same strategy, in a Nash Equilibrium the players do not have to select the same strategy.

A Nash Equilibrium is similar to a market equilibrium in that there is no incentive for producers and consumers to change from the equilibrium price. Thus a Nash Equilibrium is an "enforceable" equilibrium because the firms do not have an incentive to cheat as they might in a cartel.

Other economic examples of game-theory applications are decisions by firms about what price to charge, whether to enter a market, where to locate, and what kind of product or quality level to produce; decisions by a central bank on monetary policy actions; and decisions by a nation on the optimal tariff policy.

Part B: The Prisoner's Dilemma Game

One classic application of game theory is the *prisoner's dilemma game*. Prisoner's dilemma games are games in which each player has a dominant strategy; and when both players play the dominant strategy, the payoffs are smaller than if each player played the dominated strategy. The dilemma is how to avoid this bad outcome.

The basics of the prisoner's dilemma game are as follows: two prisoners, Charles and Frances, have the option to confess or not confess to a crime they committed. The prosecutor has only enough information to convict both criminals of a minor offense and is, therefore, relying on a confession. The minor offense carries one year in jail. The prisoners are questioned in different cells, without the ability to communicate. They are told that if one prisoner confesses while the other remains silent, the prisoner confessing will go free and the prisoner remaining silent will serve 20 years in jail. If both prisoners confess, both prisoners will serve three years in jail.

If a player goes free, the payoff is 0. If a player serves one year in jail, the payoff is −1. If a player spends 20 years in jail, the payoff is −20. Use these numbers in your payoff matrix. Note that the negative numbers come from losing years of freedom.

4. Determine the three basic elements of the game.

   (A) The players

   (B) The strategies for each player

   (C) The payoffs for each player

5. Create a payoff matrix for the prisoner's dilemma game.

6. Are there dominant strategies? Explain.

7. Identify any dominated strategies. Explain.

8. Is there a Nash Equilibrium? Explain.

Part C: Variation of the Prisoner's Dilemma Game

You are in a class with one other student. It is the end of the semester, and final exams are in a week. Your teacher has said the final exam will be graded so that anyone who scores the class average on the final exam will receive a "B" in the class. Anyone who scores above the average will receive an "A" in the class, and anyone who scores below the average will fail the class. You would certainly score higher on the exam than the other student. You and the other student have made an agreement not to take the final exam so that the class average is zero and you both receive "B" grades.

9. Determine the three basic elements of the game.

(A) The players

(B) The strategies for each player

(C) The payoffs for each player

10. Create a payoff matrix for this game.

11. Do you have a dominant strategy? Explain.

12. Using a four-point scale (A = 4, B = 3, C = 2, and D = 1), which choice results in the highest class GPA?

If you finished Parts B and C correctly, you will realize that when each player chooses his or her dominant strategy, the result is unattractive to the group.

The key to avoiding the prisoner's dilemma outcome of lower payoffs for both players is to find a way for players to credibly commit to playing a dominated strategy. Merely having both prisoners agree to Not Confess or both students to Not Take the Exam will not work. This results because it is always optimal for Prisoner 1 (or Prisoner 2) to still play the Confess strategy, and it is always optimal for the better student to play the Take the Exam strategy. One possible way to have credible commitment in the prisoner's dilemma game would be to have both prisoners reveal another past crime they committed, thus ensuring that if they confess to this crime, the other prisoner will have additional information to punish the prisoner who cheats on an agreement to not confess.

One way to do this is to form a *cartel*. A cartel is a coalition of firms that coordinate their decisions to reach a more optimal solution for all members of the group by finding ways to credibly commit players to play their dominated strategies. Cartels, however, are not always successful in maintaining their agreements because there may be an incentive for a member to cheat on the cartel.

Part D: What Should These Firms Do?

There are two firms that produce fiberglass canoes. Both River Queen and Ace Current must decide whether to market a Premium canoe or a Regular canoe. The profit of a firm depends on the type of canoe produced by the other firm. In this chart, the first value is the profit of River Queen, and the second value is the profit of Ace Current. The firms make their decisions simultaneously in a one-period situation. (The values in the chart are thousands of dollars.)

		Ace Current	
		Premium	Regular
River Queen	Premium	$400, $100	$450, $200
	Regular	$150, $400	$200, $150

13. Does River Queen have a dominant strategy? What decision will River Queen make?

14. Does Ace Current have a dominant strategy? What decision will Ace Current make?

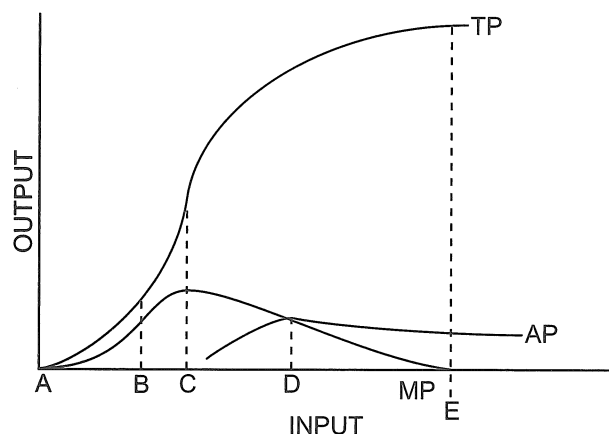15. Is there a Nash Equilibrium?

Part E: Questions

16. Is the Coke and Pepsi advertising game a prisoner's dilemma game? Explain why or why not.

17. Interpret "standing at a concert" in terms of the prisoner's dilemma game.

18. Explain at least one way the optimal outcome for players, which would be for all players to play the dominated strategy, can be reached in Question 17. What are the possible commitment problems?

19. A rivalry exists between the U.S. jet producer Boeing and the European jet producer Airbus. Each government has the opportunity to subsidize its jet producer to give it a competitive edge in the global market. Using game theory, explain what you would expect to observe in practice.

Circle the letter of each correct answer.

1. True statements about the theory of the firm in the short run and long run include which of the following?

   I. All input quantities are fixed in the short run.

   II. All input quantities are variable in the long run.

   III. At least one input quantity is fixed in the short run.

   (A) I only
   (B) II only
   (C) III only
   (D) I and II only
   (E) II and III only

3. Which of the following statements about a firm's production function are true?

   I. When total product is at its maximum, marginal product is zero.

   II. When total product rises, marginal product is rising.

   III. When marginal product is greater than average product, average product is rising.

   IV. When marginal product is less than average product, average product is falling.

   (A) I and II only
   (B) II and III only
   (C) II and IV only
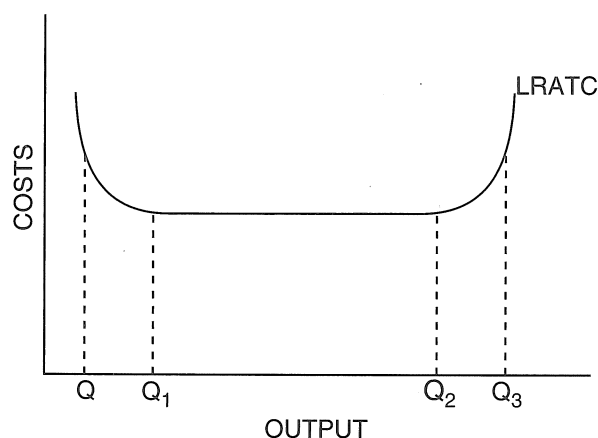   (D) I, III, and IV only
   (E) I, II, III, and IV

2. On the graph above, the onset of diminishing marginal returns occurs beyond

   (A) Point A.
   (B) Point B.
   (C) Point C.
   (D) Point D.
   (E) Point E.

4. According to the graph above, if the firm is producing any quantity greater than Q_2, the firm is experiencing

   (A) economies of scale.
   (B) minimum efficient scale.
   (C) diseconomies of scale.
   (D) constant returns.
   (E) increasing returns.

5. For a perfectly competitive firm, if the market price is $8, then

   (A) marginal revenue is greater than $8.

   (B) marginal revenue is less than $8.

   (C) marginal revenue is equal to $8.

   (D) average revenue is greater than $8.

   (E) average revenue is less than $8.

6. A firm's short-run marginal cost curve will eventually increase because of

   (A) more efficient production.

   (B) economies of scale.

   (C) diseconomies of scale.

   (D) diminishing marginal returns.

   (E) increasing marginal returns.

7. Assume that in the short run at the profit-maximizing output, the price is lower than average variable cost. The perfectly competitive firm should

   (A) increase its price.

   (B) decrease its price.

   (C) increase its output.

   (D) decrease its output.

   (E) shut down.

8. Assume that a perfectly competitive firm is operating where marginal revenue is greater than marginal costs. To increase total profits, the firm should

   (A) increase production.

   (B) decrease production.

   (C) increase price.

   (D) decrease price.

   (E) do nothing.
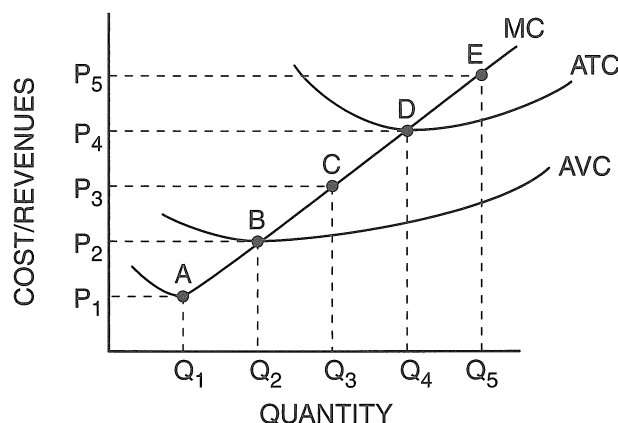
*Use the graph above to answer Questions 9, 10, and 11.*

9. If the firm is in short-run equilibrium at a price of P_5, a perfectly competitive firm will maximize total profits by producing at which of the following levels of output?

   (A) Q_1 (D) Q_4

   (B) Q_2 (E) Q_5

   (C) Q_3

10. At which price will this perfectly competitive firm make an economic profit?

    (A) P_1 (D) P_4

    (B) P_2 (E) P_5

    (C) P_3

11. Which price-quantity combination represents long-run equilibrium for this perfectly competitive firm?

    (A) Point A   (D) Point D

   (B) Point B   (E) Point E

    (C) Point C

12. If the average variable cost of producing five units of a product is $100 and the average variable cost of producing six units is $125, then the marginal cost of producing the sixth unit is

    (A) $25.   (D) $500.

    (B) $125.   (E) $750.

    (C) $250.
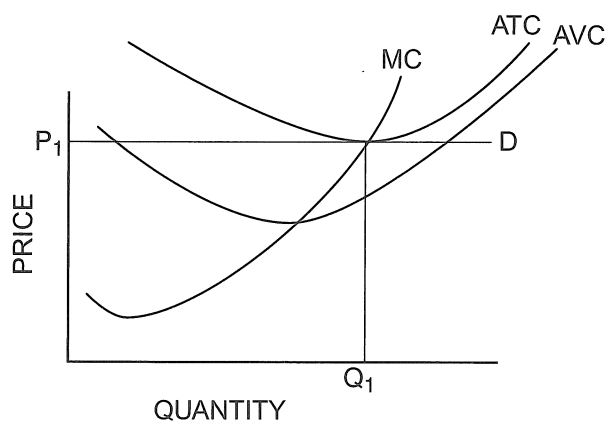
13. According to the graph above, if the firm is producing at Q_1, the firm is

    (A) losing money because the firm is operating at the shutdown point.

    (B) losing money because the price does not cover average fixed cost.

    (C) making profits because the price is above average variable cost.

    (D) making normal profits because the price just covers average total cost.

   (E) making normal profits because the price is above average variable cost.

14. Which of the following represents the correct relationship between the demand curve for a perfectly competitive industry and the demand curve for a perfectly competitive firm?

	PC industry demand	PC firm demand
(A)	Downward slope to the right	Downward slope to the right
(B)	Downward slope to the right	Perfectly elastic
(C)	Perfectly elastic	Downward slope to the right
(D)	Perfectly elastic	Perfectly elastic
(E)	Perfectly inelastic	Perfectly elastic
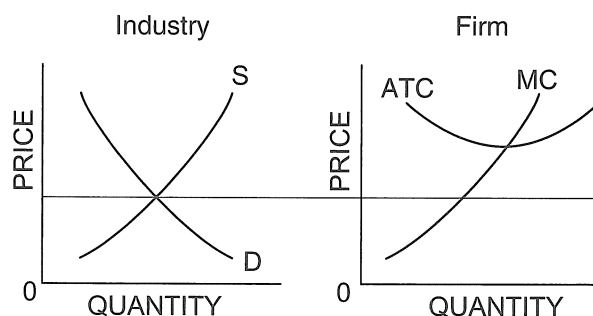
15. According to the graphs above, in which of the following ways are the industry supply curve and the equilibrium price most likely to change in the long run?

	Industry supply	Equilibrium price
(A)	Decrease	Decrease
(B)	Decrease	Increase
(C)	Increase	Decrease
(D)	Increase	Increase
(E)	Not change	Decrease
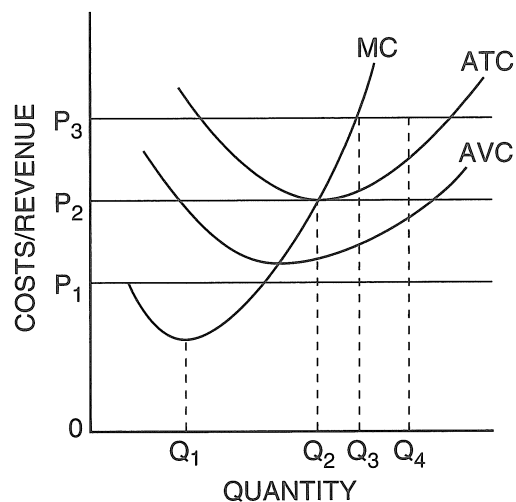
Use the graph above to answer Question 16.

16. If price is P_3, the firm will

   (A) produce Q_2 units and earn only a normal profit.

   (B) produce Q_1 units and earn an economic profit.

   (C) produce Q_3 units and earn an economic profit.

   (D) produce Q_4 units and earn an economic profit.

   (E) shut down.

17. Which of the following is true of a pure monopolist's demand curve?

   (A) It is perfectly inelastic.

   (B) It is perfectly elastic.

   (C) It coincides with its marginal revenue curve.

   (D) It lies below its marginal revenue curve.
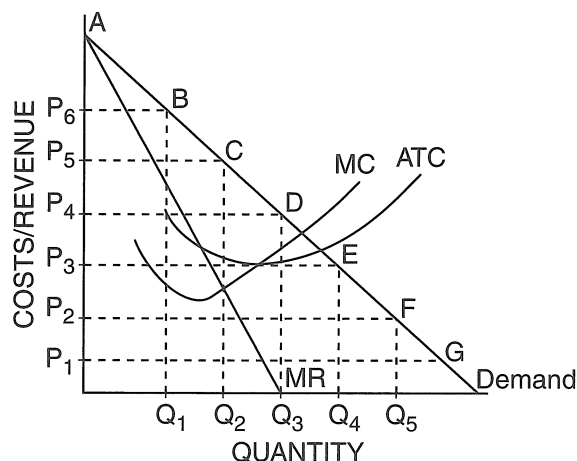
   (E) It lies above its marginal revenue curve.

18. Average fixed cost is shown as the vertical distance between

   (A) marginal cost and average variable cost.

   (B) marginal cost and average total cost.

   (C) average variable cost and average total cost.

   (D) average total cost and the horizontal axis.

   (E) marginal cost and the horizontal axis.
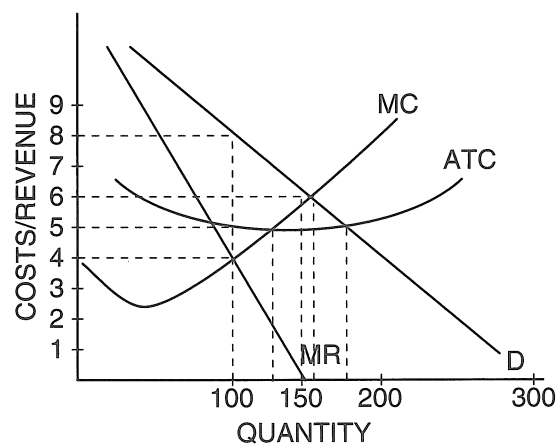
Use the graph above to answer Questions 19, 20, and 21.

19. Assume that the firm in the graph above is an unregulated monopolist. It will produce

   (A) 175 units at a price of $7.00.

   (B) 100 units at a price of $6.00.

   (C) 100 units at a price of $8.00.

   (D) 150 units at a price of about $5.00.

   (E) about 210 units at a price of about $4.00.

20. Assume that the firm in the graph is an unregulated monopolist. It will earn long-run profits of

   (A) $0.   (D) $500.

   (B) $300.   (E) $900.

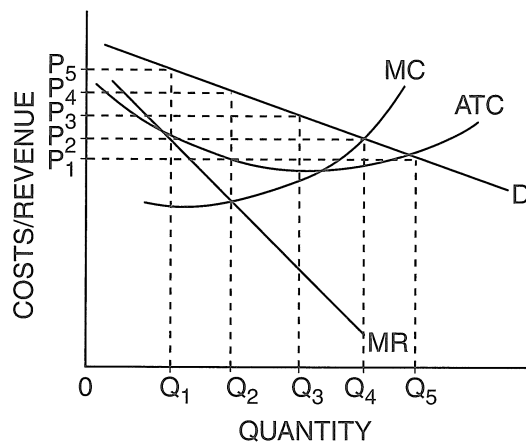   (C) $400.

21. At 100 units of output, the firm's average revenue is

(A) $0.   (D) $8.
(B) $4.   (E) $800.
(C) $6.

25. Total revenue will be maximized when price is equal to

(A) P_1.   (D) P_4.
(B) P_2.   (E) P_5.
(C) P_3.

Use the graph above to answer Questions 22 through 25.

*Questions 26, 27, and 28 are based on the graph above of cost and revenue curves for a monopoly firm.*

22. For the firm in the graph—an unregulated monopolist—the price elasticity of demand is unit elastic at a price and an output of

(A) P_6 and Q_1.   (D) P_3 and Q_4.
(B) P_5 and Q_2.   (E) P_3 and Q_4.
(C) P_4 and Q_3.

26. To maximize total profit, this monopolist should produce at which of the following levels of output?

(A) Q_1 (D) Q_4
(B) Q_2 (E) Q_5
(C) Q_3

23. Consumer surplus for this profit-maximizing monopolist will be represented by area

(A) ABP_6.   (D) AEP_3.
(B) ACP_5.   (E) AGP_1.
(C) ADP_4.

27. The price the monopolist charges at the profit-maximizing level of output will be

(A) P_1.   (D) P_4.
(B) P_2.   (E) P_5.
(C) P_3.

24. The profit-maximizing price for this firm is

(A) P_2.   (D) P_5.
(B) P_3.   (E) P_6.
(C) P_4.

28. When the firm maximizes total profit, the profit per unit will be

(A) $P_2 - P_1$.   (D) $P_4 - P_1$.
(B) $P_3 - P_2$.   (E) $P_1 - 0$.
(C) $P_4 - 0$.
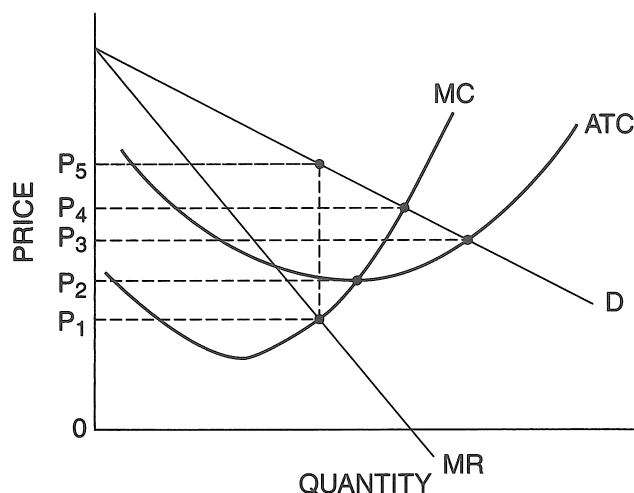
Use the graph above to answer Questions 29 and 30.

29. If this monopoly is regulated so as to have it produce the socially optimal output level, what price should the firm charge?
    (A) P_1 (D) P_4
    (B) P_2 (E) P_5
    (C) P_3

30. If a regulating agency requires this monopoly to charge a price that allows the firm to have a fair return (where all costs are covered, including a normal profit), the price would be
    (A) P_1.   (D) P_4.
    (B) P_2.   (E) P_5.
    (C) P_3.

31. What happens to a monopolist's price, profits, and output if its total fixed costs decrease?

	Price	Profits	Output
(A)	Decrease	Increase	Decrease
(B)	Decrease	Decrease	Decrease
(C)	No change	Increase	No change
(D)	Increase	Increase	Increase
(E)	Decrease	No change	Increase

32. The presence of both allocative and productive efficiency is possible in which of the following market structures?
    I.   Perfectly competitive
    II. Monopolistic
    III. Oligopolistic
    IV. Monopolistically competitive
    (A) I only
    (B) II only
    (C) III only
    (D) I and IV only
    (E) II and IV only

33. Which of the following is true of monopolists that practice price discrimination?
    (A) They charge all customers the same price.
    (B) They earn a smaller profit than those that do not practice price discrimination.
    (C) They charge customers different prices according to different elasticities of demand.
    (D) They produce lower quantities than pure monopolists.
    (E) They produce the same quantity of output as pure monopolists.

34. Characteristics of an oligopolistic market include which of the following?
    I.   Easy entry and exit of firms
    II. Few firms
    III. Interdependence among firms
    (A) I only
    (B) II only
    (C) III only
    (D) II and III only
    (E) I, II, and III

35. In the long run, a monopolistically competitive firm will make

(A) more economic profit than a perfectly competitive firm.

(B) less economic profit than a perfectly competitive firm.

(C) more economic profit than a monopoly.

(D) more economic profit than an oligopolist.

(E) zero economic profit.

36. If all of the firms in an oligopoly could, without any additional cost, form an industry-wide cartel to jointly maximize profits, the demand curve facing the cartel would be

(A) less elastic than the industry demand curve.

(B) the same as the industry demand curve.

(C) more elastic than the industry demand curve.

(D) perfectly inelastic.

(E) horizontal at the market-clearing price.

37. Characteristics of an oligopoly include which of the following?

I. Collusion can increase oligopolists' profits.

II. Oligopolistic firms are interdependent.

III. Independent price decision making leads to lower returns.

(A) I only

(B) II only

(C) III only

(D) I and II only

(E) I, II, and III

38. The shapes of the marginal product curve and the total product curve are best explained by the

(A) law of demand.

(B) law of supply.

(C) principle of diminishing marginal utility.

(D) least-cost rule.

(E) law of diminishing marginal returns.

**Royal's Burgers
and Fries**

		Concentrate on fries	Concentrate on burgers
Brewer's Fries and Burgers	Concentrate on fries	120, 85	150, 120
	Concentrate on burgers	65, 100	50, 80

Use the payoff matrix above and the information below to answer Questions 39 and 40.

Two competing fast-food restaurants in a small town, Royal's Burgers and Fries and Brewer's Fries and Burgers, realize that each must consider the method of attracting customers that the other is using. The payoff matrix above illustrates the firms' possible strategies and the profits to each restaurant under each possible outcome. (The first number in each box represents the payoff to Brewer's; the second the payoff to Royal's.)

39. Based on the payoffs above, which of the following statements is true?
    (A) Brewer's has a dominant strategy to concentrate on fries.
    (B) Brewer's has a dominant strategy to concentrate on burgers.
    (C) Royal's has a dominant strategy to concentrate on fries.
    (D) Royal's has a dominant strategy to concentrate on burgers.
    (E) Neither restaurant has a dominant strategy.

40. What is the Nash Equilibrium in this game?
    (A) Both fast-food restaurants should choose to concentrate on fries.
    (B) Both fast-food restaurants should choose to concentrate on burgers.
    (C) Brewer's should choose to concentrate on fries, and Royal's should choose to concentrate on burgers.
    (D) Brewer's should choose to concentrate on burgers, and Royal's should choose to concentrate on fries.
    (E) There is no Nash Equilibrium in this game.

41. Which of the following is true of a cartel?
    (A) A cartel is a coalition of firms that seek to coordinate their decisions so all firms can earn a higher economic profit.
    (B) A cartel is a way for firms to earn more by playing their dominant strategies.
    (C) A cartel is considered stable.
    (D) A cartel seeks to maximize total revenue of its members.
    (E) A cartel sets price and output of its members in the same way that a price discriminating monopolist would.

42. Which of the following best characterizes the firms in an oligopoly industry?
    (A) Firms can easily enter the industry when profits are high.
    (B) There are more firms than in a monopolistically competitive industry.
    (C) They are independent.
    (D) They always collude to increase profits.
    (E) They use strategic decision making.

Acme

AAA		Advertise	Don't advertise
	Advertise	Acme: 150 AAA: 150	Acme: −100 AAA: 400
	Don't advertise	Acme: 400 AAA: −100	Acme: 0 AAA: 0

Use the payoff matrix above and the information below to answer Questions 43, 44, and 45.

Acme and AAA are the two major firms in the industry. Each must decide whether to conduct a television advertising campaign. The returns from each firm's decision depend on the decision of the other. The profits resulting from each possible combination of the firms' decisions are given in the payoff matrix above.

43. If AAA advertises and Acme does not, Acme's profits will change by
    (A) −$100.   (D) $300.
    (B) $0.   (E) $400.
    (C) $150.

44. If AAA advertises, Acme will
    (A) decide not to advertise because this is its dominant strategy.
    (B) advertise because this is its dominant strategy.
    (C) not have a dominant strategy.
    (D) lose money.
    (E) increase its profit by $400 if it advertises.

45. Which of the following statements is true?
    (A) If AAA advertises, Acme's dominant strategy is to advertise.
    (B) If Acme advertises, AAA's dominant strategy is NOT to advertise.
    (C) The two firms are in a prisoner's dilemma game.
    (D) The two firms would be better off to agree to save their money and NOT advertise.
    (E) A collusive agreement to advertise would benefit both firms.