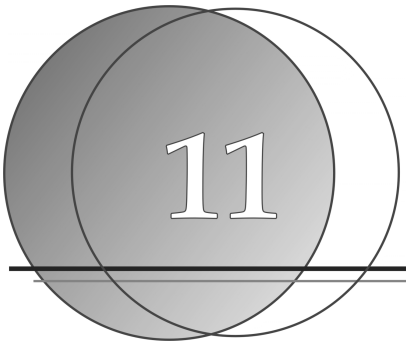


# 11 Managerial Decisions in Competitive Markets

## Learning Objectives

After reading Chapter 11 and working the problems for Chapter 11 in the textbook and in this Workbook, you should be able to:

- Discuss three characteristics of perfectly competitive markets.
- Apply the basic principles of marginal analysis to determine either (1) the profit-maximizing (or loss-minimizing) level of output, or (2) the profit-maximizing (or loss-minimizing) level of input usage.
- Explain why the demand curve facing an *individual* firm in a perfectly competitive industry is perfectly elastic, and why this demand curve is also the marginal revenue curve for a competitive firm.
- Explain why a firm should shut down in the short run if market price falls below minimum average variable cost.
- Calculate profit margin (or average profit) and explain why profit margin should be ignored when making profit-maximizing decisions.
- Explain why fixed costs are irrelevant to a manager's production decision.
- Define the concept of long-run competitive equilibrium and explain why a firm in long-run competitive equilibrium produces at the minimum point on long-run average cost.
- Give a definition of increasing cost and constant cost industries and draw a long-run industry supply curve for a constant cost industry and for an increasing cost industry.
- Explain, using the concept of economic rent, why it is possible for owners of exceptionally productive resources to "get rich" even though economic profit is zero in the long run for competitive markets.
- Find the profit-maximizing (or loss-minimizing) level of output for a firm operating in a perfectly competitive market using empirical estimates (or forecasts) of (1) the market price of the commodity, (2) the average variable cost function, and (3) the marginal cost function.

# Essential Concepts

1. Perfect competition occurs when a market possesses the following three characteristics:
   i. Firms are price-takers because each firm produces only a very small portion of total market or industry output.
   ii. All firms in the market produce a homogeneous or perfectly standardized product.
   iii. Entry into and exit from the market is unrestricted.
2. The demand curve facing a competitive price-taking firm is horizontal or perfectly elastic at the price determined by the intersection of the market demand and supply curves. Since marginal revenue equals price for a competitive firm, the demand curve is also simultaneously the marginal revenue curve (i.e., $D = MR$). Price-taking firms can sell all they want at the market price. Each additional unit of sales adds to total revenue an amount equal to price.

### Profit Maximization in the Short Run:

3. In the short run, the firm incurs fixed costs that are unavoidable – i.e., they must be paid even if output is zero—and variable costs that can be avoided if the firm chooses to *shut down*.
4. *Shut down* refers to the decision in the short run to produce zero output, which means the manager hires n variable inputs. The only costs incurred during shut down are the unavoidable fixed costs.
5. A manager makes two decisions in the short run: (1) whether to produce or shut down, and (2) if the decision is to produce, how much to produce.
6. In making the decision to produce or shut down, the manager will consider only the (avoidable) variable costs and will ignore fixed costs.
7. *Profit margin* is the difference between price and average total cost, which is equal to *average profit* (or profit per unit), as long as every unit is sold for the same price:

$$\begin{aligned}\text{Average profit} &= \frac{\pi}{Q} \\ &= \frac{(P - ATC)Q}{Q} \\ &= P - ATC = \text{ Profit margin}\end{aligned}$$

8. The output level that maximizes profit margin is not the output level that maximizes profit. For this reason, managers should *ignore profit margin* or profit per unit when making their production decisions. See Figure 11.3 in the textbook for a numerical example that shows why it is a mistake to maximize profit margin.
9. *Break-even points* are the output levels – there are usually two of these points—where price equals average total cost, and thus profit equals zero at these points.

10. In the short run, the manager of a firm will choose to produce the output where $P = SMC$, rather than shut down, as long as total revenue is greater than or equal to the firm's total avoidable cost or total variable cost ($TR \geq TVC$). Or, equivalently, a firm should produce as long as price is greater than or equal to average variable cost ($P \geq AVC$). If total revenue cannot cover total avoidable cost, that is, if total revenue is less than total variable cost (or equivalently, $P < AVC$), the manager will shut down and produce nothing, losing an amount equal to total fixed costs.

11. *Fixed costs* are irrelevant in the production decision because the level of fixed cost has no effect on either marginal cost or minimum average variable cost, and thus no effect on the optimal level of output.

12. *Sunk costs* are irrelevant in the production decision because such costs are forever unrecoverable, no matter what output decision is made, and so sunk costs cannot affect current or future decisions.

13. *Average costs* are also irrelevant for production decisions. Only marginal cost matters when finding the positive amount of output that maximizes profit. Technical note: *AVC* is not employed to find the optimal output, but rather to make sure the optimal output is not zero (i.e, whether to shut down or not).

14. Summary of the manager's output decision in the short-run:

    i. Average variable cost tells whether to produce; the firm ceases to produce—shuts down—if price falls below minimum *AVC*.

    ii. Marginal cost tells how much to produce; if $P \geq$ minimum *AVC*, the firm produces the output at which $P = SMC$.

    iii. Average total cost tells how much profit or loss is made if the firm decides to produce; profit equals the difference between *P* and *ATC* multiplied by the quantity produced and sold.

15. The short-run supply curve for an individual price-taking *firm* is the portion of the firm's marginal cost curve above minimum average variable cost. For market prices less than minimum average variable cost, quantity supplied is zero.

16. The short-run supply curve for a competitive *industry* can be obtained by horizontally summing the supply curves of all the individual firms in the industry. Short-run industry supply is always upward-sloping, and supply prices along the industry supply curve give the marginal costs of production for every firm contributing to industry supply.

17. Short-run producer surplus is the amount by which total revenue exceeds total variable cost and equals the area above the short-run supply curve below market price over the range of output supplied. Short-run producer surplus exceeds economic profit by the amount of total fixed costs.

### Profit Maximization in the Long Run:

18. In long-run competitive equilibrium, all firms are in profit-maximizing equilibrium ($P = LMC$). Long-run competitive equilibrium occurs because of the entry of new firms into the industry or the exit of existing firms from the industry. The market adjusts so that $P = LMC = LAC$, which is at the minimum point on *LAC*.

19. The long-run industry supply curve can be either flat (perfectly elastic) or upward sloping depending upon whether the industry is a *constant cost industry* or an *increasing cost industry*, respectively.
    a. For a constant cost industry, as industry output expands, input prices remain constant, and the minimum point on *LAC* is unchanged. Since long-run supply price equals minimum *LAC*, the long-run industry supply curve is perfectly elastic (horizontal).
    b. For an increasing cost industry, as industry output expands, input prices are bid up, causing the minimum point on *LAC* to rise, and long-run supply price to rise. The long-run industry supply curve for an increasing cost industry is upward sloping.
20. For both constant-cost and increasing-cost industries, long-run industry supply curves give supply prices for various levels of industry output allowing the industry to reach long-run competitive equilibrium. Thus, economic profit for every firm in the industry is zero at all points on the long-run industry supply. Furthermore, long-run supply prices give both $LAC_{\min}$ and *LMC* for all firms in the industry.
21. *Economic rent* is a payment to the owner of a scarce, superior resource in excess of the resource's opportunity cost. Firms that employ such exceptionally productive resources earn only a normal profit (economic profit is zero) in long-run competitive equilibrium because the potential economic profit from employing a superior resource is paid to the resource as rent.
22. As noted above, firms that employ exceptionally productive, superior resources earn zero economic profit in long-run competitive equilibrium. In increasing industries, all long-run producer surplus is paid to resource suppliers as economic rent. And, of course, for constant-cost industries there is zero producer surplus (and zero rent) since industry supply is perfectly horizontal.

**Profit-Maximizing Input Usage:**

23. Choosing either output or input usage to maximize profit leads to the same maximum profit level. The profit-maximizing level of *input* usage produces exactly that level of *output* that maximizes profit.
    a. The *marginal revenue product (MRP)* of an additional unit of a variable input is the additional revenue from hiring one more unit of the input. For the variable input labor:

$$MRP = \frac{\Delta TR}{\Delta L} = P \times MP$$

    When a manager chooses to produce rather than shut down ($TR > TVC$), the optimal level of input usage is found by following this rule: If the marginal revenue product of an additional unit of the input is greater (less) than the price of the input, then that unit should (not) be hired. If the usage of the variable input varies continuously, the manager should employ the amount of the input at which *MRP* = input price.

b. *Average revenue product* (*ARP*) is the average revenue per worker (*ARP* = *TR/L*). *ARP* can be calculated as the product of price times the average product of labor:

$$ARP = \frac{TR}{L} = P \times AP$$

A manager should shut down operation in the short-run if there is no level of input usage for which *ARP* is greater than or equal to *MRP*. When *ARP* is less than *MRP*, total revenue is less than total variable cost, and the manager minimizes losses in the short run by shutting down.

### Implementing the Profit-Maximizing Output Decision:

24. The following steps that use empirical estimates of price and costs can be employed to find the profit-maximizing rate of production and the level of profit a competitive firm will earn.

*Step 1*: *Forecast the price of the product*. Use the statistical techniques presented in Chapter 7 to forecast the price of the product.

*Step 2:* *Estimate average variable cost (AVC) and marginal cost (SMC)*. The cubic specification is the appropriate form for estimating a family of short-run cost curves:

$$AVC = a + bQ + cQ^2 \quad \text{and} \quad SMC = a + 2bQ + 3cQ^2$$

*Step 3*: *Check the shutdown rule*. If $P \geq AVC_{\min}$, then the manager should produce. If $P < AVC_{\min}$, then the manager should shut down (i.e., $Q^* = 0$).

*Step 4*: *If* $P \geq AVC_{\min}$, *find the output level where P = SMC*. The profit-maximizing output level occurs where *P = SMC*. To find the optimal level of output, set forecasted price equal to estimated marginal cost and solve for $Q^*$:

$$P = a + 2bQ^* + 3cQ^{*2}$$

*Step 5:* *Compute profit or loss.* Once a manager determines how much to produce, the calculation of total profit is a straightforward matter.

$$\begin{aligned} \text{Profit} &= TR - TC \\ &= P \times Q^* - AVC \times Q^* - TFC \\ &= (P - AVC)Q^* - TFC \end{aligned}$$

If $P < AVC_{\min}$, the firm shuts down, and profit is $-TFC$.

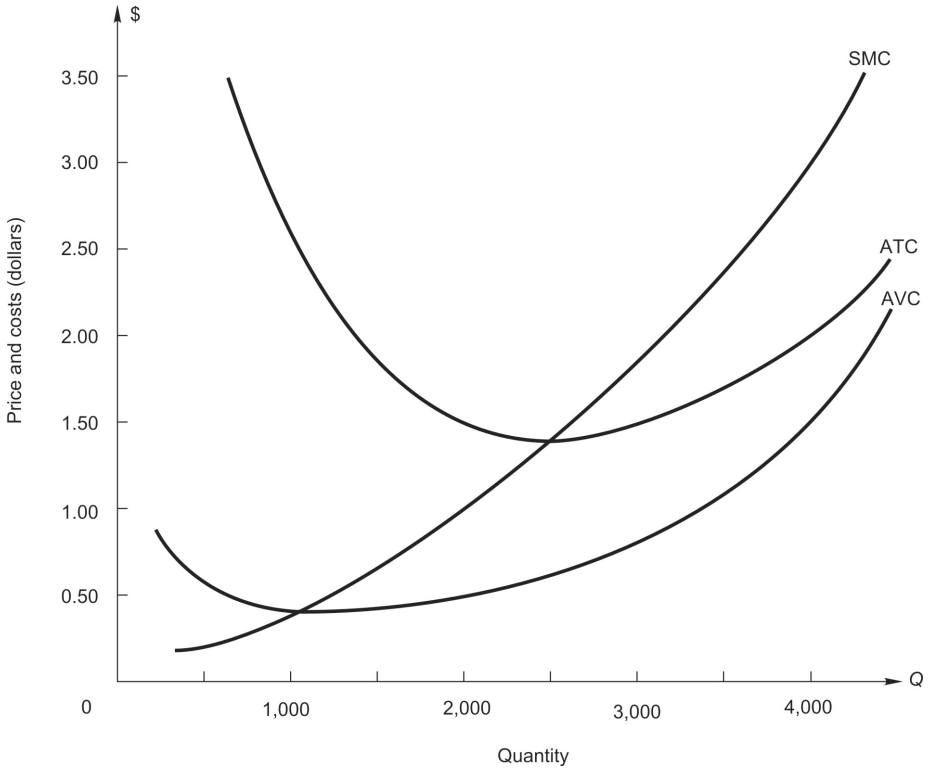
# Matching Definitions

average revenue product
break-even points
constant-cost industry
economic rent
increasing-cost industry
long-run competitive equilibrium
marginal revenue product
perfect competition
perfectly elastic demand
profit margin (or average profit)
quadratic formula
shut down
shutdown price

1. _____ A market structure in which a large number of firms sell a homogenous product or service with no restrictions on entry or exit and each firm is a price-taker.
2. _____ The demand facing a price-taking firm.
3. _____ A firm produces zero output but must still pay its fixed costs.
4. _____ Price minus average total cost.
5. _____ Output levels where $P = ATC$.
6. _____ Price below which a firm shuts down in the short run.
7. _____ All firms produce where price equals long-run marginal cost, and economic profits are zero.
8. _____ Industry in which input prices rise as all firms in the industry expand output.
9. _____ Industry in which input prices remain constant as all firms in the industry expand output.
10. _____ Payment in excess of a resource's opportunity cost.
11. _____ The additional revenue earned by hiring one more unit of a variable input.
12 _____ The average revenue per worker.
13. _____ $X_1, X_2 = \dfrac{-B \pm \sqrt{B^2 - 4AC}}{2C}$

## Study Problems

1. The manager of a competitive firm will:
   a. Produce rather than shut down if the forecasted price of the product is greater than _____.
   b. Produce and make an economic profit if the forecasted price of the product is greater than _____.
   c. Produce at a loss if the forecasted price is less than _____ but greater than _____.
   d. Shut down if the forecasted price is less than _____.
   e. Minimize loss by producing the level of output where _____ equals _____ when forecasted price is greater than _____ but less than _____.
   f. Maximize profit by producing the level of output where _____ equals _____ when forecasted price is greater than _____.
2. Answer the following questions using the cost curves for the price-taking firm shown in the figure below.




   a. If price is $3 per unit of output, draw the marginal revenue curve. The manager should produce _____ units.
   b. Since average total cost is $_____ for this output, total cost is $_____.
   c. The firm makes a profit of $_____.

d. Let price fall to $1, and draw the new marginal revenue curve. The manager should now produce _____ units.

e. At a price of $1, total revenue is now $_____ and total cost is $_____. The firm makes a loss of $_____.

f. At a price of $1, total variable cost is $_____, leaving $_____ to apply to fixed cost.

g. If price falls below $_____, the firm will produce zero output.

3. If a firm is making a loss in the short run, it can do either of two things in the long run:
(i) _____
(ii) _____
Explain the circumstances under which each of these actions will be taken.

4. In long-run competitive equilibrium, consumers pay the lowest price for each unit of the good. Explain why.

5. Consider a competitive, price-taking firm that employs only one variable input, labor, to produce a product that sells for $14 per unit. The wage rate is $24 per unit of labor and total fixed costs are $500. Fill in the blanks in each column of this table as instructed by the questions below:

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| *Units of Labor* | *Output* | *Marginal Product* | *Marginal Revenue Product* | *Average Product* | *Average Revenue Product* | *Marginal Cost* | *Profit* |
| 0 | 0 | _____ | xx | xx | xx | xx | _____ |
| 1 | 8 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | 20 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | 34 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | 45 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | 53 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | 58 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | 61 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | 63 | _____ | _____ | _____ | _____ | _____ | _____ |
| 9 | 64 | _____ | _____ | _____ | _____ | _____ | _____ |
| 10 | 62 | _____ | _____ | _____ | _____ | xx | _____ |

a. Fill in the blanks in columns 3 and 5. Marginal product begins to diminish beyond _____ units of labor. Marginal product is negative for the _____th unit of labor. [Note: You will see later in this problem that the profit-maximizing level of labor usage does indeed occur well in the range of diminishing marginal product, but *not* into the range of negative marginal product.]

b. Compute marginal and average revenue products and fill in the blanks in columns 4 and 6. The sixth unit of labor _____ (increases, decreases) _____ (total, marginal) revenue by $_____. Decreasing labor usage from three to two units _____ (increases, decreases) _____ (total, marginal) revenue by $_____.

c. The manager can maximize *total revenue* by hiring _____ units of labor. The maximum possible value of total revenue is $_____.

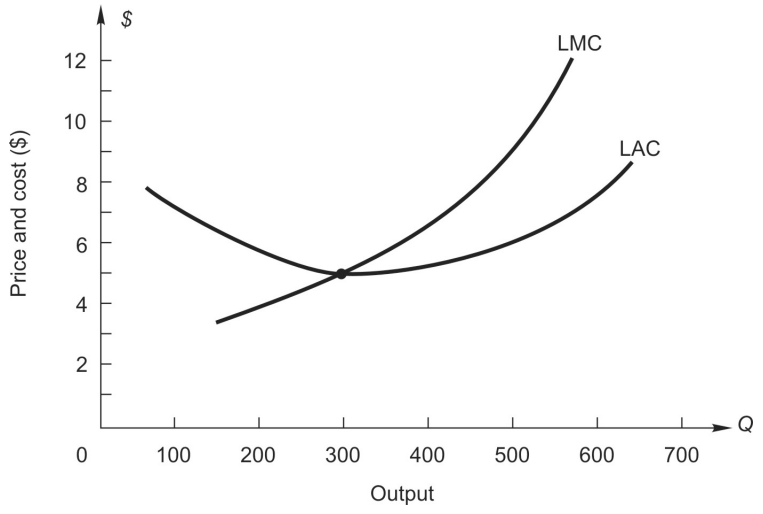
d. The manager hires _____ units of labor in order to maximize *profit*. At this level of labor usage, *ARP* = _____ which is _____ (greater, less) than *MRP*.

e. Compute marginal cost and fill in the blanks in column 7. At first, marginal cost _____ (rises, falls) as marginal product rises, then marginal cost _____ (rises, falls) as marginal product falls.

f. The profit-maximizing level of output is _____ units because this is the last level of output for which _____ exceeds _____, or equivalently, _____ exceeds _____ .

g. Compute profit and fill in the blanks in column 8. The optimal level of labor employment and the optimal level of output both result in an identical maximum profit level of $_____.

6. A textile firm in a competitive industry employs a particularly efficient manager to run the operations at its production facility. In the textile industry, a plant manager typically makes a salary of $4,500 per month. The textile firm employing the superior manager faces the *LAC* and *LMC* curves shown in the figure below. In long-run competitive equilibrium, the price of the product is $9.



a. A typical textile firm in this competitive industry has a minimum long-run average cost of $_____. The typical textile firm earns economic profit of $_____.

b. The textile firm with the superior plant manager could earn economic profit of $_____ per month, if no rent is paid to the superior manager.

c. The superior plant manager is likely to earn a salary of $_____ per month, $_____ of which is economic rent.

d. If the superior plant manager also owned the textile firm, she would earn $_____ of economic profit. Explain your answer.

7. Consider a price-taking firm in the competitive industry for raw chocolate. The market demand and supply functions for raw chocolate are estimated to be

Chocolate demand: $Q = 10{,}000 - 10{,}000P + 2M$
Chocolate supply: $Q = 40{,}000 + 10{,}000P - 4{,}000P_I$

where $Q$ is the number of 10 pound bars per month, $P$ is the price of a 10 pound bar of raw chocolate, income is $M$, and $P_I$ is the price of cocoa (the primary ingredient input). The manager of ABC Cocoa Products uses time-series data to obtain the following forecasted values of $M$ and $P_I$ for 2011:

$$M = \$25{,}000 \quad \text{and} \quad P_I = \$10$$

The manager of ABC Cocoa also estimates its average variable cost function to be

$$AVC = 3.0 - 0.0027Q + 0.0000009Q^2$$

Fixed costs at ABC will be $1,600 in 2011.

a. The price of raw chocolate in 2011 is forecasted to be $_____.

b Average variable cost reaches its minimum value at _____ bars of chocolate per month.

c. The minimum value of average variable cost is $_____.

d. Should ABC Cocoa produce or shut down?

e. The marginal cost function for the firm is

$SMC =$ _____.

f. The optimal level of production for the firm is _____ bars of chocolate per month.

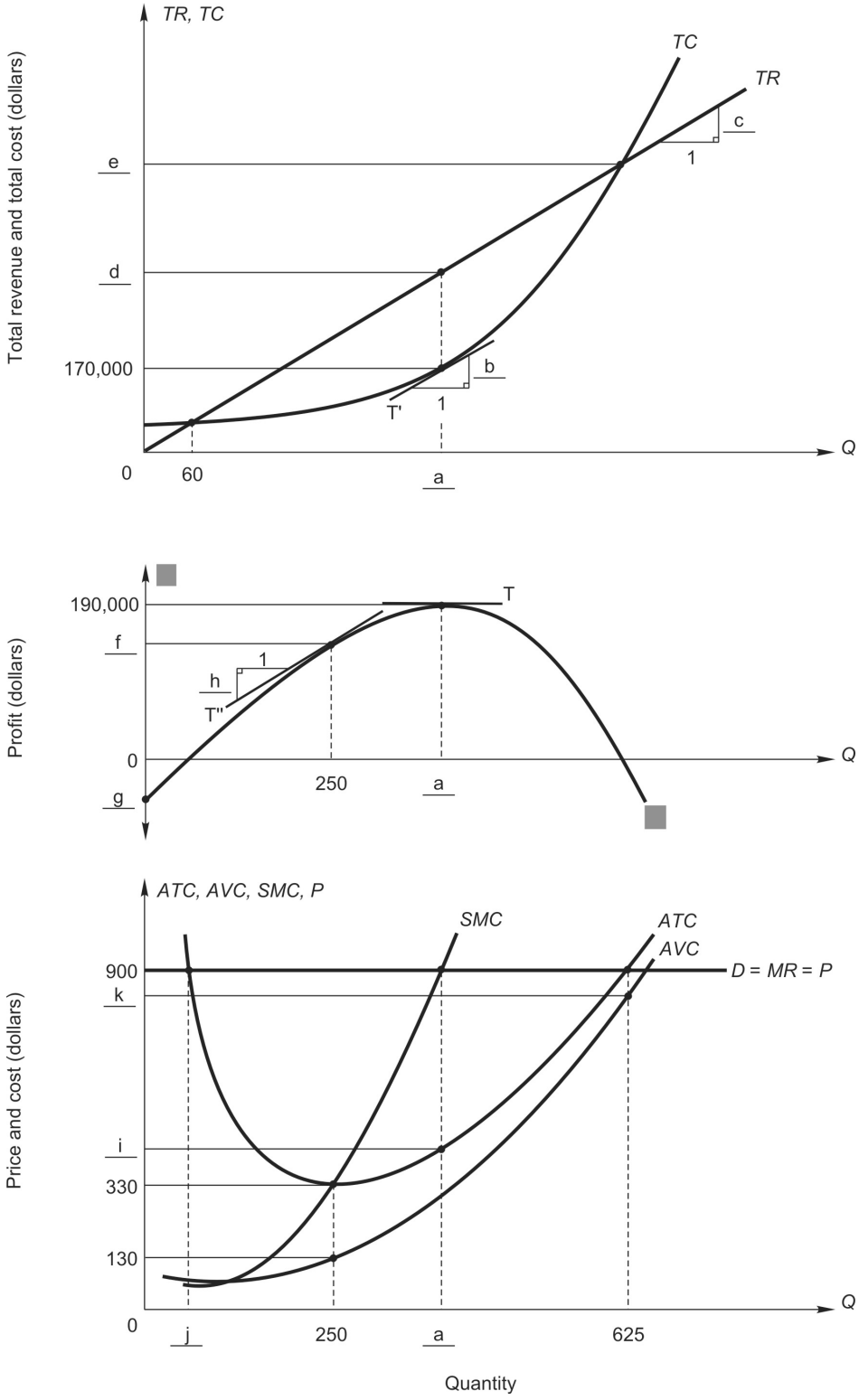
g. The maximum profit (minimum loss) that ABC can expect to earn is $_____.

Next let forecasted price of raw chocolate fall to $1.50.

h. The optimal level of production for ABC is now _____ bars of chocolate per month.

i. The profit (loss) for ABC is forecasted to be $_____.

8. The graphs below show cost, revenue, and profit conditions facing a price-taking firm in a competitive market that faces a market-determined price of \$900 per unit. Find the values that belong in blanks *a* – *k*.



9. Answer the following questions based on the figure and your answers in Study Problem 8.

   a. What is average fixed cost at 250 units? At 650 units? What is total fixed cost at 250 units? At 650 units? Using these values, explain how *AFC* and *TFC* are related to increases in *Q*.

   b. What are the two break-even values of output? In the top panel, construct a tangent line to *TC* at each one of the break-even points. At the lower break-even point, is the tangent line steeper or flatter than *TR*? In the bottom panel, should *MR* be greater or less than *SMC* at the lower break-even point? Explain. What happens at the higher output where break-even occurs?

   c. Why is the slope of the profit function zero at the profit-maximizing level of output?

   d. At what level of output is profit margin or average profit maximized? How much more profit can the firm earn by producing the output where $MR = MC$ than by producing where unit costs are minimized?

   e. When the manager is producing 400 units, the firm's marketing director complains that the firm should increase output to 500 units because this will increase revenues by $90,000. If you were the manager of this firm, how would you respond to this advice?

## Multiple Choice / True-False

1. Which of the following statements is *not* a characteristic of a perfectly competitive firm?
   a. Perfectly competitive firms view each other as fierce rivals.
   b. Firms are price-takers.
   c. All firms produce a homogeneous product.
   d. Perfectly competitive markets allow freedom of entry and exit.

2. Since the firm's demand curve is perfectly elastic for a price-taking firm,
   a. $P = MR$.
   b. $P = MRP$.
   c. $P = TR$.
   d. both *a* and *b*.
   e. both *a* and *c*.

3. In the short run, a firm shuts down when
   a. profit is negative.
   b. $TR < TVC$.
   c. $MRP > ARP$ at the level of labor usage where $MRP = w$.
   d. both *b* and *c*.
   e. all of the above.

4. In the short run, a firm continues to produce at a loss when
   a. $TR \geq TFC$.
   b. $P \geq AFC$.
   c. $(TR/Q) \geq (ATC - AFC)$.
   d. both *b* and *c*.
   e. both *a* and *c*.

5. In a competitive industry the market price of output is $24. A firm is producing that level of output at which average total cost is $30, marginal cost is $25, and average fixed cost is $5. In order to maximize profit (or minimize losses), the firm should
   a. increase output.
   b. decrease output but keep producing.
   c. leave output unchanged.
   d. shut down.

6. In long-run competitive equilibrium,
   a. economic profit is zero.
   b. $P = LMC$.
   c. $P = LAC$.
   d. $P = SMC$.
   e. all of the above.

A firm produces good *X* and sells the good in a competitive market. The market-determined price of *X* is $2. Fill in the blanks in the table, and answer questions 7–10.

| *Total Product* | *Units of Labor* | *Marginal Product* | *Average Product* | *Marginal Revenue Product* | *Average Revenue Product* |
|---|---|---|---|---|---|
| 0 | 0 | xx | xx | xx | xx |
| 10 | 1 | _____ | _____ | _____ | _____ |
| 30 | 2 | _____ | _____ | _____ | _____ |
| 48 | 3 | _____ | _____ | _____ | _____ |
| 64 | 4 | _____ | _____ | _____ | _____ |
| 79 | 5 | _____ | _____ | _____ | _____ |
| 93 | 6 | _____ | _____ | _____ | _____ |
| 105 | 7 | _____ | _____ | _____ | _____ |
| 115 | 8 | _____ | _____ | _____ | _____ |

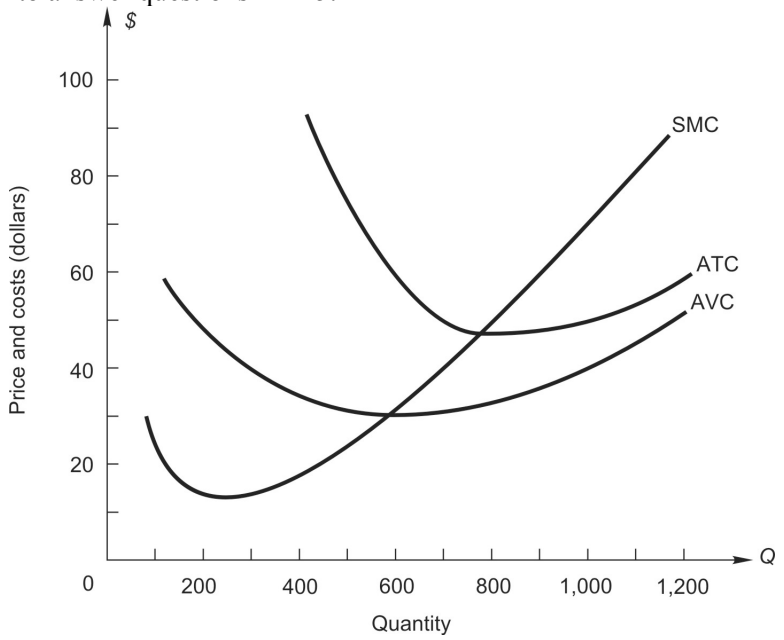
7. The marginal revenue product for the third unit of labor is _____.
   a. $18
   b. $48
   c. $16
   d. $9
   e. $36

8. At a wage rate of $22, the firm will hire
   a. 0 units of labor.
   b. 1 unit of labor.
   c. 3 units of labor.
   d. 7 units of labor.
   e. 8 units of labor.

9. At a wage rate of $26, the firm will hire
   a. 0 units of labor.
   b. 1 unit of labor.
   c. 3 units of labor.
   d. 6 units of labor.
   e. 7 units of labor.

10. At a wage rate of $40, the firm will hire
   a. 0 units of labor.
   b. 1 unit of labor.
   c. 3 units of labor.
   d. 7 units of labor.
   e. 8 units of labor.

Use the following figure showing short-run cost curves for a competitive price-taking firm to answer questions 11–15.



11. If price is $70 how much does the firm produce?
    a. 750 units
    b. 1,000 units
    c. 900 units
    d. 600 units

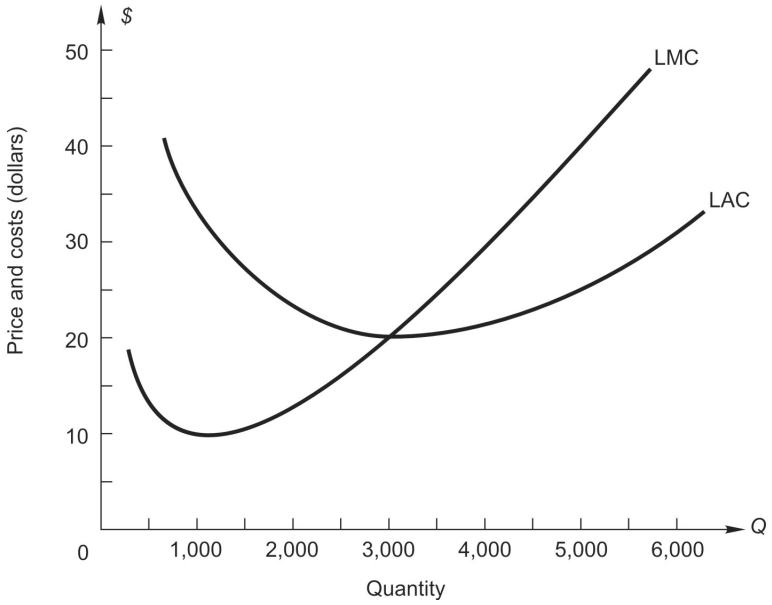
12. If price is $70 how much profit (loss) does the firm make?
    a. zero
    b. $16,500
    c. $20,000
    d. $23,000
    e. $15,500

13. Let price be $40. How much does the firm produce?
    a. zero units
    b. 500 units
    c. 600 units
    d. 700 units
    e. 800 units

14. If price is $40, how much profit (loss) does the firm make?
    a. it loses its fixed cost
    b. $5,000
    c. –$7,000
    d. –$4,000
    e. $3,500

15. Below what price will the firm shut down and produce nothing?
    a. $48
    b. $18
    c. $20
    d. $30
    e. $50

Use the following figure showing long-run cost curves for the typical firm in a perfectly competitive industry, to answer questions 16–19.




16. If price is $40, the firm will produce _____ units.
    a. 2,000
    b. 3,000
    c. 4,000
    d. 4,500
    e. 5,000

17. If price is $40, how much profit (loss) does the firm make?
    a. $75,000
    b. $60,000
    c. $50,000
    d. $10,000
    e. zero

18. If price is $40 and the firm produces the optimal level of output in this period, what is likely to occur next period?
    a. Each firm will increase output.
    b. Price will fall.
    c. Firms will exit the market.
    d. *b* and *c*.
    e. all of the above.

19. If this industry is in long-run competitive equilibrium the firm will produce _____units of output and price will be _____.
    a. 1,000; $15
    b. 2,000; $20
    c. 3,000; $20
    d. 4,000; $22
    e. 4,500; $30

For questions 20–28, use the following data for a competitive industry and a price-taking firm that operates in this market. Using time-series data, the market demand and supply functions are estimated to be

Demand: $\hat{Q} = 550 - 10P + 0.01M$

Supply: $\hat{Q} = 400 + 10P - 12.5P_I$

where output is $Q$, the price of the product is $P$, income is $M$, and the price of a key input is $P_I$. The income forecasted for 2012 is $30,000 and the price of inputs is $52.

Jartech, Inc. is a firm operating in this market. Jartech's average variable cost function is estimated to be

$$A\hat{V}C = 60.0 - 0.08Q + 0.0001Q^2$$

where $A\hat{V}C$ is measured in dollars per unit. Jartech expects to face total fixed costs of $2,500 in 2012.

20. What is the price forecast for 2012?
    a. $15
    b. $20
    c. $35
    d. $40
    e. $55

21. At what output level will Jartech's average variable cost reach its minimum value?
    a. 200 units
    b. 300 units
    c. 400 units
    d. 500 units
    e. 600 units

22. What is the minimum average variable cost?
    a. $0
    b. $55
    c. $45
    d. $44
    e. $20

23. The profit-maximizing (or loss-minimizing) output for Jartech is
    a. 0 units.
    b. 300 units.
    c. 400 units.
    d. 500 units.
    e. 600 units.

24. What is average variable cost at the profit-maximizing level of output?
    a. $0
    b. $20
    c. $44
    d. $45
    e. $50

25. How much profit (loss) does Jartech, Inc. expect to earn?
    a. –$2,500
    b. $2,500
    c. $3,000
    d. –$3,000
    e. $2,000

In questions 26–28, suppose that the 2012 input price forecast is revised to $20 ($P_I$ = $20).

26. What is the revised price forecast for 2012?
    a. $15
    b. $20
    c. $35
    d. $40
    e. $55

27. What is Jartech's profit-maximizing (or loss-minimizing) output?
    a. 0 units
    b. 300 units
    c. 400 units
    d. 500 units
    e. 600 units

28. Under the revised forecast how much profit (loss) does Jartech, Inc. expect to earn?
    a. $0
    b. –$2,500
    c. $2,500
    d. $3,000
    e. –$3,000

29. T F A perfectly competitive firm will continue to produce at a loss in the short run as long as total revenue covers the firm's fixed costs.

30. T F When we say "fixed costs don't matter," we mean that increasing fixed costs has no effect on profit.

31. T F An increase in demand will *not* cause price to rise if the industry is a constant cost industry.

32. T F If firms in a competitive industry are making an economic profit, new firms will enter and both price and profit will decrease.

33. T F If the owner's superior managerial ability is keeping the firm's costs below those of other firms, the firm will earn economic profit in long-run competitive equilibrium.

34. T F If price is greater than marginal cost, the firm should produce less.

# Answers

***MATCHING DEFINITIONS***

1. perfect competition
2. perfectly elastic demand
3. shut down
4. profit margin (or average profit)
5. break-even points
6. shutdown price
7. long-run competitive equilibrium
8. increasing-cost industry
9. constant-cost industry
10. economic rent
11. marginal revenue product
12. average revenue product
13. quadratic formula

***STUDY PROBLEMS***

1. a. minimum *AVC*
   b. *ATC*
   c. *ATC*; minimum *AVC*
   d. minimum *AVC*
   e. *P*; *SMC*; minimum *AVC*; *ATC*
   f. *P*; *SMC*; *ATC*

2. a. 4,000 units maximizes profit
   b. \$2; \$8,000
   c. profit = \$4,000
   d. 2,000 units to maximize profit
   e. $TR = \$1 \times 2{,}000 = \$2{,}000$; $TC = \$1.50 \times 2{,}000 = \$3{,}000$; profit = $\$2{,}000 - \$3{,}000 = -\$1{,}000$
   f. $TVC = \$0.50 \times 2{,}000 = \$1{,}000$; After paying \$1,000 in variable costs, \$1,000 in revenue is left to apply toward total fixed costs.
   g. \$0.40 (approximately)

3. i. If not already at its optimal level, adjust the usage of the fixed factor to its optimal level for the chosen output.
   ii. Exit the industry.

   Option (i) will be undertaken if adjusting capital usage reduces total cost below revenue.

   Option (ii) will be undertaken if adjusting capital usage cannot eliminate losses in the long run.

4. In the long run, $P = LMC$ = minimum $LAC$. Not only is price so low that economic profit is zero, but per unit costs are at the lowest possible level, which implies that total costs are minimized for the competitive industry output.

5. Columns 1–8 in your table should look like this:

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| *Units of Labor* | *Output* | *Marginal Product* | *Marginal Revenue Product* | *Average Product* | *Average Revenue Product* | *Marginal Cost* | *Profit when TFC = $500* |
| 0 | 0 | xx | xx | xx | xx | xx | –500 |
| 1 | 8 | 8 | 112 | 8 | 112 | 3 | –412 |
| 2 | 20 | 12 | 168 | 10 | 140 | 2 | –268 |
| 3 | 34 | 14 | 196 | 11.33 | 158.62 | 1.71 | –96 |
| 4 | 45 | 11 | 154 | 11.25 | 157.5 | 2.18 | 34 |
| 5 | 53 | 8 | 112 | 10.6 | 148.4 | 3 | 122 |
| 6 | 58 | 5 | 70 | 9.67 | 135.38 | 4.80 | 168 |
| 7 | 61 | 3 | 42 | 8.71 | 121.94 | 8 | 186 |
| 8 | 63 | 2 | 28 | 7.87 | 110.18 | 12 | 190 |
| 9 | 64 | 1 | 14 | 7.11 | 99.55 | 24 | 180 |
| 10 | 62 | –2 | –28 | 6.2 | 86.8 | xx | 128 |

a. 3 units of labor; 10th

b. increases; total; $70; decreases; total; $196

c. 9 units of labor maximizes total revenue (but *not* profit); \$896 = $TR_{L=9} = ARP \times 9 =$ 99.55 = $P \times Q = 14 \times 64$. As long as *MRP* is positive for an extra unit of labor, hiring that extra unit of labor will increase total revenue.

d. 8 units of labor maximizes profit. This is the last level for which $MRP > w$. $ARP_{L=8}$ = \$110.18; greater

e. falls; rises

f. 63; *MR* (or *P*); *SMC; MRP; w*

g. \$190

6. a. \$9; \$0 In long-run competitive equilibrium, price is bid down to the minimum *LAC* of the "typical" firm in the industry. In this problem, the equilibrium price is \$9, which means the typical firm has a minimum *LAC* of \$9 and earns zero economic profit at a price of \$9.

b. \$1,500 [= (\$9–\$6) × 500]. If price is \$9, the textile firm in this problem will produce up to the point where its *LMC* equals \$9. This occurs at 500 units of output. The average cost to this superior textile producer is \$6 per unit (at 500 units of output). So while the typical firm in the industry is earning zero economic profit in long-run equilibrium, this firm with the superior manager is able to earn \$1,500 of economic profit per month by producing 500 units at a per unit cost of only \$6 (\$3 less than the typical firm).

c. $6,000 per month. Since the superior manager generates $1,500 of economic profit, other firms will try to hire this manager. As they compete to hire her, they will be willing to pay up to $1,500 more than the "typical" salary of $4,500. This superior manager, if she negotiates well, should be able to earn $4,500 + $1,500 = $6,000 per month.

d. As owner of the firm, she would earn zero economic profit (that is, she would pay herself $6,000 per month salary since that is what she could make if she sold her business and went to work for some other firm in the industry). She does, however, earn a salary of $4,500 plus economic rent of $1,500.

7. a. $Q_d = 60,000 - 10,000P$ ; $Q_s = 10,000P$

Solve for $P_{2011} = \$3$

b. $\hat{Q}_{\min} = -b/2c = -(-0.0027)/0.0000018 = 1,500$ units

c. $A\hat{V}C_{\min} = 3 - 0.0027(1,500) + 0.0000009(1,500)^2 = \$0.975$ (97.5 cents)

d. $P = \$3 > \$0.975 = AVC_{\min} \Rightarrow$ produce

e. $SMC = 3 - 0.0054 - 0.0000027Q^2$

f. Set $P = SMC$ and solve for $Q^*$:

$3 = 3 - 0.0054Q + 0.0000027Q^{*2} = 0$

$Q(-0.0054 + 0.0000027Q) = 0$

Either $Q = 0$ or $Q = 2,000$. Since the firm should produce and not shut down the optimal output is $Q^* = 2,000$

g. $TR = P \times Q = \$3 \times 2,000 = \$6,000$

$TVC = \$2,400 = AVC \times Q = \left[3 - 0.0027(2,000) + 0.0000009(2,000)^2\right](2,000)$ ;

Profit = $\$6,000 - \$2,400 - \$1,600 = \$2,000$

h. Set $P = SMC$ again and solve for $Q^*$:

$3 - 0.0054Q^* + 0.0000027Q^{*2} = 1.5$

$$Q^* = 1,667 = \frac{-(-0.0054) + \sqrt{(-0.0054)^2 - 4(1.5)(0.0000027)}}{2(0.0000027)}$$

i. $TR = P \times Q = \$1.50 \times 1,667 = \$2,500$

$TVC = \$1,667 = AVC \times Q = \left[3 - 0.0027(1,667) + 0.0000009(1,667)^2\right](1,667)$ ;

Profit = $\$2,500 - \$1,667 - \$1,600 = -\$767$

8. a. 400; $\$900 \times Q - 170,000 = \$190,000 \Rightarrow Q = 400$.

b. $900; The slope of *TC* at the profit-maximizing point equals the slope of *TR*, and the slope of *TR* is *P*.

c. $900; The slope of *TR* is *P* (= $900).

d. $360,000; $TR = P \times Q = \$900 \times 400 = \$360,000$.

e. $562,500; $TC = ATC \times Q = \$900 \times 625 = \$562,500$.

f. $142,500; At 250 units, the profit margin (or average profit) is $570 (= $900 – $330) $\Rightarrow$ profit = $\$570 \times 250$.

g. –$50,000; At $Q = 0$, profit = $–TFC$. At 250 units, $ATC$ = $330 and $AVC$ = $130, so $TFC = (\$330 - \$130) \times 250$.

h. $570; The 250th unit adds $900 to total revenue and adds $330 to total cost, and so increases profit by $570 (= $900 – $330). Thus, the slope of the profit function must be $570 at 250 units.

i. $425; $ATC = TC/Q \Rightarrow ATC = \$170{,}000/400 \Rightarrow ATC = \$425$.

i. 60; Since $P = ATC$ at $j$, it is a break-even point. In the top panel, the break-even point occurs at 60 units.

k. $820; Since $TFC$ = $50,000 (see part $g$), it follows that ($900 – $AVC$) × 625 = $50,000. Solving for $AVC \Rightarrow AVC = \$820$.

9. a. At 250 units, $AFC$ is $200 (= $330 – $130), and at 650 units, $AFC$ is $80 (=$900 – $820). At 250 units, $TFC$ is $50,000 (= $200 × 250), and at 650 units, $TFC$ is $50,000 (=$80 × 625). As $Q$ increases, $AFC$ declines continuously while $TFC$ is constant.

b. Break-even points occur at 60 and 625 units of output. At 60 units, the line tangent to $TC$ is flatter than $TR$. Thus, in the bottom panel of the figure in Study Problem 8, $SMC$ (which is the value of the slope of the line tangent to $TC$ at 60 units) must be less than $MR$ (which is the slope of $TR$ and equals $P$). At 650 units, the line tangent to $TC$ is steeper than $TR$. At 650 units, $SMC$ (which is the value of the slope of the line tangent to $TC$ at 650 units) must be greater than $MR$.

c. At 400 units, profit reaches its maximum value because the slope of $TR$ equals the slope of $TC$ (i.e., $MR = SMC$). Since the 400th unit adds $900 to $TR$ and adds $900 to $TC$, the change in profit is zero and the tangent line has zero slope at the peak of the profit hill.

d. Profit margin (or average profit) is maximized where $ATC$ is minimized, which occurs at 250 units in this problem. By increasing output from 250 to 400 units, the firm can increase its profit by $47,500 (= $190,000 – $142,500).

e. Your response: "Yes, increasing production to 500 units will indeed increase revenues by $90,000. Unfortunately, total costs will increase by more than $90,000 because marginal cost exceeds $900 (i.e., $MR$) for all of these 100 extra units. Thus, increasing output from 400 to 500 units will decrease profit."

## ***MULTIPLE CHOICE / TRUE-FALSE***

1. a Perfectly competitive firms do not view each other as fierce rivals because each firm is so small relative to the total market that no one firm's increase in sales prevents any other firm from selling as much as it wishes to at the going market price.
2. a When demand is horizontal, $P = MR$, and demand is perfectly elastic.
3. d $TR < TVC \Rightarrow P < AVC \Rightarrow$ shut down and $MRP > ARP \Rightarrow$ shut down
4. c Choice $c$ is really $P > AVC$ in disguise since $TR/Q = P$.
5. d Since $ATC$ = 30 and $AFC$ = 5, $AVC$ must be 25. You are told that $SMC$ = 25, so the firm must be producing at the minimum point on $AVC$. Since $P = 24 < AVC_{min}$, the firm should shut down.
6. e In long-run competitive equilibrium, $P = LMC = LAC = SMC = ATC$, and profit = 0.
7. e $MRP_{L=3} = MP_{L=3} \times P = 18 \times \$2 = \$36$
8. d $MRP_{L=7} = \$24 > \$22 > MRP_{L=8} = \$20$
9. d $MRP_{L=6} = \$28 > \$26 > MRP_{L=7} = \$24$

10. a At the level of labor usage for which $MRP$ = \$40 (i.e., $L$ = 2), $MRP_{L=2}$ = 40 > 30 = $ARP_{L=2} \Rightarrow$ shut down

11. b $P = SMC$ = \$70 at $Q$ = 1,000

12. c $\$20,000 = (P - ATC)Q = (70 - 50)1,000$

13. d $SMC = P$ = \$40 at $Q$ = 700

14. c $-\$7,000 = (P - ATC)Q = (40 - 50)700$

15. d Minimum $AVC$ = \$30

16. e $P = SMC$ = \$40 at $Q$ = 5,000

17. a $\$75,000 = (P - LAC)Q = (40 - 25)5,000$

18. b Price falls because new firms enter and increase supply.

19. c Minimum $LAC$ equals \$20; 3,000

20. e $850 - 10P = -250 + 10P \Rightarrow P = \$55$

21. c $\hat{Q}_{\min} = -\hat{b}/2\hat{c} = 400 = -(0.08)/0.0002$

22. d $A\hat{V}C_{\min} = \$44 = 60 - 0.08(400) + 0.0001(400)^2$

23. d $SMC = 60 - 0.16Q + 0.0003Q^2 = \$55 \Rightarrow Q^* = 500$

24. d $A\hat{V}C_{Q=500} = \$45 = 60 - 0.08(500) + 0.0001(500)^2$

25. b $\text{Profit} = (\$55 \times 500) - (\$45 \times 500) - \$2,500 = \$2,500$

26. c $850 - 10P = 150 + 10P \Rightarrow P = \$35$

27. a $P < A\hat{V}C_{\min} = \$45 \Rightarrow$ shut down

28. b Profit = $-TFC$ = –\$2,500

29. *F* It is *variable* costs that must be covered in order to produce.

30. *F* Increasing fixed cost does decrease profit. The level of fixed cost does not affect the production decision. If $P < AVC$, the firm shuts down no matter how high or low fixed costs are. If $P \geq AVC$, the firm produces the level of output where $MR = SMC$, no matter how high or low fixed costs are.

31. *T* A constant-cost industry has a horizontal long-run industry supply curve. In the long-run, an increase in demand will not lead to an increase in price. [Note: In the short-run, the short-run industry supply curve is upward sloping, even for a constant cost industry, and an increase in demand *will* cause price to rise in the short run.]

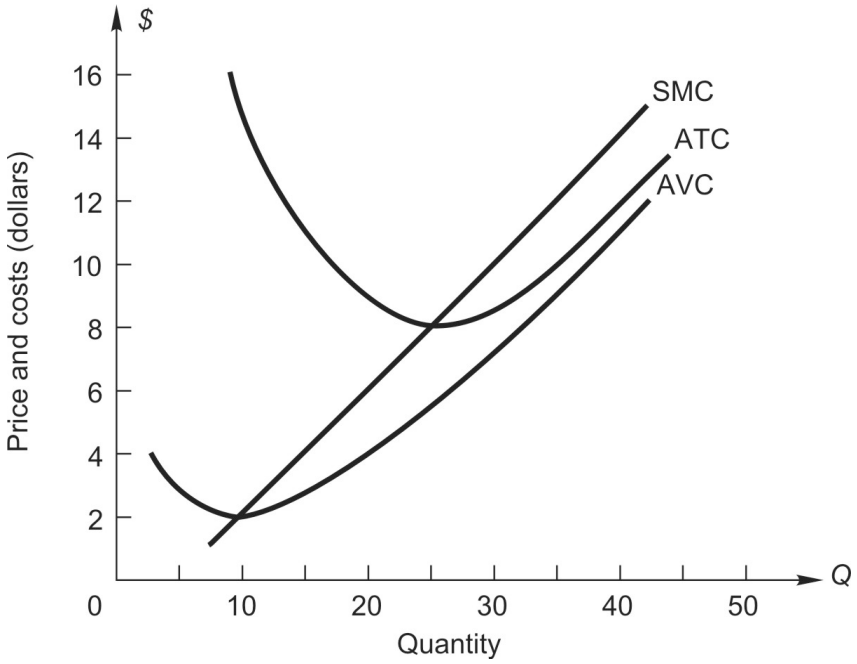
32. *T* Entry takes place when economic profits are positive and entry increases supply.

33. *F* The owner will earn a normal profit plus rent.

34. *F* Produce more if $P > SMC$

## Homework Exercises

1. Consider the cost curves for a price-taking firm in the following figure:




   a. When price is $12 per unit of output, the firm maximizes profit by producing _____ units.

   b. Since average total cost = $_____ for this output, total cost is $_____.

   c. The firm makes an economic profit (loss) of $_____.

   d. Price falls to $8. The firm now maximizes profit by producing _____ units.

   e. At this output level, total revenue = $_____ and total cost = $_____. Therefore the firm earns a profit (loss) of $_____.

   f. Price falls to $6. The firm now maximizes profit by producing _____ units.

   g. At this output level, average total cost is $_____ and total cost is $_____. Total revenue = $_____ and the firm makes a loss of $_____.

   h. Even though the firm makes a loss, it does not shut down because total variable cost is $_____, which leaves $_____ of total revenue to apply toward fixed costs.

   i. If price falls below $_____, the firm shuts down. Explain why.

2. Ajax Corporation is a price-taking firm in a competitive industry that employs only one variable input, labor, to produce a product that sells for $2 per unit. The wage rate is $8 per unit of labor and total fixed costs are $1,000. Fill in the blanks in each column of this table as instructed by the questions below:

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| *Units of Labor* | *Output* | *Marginal Product* | *Marginal Revenue Product* | *Average Product* | *Average Revenue Product* | *Marginal Cost* | *Profit* |
| 0 | 0 | xx | xx | xx | xx | xx | _____ |
| 1 | 400 | _____ | _____ | _____ | _____ | _____ | _____ |
| 2 | 950 | _____ | _____ | _____ | _____ | _____ | _____ |
| 3 | 1,250 | _____ | _____ | _____ | _____ | _____ | _____ |
| 4 | 1,350 | _____ | _____ | _____ | _____ | _____ | _____ |
| 5 | 1,370 | _____ | _____ | _____ | _____ | _____ | _____ |
| 6 | 1,373 | _____ | _____ | _____ | _____ | _____ | _____ |
| 7 | 1,369 | _____ | _____ | _____ | _____ | _____ | _____ |
| 8 | 1,364 | _____ | _____ | _____ | _____ | _____ | _____ |

a. Fill in the blanks in columns 3 and 5. Marginal product begins to diminish beyond _____ units of labor. Marginal product is negative beyond _____ units of labor.

b. Compute marginal and average revenue products and fill in the blanks in columns 4 and 6. The sixth unit of labor _____ (increases, decreases) total revenue by $_____. Decreasing labor usage from four to three units _____ (increases, decreases) total revenue by $_____.

c. The manager can maximize *total revenue* by hiring _____ units of labor. The maximum possible value of total revenue is $_____.

d. The manager hires _____ units of labor and produces _____ units of output in order to maximize *profit*. At this level of labor usage, *ARP* = _____ which is _____ (greater, less) than *MRP*.

e. Compute marginal cost and fill in the blanks in column 7. At first, marginal cost _____ (rises, falls) as marginal product rises, then marginal cost _____ (rises, falls) as marginal product falls.

f. The profit-maximizing level of output is _____ units because this is the last level of output for which _____ exceeds _____, or equivalently, _____ exceeds _____ .

g. Compute profit and fill in the blanks in column 8. The optimal level of labor employment and the optimal level of output both result in an identical maximum profit level of $\$\_\_\_\_\_$.

h. Now suppose total fixed cost increases to \$5,000. Recalculate profit at each level of labor usage (and output) and fill in the blanks in column 9 below. When total fixed cost is \$5,000, the optimal level of labor usage is _____ units of labor, and the optimal level of output is _____ units. How high must total fixed costs rise in order for it to be optimal for this firm to shut down? Explain briefly.

| (1) | (2) | (9) |
|---|---|---|
| *Units of Labor* | *Output* | *Profit TFC = \$5,000* |
| 0 | 0 | _____ |
| 1 | 400 | _____ |
| 2 | 950 | _____ |
| 3 | 1,250 | _____ |
| 4 | 1,350 | _____ |
| 5 | 1,370 | _____ |
| 6 | 1,373 | _____ |
| 7 | 1,369 | _____ |
| 8 | 1,364 | _____ |

3. Sunnyvale Orchards is one of many small, perfectly competitive firms growing apples for the U.S. market. The forecasted price of apples in 2012 is \$23.60 per crate. The management of Sunnyvale Orchards estimates its short-run average variable cost function to be

$$AVC = 20 - 0.04Q + 0.00005Q^2$$

where $Q$ is the number of crates of apples produced each week. Total fixed cost at Sunnyvale Orchards is \$1,200 per week.

a. Average variable cost reaches its minimum value at _____ crates of apples per week.

b. The minimum value of average variable cost is \$_____ per crate.

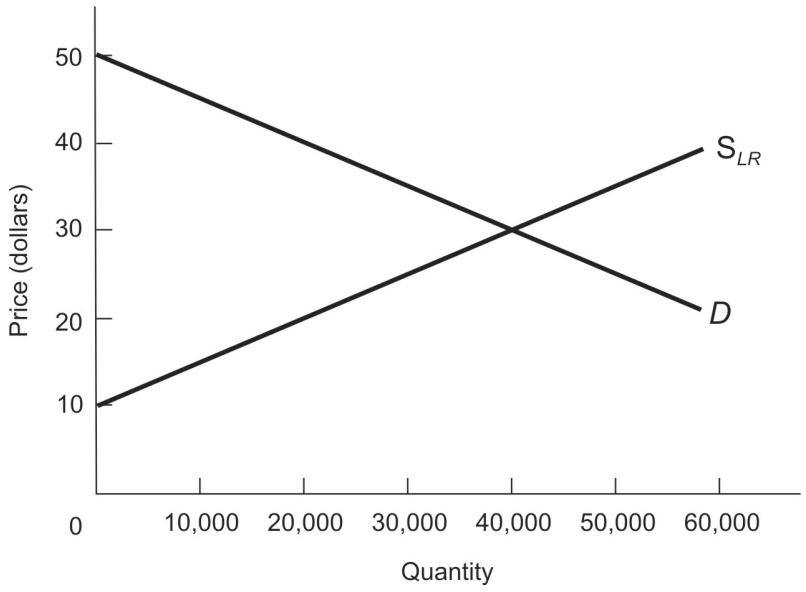
c. Sunnyvale faces the marginal cost function $SMC$ = _____

d. Sunnyvale will maximize profit (or minimize loss) by producing _____ crates of apples per week in 2012.

e. Sunnyvale's profit will be $_____ per week. [Note: If a loss occurs, then express profit as a negative value.]

f. If the price of apples falls to $10 per crate, Sunnyvale should produce _____ crates per week, and its profit will be $_____per week. [Note: If a loss occurs, then express profit as a negative value.]

4. The figure below shows a long-run industry supply curve ($S_{LR}$) and the demand curve ($D$) facing the competitive industry. The firms in this industry employ inputs of varying quality and productivity.




a. The long-run marginal cost of producing the 20,000th unit of output is $_____.

b. If the firms in this industry produce a total industry output of 20,000 units, every firm produces at the minimum long-run average cost of $_____ per unit and earns $_____ of economic profit.

c. In long-run competitive equilibrium, the industry will produce _____ units of the good and sell these units at the market-clearing price of $_____.

d. The long-run marginal cost at the equilibrium output in part c is $_____, and the long-run average cost at the equilibrium output is $_____.

e. "The firms employing the superior inputs have lower costs than their rivals, but they still cannot earn any profit." True or false? Explain.

f. Total producer surplus in long-run competitive equilibrium is $_____ for this industry.

g. Who gets the producer surplus that you calculated in part *f*? Explain briefly.