

## CHAPTER 2: Optimal Decisions Using Marginal Analysis

### MULTIPLE CHOICE

1. According to the model of the firm, the management's main goal is to:
  - a) increase revenue from sales.
  - b) maximize profit.
  - c) maximize its market share.
  - d) minimize its variable cost per unit.
  - e) maintain a steady and predictable growth in earnings.

ANSWER: b

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

2. According to the law of demand, if a firm reduces the price of its good:
  - a) consumers in the market will demand more units of the good.
  - b) some consumers will exit the market.
  - c) consumers will demand fewer units than before the price cut.
  - d) the quantity of goods produced and sold by the firm will decline.
  - e) competing firms will reduce prices.

ANSWER: a

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

3. Which of the following is true of a firm facing a downward sloping demand curve?
  - a) In order to sell more units, the firm needs to lower its price.
  - b) A price cut will reduce total revenue.
  - c) The firm's total revenue and price are directly correlated.
  - d) The marginal revenue from each unit sold is constant.
  - e) The firm faces a constant marginal cost curve.

ANSWER: a

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

4. The demand for a product is given by  $Q = 600 - 30P$ . At  $P = \$15$ , the firm sells:
- a) 100 units.
  - b) 150 units.
  - c) 300 units.
  - d) 450 units.
  - e) 600 units.

ANSWER: b

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

5. The demand for a product is given by  $P = 1,750 - 25Q$ . If the firm wishes to sell 50 units, each unit should be priced at:
- a) \$100.
  - b) \$200,
  - c) \$300.
  - d) \$400.
  - e) \$500.

ANSWER: e

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

6. A firm's demand curve is given by  $Q = 800 - 2P$ , where  $P =$  price and  $Q =$  quantity. Therefore, its inverse demand equation is:
- a)  $MR = 800 - 4P$
  - b)  $P = 800 - 2Q$
  - c)  $P = 400 - .5Q$
  - d)  $P = 800 - .5Q$
  - e)  $800 = Q + 2P$

ANSWER: c

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

7. Suppose a firm's inverse demand function is  $P = 40 - 8Q$ . What is the firm's revenue function?
- $R = 40Q - 8Q^2$
  - $R = 40 - 16Q$
  - $R = -8Q$
  - $R = 40/Q - 8$
  - $R = 40Q - 4Q^2$

ANSWER: a

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

The following table shows the total revenue and total cost (in dollars) from different sales volumes of the good.

Table 2-1

Price	Quantity	Total Revenue	Total Cost
15	1	15	3
14	2	28	7
13	3	39	12
12	4	48	18
11	5	55	25
10	6	60	33

8. Refer to Table 2-1. What is the firm's profit from selling 3 units of the good?
- \$13
  - \$11
  - \$12
  - \$39
  - \$27

ANSWER: e

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

9. Refer to Table 2-1. What is the marginal profit of the firm from the sale of the 3rd unit of the good?
- \$9
  - \$6
  - \$2
  - \$5
  - \$21

ANSWER: b

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

10. Suppose, at its current output level, a firm's marginal profit is positive. Therefore, to maximize profit, it should:
- decrease output until marginal profit is zero.
  - increase output because MR is less than MC.
  - increase both its output and its price.
  - increase output because MR is greater than MC.
  - increase output until it is producing at full capacity.

ANSWER: d

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

11. Suppose a firm's profit is given by the equation  $\pi = -200 + 80Q - .2Q^2$ . Which of the following is true?
- The firm's marginal profit is given by the equation:  $M\pi = 80 - .2Q$ .
  - The firm's profit-maximizing output is  $Q = 400$ .
  - The firm's profit-maximizing output is  $Q = 200$ .
  - The firm's marginal profit is given by the equation:  $M\pi = 80 - 2Q$ .
  - The firm's profit-maximizing output is  $Q = 800$ .

ANSWER: c

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

12. If a firm's profit is given by  $\pi = -150 + 360Q - 36Q^2$ , then its optimal output is:
- 12 units.
  - 5 units.
  - 2 units.
  - 20 units.
  - 36 units.

ANSWER: b

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Hard

13. If a firm's demand function is of the form  $P = a - bQ$ , what is its marginal revenue equation?
- $MR = a - Q$
  - $MR = a - 2bQ$
  - $MR = a - 2Q$
  - $MR = a - 2b$
  - $MR = a + 2bQ$

ANSWER: b

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Hard

14. A firm's total revenue function is given by  $R = 100 + 100Q - 2Q^2$ . At  $Q = 10$ , which of the following is true?
- The firm's marginal revenue is \$80.
  - The firm's marginal revenue is constant.
  - The firm's average revenue is \$50.
  - The firm's total revenue is \$500.
  - The firm's marginal revenue is \$60.

ANSWER: e

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

15. Which of the following correctly defines marginal revenue?
- Marginal revenue is the price at which the firm sells the last unit of the good.
  - Marginal revenue is the change in revenue from a unit increase in the price of the good.
  - Marginal revenue is the additional revenue from a unit increase in output and sales.
  - Marginal revenue is the additional revenue earned from an increase in demand for the good.
  - Marginal revenue is the difference between price and marginal cost for the last unit sold.

ANSWER: c

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Easy

16. For a downward-sloping demand curve, the associated marginal revenue curve:
- a) coincides with the demand curve.
  - b) lies below and is parallel to the demand curve.
  - c) has twice the slope as the demand curve.
  - d) is positive for all levels of sales.
  - e) is parallel to the quantity axis.

ANSWER: c

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Easy

The following table shows the total revenue (in dollars) and total cost (in dollars) from the production and sale of different units of a product.

Table 2-1

Price	Quantity	Total Revenue	Total Cost
15	1	15	3
14	2	28	7
13	3	39	12
12	4	48	18
11	5	55	25
10	6	60	33

17. Refer to Table 2-1. What is the marginal revenue associated with the sale of the 5th unit of the good?
- a) \$55
  - b) \$8
  - c) \$7
  - d) \$48
  - e) \$4

ANSWER: c

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Medium

18. Refer to Table 2-1. What is the profit-maximizing level of output for the firm?
- a) 3 units
  - b) 2 units

- c) 1 unit
- d) 5 units
- e) 6 units

ANSWER: d

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

19. Given that a firm's inverse demand function is  $P = 100 - 5Q$  and total cost is given by  $C = 550 + 10Q$ , what is the firm's profit-maximizing level of output?
- a) 10 units
  - b) 15 units
  - c) 9 units
  - d) 8 units
  - e) 5 units

ANSWER: c

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

20. Which of the following correctly defines marginal cost?
- a) Marginal cost is the addition made to fixed cost when an extra unit is produced.
  - b) Marginal cost is the additional cost of producing an extra unit of output.
  - c) Marginal cost is the additional cost of increasing the scale of production in the long run.
  - d) Marginal cost is the difference between price and marginal revenue for the last unit sold.
  - e) Marginal cost is the same as the firm's variable cost at all levels of output.

ANSWER: b

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Easy

21. Given the total cost equation for a firm, the marginal cost equation can be derived by:
- a) dividing total cost by total output.
  - b) taking the first derivative of the cost function with respect to quantity.
  - c) dividing total variable cost by total output.
  - d) subtracting variable cost from the fixed cost at all levels of output.
  - e) multiplying the total cost equation by price.

ANSWER: b

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Easy

22. To maximize profit, the firm should set output at the level where:
- a) the average cost per unit is minimized.
  - b) average revenue just equals average cost.
  - c) marginal cost equals zero.
  - d) marginal revenue is equal to marginal cost.
  - e) marginal revenue equals zero.

ANSWER: d

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Easy

23. Assume that a firm is producing at its profit-maximizing level of output. A decrease in the price of raw materials used in production is most likely to lead to:
- a) an increase in quantity produced at an unchanged price.
  - b) a fall in the price of the good and an increase in the quantity produced.
  - c) a fall in both the price of the good and the quantity produced.
  - d) an increase in both the price of the good and the quantity produced.
  - e) a fall in the quantity produced of the good at an unchanged price.

ANSWER: b

SECTION REFERENCE: Sensitivity Analysis  
LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.  
DIFFICULTY LEVEL: Medium

24. A firm negotiates a new labor contract with a higher average hourly wage. What is the most likely effect of the higher wage on the firm's price and output?
- a) Neither price nor output will be affected.
  - b) Price will increase but output will not change.
  - c) Both price and output will increase.
  - d) Price will not change but output will decrease.
  - e) Price will increase and output will decrease.

ANSWER: e

SECTION REFERENCE: Sensitivity Analysis  
LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.  
DIFFICULTY LEVEL: Medium



25. Assume that a firm is producing at its profit-maximizing level of output. A decrease in fixed cost implies that:
- a) marginal revenue will increase but marginal cost will decrease.
  - b) marginal revenue will not change but marginal cost will decrease.
  - c) neither average total cost nor marginal cost will change.
  - d) neither marginal revenue nor marginal cost will change.
  - e) both marginal revenue and marginal cost will decrease.

ANSWER: d

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

26. Due to an increase in the price of a competitor's product, the demand for a firm's product increases sharply. How is this most likely to affect the firm's marginal revenue and marginal cost?
- a) Marginal revenue will increase but marginal cost will decrease.
  - b) Both marginal revenue and marginal cost will not be affected.
  - c) Both marginal revenue and marginal cost will increase.
  - d) Marginal revenue will not change but marginal cost will increase.
  - e) Marginal revenue will increase but marginal cost will not change.

ANSWER: e

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

27. Assume that Burger King, a fast food chain, enters into a franchise agreement. The royalty paid to Burger King by the franchisee is calculated as a percentage of the franchisee's revenue. Given that the franchisee faces a downward-sloping demand curve, which of the following is likely to be true?
- a) The franchisee's revenue-maximizing output will be greater than its profit-maximizing output.
  - b) To maximize revenue, Burger King will want the franchisee to produce at the level where total revenue is positive but falling.
  - c) The franchisee will produce at the level where the slope of the total revenue curve is zero in order to maximize profits.
  - d) The profit-maximizing level of output for the franchisee will be at the level where marginal revenue is less than marginal cost.
  - e) To maximize revenue, Burger King will want the franchisee to produce at the level where marginal revenue equals marginal cost.

ANSWER: a

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Hard

## SHORT ANSWERS

28. Are there any types of goods or situations where the law of demand does not hold? Explain.

ANSWER: The law of demand states that all other factors held constant, the higher the unit price of a good, the fewer the number of units demanded by consumers and, consequently, sold by firms. For certain goods, a high price is associated with a higher status or luxury, for example, a fancy wine or a designer bag. For such goods, a high price is seen as a sign of exclusivity, which means that the demand for these goods might increase as price increases. These are called Veblen goods.

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Medium

29. What is the law of demand? How do managers use it in decision-making?

ANSWER: The law of demand states that all other factors held constant, the higher the unit price of a good, the fewer the number of units demanded by consumers and, consequently, sold by the firm. Managers use the demand curve as the basis for predicting the revenue consequences of alternative output and pricing policies.

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

30. Carefully define marginal analysis, and explain how it is useful in managerial economics.

ANSWER: Marginal analysis is the process of considering small changes in a decision and determining whether such a change will improve the ultimate objective. The manager can follow a clear rule: Make a small move to a nearby alternative if and only if the move will improve one's objective. Keep moving until no further move will help.

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Easy

31. Suppose that a firm operates in a competitive market where the commodity price is \$15 per unit. The firm's cost equation is  $C = 25 + .25Q^2$ , where  $C$  = total cost and  $Q$  = quantity.  
 (a) Find the profit-maximizing level of output for the firm. Determine its level of profit.

ANSWER: In a competitive market,  $R = P \times Q = 15Q$  implying  $MR = dR/dQ = \$15$ . In turn, marginal cost is:  $MC = dC/dQ = .5Q$ . Setting  $MR = MC$  implies  $15 = .5Q$ , or  $Q = 30$  units. At  $Q = 30$  units,  $R = \$450$ ,  $C = \$250$ , and profit = \$200.

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

- (b) Suppose that fixed costs increase to \$75. Verify that this change in fixed costs does not affect the firm's optimal output.

ANSWER: The increase in fixed cost has no effect on MR or MC, so setting  $MR = MC$ , again implies  $Q^* = 30$  units. The firm's optimal level of output is unaffected. However, with the \$50 rise in fixed cost, the firm's profit falls to \$150.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

32. The demand for a firm's product is given by the equation:  $P = 36 - .2Q$ . The firm's cost equation is given by  $C = 200 + 20Q$ .  
 (a) Determine the firm's optimal quantity and price.

ANSWER:  $MR = dR/dQ = 36 - .4Q$  and  $MC = dC/dQ = \$20$ . Setting  $MR = MC$  implies  $Q^* = 40$  units, as the optimal output. From the price equation, it follows that the optimal price is:  $P^* = 36 - (.2)(40) = \$28$ . Finally, profit is given by:  $\pi = \$1,120 - 1,000 = \$120$ .

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

- (b) Suppose that the firm's costs change to  $C = 100 + 24Q$ . Determine the new optimal quantity and price. Explain why the results differ from the previous case.

ANSWER: With the new cost function,  $MC = \$24$ . Setting  $MR = MC$  implies  $36 - .4Q = 24$ , or  $Q^* = 30$  units. In turn,  $P^* = 36 - (.2)(30) = \$30$ . Finally, profit is given by:  $\pi = \$900 - \$820 = \$80$ . Here, the reduction in fixed cost has no impact on output, but the increase in marginal cost induces a smaller output quantity and a greater price.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

33. A firm faces the demand curve,  $P = 80 - 3Q$ , and has the cost equation:  $C = 200 + 20Q$ , where  $P$  = price,  $C$  = total cost, and  $Q$  = quantity.  
(a) Find the optimal quantity and price for the firm.

ANSWER: Profit is maximized by setting  $MR = MC$ . From the price equation,  $MR = 80 - 6Q$ . Equating this with  $MC = \$20$  implies  $80 - 6Q = 20$ , so the optimal level of output is:  $Q^* = 10$  units. In turn, the optimal price is:  $P^* = 80 - (3)(10) = \$50$ .

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

- (b) Now suppose that the demand for the firm's product changes to:  $P = 110 - 3Q$ . Find the new optimal quantity and price. Has there been an increase or a decrease in demand? Explain.

ANSWER: Given the new price equation,  $P = 110 - 3Q$ , it follows that  $MR = 110 - 6Q$ . Setting  $MR = MC$  implies  $110 - 6Q = 20$ , or  $Q^* = 15$  units. In turn,  $P^* = 110 - (3)(15) = \$65$ . The increase in demand (in this case a parallel outward shift of the demand curve) has induced the firm to increase both its price and quantity.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

34. Suppose the inverse demand curve of a firm is given by the equation:  $P = 2,500 - 10Q$ . Compute the firm's total revenue and marginal revenue, and determine the quantity that maximizes total revenue.

ANSWER:  $R = P \times Q = 2,500Q - 10Q^2$ . In turn,  $MR = 2,500 - 20Q$ . Revenue is maximized when  $MR$  equal to 0. Therefore,  $2,500 - 20Q = 0$  implies  $Q = 125$ .

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

35. Suppose that a firm sells in a competitive market at a fixed price of \$12 per unit. The firm's cost function is:  $C = 200 + 4Q$ . In this case, how can the firm use marginal revenue and marginal cost to maximize its profit?

ANSWER: Here, total revenue =  $12Q$  so that  $MR = \$12$ . In turn,  $MC = \$4$ . Since  $MR > MC$ , the firm gains additional profit by continuing to increase output. It should do so until it reaches the capacity limit of its production facility.

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

36. In each case below, find the profit-maximizing level of output. Verify that each output level is a maximum by checking the second derivative.

(a)  $\pi = -50 + 200Q - 10Q^2$

ANSWER:  $M\pi = 200 - 20Q$ . Setting  $M\pi = 0$  implies:  $Q^* = 10$ . The second derivative is equal to  $-20$ , which is negative implying that  $Q^* = 10$  is the profit-maximizing level of output.

SECTION REFERENCE: Calculus and Optimization Techniques (Appendix)

LO: Review the use of calculus in optimization problems.

DIFFICULTY LEVEL: Medium

(b)  $\pi = -100 + 300Q - 4Q^3$

ANSWER:  $M\pi = 300 - 12Q^2$ . Setting  $M\pi = 0$  implies:  $Q^* = 5$ . The second derivative is equal to  $-24Q$ , which is negative implying that  $Q^* = 5$  is the profit-maximizing level of output.

SECTION REFERENCE: Calculus and Optimization Techniques (Appendix)

LO: Review the use of calculus in optimization problems.

DIFFICULTY LEVEL: Medium

37. Carefully explain the economic importance of the Lagrange multiplier. How might a manager use it in decision making?

ANSWER: The Lagrange multiplier measures the marginal change in the objective function at the constrained optimum. Thus, it measures the cost to the firm (in terms of lost profit) of the binding constraint. Managers can use the value of the Lagrange multiplier to determine whether it is worthwhile to relax or shift the constraint. For example, suppose that the cost of relaxing a constraint (for instance, increasing the firm's limited production capacity) is larger than the increase in profits that would result from the change. In this case, it does not pay to expand capacity. Management should accept the constrained level of profit as the optimal outcome.

SECTION REFERENCE: Calculus and Optimization Techniques (Appendix)

LO: Review the use of calculus in optimization problems.

DIFFICULTY LEVEL: Medium

## ESSAY

38. How will an increase in price affect the quantity of output sold by a firm? What are the reasons for this change?

ANSWER: According to the law of demand, a change in price will lead to a drop in the quantity of output sold by a firm. There are three sources of the decrease in demand: (1) decreased sales to the firm's current customers, as they choose to buy less at the higher price; (2) sales lost to competing suppliers; and (3) decrease in new customers, who choose to buy from competing suppliers. In particular circumstances, these factors will be important to a greater or lesser degree.

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Easy

39. Assume that Turbo is a firm that produces two kinds of flash-memory drives. Its deluxe model has the inverse demand equation:  $P_D = 70 - .05Q_D$ , where  $Q_D$  is the number of units sold per week. For its economy model, the price equation is:  $P_E = 30 - .05Q_E$ . Turbo's marginal cost is \$10 per unit for either drive, and it produces both on a single assembly line that has a maximum capacity of 875 drives per week.

(a) Determine the profit-maximizing outputs and prices of the drives.

ANSWER: Setting the marginal profit from the sale of the deluxe model equal to zero implies  $M\pi_D = 60 - .1Q_D = 0$  or  $Q_D = 600$  drives. For the economy version,  $M\pi_E = 20 - .1Q_E = 0$ , so  $Q_E = 200$  drives. The corresponding prices are:  $P_D = \$40$  and  $P_E = \$20$ . The total output ( $600 + 200 < 875$ ) is within the firm's capacity.

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

(b) Suppose demand for the economy drive increases to:  $P_E = 50 - .04Q_E$ . What are the profit-maximizing outputs and prices of the drives?

ANSWER: Given the increase in demand for the economy drives, Turbo's new optimal output becomes  $Q_E = 500$  drives, so total output would exceed total capacity. The constrained optimization problem (using the Lagrangian approach) must satisfy the optimality condition:  $M\pi_D = M\pi_E$ , or  $60 - .1Q_D = 40 - .08Q_E$ , as well as the capacity constraint,  $Q_D + Q_E = 875$ . Solving these two equations in two unknowns implies  $Q_D = 500$  drives and  $Q_E = 375$  drives. The new prices are:  $P_D = \$45$  and  $P_E = \$35$ .

SECTION REFERENCE: Calculus and Optimization Techniques (Appendix)

LO: Review the use of calculus in optimization problems.

DIFFICULTY LEVEL: Hard

40. War Game, Inc. produces games that simulate historical battles. The market is small but loyal, and War Game is the largest manufacturer. It is thinking about introducing a new game in honor of the sixtieth anniversary of the end of World War II. Based on historical

data regarding sales, War Game management forecasts demand for this game to be  $P = 50 - .002Q$ , where  $Q$  denotes unit sales per year, and  $P$  denotes price in dollars. The cost of manufacturing (based on royalty payments to the designer of the game, and the costs of printing and distributing) is  $C = 140,000 + 10Q$ .

(a) If the goal of War Game is to maximize profit, calculate the optimal output and price.

ANSWER: The company's profit equation is:  $\pi = (50Q - .002Q^2) - 10Q - 140,000$ . To maximize profit, set marginal profit equal to 0. Therefore,  $M\pi = 40 - .004Q = 0$ , implying optimal output,  $Q^* = 10,000$  units. In turn,  $P = 50 - (.002)(10,000) = \$30$  per unit of the game.

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

(b) If instead the company's goal is to maximize sales revenue, what is its optimal price and quantity?

ANSWER: The company's revenue equation is given by:  $R = P \times Q = 50Q - .002Q^2$ . To maximize revenue, set marginal revenue equal to 0. Therefore,  $50 - .004Q = 0$ , implying optimal output,  $Q^* = 12,500$  units. In turn,  $P = 50 - (.002)(12,500) = \$25$  per unit of the game.

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

41. A manufacturing company produces and sells small farm tractors. Its annual fixed costs are \$15 million, and its marginal cost per tractor is \$20,000. Demand for small tractors is given by:  $P = 30,000 - Q$ , where  $P$  denotes price in dollars and  $Q$  is annual sales.

(a) Find the firm's profit-maximizing output, price, and annual profit.

ANSWER: To maximize profit, marginal revenue should be equal to marginal cost. Therefore,  $MR = 30,000 - 2Q = 20,000$ , implying optimal output,  $Q^* = 5,000$  tractors and  $P = 30,000 - 5,000 = \$25,000$  per tractor. The firm's total profit is:  $(\$25,000 - \$20,000)(5,000) - \$15,000,000 = \$10,000,000$ .

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

(b) Assume that agriculture prices fall and the farming sector faces a mild recession. The demand for the small tractors drops to:  $P = 26,000 - Q$ . Suppose the recession is only temporary, and demand will recover soon. What price and output adjustment should the firm make during the recession?

ANSWER: With the fall in demand, the firm's new optimal output can be obtained by setting  $MR = MC$ :  $MR = 26,000 - 2Q = 20,000$ , implying  $Q^* = 3,000$  tractors and  $P^* = 26,000 - 3,000 = \$23,000$  per tractor. The firm's total profit is:  $(\$23,000 - \$20,000)(3,000) - \$15,000,000 = -\$6,000,000$ . In the short run, the firm is minimizing its losses while waiting for sales to recover.

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Medium

42. KopyKat is a firm that specializes in printing business cards and résumé's, using the latest laser technology. The manager has estimated that weekly demand can be approximated by  $P = 25 - .001Q$ , where  $P$  is price and  $Q$  is output per week. The firm's cost function is  $C = 25,000 + 13Q + .002Q^2$ , where  $C$  is total cost.
- (a) Determine the firm's profit maximizing price and output.

ANSWER: The firm's inverse demand function is  $P = 25 - .001Q$  which implies  $MR = 25 - .002Q$ . Also  $MC = dC/dQ = 13 + .004Q$ . Setting  $MR = MC$ , yields:  $25 - .002Q = 13 + .004Q$ , or  $.006Q = 12$ . Thus, the profit-maximizing output is 2,000 units per week. The optimal price is:  $P = 25 - (.001)(2,000) = \$23$  per unit.

SECTION REFERENCE: Marginal Revenue and Marginal Cost  
LO: Discuss the concepts of marginal revenue and marginal cost.  
DIFFICULTY LEVEL: Medium

- (b) The night supervisor believes that extending KopyKat's hours by two hours in the evening would substantially increase volume. The manager is willing to stay open for two hours over the next three months as an experiment. What results would lead the manager to decide if the store can remain open later in the evening on a permanent basis?

ANSWER: Keeping KopyKat open for additional hours means incurring some additional labor costs (If volume increases, production cost will increase as well). As always, the decision for the manager hinges on whether the increased volume from longer hours generates enough additional revenue to cover the increased cost of longer hours. An experiment for three months should presumably provide enough data to let the manager decide if the move is worth it in terms of the increased revenues and increased cost.

SECTION REFERENCE: Sensitivity Analysis  
LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.  
DIFFICULTY LEVEL: Hard

- (c) A former employee decides to sue KopyKat, alleging employment discrimination. Although management claims innocence, they agree to settle out of court. The settlement requires KopyKat to pay the employee \$10,000 per month for the next year. Determine the optimal price and output for the firm under these new conditions.



ANSWER: The payment of \$10,000 per month represents an increase in the firm's fixed costs and has no impact on marginal revenue or marginal cost. Thus, the firm should not alter its pricing or production decisions.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Hard

43. Max Whitley, manager of Whitley Construction, builds new homes in a booming community in the Midwest. Although sales have slowed because of a national recession, it now looks as if the recession is about to end. Max wants to be ready with material, labor, and foremen to meet the demand for housing. Last year, Max built and sold 40 starter homes which is the most popular model. Max thinks that his sales will increase to 50 units over the current year. The going market price for this model (which Max and his numerous competitors have charged) has been \$275,000. In addition, Whitley Construction's marginal cost of building this model averages \$245,000.
- (a) Based on these facts, recommend a course of action for Max.

ANSWER: Since Max can expect to make \$30,000 marginal profit on each home, he should attempt to build and sell a maximum number of units. He should monitor market demand and examine whether home sales really robust enough to justify building 50 units. If the price is truly market determined (note that he has many competitors), Max may not be able to increase his sale price considerably. However, he should take advantage of every opportunity to sell more homes, since marginal revenue is above marginal cost.

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

- (b) Suppose that the economic boom raises the cost of labor and raw materials, so that the additional cost of a starter house rises to \$265,000. What is Max's most profitable course of action? Explain.

ANSWER: If the market price is competitively determined, Max will have little opportunity to pass on such a cost increase in the form of a higher price (Whitley's new home sales would dwindle quickly if it charged a price above the competitive level). The most profitable course of action is to sell new homes at the lower profit margin of \$10,000 per house. An alternative choice is to reduce construction of starter homes and increase production of larger, more expensive homes, assuming that the profit margins are greater on these.

SECTION REFERENCE: A Simple Model of the Firm

LO: Explain how, in a simple model of profit maximization, revenues and costs depend on price and output decisions.

DIFFICULTY LEVEL: Hard

44. Night Timers is a small company manufacturing glow-in-the-dark products. One of the hottest items the engineering department has developed is adhesive tape that can be applied

to walls and floors. Night Timers' chief engineer anticipates that the product will be sold in ten-foot rolls. At present, the company's maximum production capacity is 140,000 rolls per year. The engineer believes the cost function to be described by  $C = \$50,000 + 0.25Q$ , where  $C$  is total cost and  $Q$  is number of rolls (The high fixed costs represent development cost and tooling to prepare coating equipment). Night Timers' president seeks to establish a price that maximizes profit (since she is the chief stockholder). She thinks that the firm should be able to sell at least 125,000 rolls of tape per year.

(a) If Night Timers plans to sell 125,000 rolls per year, what is the necessary price if the firm is to break even? What if it can only sell 100,000?

ANSWER: Break even implies  $R = C$ , or  $P \times Q = 50,000 + .25Q$  at the level of output indicated. To find the break-even price, substitute  $Q = 125,000$  and solve for  $P$ . Thus  $P = \$.65$  per unit. If  $Q = 100,000$ , the break-even price rises to  $P = \$.75$  per unit.

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Discuss the concepts of marginal revenue and marginal cost.

DIFFICULTY LEVEL: Medium

(b) The marketing manager forecasts demand for the tape to be:  $Q = 350,000 - 200,000P$ . Find the firm's profit-maximizing output and price.

ANSWER: The demand equation can be rearranged as:  $P = 1.75 - Q/200,000$ . Thus,  $MR = 1.75 - Q/100,000$ . From the cost function,  $MC = \$.25$ . Setting  $MR = MC$  implies:  $1.75 - Q/100,000 = 0.25$ . Therefore,  $Q = (1.5)(100,000) = 150,000$  rolls. However, maximum capacity is 140,000 rolls. Thus, an output of 140,000 is the maximum the company can expect to sell. The requisite price is:  $P = 1.75 - 140,000/200,000 = \$1.05$ . The firm's projected profit is:  $(1.05 - 0.25)(140,000) - 50,000 = \$62,000$ .

SECTION REFERENCE: Marginal Revenue and Marginal Cost

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Medium

(c) If the estimated demand as given by  $Q = 350,000 - 200,000P$  is realized in the first year of production, should the company consider expanding capacity? Explain.

ANSWER: The relevant question is whether the increased profit of expanding capacity exceeds the increased cost of doing so. If the firm could produce and sell 150,000 rolls (by lowering price to \$1), the company's profit would increase very slightly to  $(\$1 - \$0.25)(150,000) - \$50,000 = \$62,500$ . The extra \$500 in profit is clearly not worth the cost of expansion.

SECTION REFERENCE: Marginal Analysis

LO: Describe how marginal analysis looks at the change in profit that results from making a small change in a decision variable.

DIFFICULTY LEVEL: Hard

45. (a) How will an increase in overhead costs affect the demand and supply curves for a firm? Will an increase in the price of a raw material used in production have the same effect?

ANSWER: An increase in the overhead cost is the same as an increase in the fixed cost of a firm. An increase in fixed cost will shift the total cost line upward, parallel to the previous total cost line. At every level of output, the difference between revenue and cost will reduce by the amount of the overhead cost. The level of output will be the same; at the point of intersection of the marginal revenue and marginal cost curves. When the price of a raw material increases, the fixed cost remains the same but the marginal cost of producing each unit of the good increases. The marginal cost curve will shift upward in a parallel manner. Since it intersects the marginal revenue curve, the level of output produced will fall and the price will increase.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Medium

(b) Given that the output in the market is supplied by both domestic and foreign firms, how would a depreciation of the domestic currency in terms of the foreign currency affect the domestic firm?

ANSWER: A depreciation of the domestic currency which is valued in terms of the foreign currency, will increase the price of imports for domestic consumers. This means that the demand curve facing the foreign firms will shift inward. Correspondingly, the domestic demand curve facing domestic firms will shift outward. With an outward shift of the demand curve, domestic firms will increase their output and price.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

DIFFICULTY LEVEL: Hard

46. The current manager of a small bicycle shop estimates the demand curve for a child's starter bike to be:  $P = 80 - 2Q$ . Costs are given by:  $C = 200 + 20Q$ . The former owner of the shop (now retired) urges the manager to keep prices low so as to increase sales and maximize revenue. (The shop pays the former owner 5% of each dollar of earned revenue). If current management follows the former owner's goal, what sales output and price should it set? What strategy would you recommend to maximize profits?

ANSWER: If the manager obeys the wishes of the former owner and maximizes revenue, she would set output at the point where marginal revenue equals 0. The total revenue can be obtained from the firm's demand curve as:  $R = \text{price} \times \text{quantity} = (80 - 2Q)Q = 80Q - 2Q^2$ , so that  $MR = dR/dQ = 80 - 4Q$ . Setting  $MR = 0$  implies  $Q = 20$  bikes. In turn,  $P = \$40$  per bike and  $\pi = R - C = 800 - 600 = \$200$ . However, the firm's real goal should be to maximize profit. Thus, the manager should follow the optimal  $MR = MC$  rule. It follows that  $80 - 4Q = 20$ , or  $Q = 15$  bikes. In turn,  $P = \$50$  per bike, and  $\pi = R - C = 750 - 500 = \$250$ . With an optimal output and pricing policy, the shop can increase its profit by 25% compared to the revenue-maximizing outcome.

SECTION REFERENCE: Sensitivity Analysis

LO: Understand the use of marginal revenue and marginal cost in sensitivity analysis.

Optimal Decisions Using Marginal Analysis

DIFFICULTY LEVEL: Medium