6 Elasticity and Demand

Learning Objectives

After reading Chapter 6 and working the problems for Chapter 6 in the textbook and in this Workbook, you should be able to:

- Explain how price elasticity of demand (E) is used to measure the responsiveness or sensitivity of consumers to a change in the price of a good.
- Explain the role that price elasticity plays in determining how a change in the price of a commodity affects the total revenue ($TR = P \times Q$) received.
- List and explain several factors that affect the elasticity of demand.
- Calculate the elasticity of demand (a) over an interval using the interval (or arc) formula, and (b) at a point on a demand curve.
- Define and compute the income elasticity of demand (E_M) and the cross-price elasticity of demand (E_{XY}).
- Relate marginal revenue to total revenue and demand elasticity.
- Write the marginal revenue equation for linear inverse demand functions.

Essential Concepts

1. The price elasticity of demand (E) measures the responsiveness or sensitivity of consumers to changes in the price of a good by taking the ratio of the percentage change in quantity demanded to the percentage change in the price of the good:

$$E = \frac{\%\Delta Q}{\%\Delta P}$$

Since P and Q are inversely related by the law of demand, the numerator and denominator of E always have opposite algebraic signs, and E is always negative. The larger the absolute value of E, the more sensitive buyers will be to a change in price.

2. Demand is elastic when $|E| > 1$, demand is inelastic when $|E| < 1$, and demand is unitary elastic when $|E| = 1$. [Note: The symbol "| |" denotes the absolute value.]

3. Using price elasticity, the percentage change in quantity demanded ($\%\Delta Q_d$) can be predicted for a given percentage change in price ($\%\Delta P$) as

$$\%\Delta Q_d = \%\Delta P \times E$$

Alternatively, the percentage change in price required for a given change in quantity demanded can be predicted as

$$\%\Delta P = \%\Delta Q_d \div E$$

4. The effect of a change in price on total revenue ($TR = P \times Q$) is determined by the price elasticity of demand. When demand is elastic (inelastic), the quantity (price) effect dominates. Total revenue always moves in the same direction as the variable (P or Q) having the dominant effect. When demand is unitary elastic, neither effect dominates, and changes in price leave total revenue unchanged. These results are summarized in the following table:

Relations Between Price Elasticity (E) and Total Revenue (TR)

	Elastic	*Unitary elastic*	*Inelastic*
	$\lvert\%\Delta Q\rvert > \lvert\%\Delta P\rvert$	$\lvert\%\Delta Q\rvert = \lvert\%\Delta P\rvert$	$\lvert\%\Delta Q\rvert < \lvert\%\Delta P\rvert$
	Q-effect dominates	No dominant effect	*P*-effect dominates
Price rises	*TR* falls	No change in *TR*	*TR* rises
Price falls	*TR* rises	No change in *TR*	*TR* falls

5. Several factors affect the elasticity of demand for a good: (1) the better and more numerous the substitutes for a good, the more elastic is the demand for the good, (2) the greater the percentage of the consumers' budgets spent on the good, the more elastic is demand, and (3) the longer the time period consumers have to adjust to price changes, the more responsive they will be and the more elastic is demand.

6. When calculating the value of E, computing percentage changes can be avoided by using a simpler formula for computing elasticity which can be obtained through the following algebraic operations:

$$E = \frac{\%\Delta Q}{\%\Delta P} = \frac{\frac{\Delta Q}{Q} \times 100}{\frac{\Delta P}{P} \times 100} = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q}$$

Thus, price elasticity can be calculated by multiplying the slope of demand ($\Delta Q/\Delta P$) times the ratio of price to quantity (P/Q), which avoids making tedious percentage change computations.

7. Price elasticity can be measured either (1) over an interval (or arc) along demand, or (2) at a specific point on the demand curve. In either case, E still measures the sensitivity of consumers to changes in the price of the commodity. The choice of whether to measure demand elasticity at a point or over an interval of demand depends on the length of demand over which E is measured. If the change in price is relatively small, a point measure is generally suitable. Alternatively, when the price change spans a sizable arc along the demand curve, the interval measurement of

elasticity provides a better measure of consumer responsiveness than the point measure.

8. When calculating the price elasticity of demand over an interval of demand, use the arc or interval elasticity formula:

$$E = \frac{\Delta Q}{\Delta P} \cdot \frac{\text{Average } P}{\text{Average } Q}$$

9. When calculating the price elasticity of demand at a point on demand, multiply the slope of demand ($\Delta Q/\Delta P$), computed at the point of measure, times the ratio P/Q, computed using the values of P and Q at the point of measure. The method of measuring the point elasticity depends on whether demand is linear or curvilinear.

Point Elasticity when Demand is Linear

For a generalized linear demand function of the form $Q = a + bP + cM + dP_R$, let income and the price of the related good take specific values of $\bar{M}$ and $\bar{P}_R$, respectively. The demand equation can then be expressed as $Q = a' + bP$, where $a' = a + c\bar{M} + d\bar{P}_R$ and the slope parameter b measures the rate of change in quantity demanded per unit change in price ($b = \Delta Q / \Delta P$). The price elasticity of a linear demand can be computed using either of two formulas that give the same value for E:

$$E = b\frac{P}{Q} \text{ or } \quad E = \frac{P}{P - A}$$

where P and Q are the values of price and quantity demanded at the point of measure along demand, and A ($= -a'/b$) is the price-intercept of demand.

Point Elasticity when Demand is Curvilinear

For curvilinear demand functions, the price elasticity at a point can be computed using either of two equivalent formulas:

$$E = \frac{\Delta Q}{\Delta P}\frac{P}{Q} = \frac{P}{P - A}$$

where $\Delta Q / \Delta P$ is the slope of the curved demand at the point of measure (which is the inverse of the slope of the tangent line at the point of measure), P and Q are the values of price and quantity demanded at the point of measure, and A is the price-intercept of the tangent line extended to cross the price-axis.

10. In general, the price elasticity of demand varies along a demand curve. For linear demand curves, price and $|E|$ vary directly: the higher (lower) the price, the more (less) elastic is demand. For a curvilinear demand, there is no general rule about the relation between price and elasticity, except for the special case of $Q = aP^b$, which has a constant demand (equal to b) for all prices.

11. Marginal revenue (MR) is the change in total revenue per unit change in output:

$$MR = \frac{\Delta TR}{\Delta Q}$$

Since *MR* measures the rate of change in total revenue as quantity changes, MR is the slope of the total revenue (*TR*) curve. When *MR* is positive (negative), *TR* is rising (falling). When *MR* is zero, *TR* is neither rising nor falling; *TR* is at its maximum value.

12. When inverse demand is linear, $P = A + BQ$, marginal revenue is also linear, intersects the vertical (price) axis at the same point demand does, and is twice as steep as demand. The equation of the linear marginal revenue cure is $MR = A + 2BQ$.

13. For any demand curve (linear or curvilinear), when demand is elastic ($|E| > 1$), *MR* is positive. When demand is inelastic ($|E| < 1$), *MR* is negative. When demand is unitary elastic ($|E| = 1$), *MR* is zero.

Marginal Revenue, Total Revenue, and Price Elasticity of Demand

Marginal Revenue	***Total Revenue***	***Price Elasticity***
MR > 0	Increases as *Q* increases	Elastic ($|E| > 1$)
MR = 0	Is maximized	Unit Elastic ($|E| = 1$)
MR < 0	Decreases as *Q* increases	Inelastic ($|E| < 1$)

14. For all demand and marginal revenue curves, the relation between marginal revenue, price, and elasticity can be expressed as

$$MR = P\left(1 + \frac{1}{E}\right)$$

15. Income elasticity (E_M) measures the responsiveness of quantity demanded to changes in income, holding the price of the good and all other demand determinants constant.

$$E_M = \frac{\%\Delta Q_d}{\%\Delta M} = \frac{\Delta Q_d}{\Delta M} \cdot \frac{M}{Q_d}$$

Income elasticity is positive (negative) if the good is normal (inferior).

16. Cross-price elasticity (E_{XY}) measures the responsiveness of quantity demanded of good *X* to changes in the price of related good *Y*, holding the price of good *X* and all other demand determinants for good *X* constant.

$$E_{XY} = \frac{\%\Delta Q_X}{\%\Delta P_Y} = \frac{\Delta Q_X}{\Delta P_Y} \cdot \frac{P_Y}{Q_X}$$

Cross-price elasticity is positive (negative) when the two goods are substitutes (complements).

17. To calculate interval measures of income and cross-price elasticities, the following formulas can be employed:

$$E_M = \frac{\Delta Q}{\Delta M} \cdot \frac{\text{Average } M}{\text{Average } Q} \quad \text{and} \quad E_{XR} = \frac{\Delta Q}{\Delta P_R} \cdot \frac{\text{Average } P_R}{\text{Average } Q}$$

For the linear demand function $Q_X = a + bP_X + cM + dP_Y$, point measures of income and cross-price elasticities can be calculated as

$$E_M = c\frac{M}{Q} \quad \text{and} \quad E_{XR} = d\frac{P_R}{Q}$$

Matching Definitions

interval (or arc) elasticity	marginal revenue
cross-price elasticity	point elasticity
price elasticity of demand	price effect
elastic demand	quantity effect
income elasticity	total revenue
inelastic demand	unitary elastic demand
inframarginal units	

1. _____ A measure of consumers' sensitivity or responsiveness to changes in the price of a good or service.
2. _____ When the percentage change in price (in absolute value) is *more* than the percentage change in quantity demanded (in absolute value).
3. _____ When the percentage change in quantity demanded (in absolute value) is *more* than the percentage change in price (in absolute value).
4. _____ When the percentage change in quantity demanded (in absolute value) is *just equal* to the percentage change in price (in absolute value).
5. _____ Total amount paid to a producer for a good or service: $P \times Q$.
6. _____ The effect on total revenue of a change in price, holding quantity constant.
7. _____ The effect on total revenue of a change in quantity, holding price constant.
8. _____ An elasticity calculated over an interval of a demand curve or demand schedule.
9. _____ Elasticity at a specific price or point on a demand curve.
10. _____ A measure of how responsive quantity demanded is to a change in income, all other things constant.
11. _____ A measure showing how responsive the quantity demanded of one good is to changes in the price of another good, other factors constant.
12. _____ The additional revenue received by producing and selling one more unit of output.
13. _____ Units of output that could have been sold at a higher price had the firm not lowered its price to sell additional (marginal) units.

Study Problems

1. Moving along a demand curve, quantity demanded decreases 21 percent when price increases 7 percent.

   a. The price elasticity of demand elasticity is calculated to be _____.
   b. Given the price elasticity calculated in part *a*, demand is _____ (elastic, inelastic, unitary elastic) along this portion of the demand curve.
   c. For this interval of demand, the percentage change in quantity is _____ (greater than, less than, equal to) the percentage change in price.

2. Fill in the blanks:

   a. The price elasticity of demand for a firm's product is equal to –0.5 over the range of prices being considered by the firm's manager. If the manager decreases the price of the product by 12 percent, the manager predicts the quantity demanded will _____ (increase, decrease) by _____ percent.
   b. The price elasticity of demand for an industry's demand curve is equal to –0.5 for the range of prices over which supply increases. If total industry output is expected to increase by 6 percent as a result of the supply increase, managers in this industry should expect the market price of the good to _____ (increase, decrease) by _____ percent.

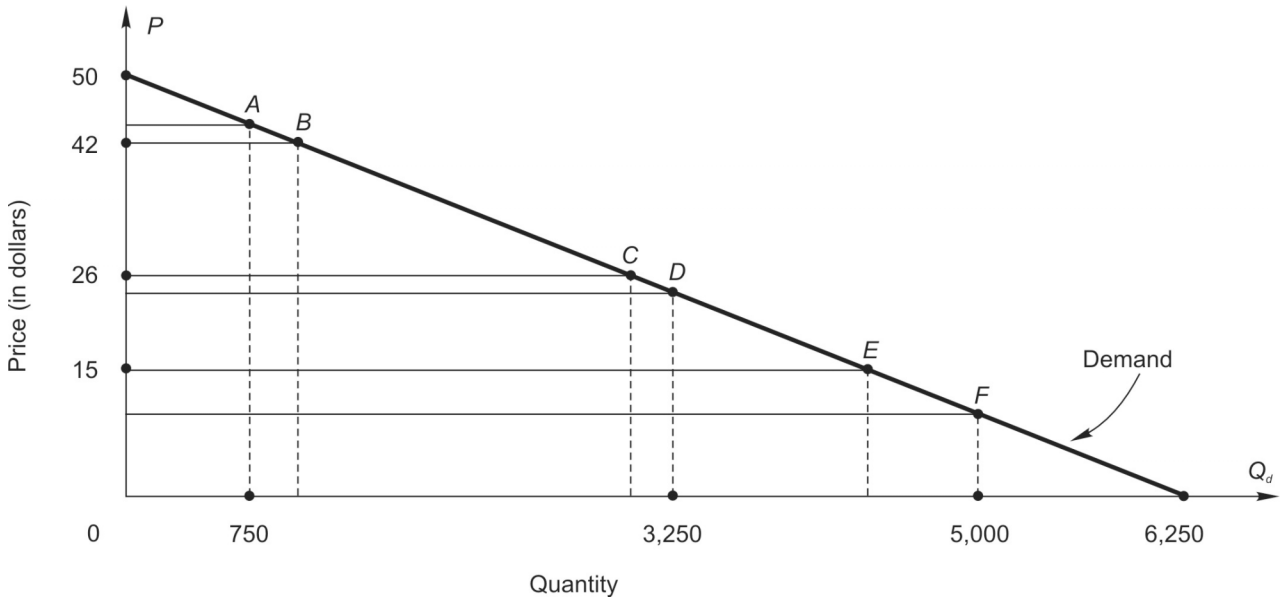
3. Fill in the blanks:

   a. When the price effect dominates the quantity effect, demand is _____.
   b. When the quantity effect dominates the price effect, demand is _____.
   c. When the quantity effect and price effect exactly offset one another, demand is _____.
   d. When a change in price causes a change in quantity demanded, total revenue always moves in the _____ direction as the variable (*P* or *Q*) having the _____ effect.

4. Fill in the blanks:

   a. When demand is elastic, a decrease in price causes quantity demanded to _____ and total revenue to _____.
   b. When demand is inelastic, an increase in price causes quantity demanded to _____ and total revenue to _____.
   c. When demand is unitary elastic, a decrease in price causes quantity demanded to _____ and total revenue to _____.
   d. If quantity decreases and total revenue falls, demand must be _____.
   e. If quantity decreases and total revenue stays the same, demand must be _____.
   f. If quantity increases and total revenue rises, demand must be _____.

5. Use the graph below of a linear demand curve to answer questions 5 and 6:



a. The equation for the linear demand in the figure above is Q_d = _____.

b. The equation for the *inverse* linear demand is P = _____.

c. Using the equations in parts *a* and *b*, find the missing prices and quantities at points *A* – *F*:

A: P = $_____ *C*: Q = _____ *E*: Q = _____

B: Q = _____ *D*: P = $_____ *F*: P = $_____

d. Compute the following interval (or arc) elasticities:

Interval *A* to *B*: E_{AB} = _____

Interval *C* to *D*: E_{CD} = _____

Interval *E* to *F*: E_{EF} = _____

e. Compute the following point elasticities using the two formulas $E = (\Delta Q / \Delta P) \times (P / Q)$ and $E = P / (P - A)$:

Point	$E = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q}$	$E = \frac{P}{P - A}$
A	E_A =_____	E_A =_____
C	E_C =_____	E_C =_____
E	E_F =_____	E_F =_____

f. Demand is unitary elastic at a price of $ _____ and quantity of _____.

g. As quantity increases along the demand curve, demand becomes _____ (more, less) elastic. As price falls along the demand curve, demand becomes _____ (more, less) elastic.

6. Use the figure in question 5 to answer the following:

   a. The equation for marginal revenue is MR = _____.

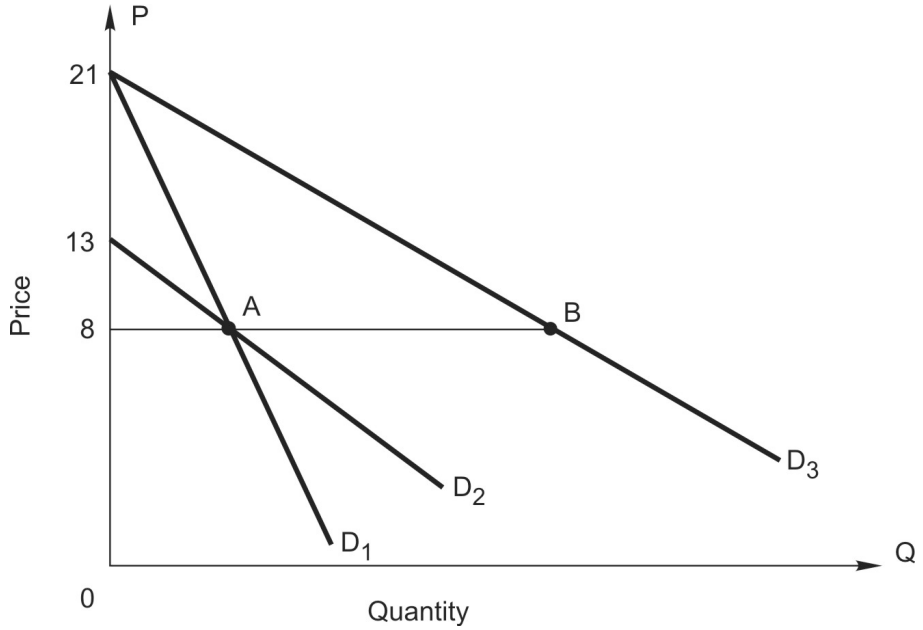
   b. MR crosses the price-axis at P = $_____. MR is zero at Q = _____.

   c. If MR is _____ (rising, falling, zero, positive, negative), then demand is elastic.

   d. If MR is _____ (rising, falling, zero, positive, negative), then demand is unitary elastic.

   e. If MR is _____ (rising, falling, zero, positive, negative), then demand is inelastic.

7. Use the figure below to answer the following questions:



   a. Compute the point elasticity of demand at a price of \$8 for D_1, D_2, and D_3.

   D_1: E = _____

   D_2: E = _____

   D_3: E = _____

   b. At what price is demand unitary elastic for each of these three demand curves?

   D_1: P = _____

   D_2: P = _____

   D_3: P = _____

   c. At a price of \$8, the point price elasticity of demand for D_1 and D_3 are _____. Explain this result.

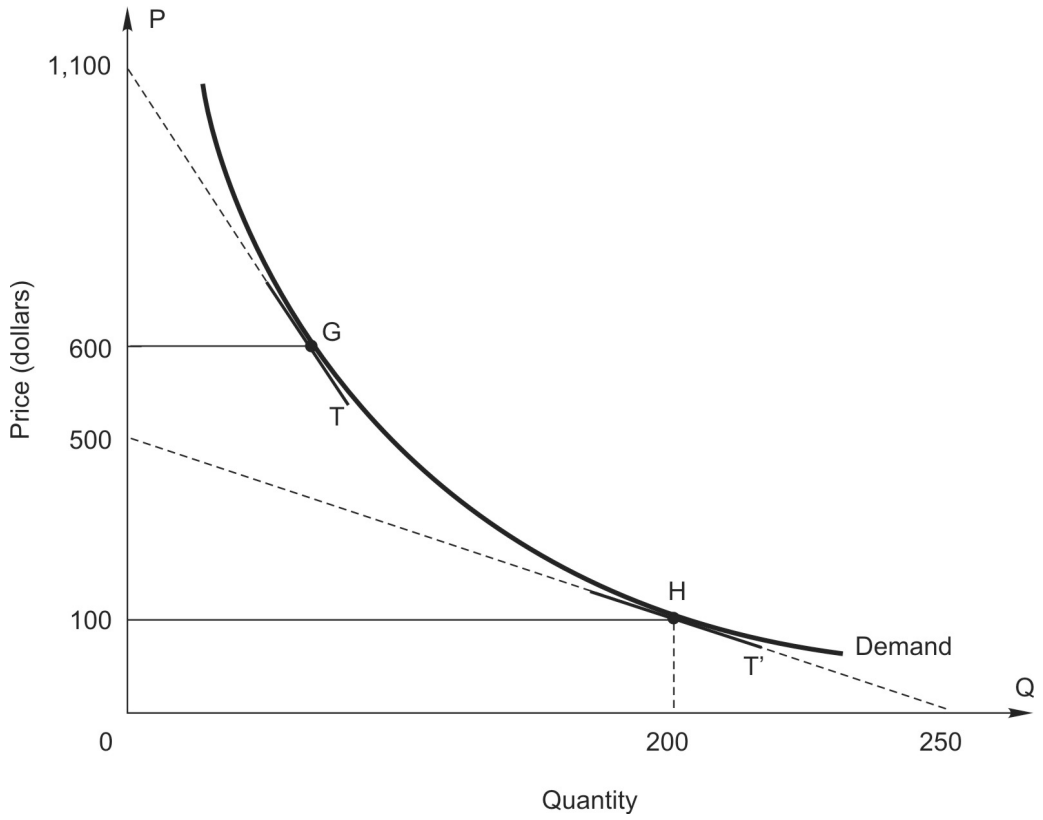
8. If a firm sells an additional unit of output and total revenue rises, then marginal revenue must be _____ (negative, positive) and demand must be _____ (elastic, inelastic, unitary elastic). Alternatively, if a firm sells an additional unit and total revenue falls, then marginal revenue must be _____ (negative, positive) and demand must be _____ (elastic, inelastic, unitary elastic).

9. Suppose the demand for good X is $Q_d = 100P^{-1}$.

   a. What is total revenue when P = \$2? When P = \$4? When P = \$10?

   b. This demand curve has a _____ (rising, constant, falling) elasticity of demand equal to _____.

10. Use the figure below to answer the following questions:



   a. Using the formula $E = (\Delta Q / \Delta P)(P / Q)$, the computed value of the price elasticity at point H is E = _____.

   b. Using the formula $E = P / (P - A)$, the computed value of the price elasticity at point H is E = _____.

   c. Compare the elasticities in parts *a* and *b*. Are they equal? Should they be equal?

   d. Calculate price elasticity at point *G*.

   e. Which formula did you use to compute elasticity at point *G* in part *d*? Why?

11. The general linear demand for good X is estimated to be

$$Q = 125{,}000 - 400P - 0.76M + 360P_R$$

where P is the price of good X, M is average income of consumers who buy good X, and P_R is the price of related good R. The values of P, M, and P_R are expected to be \$200, \$45,000, and \$120, respectively. Use these values at this point on demand to make the following computations.

a. Compute the quantity of good X demanded for the given values of P, M, and P_R.

b. For the quantity in part a, calculate the point price elasticity of demand. At this point on the demand, is demand elastic, inelastic, or unitary elastic? How would decreasing the price of X affect total revenue? Explain.

c. Calculate the income elasticity of demand E_M. Is good X normal or inferior? Explain how a 3.5 percent decrease in income would affect demand for X, all other factors affecting the demand for X remaining the same.

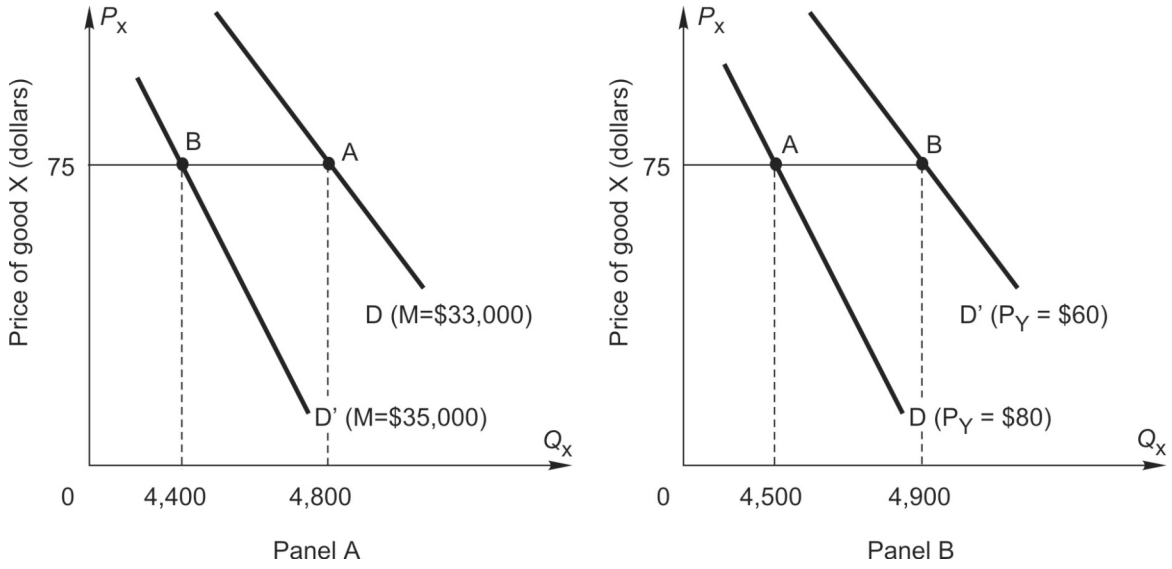
d. Calculate the cross-price elasticity E_{XR}. Are the goods X and R substitutes or complements? Explain how a 6 percent increase in the price of related good R would affect demand for X, all other factors affecting the demand for X remaining the same?

e. Find the equations for demand, inverse demand and marginal revenue for the given values of P, M, and P_R. At the point on demand in parts a and b, is marginal revenue positive, negative or zero? Is this as you expected? Explain why or why not.

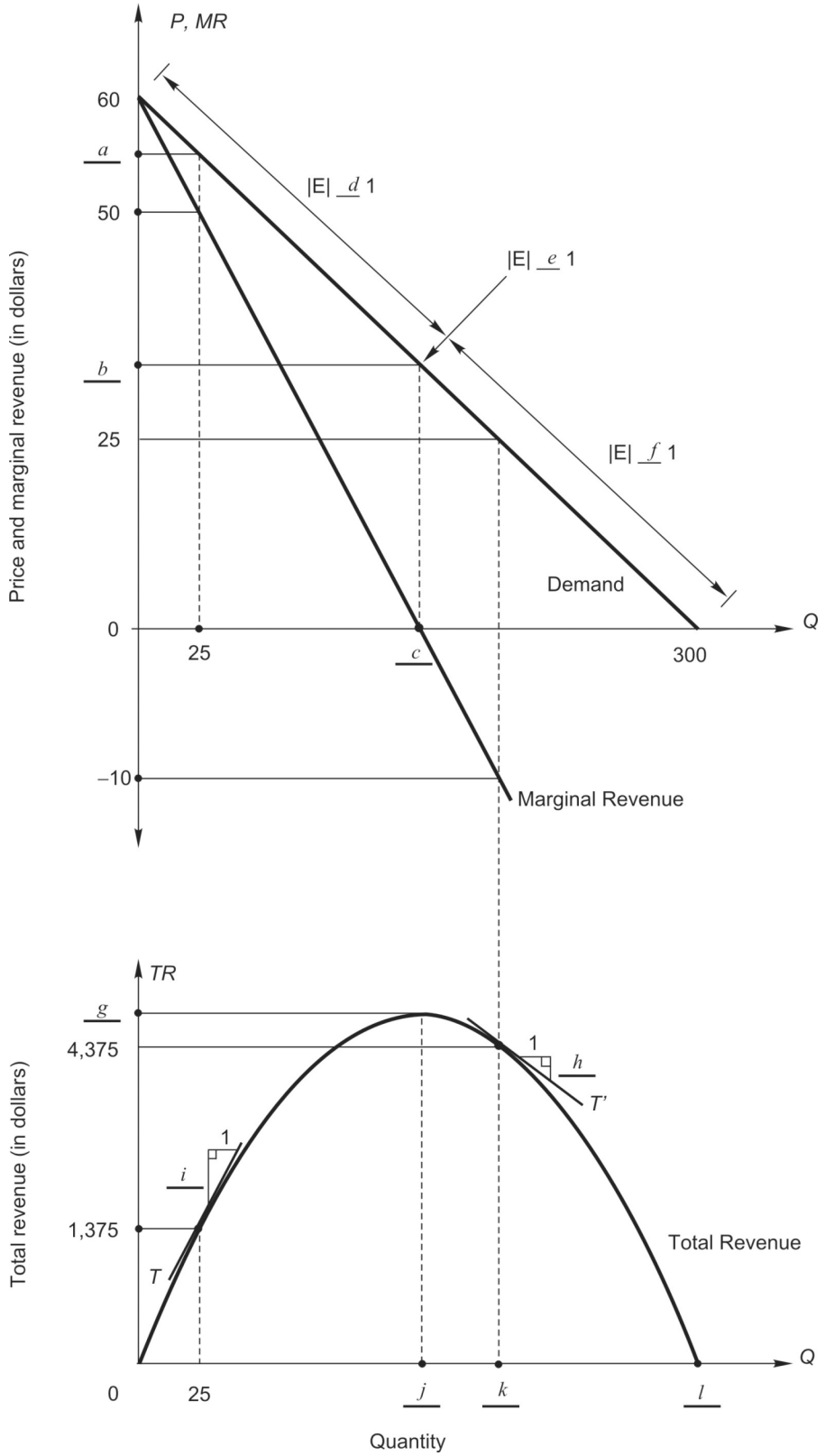
12. When the price of good X is \$75, calculate the following elasticities:

a. Panel A shows how the demand for X shifts when income increases from \$33,000 to \$35,000. The income elasticity of demand for X equals _____. Good X is a(an) _____ good.

b. Panel B shows how the demand for X shifts when the price of related good Y decreases from \$80 to \$60. The cross-price elasticity equals _____. Goods X and Y are _____.



13. The following figure shows a linear demand curve. Fill in the blanks *a* through *l* as indicated in the following figure:



Multiple Choice / True-False

1. The absolute value of price elasticity of demand $|E|$
   a. is $|\%\Delta P| \div |\%\Delta Q_d|$
   b. is less than one when marginal revenue is positive.
   c. is always greater than one.
   d. is always greater than one when marginal revenue is negative.
   e. gets smaller as price falls along demand.

2. The cross-price elasticity is
   a. positive for normal goods.
   b. negative for substitute goods.
   c. negative for complementary goods.
   d. positive for inferior goods.

3. The income elasticity of demand is
   a. positive for normal goods.
   b. negative for substitute goods.
   c. negative for complementary goods.
   d. positive for inferior goods.

4. The interval method is used to compute price elasticity
   a. when a price change causes a relatively large movement along demand.
   b. so elasticity can be computed for rather small changes in price.
   c. for nonlinear demand curves because point elasticity cannot be computed for curves.
   d. because demand curves are downward sloping.

5. The demand for most agricultural products is rather inelastic. Thus, when bad weather reduces the size of crops (i.e., supply decreases),
   a. farmers' incomes rise.
   b. the marginal revenue of selling one more unit of an agricultural product is negative.
   c. the percentage decrease in crop sales exceeds the percentage increase in price.
   d. both *a* and *b*.
   e. both *b* and *c*.

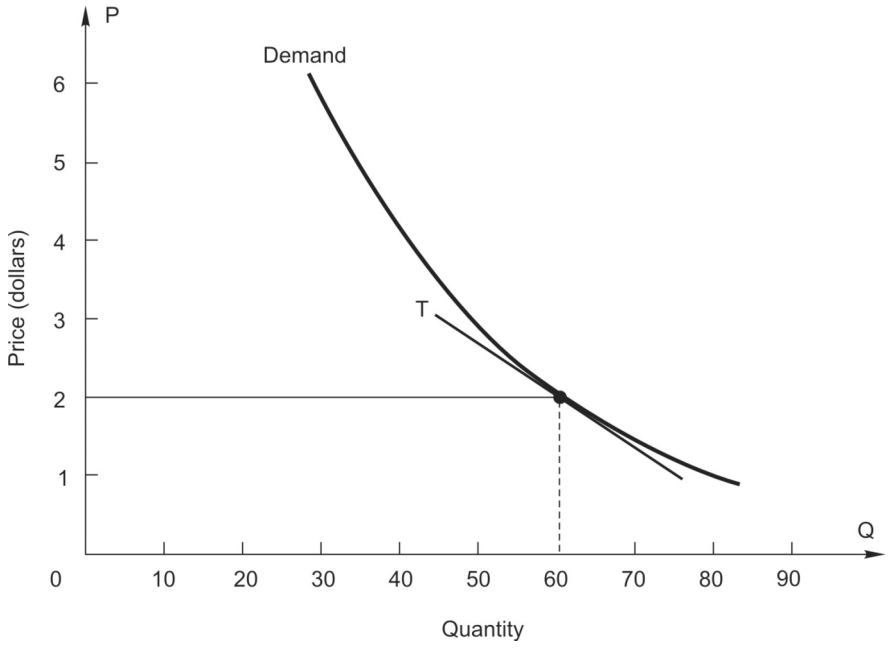
6. If price elasticity of demand is –1.8 and price falls by 20 percent, then sales increase by
   a. 11.1 percent.
   b. 36 percent.
   c. 9 percent.
   d. 90 percent.

7. If price falls along a segment of demand that is price inelastic,
   a. arrows representing the price and quantity effects both point down.
   b. an arrow representing the price effect points down and is longer than an arrow for the quantity effect.
   c. an arrow representing the price effect points down and is shorter than an arrow for the quantity effect.
   d. arrows representing the price and quantity effects both point up.

8. If price rises along a segment of demand that is price elastic,
   a. an arrow representing the quantity effect points down and is longer than an arrow for the price effect.
   b. an arrow representing the quantity effect points up and is longer than an arrow for the price effect.
   c. total revenue moves in the direction of the arrow for the price effect.
   d. the arrows for the price and quantity effects point in opposite directions and are of equal length.

9. Which of the following would *NOT* tend to make demand for a good *X* more elastic?
   a. A major competitor of good *X* goes out of business.
   b. Product *X* is improved so that it becomes more durable.
   c. Incomes fall, which increases the share of families' budgets spent on *X*.
   d. both *a* and *c*.

Use the figure below to answer questions 10–12:



10. The point elasticity of demand when price is $2 is
   a. –6/90.
   b. –15.
   c. –1/2.
   d. –2.

11. If price falls from \$2 to \$1.99, then
    a. total revenue rises because $E = -15$.
    b. total revenue falls because $E = -1/2$.
    c. marginal revenue must be positive because total revenue rises.
    d. total revenue equals \$1.99.

12. When price is \$2, marginal revenue is
    a. negative.
    b. zero.
    c. positive.
    d. equal to price.

13. If the income elasticity of demand is –0.80 and quantity demanded increases by 10 percent as a result of a change in income, the income must have
    a. increased by 8 percent.
    b. increased by 80 percent.
    c. decreased by 8 percent.
    d. decreased by 12.5 percent.

14. When demand is unitary elastic
    a. marginal revenue is zero.
    b. the percentage change in quantity equals the percentage change in price.
    c. an increase in price has no effect on the quantity demanded.
    d. both *a* and *b*
    e. all of the above

15. When marginal revenue is negative
    a. $MR < P$.
    b. $|E|$ is less than one.
    c. an increase in price causes total revenue to rise.
    d. both *a* and *c*
    e. all of the above

16. Which of the following will NOT affect the price elasticity for a product?
    a. The number of substitutes.
    b. How long consumers have to adapt to price changes.
    c. The cost of producing the product.
    d. The percentage of consumers' budgets spent on the product.
    e. All of the above will affect the elasticity of demand for a product.

17. T F Total revenue is maximized when marginal revenue is zero.

18. T F The price elasticity of demand varies along a linear demand curve.

19. T F If total revenue is constant as price changes along a demand curve, then demand is inelastic.

20. T F The shorter the period of time that consumers have to adjust to a change in the price of a good, the less elastic will be demand.

ANSWERS

MATCHING DEFINITIONS

1. demand elasticity
2. inelastic demand
3. elastic demand
4. unitary elastic demand
5. total revenue
6. price effect
7. quantity effect
8. arc elasticity
9. point elasticity
10. income elasticity
11. cross-price elasticity
12. marginal revenue
13. inframarginal units

STUDY PROBLEMS

1. a. -3.00 $(= -21\% \div 7\%)$

   b. elastic; $|E| > 1$

   c. greater than (When $|E| > 1$, the numerator of E must be larger, in absolute value, than the denominator of E.)

2. a. increase; 6% [Note that $E = -0.50 = \%\Delta Q \div -12\%$. Then solve for $\%\Delta Q = +6\%$.]

   b. decrease; 12% [Note that $E = -0.50 = +6\% \div \%\Delta P$. Thus, $\%\Delta P = -12\%$.]

3. a. inelastic

   b. elastic

   c. unit elastic

   d. same; dominant

4. a. increase; increase

   b. decrease; increase

   c. increase; remain the same

   d. elastic [If Q decreases, P must have increased. When price increases and revenue decreases, demand is elastic.]

   e. unit elastic [No change in total revenue indicates demand is unitary elastic.]

   f. elastic [If Q increases, P must have decreased. When price decreases and revenue increases, demand is elastic.]

5. a. $Q_d = 6,250 - 125P$. Begin with the general linear form $Q_d = a + bP$. The intercept parameter, a, is the Q-intercept (= 6,250), and the slope parameter, b, measures $\Delta Q_d/\Delta P$ (= –6,250/50 = –125). If this is confusing, see *Linear Functions* on page 3 of this Workbook.

   b. $P = 50 - 0.008Q_d$. To find the inverse function, solve algebraically for P in the equation from part *a*. If this is confusing, see *Inverse Functions* on page 2 of this Workbook.

   c. A: $P = \$44$ C: $Q = 3,000$ E: $Q = 4,375$
   B: $Q = 1,000$ D: $P = \$24$ F: $P = \$10$

   d. $$E_{AB} = \frac{\Delta Q}{\Delta P} \cdot \frac{\text{Average } P}{\text{Average } Q} = \frac{+250}{-2} \cdot \frac{43}{875} = -6.14$$

$$E_{CD} = \frac{\Delta Q}{\Delta P} \cdot \frac{\text{Average } P}{\text{Average } Q} = \frac{+250}{-2} \cdot \frac{25}{3{,}125} = -1.0$$

$$E_{EF} = \frac{\Delta Q}{\Delta P} \cdot \frac{\text{Average } P}{\text{Average } Q} = \frac{+250}{-2} \cdot \frac{12.50}{4{,}687.5} = -0.33$$

e. $E_A = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q} = -125 \cdot \frac{44}{750} = -7.33 = \frac{44}{44 - 50}$

$$E_C = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q} = -125 \cdot \frac{26}{3{,}000} = -1.08 = \frac{26}{26 - 50}$$

$$E_E = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q} = -125 \cdot \frac{15}{4{,}375} = -0.43 = \frac{15}{15 - 50}$$

f. \$25; 3,125. For a linear demand, the unit elastic point occurs at the midpoint of the demand line.

g. less; less. Moving down linear demand, Q increases, P decreases, and $|E|$ decreases.

6. a. $MR = 50 - 0.016Q$. Inverse demand and marginal revenue have the same intercept parameters and the slope parameter of MR is twice the slope parameter of inverse demand. Since inverse demand is $P = 50 - 0.008Q_d$, MR has an intercept of 50 and a slope of –0.016 (= 2 × –0.008).

b. 50; 3,125. Inverse demand and marginal revenue have the same vertical intercepts. If MR is twice as steep as inverse demand, then MR must cross the Q axis midway between 0 and 6,250.

c. positive. See Figure 6.5 and Table 6.4 in the textbook.

d. zero. See Figure 6.5 and Table 6.4 in the textbook.

e. negative. See Figure 6.5 and Table 6.4 in the textbook.

7. a. $E_{D1} = 8/(8 - 21) = 8/-13 = -0.615$

$E_{D2} = 8/(8 - 13) = 8/-5 = -1.6$

$E_{D3} = 8/(8 - 21) = 8/-13 = -0.615$

b. D_1: P = \$10.50; D_2: P = \$6.50; D_3: P = \$10.50

c. equal; The two demand curves have equal point elasticities because they both have the same price-intercept (a = \$21). Measured at the same price (in this case, P= \$8), their point elasticities must be equal.

8. positive; elastic; negative; inelastic

9. a. $TR_{P=2} = P \times Q = 2 \times 50 = \$100$

$TR_{P=4} = P \times Q = 4 \times 25 = \$100$

$TR_{P=10} = P \times Q = 10 \times 10 = \$100$

b. constant; –1

10. a. $E_H = \dfrac{\Delta Q}{\Delta P} \cdot \dfrac{P}{Q} = \dfrac{+250}{-500} \cdot \dfrac{100}{200} = -0.25$

b. $E_H = \dfrac{P}{P - A} = \dfrac{100}{100 - 500} = -0.25$

c. They *are* equal, as they should be, since the two formulas are equivalent methods of computing point elasticity.

d. $E_G = \dfrac{P}{P - A} = \dfrac{600}{600 - 1{,}100} = -1.2$

e. At point *G*, the formula $E = P / (P - A)$ must be used because the slope of *T* ($\Delta Q/\Delta P$) cannot be determined from the information given in the figure.

11. a. 54,000 [= 125,000 + (–400 × 200) + (–0.76 × 45,000) + (360 × 120)

b. $E = b\dfrac{P}{Q} = -400\dfrac{200}{54{,}000} = -1.481$; elastic; increase *TR* because demand is elastic.

c. $E_M = c\dfrac{M}{Q} = -0.76\dfrac{45{,}000}{54{,}000} = -0.633$; inferior (c <0); $\%\Delta Q = +2.21 (= -3.5 \times -0.633)$

d. $E_{XR} = d\dfrac{P_R}{Q} = 360\dfrac{120}{54{,}000} = 0.80$; substitutes (d > 0); $\%\Delta Q = +4.8\% (= 6 \times 0.80)$

e. Demand:

$$Q = (125{,}000 - 0.76 \times 45{,}000 + 360 \times 120) - 400P$$
$$= 134{,}000 - 400P$$

Inverse Demand:

$$P = -134{,}000 / -400 + (1 / -400)Q$$
$$= 335 - 0.0025Q$$

Marginal Revenue:

$$MR = 335 + 2 \times (-0.0025)Q$$
$$= 335 - 0.005Q$$

At Q = 54,000, MR = 65. MR is expected to be positive because demand is elastic at this quantity (Recall that E = –1.481 in part *b*).

12. a. $E_M = \dfrac{\Delta Q}{\Delta M} \cdot \dfrac{\text{Average } M}{\text{Average } Q} = \dfrac{-400}{+2{,}000} \cdot \dfrac{34{,}000}{4{,}600} = -1.48$; inferior

b. $E_{XY} = \dfrac{\Delta Q_X}{\Delta P_Y} \cdot \dfrac{\text{Average } P_Y}{\text{Average } Q_X} = \dfrac{+400}{-20} \cdot \dfrac{70}{4{,}700} = -0.30$; complements

13. a. \$55 *TR* is \$1,375 at Q = 25, so P must be \$55 (= 1,375/25).

b. \$30 This is the unit elastic point on demand, so price is the midpoint between 0 and 60 on the vertical axis.

c. 150 This is the unit elastic point on demand, so quantity is the midpoint between 0 and 300 on the horizontal axis.

d.	>	Since *MR* is positive over this range of demand, demand is elastic.
e.	=	Since *MR* is zero at this point on demand, demand is unitary elastic.
f.	<	Since *MR* is negative over this range of demand, demand is inelastic.
g.	\$4,500	$TR = P \times Q = \$30 \times 150$.
h.	–10	The slope of *TR* is *MR*, which is shown to be –10 on the *MR* curve.
i.	50	The slope of *TR* is *MR*, which is shown to be 50 on the *MR* curve.
j.	150	Total revenue reaches its peak at the quantity where demand is unit elastic, which is 150 (see blank *c*).
k.	175	*TR* is \$4,375 = \$25 × *Q*, so *Q* = 4,375/25 = 175.
l.	300	Total revenue equals zero at a positive output when *P* is zero, which occurs where the demand curve touches the horizontal axis.

MULTIPLE CHOICE/TRUE-FALSE

1. e The absolute value of price elasticity is directly related to price. Thus, as price falls along demand, so does $|E|$.
2. c $E_{XY} < 0$ for complementary goods.
3. a $E_M > 0$ for normal goods.
4. a An interval measure instead of a point measure of elasticity is used when price changes over a relatively wide arc of demand.
5. d When demand is inelastic, an increase in price (in this case due to bad weather) increases total revenue (income to farmers). It is also true that $MR < 0$ when $E < 1$.
6. b $$-1.8 = \frac{\%\Delta Q}{-20\%} \Rightarrow \%\Delta Q = +36\%$$
7. b When demand is inelastic, the price effect dominates. In this case, price falls and the arrow representing the price effect points down and is longer than the arrow for the output effect (which points up). Total revenue moves in the direction of the dominant effect, and so in this case total revenue falls.
8. a When demand is elastic, the quantity effect dominates. In this case, price rises and the arrow representing the quantity effect points down and is longer than the arrow for the price effect (which points up). Total revenue moves in the direction of the dominant effect, and so in this case total revenue falls.
9. a The exit of a major competitor would decrease the number of substitutes, thereby making demand *less* elastic.
10. c Extend tangent line *T* to cross the *P*-axis to find the value of *A*, which equals 6. Then, substituting $A = 6$, $E = -1/2 = P/(P - A) = 2/(2 - 6)$. Since tangent line *T* crosses the *Q*-axis at 90, the same answer can be obtained using the equivalent formula: $-1/2 = (\Delta Q / \Delta P)(P / Q) = (90 / -6)(2 / 60)$.
11. b Since demand is inelastic at \$2, *TR* must fall when price decreases to \$1.99.
12. a Since total revenue is falling at *P* = \$2, marginal revenue must be negative (which must, of course, be less than the *positive* value of price).
13. d $$-0.80 = \frac{+10\%}{\%\Delta M} \Rightarrow \%\Delta M = -12.5\%$$
14. d When $E = -1$, $|\%\Delta Q| = |\%\Delta P|$. Since $MR = P(1 + 1/E)$, $MR = 0$ when $E = -1$.
15. e All are true when $MR < 0$.
16. c Cost of producing the product is a factor affecting supply not demand.

17. T *MR* measures the rate of change in *TR* as *Q* changes ($MR = \Delta TR / \Delta Q$), which is the slope of *TR*. When *TR* reaches its peak, its slope is zero.

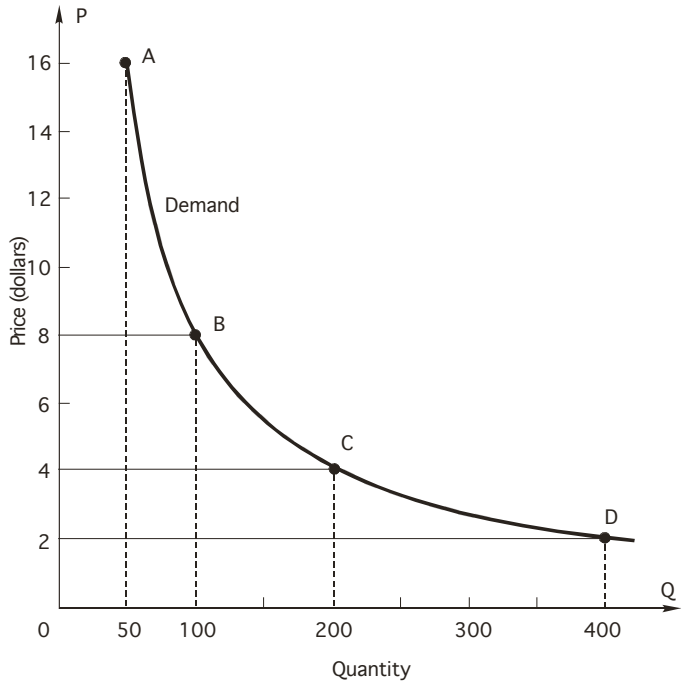
18. T Along a linear demand curve, demand is elastic above the midpoint, inelastic below the midpoint, and unitary elastic at the midpoint.

19. F If *TR* is constant as *P* changes, then demand is *unitary* elastic.

20. T With little time to adjust to a price change, consumers will be less able to substitute.

HOMEWORK EXERCISES

1. Use the figure below to answer the following questions.



a. Calculate total revenue at points *A*, *B*, *C*, and *D*. If price falls from \$16 to \$8, total revenue _____ (increases, decreases, stays the same). If price falls from \$8 to \$4, total revenue _____ (increases, decreases, stays the same). If price falls from \$4 to \$2, total revenue _____ (increases, decreases, stays the same).

b. Given your answer in part *b*, is there any reason to believe this demand curve has a constant price elasticity of demand? Explain.

c. Write the equation of this demand curve in the form $Q = aP^b$: Q = _____. Since $|b|$ is _____ (greater than, less than, equal to) one, demand is _____(elastic, inelastic, unitary elastic) at every price.

d. Compute point price elasticities for prices of \$8, \$4, and \$2. [Hint: Use a straight-edge to construct carefully the appropriate tangent lines. Your tangent lines will be approximations since you are constructing them by sight.]
E_B = _____ E_C = _____ E_D = _____

e. Do the point elasticities in part *d* support your answer in part *c*? Explain why or why not.

2. Market researchers at Chrysler have estimated the demand for their new Chrysler Crossfire sports cars as follows:

$$Q_C = 1{,}050{,}000 - 95P_C + 14.25M + 60P_{BMW} + 25P_P$$

where Q_C is the quantity of Chrysler Crossfires sold annually, P_C is the price of a Chrysler Crossfire, M is average household income, P_{BMW} is the price of BMW's 330i sports sedan, and P_P is the price of Porsche's Boxster S sports car. The marketing team at Chrysler plans to price the Crossfire at $32,000. They predict that average household income is $75,000 for buyers in the market for their sports sedan. The current prices for BMW's 330i and Porsche's Boxster S are $34,000 and $50,000, respectively. Use this information to answer the following questions.

a. Compute the predicted annual sales of the Chrysler Crossfire:

Q_C = _____ units per year.

b. Compute the income elasticity of demand for the Chrysler Crossfire:

E_M = _____.

The computed value of income elasticity indicates the Crossfire is a(n) _____ good. Average household income is predicted to fall next year by 2.5 percent, which will cause sales to _____ (rise, fall) by _____ percent (assuming other factors remain the same).

c. Compute the price elasticity of demand for the Chrysler Crossfire:

E = _____.

At the current price of $32,000, Chrysler is choosing to price in the _____ (elastic, inelastic) region of demand. At this point, a 5 percent increase in the price of Crossfires would be expected to cause sales to fall by _____ percent (assuming other factors remain the same).

d. Compute the cross-price elasticity of demand for Chrysler Crossfires with respect to changes in the price of the BMW 330i:
$E_{C\text{-}BMW}$ = _____.

Compute the cross-price elasticity of demand for Chrysler Crossfires with respect to changes in the price of the Porsche Boxster S:
$E_{C\text{-}P}$ = _____.

Both cross-price elasticities are _____ (positive, negative, greater than 1, less than 1) because these two cars are viewed by car-buyers as _____ (substitute, complement, inferior, normal) goods.

e. In part *d*, which of the two cross-price elasticities is larger in absolute value? Why do you suppose one is larger than the other?

3. Cactus Enterprises faces the following linear demand:

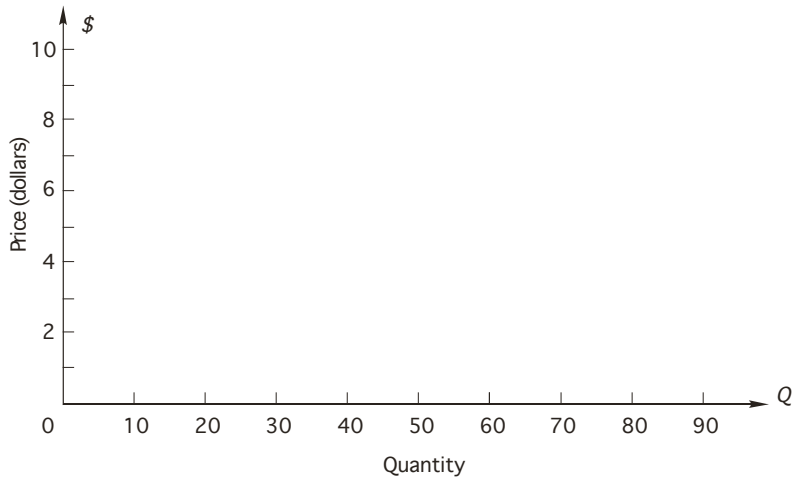
$$Q_d = 80 - 8P$$

a. Plot Cactus' demand curve in Panel *A* of the figure below. Label Cactus' demand curve "*D*."

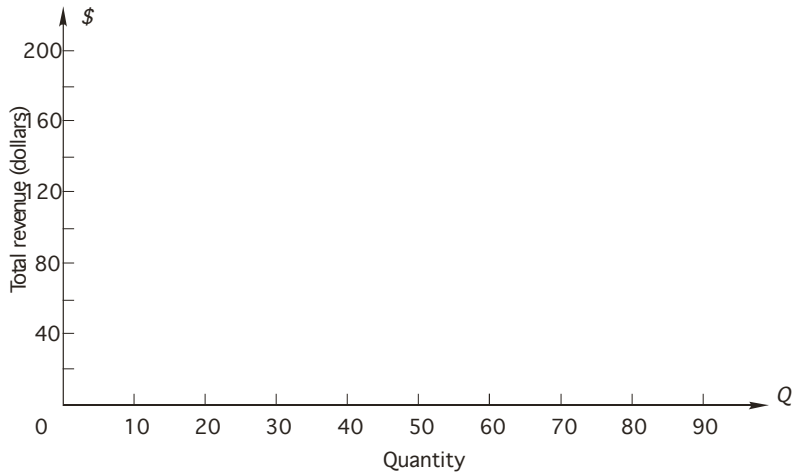
b. The equation for Cactus Enterprises' marginal revenue curve can be expressed as *MR* = _____. Plot Cactus' marginal revenue curve in Panel *A* of the figure below.

c. Over the range _____ to _____ units, total revenue is rising. Over the range _____ to _____ units, total revenue is falling. Total revenue is maximized at _____ units.

d. Compute the total revenue received by Cactus Enterprises for the levels of output $Q = 10, 20, 30, ..., 80$. Plot the total revenue curve in Panel *B* below.



Panel A: Demand and Marginal Revenue



Panel B: Total Revenue

4. Over the past 30 years, cigarette makers did not worry too much about rising excise taxes on their product because they could simply raise prices to generate the extra revenue needed to pay the higher taxes. Apparently, according to recent stories in the *Wall Street Journal*, this pricing tactic no longer works. Explain carefully, using graphical analysis, why continued increases in the price of cigarettes eventually becomes an ineffective means of raising revenues.

5. As part of his plan to reduce the budget deficit, President Clinton proposed raising the excise tax on gasoline by 50 cents per gallon. While passage of this proposal was blocked by Congress, what would have happened to the sales of gasoline if the price of gasoline were to rise by 45 cents per gallon (i.e., producers cannot pass the entire 50-cent tax increase on to consumers)? Assume that the average price of gasoline is now $1.30 per gallon and use the short-run price elasticity for gasoline presented in Illustration 6.2 (page 231 of the text) to answer this question. Would you have expected consumers' total expenditure on gasoline to have risen or fallen had Clinton's proposed 50-cent-per-gallon excise tax been enacted? Explain.

6. One way to reduce the amount consumers spend on health care is to raise the price of health care by increasing the health insurance copayment (i.e., the portion of the price patients must pay themselves). At current copayment levels, if the price elasticity of demand for visits to see the doctor is –0.25, by what percentage will the quantity demanded of doctor visits decrease if the copayment is raised from 20 percent to 25 percent? (Be careful, the percentage change in price is *not* 5 percent in this problem.)