# Appendix

# GRAPHS IN ECONOMICS

## Key Concepts

### ■ Graphing Data

Graphs represent quantity as a distance on a line. On a graph, the horizontal scale line is the *x-axis*, the vertical scale line is the *y-axis*, and the intersection of the two scale lines is the *origin*.

The three main types of economic graphs are:

♦ **Time-series graphs** demonstrate the relationship between time, measured on the *x*-axis, and other variable(s), measured on the *y*-axis. Time-series graphs show the variable's level, direction of change, speed of change, and **trend**, which is its general tendency to rise or fall.

♦ **Cross-section graphs** show the values of a variable for different groups in a population at a point in time.

♦ **Scatter diagrams** plot the value of one variable against the value of another to show the relationship between two variables. Such a relationship indicates how the variables are *correlated*, not whether one variable *causes* the other.

### ■ Graphs Used in Economic Models

The four important relationships between variables are:

♦ **Positive relationship** or **direct relationship** — the variables move together in the same direction, as illustrated in Figure A1.1. The relationship is upward-sloping.

♦ **Negative relationship** or **inverse relationship** — the variables move in opposite directions, as shown in Figure A1.2. The relationship is downward-sloping.
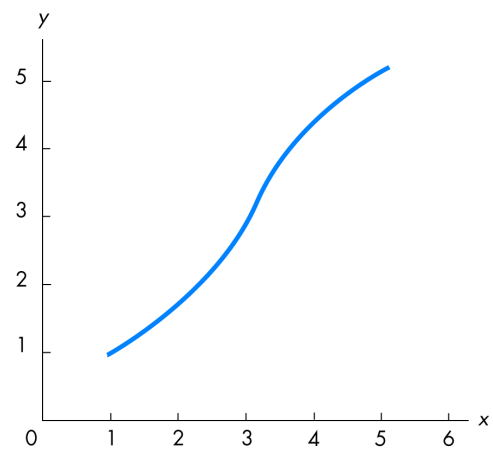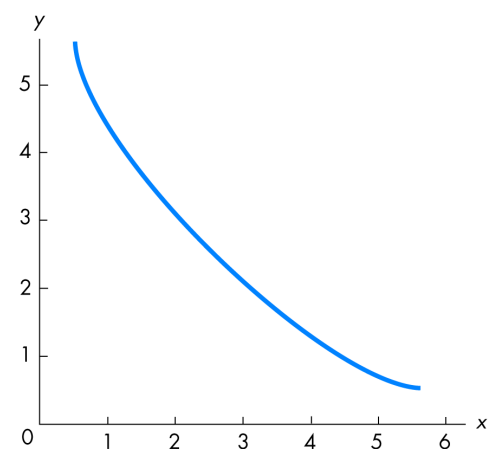
**A Positive Relationship**

**A Negative Relationship**

♦ Maximum or minimum — the relationship reaches a maximum or a minimum point, then changes direction. Figure A1.3 shows a minimum.

♦ Unrelated — the variables are not related so that, when one variable changes, the other is unaffected. The graph is either a vertical or horizontal straight line, as illustrated in Figure A1.4.

A relationship illustrated by a straight line is called a **linear relationship.**

### ■ The Slope of a Relationship

The **slope** of a relationship is the change in the value of the variable on the *y*-axis divided by the change in the value of the variable on the *x*-axis. The formula for slope is $\Delta y / \Delta x$, with $\Delta$ meaning "change in."

A straight line (or linear relationship) has a constant slope. A curved line has a varying slope, which can be calculated two ways:

♦ *Slope at a point* — by drawing the straight line tangent to the curve at that point and then calculating the slope of the line.

♦ *Slope across an arc* — by drawing a straight line across the two points on the curve and then calculating the slope of the line.

### ■ Graphing Relationships Among More Than Two Variables

Relationships between more than two variables can be graphed by holding constant the values of all the variables except two (the *ceteris paribus* assumption, that is, "other things remaining the same") and then graphing the relationship between the two with, *ceteris paribus*, only the variables being studied changing. When one of the variables not illustrated in the figure changes, the entire relationship between the two that have been graphed shifts.

### H e l p f u l   H i n t s

1. **IMPORTANCE OF GRAPHS AND GRAPHICAL ANALYSIS :** Economists almost always use graphs to present relationships between variables. This fact should not "scare" you nor give you pause.
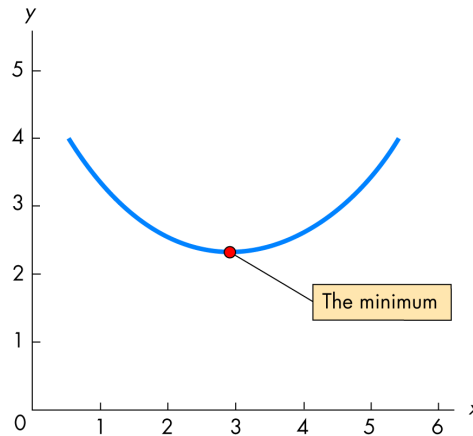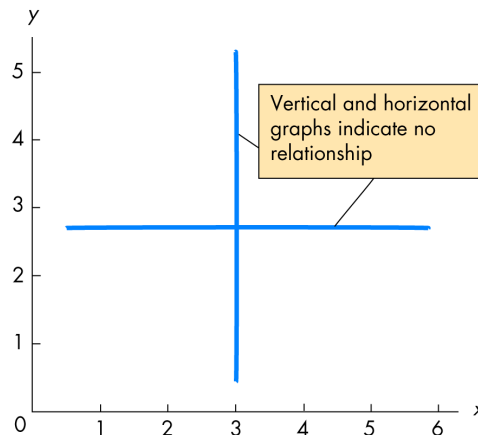
**A Minimum**



FIGURE **A1.4**
**No Relationship**



Economists do so because graphs *simplify* the analysis. All the key concepts you need to master are presented in this appendix. If your experience with graphical analysis is limited, this appendix is crucial to your ability to readily understand economic analysis. However, if you are experienced in constructing and using graphs, this appendix may be "old hat." Even so, you should skim the appendix and work through the questions in this *Study Guide*.

2. **CALCULATING THE SLOPE :** Often the slopes of various relationships are important. Usually what is key is the sign of the slope — whether the slope is positive or negative — rather than the actual value of the slope. An easy way to remember the formula for slope is to think of it as the "rise over the run," a saying used by carpenters and others. As illustrated in Figure A1.5, the *rise* is the change in the variable measured on the vertical axis, or in terms of symbols, $\Delta y$. The *run* is the change in the variable measured on the horizontal axis, or $\Delta x$. This "rise over the run" formula also makes it easy to remember whether the slope is positive or negative. If the rise is actually a drop, as shown in Figure A1.5, then the slope is negative because when the variable measured on the horizontal axis increases, the variable measured on the vertical axis decreases. However, if the rise actually is an increase, then the slope is positive. In this case, an increase in the variable measured on the *x*-axis is associated with an increase in the variable measured on the *y*-axis.
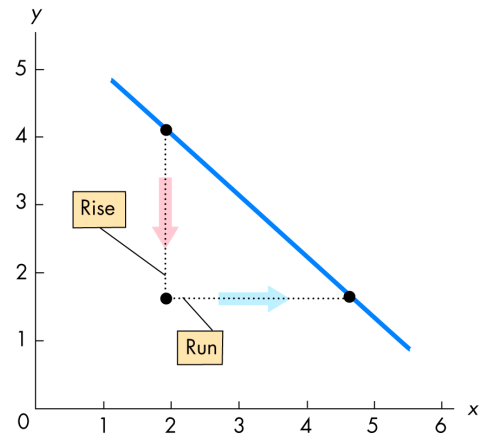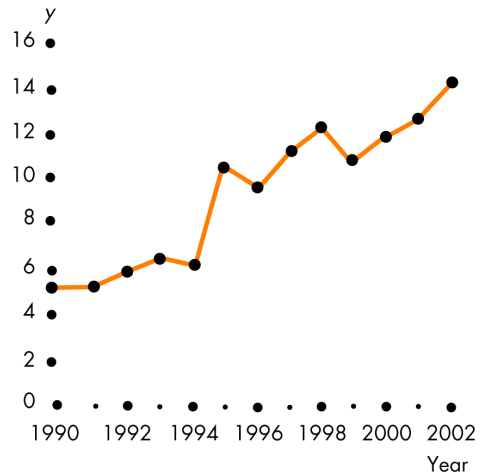
## Questions

### ■ True/False and Explain

**Graphing Data**

1. The origin is the point where a graph starts.

2. A graph showing a positive relationship between stock prices and the nation's production means that an increase in stock prices causes an increase in production.

3. In Figure A1.6 the value of *y* decreased between 1998 and 1999.

4. In Figure A1.6 the value of *y* increased most rapidly between 2001 and 2002.

5. Figure A1.6 shows a trend with *y* increasing, generally speaking.

6. A cross-section graph compares the values of different groups of a variable at a single point in time.

**Graphs Used in Economic Models**

7. If the graph of the relationship between two variables slopes upward to the right, the relationship between the variables is positive.

**Rise Over The Run**

**True/False Questions 3, 4, 5**



8. If the relationship between *y* (measured on the vertical axis) and *x* (measured on the horizontal axis) is one in which *y* reaches a maximum, the slope of the relationship must be negative before and positive after the maximum.

9. To the left of a minimum point, the slope is negative; to the right, the slope is positive.

10. Graphing things that are unrelated on one diagram is <u>NOT</u> possible.

### The Slope of a Relationship

11. It is possible for the graph of a positive relationship to have a slope that becomes smaller when moving rightward along the graph.

12. The slope of a straight line is calculated by dividing the change in the value of the variable measured on the horizontal axis by the change in the value of the variable measured on the vertical axis.

13. For a straight line, if a large change in *y* is associated with a small change in *x*, the line is steep.

14. The slope of a curved line is <u>NOT</u> constant.

15. The slope of a curved line at a point equals the slope of a line tangent to the curved line at the point.

### Graphing Relationships Among More Than Two Variables

16. *Ceteris paribus* means "everything else changes."

17. The amount of corn a farmer grows depends on its price and the amount of rainfall. The curve showing the relationship between the price of a bushel of corn and the quantity grown is the same curve regardless of the amount of rainfall.

### ■ Multiple Choice

### Graphing Data

1. Demonstrating how an economic variable changes from one year to the next is best illustrated by a
   a. one-variable graph.
   b. time-series graph.
   c. linear graph.
   d. cross-section graph.

2. You notice that, when the inflation rate increases, the interest rate also tends to increase. This fact indicates that
   a. there might be false causality between inflation and the interest rate.
   b. higher inflation rates must cause higher interest rates.
   c. a scatter diagram of the inflation rate and the interest rate will show a positive relationship.
   d. a cross-section graph of the inflation rate and the interest rate will show a positive relationship.

3. You believe that the total amount of goods produced in the United States has generally increased. In a time-series graph illustrating the total amount produced, you expect to find
   a. an upward trend.
   b. no relationship between time and the amount of goods produced.
   c. an inverse relationship between time and the amount of goods produced.
   d. a linear relationship.

4. You hypothesize that more natural gas is sold in the Northeast when winters are colder. Which of the following possibilities would best reveal if your belief is correct?
   a. A time-series diagram showing the amount of natural gas sold in the Northeast during the last 30 years.
   b. A time-series diagram showing the average temperature in the Northeast during the last 30 years.
   c. A scatter-diagram plotting the average temperature in the Northeast against the amount of natural gas sold.
   d. A trend diagram that plots the trend in natural gas sales over the last 30 years against the average temperature in the Northeast 30 years ago and this year.

5. Which type of graph can mislead?
   a. A time-series graph.
   b. A cross-section graph.
   c. A scatter diagram.
   d. *Any* type of graph might mislead.
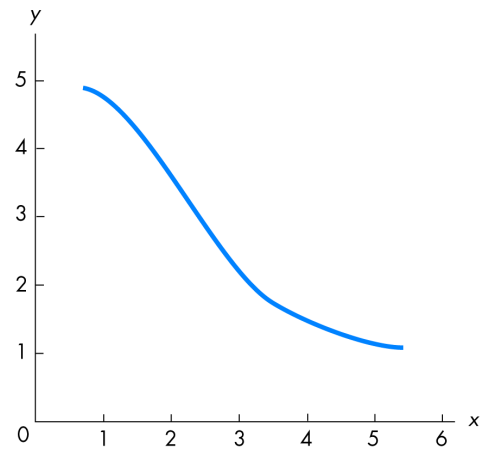
### Graphs Used in Economic Models

6. If variables *x* and *y* move up and down together, they are
   a. positively related.
   b. negative related.
   c. unrelated.
   d. trend related.

FIGURE **A1.7**
**Multiple Choice Questions 7 and 8**



FIGURE **A1.8**
**Multiple Choice Question 10**
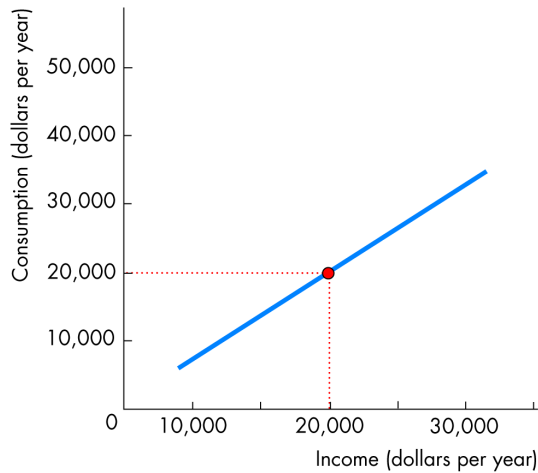


7. In Figure A1.7 when income equals $20,000, what does consumption equal?
   a. $0
   b. $10,000
   c. $20,000
   d. Impossible to tell

8. The relationship between income and consumption illustrated in Figure A1.7 is
   a. positive and linear.
   b. positive and nonlinear.
   c. negative and linear.
   d. negative and nonlinear

9. The term "direct relationship" means the same as
   a. correlation.
   b. trend.
   c. positive relationship.
   d. negative relationship.

10. Figure A1.8 shows
    a. a positive relationship.
    b. a time-series relationship.
    c. a negative relationship.
    d. no relationship between the variables.

11. The relationship between two variables, $x$ and $y$, is a vertical line. Thus $x$ and $y$ are
    a. positively correlated.
    b. negatively correlated.
    c. not related.
    d. falsely related.
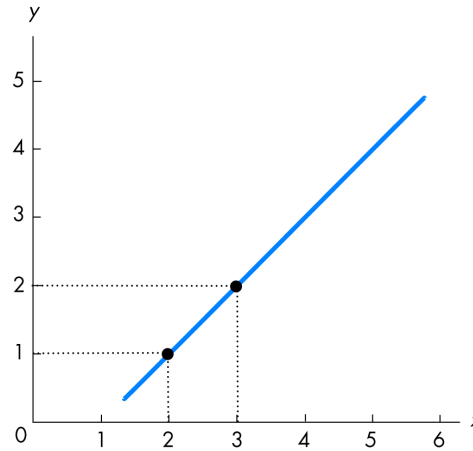
**The Slope of a Relationship**

12. The slope of a negative relationship is
    a. negative.
    b. undefined.
    c. positive to the right of the maximum point and negative to the left.
    d. constant as long as the relationship is nonlinear.

13. A linear relationship
    a. always has a maximum.
    b. always has a constant slope.
    c. always slopes up to the right.
    d. never has a constant slope.

**Multiple Choice Questions 14 and 15**

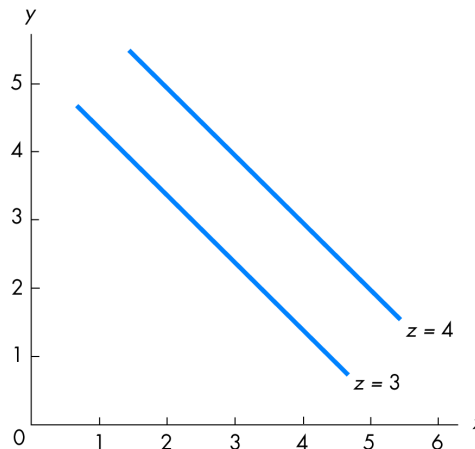**Multiple Choice Questions 16 and 17**
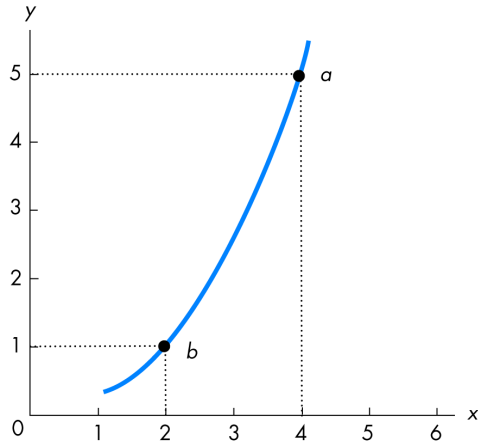


14. The relationship between $x$ and $y$ in Figure A1.9 is
    a. positive with an increasing slope.
    b. positive with a decreasing slope.
    c. negative with an increasing slope.
    d. negative with a decreasing slope.

15. In Figure A1.9 the slope across the arc between points $a$ and $b$ equals
    a. 5.
    b. 4.
    c. 2.
    d. 1.

16. In Figure A1.10, between $x = 2$ and $x = 3$, what is the slope of the line?
    a. 1
    b. −1
    c. 2
    d. 3

17. In Figure A1.10 how does the slope of the line between $x = 4$ and $x = 5$ compare with the slope between $x = 2$ and $x = 3$?
    a. The slope is greater between $x = 4$ and $x = 5$.
    b. The slope is greater between $x = 2$ and $x = 3$.
    c. The slope is the same.
    d. The slope is not comparable.

## Graphing Relationships Among More Than Two Variables

**Multiple Choice Questions 18, 19, 20**



18. In Figure A1.11 $x$ is
    a. positively related to $y$ and negatively related to $z$.
    b. positively related to both $y$ and $z$.
    c. negatively related to $y$ and positively related to $z$.
    d. negatively related to both $y$ and $z$.

19. In Figure A1.11, *ceteris paribus*, an increase in *x* is associated with

   a. an increase in *y*.
   b. a decrease in *y*.
   c. a decrease in *z*.
   d. None of the above answers is correct.

20. In Figure A1.11 an increase in *z* causes a

   a. movement up along one of the lines showing the relationship between *x* and *y*.
   b. movement down along one of the lines showing the relationship between *x* and *y*.
   c. shift rightward in the line showing the relationship between *x* and *y*.
   d. shift leftward in the line showing the relationship between *x* and *y*.

## ■ Short Answer Problems

1. a. The data in Table A1.1 show the U.S. unemployment rate between 1979 and 2001. Draw a time-series graph of these data.
   b. When was the unemployment rate the highest?

TABLE **A1.2**

**Short Answer Problem 2**

| x | y |
|---|---|
| 1 | 2 |
| 2 | 4 |
| 3 | 6 |
| 4 | 8 |
| 5 | 7 |
| 6 | 6 |

2. a. Use the data in Table A1.2 to graph the relationship between *x* and *y*.
   b. Over what range of values for *x* is this relationship positive? Over what range is it negative?
   c. Calculate the slope between *x* = 1 and *x* = 2.
   d. Calculate the slope between *x* = 5 and *x* = 6.
   e. What relationships do your answers to parts c and d have to your answer for part b?

3. a. In Figure A1.12, use the tangent line in the figure to calculate the slope at point *b*.
   b. Compute the slope across the arc between points *b* and *a*.
   c. Calculate the slope across the arc between points *c* and *b*.

TABLE **A1.1**

**Short Answer Problem 1**

| Year | Unemployment rate |
|------|-------------------|
| 1981 | 7.6 |
| 1982 | 9.7 |
| 1983 | 9.6 |
| 1984 | 7.5 |
| 1985 | 7.2 |
| 1986 | 7.0 |
| 1987 | 6.2 |
| 1988 | 5.5 |
| 1989 | 5.3 |
| 1990 | 5.5 |
| 1991 | 6.7 |
| 1992 | 7.4 |
| 1993 | 6.8 |
| 1994 | 6.1 |
| 1995 | 5.6 |
| 1996 | 5.4 |
| 1997 | 5.6 |
| 1998 | 5.0 |
| 1999 | 4.2 |
| 2000 | 4.0 |
| 2001 | 4.7 |
| 2002 | 5.8 |
| 2003 | 6.0 |

FIGURE **A1.12**

**Short Answer Problem 3**
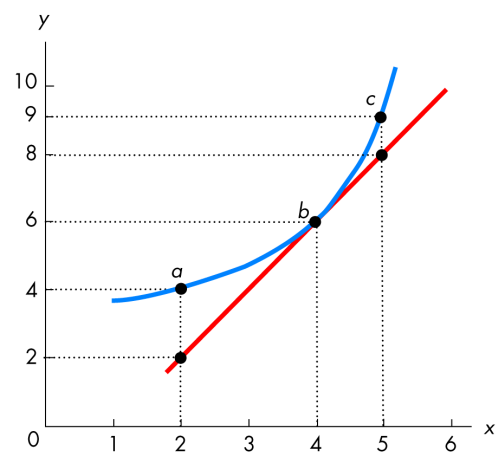
4. Can a curve have a positive but decreasing slope? If so, draw an example.

5. a. Bobby says that he buys fewer compact discs when the price of a compact disc is higher. Bobby also says that he will buy more compact discs after he graduates and his income is higher. Is the relationship between the number of compact discs Bobby buys and the price positive or negative? Is the relationship between Bobby's income and the number of compact discs positive or negative?

   b. Table A1.3 shows the number of compact discs Bobby buys in a month at different prices when his income is low and when his income is high. On a diagram with price on the vertical axis and the quantity purchased on the horizontal axis, plot the relationship between the number of discs purchased and the price when Bobby's income is low.

   c. On the same diagram, draw the relationship between the number of discs purchased and the price when Bobby's income is high.

   d. Does an increase in Bobby's income cause the relationship between the price of a compact disc and the number purchased to shift rightward or leftward?

TABLE **A1.3**

**Short Answer Problem 5**

| Price (dollars per compact disc) | Quantity of compact discs purchased, low income | Quantity of compact discs purchased, high income |
|---|---|---|
| $11 | 5 | 6 |
| 12 | 4 | 5 |
| 13 | 3 | 4 |
| 14 | 1 | 3 |
| 15 | 0 | 2 |

■ **You're the Teacher**

1. "Hey, I thought this was an *economics* class, not a *math* class. Where's the economics? All I've seen so far is math!" Reassure your friend by explaining why the concentration in this chapter is on mathematics rather than economics.

2. "I don't understand why we need to learn all about graphs. Instead of this, why can't we just use numbers? If there is any sort of relationship we need to see, we can see it easier using numbers instead of all these complicated graphs!" Explain why graphs are useful when studying economics.

3. "There must be a relationship between the direction a curve is sloping, what its slope is, and whether the curve shows a positive or negative relationship between two variables. But I can't see the tie. Is there one? And what is it?" Help this student by answering the questions posed.

# A n s w e r s

## ■ True/False Answers

### Graphing Data

1.  **F**  The origin is where the horizontal and vertical axes start, *not* where the graph starts.
2.  **F**  The graph shows a correlation between stock prices and production, but that does not necessarily mean that an increase in stock prices causes the increase in production.
3.  **T**  According to the figure, *y* decreased from about 12 to about 10.
4.  **F**  Between 1994 and 1995, *y* rose the most.
5.  **T**  As the figure makes clear, there has been an upward trend in *y*. A time-series graph makes it more straightforward to identify a trend in a variable.
6.  **T**  This is the definition of a cross-section graph.

### Graphs Used in Economic Models

7.  **T**  If the graph slopes upward to the right, then an increase in the variable measured along the horizontal axis is associated with an increase in the variable measured on the vertical axis.
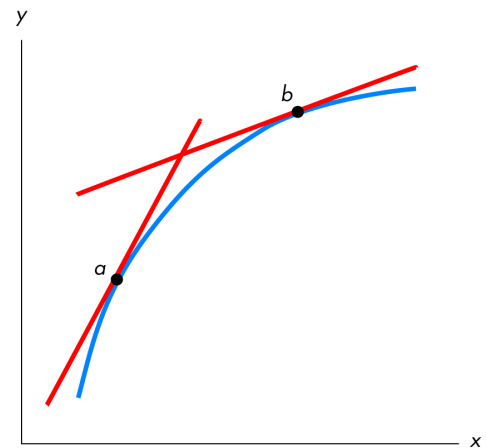
FIGURE **A1.13**
**True/False Question 8**
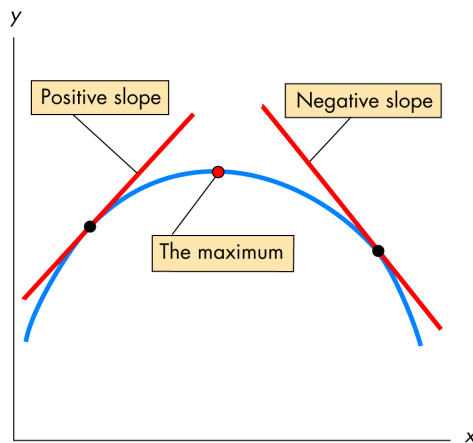


8.  **F**  As Figure A1.13 illustrates, before the maximum is reached, the relationship must be positive; af-

ter the maximum is attained, the relationship must be negative.
9.  **T**  To verify this answer, flip Figure A1.13 upside down. To the left of the minimum the line is falling, so its slope is negative; to the right the line is rising, so its slope is positive.
10. **F**  If two unrelated variables are graphed on the same diagram, the "relationship" between the two is either a vertical or a horizontal straight line.

### The Slope of a Relationship

FIGURE **A1.14**
**True/False Question 11**



11. **T**  Figure A1.14 shows a positive relationship whose slope decreases when moving rightward along it from point *a* to point *b*.
12. **F**  Just the reverse is true: Divide the change in the variable on the *vertical* axis by the change in the variable on the *horizontal* axis.
13. **T**  The definition of slope is $\Delta y/\Delta x$. So if a large change in *y* (the numerator) is associated with a small change in *x* (the denominator), the magnitude of the slope is relatively large. The large magnitude for the slope indicates that the line is relatively steep.
14. **T**  Only the slope of a straight line is constant.
15. **T**  This question tells precisely how to calculate the slope at a point on a curved line.

### Graphing Relationships Among More Than Two Variables

16. **F** *Ceteris paribus* means that only the variables being studied change; all other variables do not change.

17. **F** For different amounts of rainfall, there are different curves showing the relationship between the price of a bushel of corn and the quantity that is grown.

### ■ Multiple Choice Answers

### Graphing Data

1. **b** A time-series graph illustrates how the variable changes over time.

2. **c** A positive correlation between inflation rates and interest rates is reflected in a scatter diagram as a positive relationship; that is, the dots would tend to cluster along a line that slopes upward to the right.

3. **a** The upward trend indicates a general increase in production over time.

4. **c** A scatter diagram will show the correlation between temperature and natural gas sales.

5. **d** Any type of graph can be misleading.

### Graphs Used in Economic Models

6. **a** In this case, an increase (or decrease) in $x$ is associated with an increase (or decrease) in $y$, so the variables are positively related.

7. **c** Figure A1.7 shows that when income is $20,000 a year, then consumption is also $20,000 a year.

8. **a** The relationship is positive (higher income is related to higher consumption) and is linear.

9. **c** The term "positive relationship" means the same as "direct relationship."

10. **c** As $x$ increases, $y$ decreases; thus the relationship between $x$ and $y$ is negative.

11. **c** Figure A1.15 demonstrates that the change in $y$ from 2 to 3 has no effect on $x$ — it remains equal to 3.

### The Slope of a Relationship

12. **a** A negative relationship has a negative slope; a positive relationship has a positive slope.

13. **b** A straight line — that is, a linear relationship — has a constant slope whereas nonlinear relation-

FIGURE **A1.15**
**Multiple Choice Question 11**
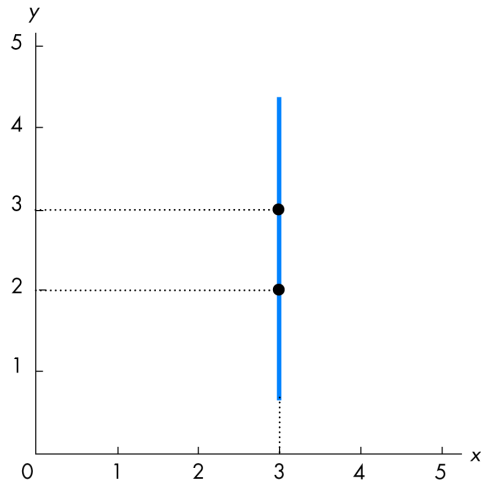


ships have slopes that vary. Thus the slope of a straight line is the same anywhere on the line.

14. **a** The slope is positive and, because the line is becoming steeper, the slope is increasing.

15. **c** The slope between the two points equals the change in the vertical distance (the "rise") divided by the change in the horizontal distance (the "run"), that is, $(5 − 1)/(4 − 2) = 2$.

16. **a** The slope equals the change in the variable measured along the vertical axis divided by the change in the variable measured along the horizontal axis, or $(2 − 1)/(3 − 2) = 1$.

17. **c** The figure shows a straight line. The slope of a straight line is constant, so the slope between $x = 4$ and $x = 5$ is the same as the slope between $x = 2$ and $x = 3$.

### Graphing Relationships Among More Than Two Variables

18. **c** The curves showing the relationship between $x$ and $y$ demonstrate that $x$ and $y$ are negatively related. For any value of $y$, an increase in $z$ is associated with a higher value for $x$, so $x$ and $z$ are positively related.

19. **b** Moving along one of the lines showing the relationship between $x$ and $y$ (say, the line with $z = 3$) shows that as $x$ increases, $y$ decreases.

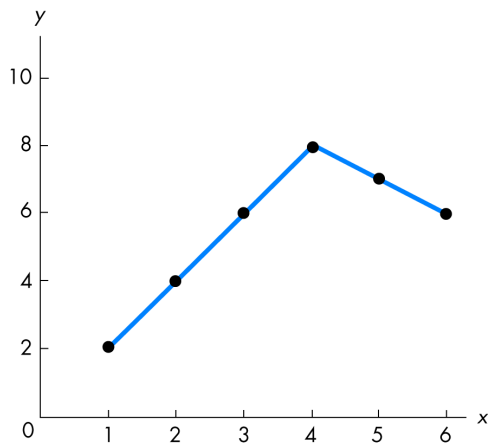20. **c** The higher value of $z$ shifts the entire relationship between $x$ and $y$ rightward.

■ **Answers to Short Answer Problems**

FIGURE **A1.16**
**Short Answer Problem 1**
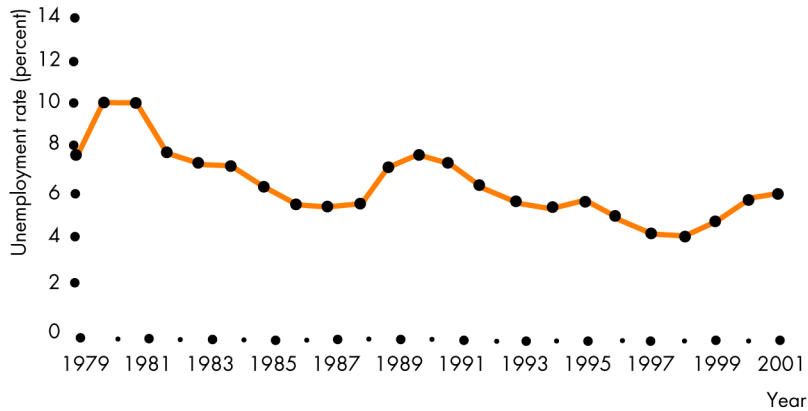


1.  a.  Figure A1.16 shows the time series of unem-
       ployment rates in the United States.
    b.  The unemployment rate was the highest in
       1982, when it equaled 9.7 percent.

FIGURE **A1.17**
**Short Answer Problem 2**



2.  a.  The relationship between $x$ and $y$ is illustrated in
       Figure A1.17.
    b.  The relationship between $x$ and $y$ changes when
       $x$ is 4. The relationship is positive between $x = 1$
       and $x = 4$. Between $x = 4$ and $x = 6$, the relation-
       ship is negative.

    c.  The slope equals $\Delta y/\Delta x$ or, in this case between
       $x = 1$ and $x = 2$, the slope is $(2 - 4)/(1 - 2) = 2$.
    d.  Between $x = 5$ and $x = 6$, the slope is equal to
       $(7 - 6)/(5 - 6) = -1$.
    e.  Over the range of values where the relationship
       between $x$ and $y$ is positive — from $x = 1$ to $x = 4$ — the slope is positive. Over the range where
       the relationship between $x$ and $y$ is negative —
       from $x = 4$ to $x = 6$ — the slope is negative.
       Thus positive relationships have positive slopes,
       and negative relationships have negative slopes.
3.  a.  The slope is $(8 - 2)/(5 - 2) = 2$.
    b.  The slope is $(6 - 4)/(4 - 2) = 1$.
    c.  The slope is $(9 - 6)/(5 - 4) = 3$.
4.  Yes, a curve can have a positive, decreasing slope.
    Figure A1.18 (on the next page) illustrates such a
    relationship. In it, at relatively low values of $x$ the
    slope is quite steep, indicating a high value for the
    slope. But as $x$ increases, the curve becomes flatter,
    which means that the slope decreases. (To verify
    these statements, draw the tangent lines at points $a$
    and $b$ and then compare their slopes.) This figure
    points out that there is a major difference between
    the value of a curve at some point, that is, what $y$
    equals, and what the curve's slope is at that point!

FIGURE **A1.18**
**Short Answer Problem 4**
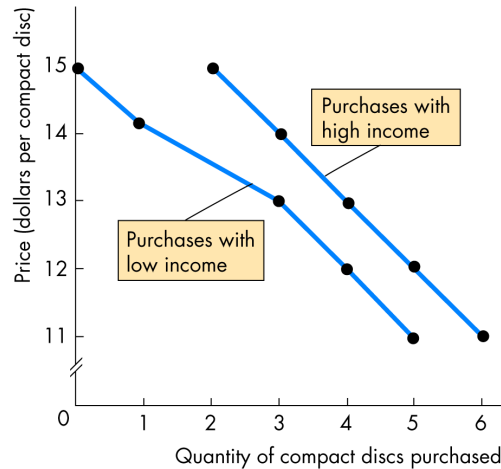


FIGURE **A1.19**
**Short Answer Problem 5**
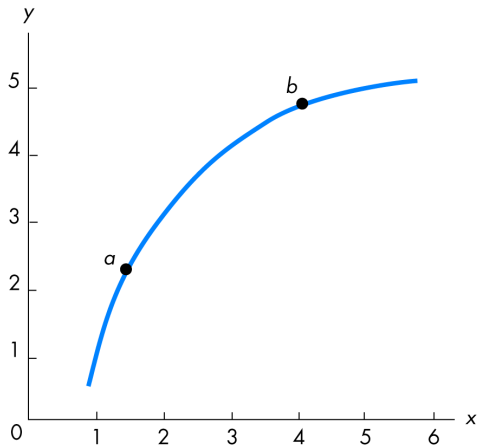


5. a. Because Bobby buys more compact discs when their price is lower, the relationship between the number of compact discs Bobby buys and the price is negative. Similarly, the relationship between Bobby's income and the number of compact discs he buys is positive.

   b. Figure A1.19 illustrates the relationship between the price of a compact disc and the number Bobby buys when his income is low.

   c. Also illustrated in Figure A1.19 is the relationship between the number of compact discs Bobby buys and their price when Bobby's income is high.

   d. An increase in Bobby's income shifts the relationship between the price of a compact disc and the number Bobby buys rightward.

■ **You're the Teacher**

1. "This *is* an economics class. But understanding some simple graphing ideas makes economics a lot easier to learn. Learning about graphing for its own sake is not important in this class; what is important is learning about graphing to help with the economics that we'll take up in the next chapter. So look at this chapter as a resource. Whether you already knew everything in it before you looked at it or even if everything in it was brand new, anytime you get confused by something dealing with a tech-

nical point on a graph, you can look back at this chapter for help. So, chill out; we'll get to the economics in the next chapter!"

2. "Graphs make understanding economics and the relationships between economic variables easier in three ways. First, graphs are extremely useful in showing the relationship between two economic variables. Imagine trying to determine the relationship between the interest rate and inflation rate if all we had was a bunch of numbers showing the interest rate and inflation rate each year for the past 30 years. We'd have 60 numbers; good luck in trying to eyeball a relationship from them! Second, graphs can help us more easily understand what an economic theory is trying to explain because they allow us to see quickly how two variables are related. By showing us the general relationship, we can be assured that any conclusions we reach don't depend on the numbers that we decided to use. Finally, graphs sometimes show us a result we might not have otherwise noticed. If all we had were numbers, we could easily become lost trying to keep track of them. Graphs make our work easier, and for this reason we need to know how to use them!"

3. "The connection between the direction a line slopes, its slope, and whether the relationship is positive or negative is easy — once you see it! Take a look at Figure A1.20. In this figure, the line slopes upward to the right. The slope of this line is posi-
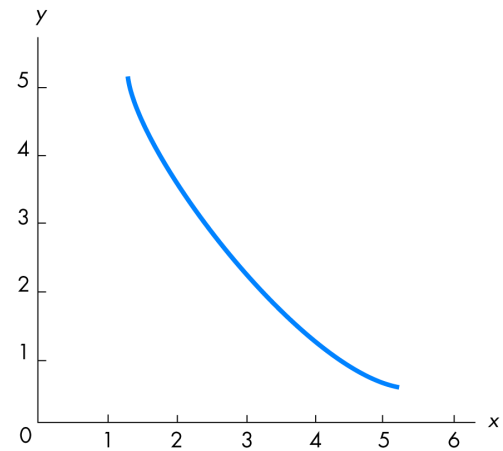
FIGURE **A1.20**
**You're the Teacher Question 3**



FIGURE **A1.21**
**You're the Teacher Question 3**
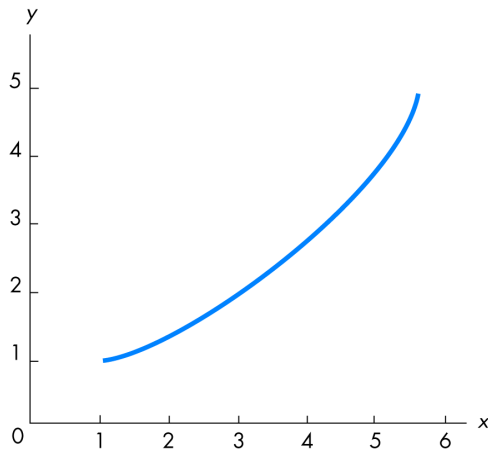


itive: An increase in $x$ is associated with an increase in $y$. Because increases in $x$ are related to increases in $y$, the graph shows a positive relationship between $x$ and $y$.

Now look at Figure A1.21. Here the line slopes downward to the right. The slope of this line is negative: An increase in $x$ is related to a decrease in $y$. Because $x$ and $y$ are inversely related, the relationship shown in Figure A1.21 is negative.

So, look: Positive relationships have positive slopes and negative relationships have negative slopes!

We can summarize these results for you so that you'll always be able to remember them by putting them all together:

| Direction of line | | Sign of slope | | Type of relationship |
|---|---|---|---|---|
| Upward to the right | ⇔ | Positive | ⇔ | Positive |
| Downward to the right | ⇔ | Negative | ⇔ | Negative |

This summary should help you keep everything straight. Things should be easier now."