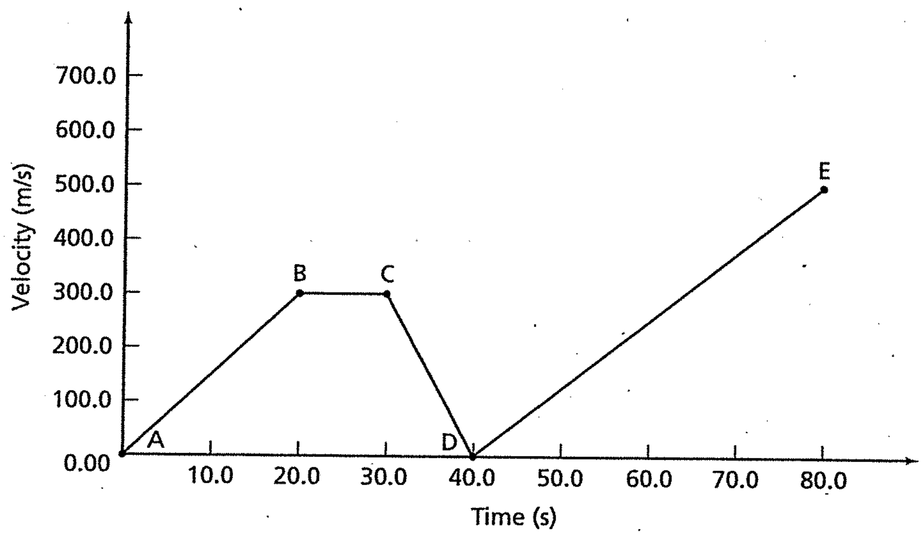
Date ____________ Period ____________ Name ____________________

CHAPTER 3

Supplemental Problems

Accelerated Motion

1. Use the velocity-time graph below to calculate the velocity of the object whose motion is plotted on the graph.
   a. What is the acceleration between the points on the graph labeled A and B?
   b. What is the acceleration between the points on the graph labeled B and C?
   c. What is the acceleration between the points on the graph labeled D and E?
   d. What is the total distance that the object travels between points B and C?



2. If you throw a ball straight upward, it will rise into the air and then fall back down toward the gound. Imagine that you throw the ball with an initial velocity of 13.7 m/s.
   a. How long does it take the ball to reach the top of its motion?
   b. How far will the ball rise before it begins to fall?
   c. What is its average velocity during this period?

3. A car is traveling at 20 m/s when the driver sees a ball roll into the street. From the time the driver applies the brakes, it takes 2 s for the car to come to a stop.
   a. What is the average acceleration of the car during that period?
   b. How far does the car travel while the brakes are being applied?

4. A hot air balloon is rising at a constant speed of 1.00 m/s. The pilot accidentally drops his pen 10.0 s into the flight.
   a. How far does the pen drop?
   b. How fast is the pen traveling when it hits the ground, ignoring air resistance?

5. A sudden gust of wind increases the velocity of a sailboat relative to the water surface from 3.0 m/s to 5.5 m/s over a period of 30.0 s.
   a. What is the average acceleration of the sailboat?
   b. How far does the sailboat travel during the period of acceleration?

6. During a serve, a tennis ball leaves a racket at 180 km/h after being accelerated for 80.0 ms.
   a. What is the average acceleration on the ball during the serve in m/s^2?
   b. How far does the ball move during the period of acceleration?

7. The table below shows the velocity of a student walking down the hallway between classes.
   a. What is happening to the student's speed during t = 60.0 s and t = 61.0 s?
   b. What is his acceleration between t = 10.0 s and t = 20.0 s?
   c. What is his acceleration between t = 60.0 s and t = 61.0 s?
   d. Assuming constant acceleration, how far did he walk during the first 5 s?

Time (s)	Velocity (m/s)
0.0	0.0
10.0	1.5
20.0	1.5
30.0	1.5
31.0	0.0
40.0	0.0
50.0	3.0
60.0	3.0
61.0	0.0

8. Anna walks off the end of a 10.0-m diving platform.
   a. What is her acceleration in m/s^2 toward the pool?
   b. How long does it take her to reach the water?
   c. What is her velocity when she reaches the water?

9. A rocket used to lift a satellite into orbit undergoes a constant acceleration of 6.25 m/s^2. When the rocket reaches an altitude of 45 km above the surface of Earth, it is traveling at a velocity of 625 m/s. How long does it take for the rocket to reach this speed?

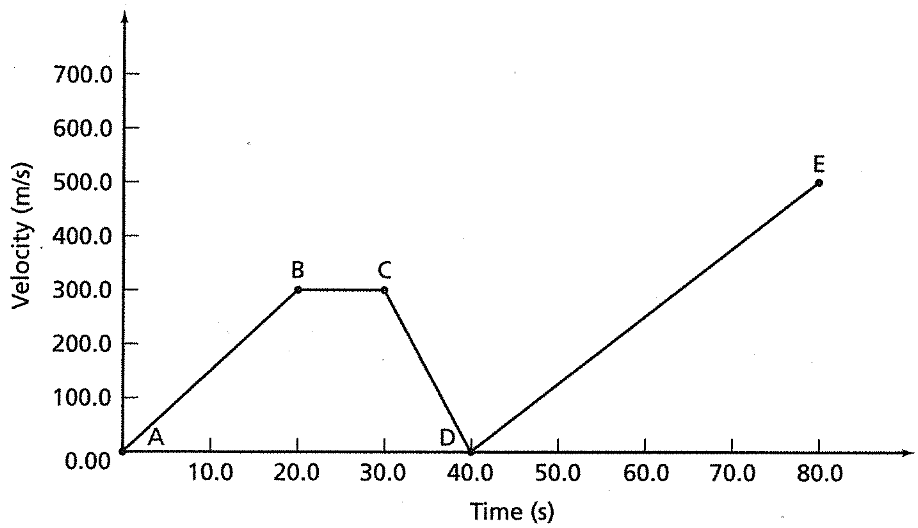
10. On the surface of Mars, the acceleration due to gravity is 0.379 times as much as that on the surface of Earth. A robot on Mars pushes a rock over a 500.0-m cliff.
    a. How long does it take the rock to reach the ground below the cliff?
    b. How fast is the rock traveling when it reaches the surface?
    c. How long would it take the rock to fall the same distance on the surface of Earth?

11. A sky diver jumps from an airplane 1000.0 m above the ground. He waits for 8.0 s and then opens his parachute. How far above the ground is the sky diver when he opens his parachute?

12. A speeding car is traveling at 92.0 km/h toward a police car at rest, facing the same direction as the speeding car. If the police car begins accelerating when the speeding car is 250.0 m behind the police car, what must the police car's acceleration be in order for the police car to reach the speeding car's velocity at the moment the speeding car catches up? Assume that the speeding car does not slow down.

Chapter 3

1. Use the velocity-time graph below to calculate the velocity of the object whose motion is plotted on the graph.



a. What is the acceleration between the points on the graph labeled A and B?

$$a = \frac{\Delta v}{t} = \frac{(v_f - v_i)}{t}$$

$$= \frac{300.0\ \text{m/s} - 0.0\ \text{m/s}}{20.0\ \text{s}}$$

$$= 15.0\ \text{m/s}^2$$

b. What is the acceleration between the points on the graph labeled B and C?

$\Delta v = 0$, therefore $a = 0$
(no acceleration)

c. What is the acceleration between the points on the graph labeled D and E?

$$a = \frac{\Delta v}{t} = \frac{(v_f - v_i)}{t}$$

$$= \frac{0.0\ \text{m/s} - 500.0\ \text{m/s}}{40.0\ \text{s}}$$

$$= -125\ \text{m/s}^2$$

d. What is the total distance that the object travels between points B and C?

$$d = vt$$

$$= 300.0\ \text{m/s} \times 10.0\ \text{s}$$

$$= 3.00\times10^3\ \text{m}$$

2. If you throw a ball straight upward, it will rise into the air and then fall back down toward the gound. Imagine that you throw the ball with an initial velocity of 13.7 m/s.

a. How long does it take the ball to reach the top of its motion?

$v_f = v_i + at$

therefore $t_f = \frac{v_f - v_i}{a}$

$t = \frac{13.7 \text{ m/s} - 0.00 \text{ m/s}}{9.80 \text{ m/s}^2}$

$= 1.40 \text{ s}$

b. How far will the ball rise before it begins to fall?

$d = \frac{1}{2}(v_f + v_i)t$

$= \frac{1}{2}(13.7 \text{ m/s} + 0.00 \text{ m/s})(1.40 \text{ s})$

$= 9.59 \text{ m}$

c. What is its average velocity during this period?

$v_{ave} = \frac{d_f - d_i}{t}$

$= \frac{9.59 \text{ m} - 0.00 \text{ m}}{1.40 \text{ s}}$

$= 6.85 \text{ m/s}$

3. A car is traveling at 20 m/s when the driver sees a ball roll into the street. From the time the driver applies the brakes, it takes 2 s for the car to come to a stop.

a. What is the average acceleration of the car during that period?

$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$

$= \frac{0 \text{ m/s} - 20 \text{ m/s}}{2 \text{ s}}$

$= -10 \text{ m/s}^2$

b. How far does the car travel while the brakes are being applied?

$d = d_i + v_i t + \frac{1}{2}at^2$

$= 0 \text{ m} + (20 \text{ m/s})(2 \text{ s}) + \frac{1}{2}(-10 \text{ m/s}^2)(2 \text{ s})^2$

$= 0 \text{ m} + 40 \text{ m} + (-20 \text{ m/s})$

$= 20 \text{ m}$

4. A hot air balloon is rising at a constant speed of 1.00 m/s. The pilot accidentally drops his pen 10.0 s into the flight.

a. How far does the pen drop?

The pen falls from the altitude of the balloon at 10 s.

$d = vt$

$= (1.00 \text{ m/s})(10.0 \text{ s})$

$= 10.0 \text{ m}$

b. How fast is the pen traveling when it hits the ground, ignoring air resistance?

$v_f^2 = v_i^2 + 2a(d_f - d_i)$

$= 0 + 2(9.80 \text{ m/s}^2)(10.0 \text{ m} - 0.00 \text{ m})$

$= 196 \text{ m}^2/\text{s}^2$

$v = 14.0 \text{ m/s}$

5. A sudden gust of wind increases the velocity of a sailboat relative to the water surface from 3.0 m/s to 5.5 m/s over a period of 30.0 s.

a. What is the average acceleration of the sailboat?

$a = \frac{\Delta v}{t}$

$= \frac{(v_f - v_i)}{t}$

$= \frac{5.5 \text{ m/s} - 3.0 \text{ m/s}}{30.0 \text{ s}}$

$= 0.083 \text{ m/s}^2$

b. How far does the sailboat travel during the period of acceleration?

$d_f = d_i + v_i t + \frac{1}{2}at^2$

$= 0.0 \text{ m} + \frac{3.0 \text{ m/s}}{30.0 \text{ s}} + \frac{1}{2}(0.083 \text{ m/s}^2)(30.0 \text{ s})^2$

$= 130 \text{ m}$

6. During a serve, a tennis ball leaves a racket at 180 km/h after being accelerated for 80.0 ms.

a. What is the average acceleration on the ball during the serve in m/s^2?

$v_f = (180 \text{ km/h})\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)$

$= 5.0\times10^1 \text{ m/s}$

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$$

$$= \frac{5.0\times10^1 \text{ m/s} - 0.0 \text{ m/s}}{8.0\times10^{-2} \text{ s}}$$

$$= 630 \text{ m/s}^2$$

b. How far does the ball move during the period of acceleration?

$$d_f = d_i + v_i t + \frac{1}{2} at^2$$

$$= 0.0 \text{ m} + (0.0 \text{ m/s})(0.080 \text{ s}) + \frac{1}{2}(630 \text{ m/s}^2)(0.0800 \text{ s})^2$$

$$= 2.0 \text{ m}$$

7. Anna walks off the end of a 10.0-m diving platform.

a. What is her acceleration in m/s² toward the pool?

Her acceleration due to gravity is 9.80 m/s².

b. How long does it take her to reach the water?

$$d_f = d_i + v_i t + \frac{1}{2}at^2,\ v_i \text{ and } d_i = 0$$

Solve for t:

$$t = \sqrt{\frac{2d}{a}}$$

$$= \sqrt{\frac{2 \times 10.0 \text{ m}}{9.80 \text{ m/s}^2}}$$

$$= 1.43 \text{ s}$$

c. What is her velocity when she reaches the water?

$$v_f = v_i + at$$

$$= 0.0 \text{ m/s} + (9.80 \text{ m/s}^2)(1.43 \text{ s})$$

$$= 14.0 \text{ m/s}$$

8. A rocket used to lift a satellite into orbit undergoes a constant acceleration of 6.25 m/s². When the rocket reaches an altitude of 45 km above the surface of Earth, it is traveling at a velocity of 625 m/s. How long does it take for the rocket to reach this speed?

Solve $d_f = d_i + v_i t + \frac{1}{2}at^2$ for t (let v_i and $d_i = 0$)

$$t = \sqrt{\frac{2d}{a}}$$

$$= \sqrt{\frac{(2 \times 45 \text{ km})\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)}{6.25 \text{ m/s}^2}}$$

$$= 120 \text{ s}$$

9. The table below shows the velocity of a student walking down the hallway between classes.

Time (s)	Velocity (m/s)
0.0	0.0
10.0	1.5
20.0	1.5
30.0	1.5
31.0	0.0
40.0	0.0
50.0	3.0
60.0	3.0
61.0	0.0

a. What is happening to the student's speed during $t = 60.0$ s and $t = 61.0$ s?

He is slowing down.

b. What is his acceleration between $t = 10$ s and $t = 20$ s?

$$a = \frac{\Delta v}{t}$$

$$= \frac{v_f - v_i}{t_f - t_i}$$

$$= \frac{1.5 \text{ m/s} - 1.5 \text{ m/s}}{200 \text{ s} - 100 \text{ s}}$$

$$= 0.0 \text{ m/s}$$

c. What is his acceleration between $t = 60.0$ s and $t = 61.0$ s?

$$a = \frac{\Delta v}{t}$$

$$= \frac{v_f - v_i}{t_f - t_i}$$

$$= \frac{0.0 \text{ m/s} - 3.0 \text{ m/s}}{61.0 \text{ s} - 60.3 \text{ s}}$$

$$= 3.0 \text{ m/s}$$

d. Assuming constant acceleration, how far did he walk during the first 5 s?

$$a = \frac{\Delta v}{t}$$

$$= \frac{v_f - v_i}{t_f - t_i}$$

$$= \frac{1.5\text{ m/s} - 0.0\text{ m/s}}{10.0\text{ s} - 0.0\text{ s}}$$

$$= 0.15\text{ m/s}^2$$

$$d = d_i + v_i t + \frac{1}{2}at^2$$

$$= 0.0\text{ m} + (0.0\text{ m/s})(5.0\text{ s}) + \frac{1}{2}(0.15\text{ m/s}^2)(5.0\text{ s})^2$$

$$= 1.9\text{ m}$$

10. On the surface of Mars, the acceleration due to gravity is 0.379 times as much as that on the surface of Earth. A robot on Mars pushes a rock over a 500.0-m cliff.

a. How long does it take the rock to reach the ground below the cliff?

$$a = 9.80\text{ m/s}^2 \times 0.379$$

$$= 3.71\text{ m/s}^2$$

Solve for $d_f = d_i + v_i t + \frac{1}{2}at^2$

for t (let v_i and $d_i = 0$)

$$t = \sqrt{\frac{2d}{a}}$$

$$= \sqrt{\frac{2(500.0\text{ m})}{3.71\text{ m/s}^2}}$$

$$= 16.4\text{ s}$$

b. How fast is the rock traveling when it reaches the surface?

$$v_f = v_i + at$$

$$= 0.0\text{ m/s} + (3.71\text{ m/s}^2)(16.4\text{ s})$$

$$= 60.8\text{ m/s}$$

c. How long would it take the rock to fall the same distance on the surface of Earth?

$$t = \sqrt{\frac{2d}{a}}$$

$$= \sqrt{\frac{2(500.0\text{ m})}{9.80\text{ m/s}^2}}$$

$$= 10.1\text{ s}$$

11. A sky diver jumps from an airplane 1000.0 m above the ground. He waits for 8.0 s and then opens his parachute. How far above the ground is the sky diver when he opens his parachute?

$$d_f = d_i + v_i t_f + \frac{1}{2}at^2$$

$$d_f - d_i = v_i t_f + \frac{1}{2}at^2$$

$$v_i = 0$$

$\Delta d = at^2$ where $a = -g$

$$\Delta d = \frac{1}{2}gt^2$$

$$= -\frac{1}{2}(9.80\text{ m/s}^2)(8.0\text{ s})^2$$

$$= -310\text{ m}$$

$1000.0\text{ m} + (-310\text{ m}) = 690\text{ m}$ above the ground

12. A speeding car is traveling at 92.0 km/h toward a police car at rest, facing the same direction as the speeding car. If the police car begins accelerating when the speeding car is 250.0 m behind the police car, what must the police car's acceleration be in order for the police car to reach the speeding car's velocity at the moment the speeding car catches up? Assume that the speeding car does not slow down.

$$\bar{a}_{police} = \frac{\Delta v_{police}}{\Delta t}$$

$$\Delta t = \frac{\Delta d}{\bar{v}_{speeder}}$$

$$\bar{a}_{police} = \Delta v_{police}\left(\frac{\bar{v}_{speeder}}{d}\right)$$

$$\frac{\Delta v_{police}}{\left(\frac{\Delta d}{\bar{v}_{speeder}}\right)} = \frac{v_{f,\,police} - v_{i,\,police}}{\frac{\Delta d}{\bar{v}_{speeder}}}$$

$$= \frac{(25.6\text{ m/s} - 0.0\text{ m/s})}{\left(\frac{250.0\text{ m}}{25.6\text{ m/s}}\right)}$$

$$= 2.62\text{ m/s}^2$$