Name: ______________________ Class: _________________ Date: _________ ID: A

Ch 2 Linear Motion Problems

Problem

1. A biker travels at an average speed of 18 km/h along a 0.30 km straight segment of a bike path. How much time does the biker take to travel this segment?
2. A hiker travels south along a straight path for 1.5 h with an average speed of 0.75 km/h and then travels north for 2.5 h with an average speed of 0.90 km/h. What is the hiker's displacement for the total trip?
3. A stroller walks the first half of a straight 1.0 km trail at a steady pace of 0.75 m/s, east. He walks the second half at a constant stride of 0.60 m/s, east. What is his average velocity along the trail?
4. A shopping cart is given an initial velocity of 2.0 m/s and undergoes a constant acceleration of 3.0 m/s^2. What is the magnitude of the cart's displacement after the first 4.0 s of its motion?
5. A skater glides off a frozen pond onto a patch of ground at a speed of 1.8 m/s. Here she is slowed at a constant rate of 3.00 m/s^2. How fast is the skater moving when she has slid 0.37 m across the ground?
6. A sports car traveling at 27.8 m/s slows at a constant rate to a stop in 8.00 s. What is the displacement of the sports car in this time interval?
7. A toy car is given an initial velocity of 5.0 m/s and experiences a constant acceleration of 2.0 m/s^2. What is the final velocity after 6.0 s?
8. A soccer ball is moving horizontally at a speed of 3.0 m/s. It then undergoes a constant negative acceleration. After 4.0 s, the ball is moving at 1.5 m/s. What is the ball's displacement?
9. A race car accelerates from 0.0 m/s to 30.0 m/s with a displacement of 45.0 m. What is the car's acceleration?
10. A kitten pushes a ball of yarn rolling toward it at 1.00 cm/s with its nose, displacing the ball of yarn 17.5 cm in the opposite direction in 2.00 s. What is the acceleration of the ball of yarn?
11. A rock is thrown downward from the top of a cliff with an initial speed of 12 m/s. If the rock hits the ground after 2.0 s, what is the height of the cliff? (Disregard air resistance. $a = -g = -9.81$ m/s^2.)
12. A rock is thrown straight upward with an initial velocity of 24.5 m/s where the acceleration due to gravity has a magnitude of 9.81 m/s^2. What is the rock's displacement after 1.00 s?
13. A coin released at rest from the top of a tower hits the ground after falling 1.5 s. What is the speed of the coin as it hits the ground? (Disregard air resistance. $a = -g = -9.81$ m/s^2.)
14. A rock is thrown straight upward with an initial velocity of 9.6 m/s in a location where the acceleration due to gravity has a magnitude of 9.81 m/s^2. To what height does it rise?
15. Someone throws a rubber ball vertically upward from the roof of a building 8.00 m in height. The ball rises, then falls. It just misses the edge of the roof, and strikes the ground. If the ball is in the air for 3.00 s, what was its initial velocity? (Disregard air resistance. $a = -g = -9.81$ m/s^2.)

Ch 2 Linear Motion Problems
Answer Section

PROBLEM

1. ANS:
   1.7×10^{-2} h

   Given
   v_{avg} = 1.8 km/h
   Δx = 0.30 km

   Solution
   $$v_{avg} = \frac{\Delta x}{\Delta t}$$
   $$\Delta t = \frac{\Delta x}{v_{avg}} = \frac{0.30\ \text{km}}{1.8\ \text{km/h}} = 1.7 \times 10^{-2}\ \text{h}$$

   PTS: 1 DIF: IIIB OBJ: 2-1.2

2. ANS:
   1.1 km, north

   Given
   $v_{avg,1}$ = −0.75 km/h
   Δt_1 = 1.5 h
   $v_{avg,2}$ = 0.90 km/h
   Δt_2 = 2.5 h

   Solution
   $\Delta x = \Delta x_1 + \Delta x_2 = v_{avg,1}\Delta t_1 + v_{avg,2}\Delta t_2$
   Δx = (−0.75 km/h)(1.5 h) + (0.90 km/h)(2.5 h)
   Δx = −1.1 km/h + 2.2 km/h = +1.1 km = 1.1 km, north

   PTS: 1 DIF: IIIB OBJ: 2-1.2

3. ANS:
   0.67 m/s, east

   Given
   $\Delta x_1 = \Delta x_2 = \frac{1}{2}(1.0\text{ km}) = 5.0 \times 10^2 \text{ m}$
   $v_{avg,1} = 0.75 \text{ m/s}$
   $v_{avg,2} = 0.60 \text{ m/s}$

   Solution
   $$\Delta t = \Delta t_1 + \Delta t_2 = \frac{\Delta x_1}{v_{avg,1}} + \frac{\Delta x_2}{v_{avg,2}}$$
   $$\Delta t = \frac{5.0 \times 10^2 \text{ m}}{0.75 \text{ m/s}} + \frac{5.0 \times 10^2 \text{ m}}{0.60 \text{ m/s}} = 15.0 \times 10^2 \text{ s} = 1.50 \times 10^3 \text{ s}$$
   $$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{1.0 \times 10^3 \text{ m}}{1.50 \times 10^3 \text{ s}} = +0.67 \text{ m/s} = 0.67 \text{ m/s, east}$$

   PTS: 1 DIF: IIIC OBJ: 2-1.2
4. ANS:
   32 m

   Given
   $v_i = 2.0 \text{ m/s}$
   $a = 3.0 \text{ m/s}^2$
   $\Delta t = 4.0 \text{ s}$

   Solution
   $$\Delta x = v_i \Delta t + \tfrac{1}{2} a (\Delta t)^2$$
   $$\Delta x = (2.0 \text{ m/s})(4.0 \text{ s}) + \tfrac{1}{2}(3.0 \text{ m/s}^2)(4.0 \text{ s})^2 = 8.0 \text{ m} + 24 \text{ m}$$
   $$\Delta x = 32 \text{ m}$$

   PTS: 1 DIF: IIIA OBJ: 2-2.3

5. ANS:
   1.0 m/s

   Given
   $v_i = 1.8$ m/s

   $a = -3.00$ m/s^2
   $\Delta x = 0.37$ m

   Solution
   $v_f^{\,2} = v_i^{\,2} + 2a\Delta x$

   $v_f = \sqrt{v_i^{\,2} + 2a\Delta x} = \sqrt{(1.8\text{ m/s})^2 + 2(-3.00\text{ m/s}^2)(0.37\text{ m})}$

   $v_f = \sqrt{3.2\text{ m}^2/\text{s}^2 - 2.2\text{ m}^2/\text{s}^2} = \sqrt{1.0\text{ m}^2/\text{s}^2}$

   $v_f = 1.0$ m/s

   PTS: 1 DIF: IIIA OBJ: 2-2.3
6. ANS:
   111 m

   Given
   $v_i = 27.8$ m/s
   $v_f = 0.0$ m/s
   $\Delta t = 8.00$ s

   Solution
   $\Delta x = \frac{1}{2}(v_i + v_f)\Delta t = \frac{1}{2}(27.8\text{ m/s} + 0.0\text{ m/s})(8.00\text{ s}) = 111\text{ m}$

   PTS: 1 DIF: IIIA OBJ: 2-2.3
7. ANS:
   17 m/s

   Given
   $v_i = 5.0$ m/s

   $a = 2.0$ m/s^2
   $\Delta t = 6.0$ s

   Solution
   $v_f = v_i + a\Delta t = 5.0\text{ m/s} + (2.0\text{ m/s}^2)(6.0\text{ s}) = 17\text{ m/s}$

   PTS: 1 DIF: IIIB OBJ: 2-2.3

8. ANS:
   9.0 m

   Given
   $v_i = 3.0$ m/s
   $v_f = 1.5$ m/s
   $\Delta t = 4.0$ s

   Solution
   $\Delta x = \frac{1}{2}(v_i + v_f)\Delta t = \frac{1}{2}(1.5\text{ m/s} + 3.0\text{ m/s})(4.0\text{ s}) = 9.0\text{ m}$

   PTS: 1 DIF: IIIB OBJ: 2-2.3
9. ANS:
   10.0 m/s^2

   Given
   $v_i = 0.0$ m/s
   $v_f = 30.0$ m/s
   $\Delta x = 45.0$ m

   Solution
   $v_f^2 = v_i^2 + 2a\Delta x$

   $$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{(30.0\text{ m/s})^2 - (0.0\text{ m/s})^2}{2(45.0\text{ m})} = 10.0\text{ m/s}^2$$

   PTS: 1 DIF: IIIB OBJ: 2-2.3

10. ANS:
9.75 cm/s^2

Given
$v_i = -1.00$ cm/s
$\Delta x = 17.5$ cm
$\Delta t = 2.00$ s

Solution
$\Delta x = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$

$$a = \frac{2\Delta x}{(\Delta t)^2} - \frac{2v_i}{\Delta t} = \frac{2(17.5\text{ cm})}{(2.00\text{ s})^2} - \frac{2(-1.00\text{ cm/s})}{2.00\text{ s}}$$

$$a = 8.75\text{ cm/s}^2 + 1.00\text{ cm/s}^2 = 9.75\text{ cm/s}^2$$

PTS: 1 DIF: IIIB OBJ: 2-2.3

11. ANS:
44 m

Given
$a = -g = -9.81$ m/s^2
$\Delta t = 2.0$ s
$v_i = -12$ m/s

Solution
$\Delta x = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$

$$\Delta x = (-12\text{ m/s})(2.0\text{ s}) + \tfrac{1}{2}(-9.81\text{ m/s}^2)(2.0\text{ s})^2 = -44\text{ m}$$

height of cliff = 44 m

PTS: 1 DIF: IIIA OBJ: 2-3.2

12. ANS:
19.6 m

Given
$a = -g = -9.81 \text{ m/s}^2$
$v_i = 24.5 \text{ m/s}$
$\Delta t = 1.00 \text{ s}$

Solution

$$\Delta x = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$$

$$\Delta x = (24.5 \text{ m/s})(1.00 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(1.00 \text{ s})^2 = 19.6 \text{ m}$$

PTS: 1 DIF: IIIA OBJ: 2-3.2

13. ANS:
15 m/s

Given
$a = -g = -9.81 \text{ m/s}^2$
$v_i = 0.0 \text{ m/s}$
$\Delta t = 1.5 \text{ s}$

Solution
$v_f = v_i + a\Delta t = 0.0 \text{ m/s} + (-9.81 \text{ m/s}^2)(1.5 \text{ s}) = -15 \text{ m}$
speed = 15 m/s

PTS: 1 DIF: IIIB OBJ: 2-3.2

14. ANS:
4.7 m

Given
$a = -g = -9.81 \text{ m/s}^2$
$v_i = 9.6 \text{ m/s}$
$v_f = 0.0 \text{ m/s}$

Solution
$v_f^2 = v_i^2 + 2a\Delta x$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(0.0 \text{ m/s})^2 - (9.6 \text{ m/s})^2}{(2)(-9.81 \text{ m/s}^2)} = 4.7 \text{ m}$$

PTS: 1 DIF: IIIB OBJ: 2-3.2

15. ANS:
12.0 m/s

Given
$a = -g = -9.81 \text{ m/s}^2$
$\Delta x = -8.00 \text{ m}$
$\Delta t = 3.00 \text{ s}$

Solution
$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$

$$v_i = \frac{\Delta x}{\Delta t} - \frac{1}{2} a \Delta t = \frac{-8.00 \text{ m}}{3.00 \text{ s}} - \frac{(-9.81 \text{ m/s}^2)(3.00 \text{ s})}{2}$$

$v_i = -2.67 \text{ m/s} + 14.7 \text{ m/s} = 12.0 \text{ m/s}$

PTS: 1 DIF: IIIB OBJ: 2-3.2