Back Lesson Print

NAME ______________________ DATE ____________ CLASS ____________

Motion in One Dimension

Problem E

FINAL VELOCITY AFTER ANY DISPLACEMENT

PROBLEM

In 1970, a rocket-powered car called *Blue Flame* achieved a maximum speed of 1.00 (10^3 km/h (278 m/s). Suppose the magnitude of the car's constant acceleration is 5.56 m/s^2. If the car is initially at rest, what is the distance traveled during its acceleration?

SOLUTION

1. DEFINE

Given:

$v_i = 0$ m/s

$v_f = 278$ m/s

$a = 5.56$ m/s^2

Unknown: $\Delta x = ?$

2. PLAN

Choose an equation(s) or situation: Use the equation for the final velocity after any displacement.

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

Rearrange the equation(s) to isolate the unknown(s):

$$\Delta x = \frac{v_f^2 - v_i^2}{2a}$$

3. CALCULATE

Substitute the values into the equation(s) and solve:

$$\Delta x = \frac{\left(278\,\frac{\text{m}}{\text{s}}\right)^2 - \left(0\,\frac{\text{m}}{\text{s}}\right)^2}{(2)\left(5.56\,\frac{\text{m}}{\text{s}^2}\right)} = \boxed{6.95 \times 10^3 \text{ m}}$$

4. EVALUATE

Using the appropriate kinematic equation, the time of travel for *Blue Flame* is found to be 50.0 s. From this value for time the distance traveled during the acceleration is confirmed to be almost 7 km. Once the car reaches its maximum speed, it travels about 16.7 km/min.

ADDITIONAL PRACTICE

1. In 1976, Kitty Hambleton of the United States drove a rocket-engine car to a maximum speed of 965 km/h. Suppose Kitty started at rest and underwent a constant acceleration with a magnitude of 4.0 m/s^2. What distance would she have had to travel in order to reach the maximum speed?

2. With a cruising speed of 2.30×10^3 km/h, the French supersonic passenger jet Concorde is the fastest commercial airplane. Suppose the landing speed of the Concorde is 20.0 percent of the cruising speed. If the plane accelerates at –5.80 m/s^2, how far does it travel between the time it lands and the time it comes to a complete stop?

3. The Boeing 747 can carry more than 560 passengers and has a maximum speed of about 9.70×10^2 km/h. After takeoff, the plane takes a certain time to reach its maximum speed. Suppose the plane has a constant acceleration with a magnitude of 4.8 m/s^2. What distance does the plane travel between the moment its speed is 50.0 percent of maximum and the moment its maximum speed is attained?

4. The distance record for someone riding a motorcycle on its rear wheel without stopping is more than 320 km. Suppose the rider in this unusual situation travels with an initial speed of 8.0 m/s before speeding up. The rider then travels 40.0 m at a constant acceleration of 2.00 m/s^2. What is the rider's speed after the acceleration?

5. The skid marks left by the decelerating jet-powered car *The Spirit of America* were 9.60 km long. If the car's acceleration was –2.00 m/s^2, what was the car's initial velocity?

6. The heaviest edible mushroom ever found (the so-called "chicken of the woods") had a mass of 45.4 kg. Suppose such a mushroom is attached to a rope and pulled horizontally along a smooth stretch of ground, so that it undergoes a constant acceleration of +0.35 m/s^2. If the mushroom is initially at rest, what will its velocity be after it has been displaced +64 m?

7. Bengt Norberg of Sweden drove his car 44.8 km in 60.0 min. The feature of this drive that is interesting is that he drove the car on two side wheels.

a. Calculate the car's average speed.

b. Suppose Norberg is moving forward at the speed calculated in (a). He then accelerates at a rate of –2.00 m/s^2. After traveling 20.0 m, the car falls on all four wheels. What is the car's final speed while still traveling on two wheels?

8. Starting at a certain speed, a bicyclist travels 2.00×10^2 m. Suppose the bicyclist undergoes a constant acceleration of 1.20 m/s^2. If the final speed is 25.0 m/s, what was the bicyclist's initial speed?

9. In 1994, Tony Lang of the United States rode his motorcycle a short distance of 4.0×10^2 m in the short interval of 11.5 s. He started from rest and crossed the finish line with a speed of about 2.50×10^2 km/h. Find the magnitude of Lang's acceleration as he traveled the 4.0×10^2 m distance.

10. The lightest car in the world was built in London and had a mass of less than 10 kg. Its maximum speed was 25.0 km/h. Suppose the driver of this vehicle applies the brakes while the car is moving at its maximum speed. The car stops after traveling 16.0 m. Calculate the car's acceleration.

Additional Practice E

II

Givens | *Solutions*

1. $v_i = 0$ km/h

$v_f = 965$ km/h

$a = 4.0 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{\left[(965 \text{ km/h})^2 - (0 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.0 \text{ m/s}^2)}$$

$$\Delta x = \frac{7.19 \times 10^4 \text{m}^2/\text{s}^2}{8.0 \text{ m/s}^2} = 9.0 \times 10^3 \text{ m} = \boxed{9.0 \text{ km}}$$

2. $v_i = (0.20)\, v_{max}$

$v_{max} = 2.30 \times 10^3$ km/h

$v_f = 0$ km/h

$a = -5.80 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{\left[(0 \text{ km/h})^2 - (0.20)^2\,(2.30 \times 10^3 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(-5.80 \text{ m/s}^2)}$$

$$\Delta x = \frac{-1.63 \times 10^4 \text{m}^2/\text{s}^2}{-11.6 \text{ m/s}^2} = 1.41 \times 10^3 \text{ m} = \boxed{1.41 \text{ km}}$$

3. $v_f = 9.70 \times 10^2$ km/h

$v_i = (0.500)v_f$

$a = 4.8 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{\left[(9.70 \times 10^2 \text{ km/h})^2 - (0.50)^2\,(9.70 \times 10^2 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{(9.41 \times 10^5 \text{ km}^2/\text{h})^2 - 2.35 \times 10^5 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{(7.06 \times 10^5 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{5.45 \times 10^4 \text{m}^2/\text{s}^2}{9.6 \text{ m/s}^2} = 5.7 \times 10^3 \text{ m} = \boxed{5.7 \text{ km}}$$

4. $v_i = 8.0$ m/s

$\Delta x = 40.0$ m

$a = 2.00 \text{ m/s}^2$

$$v_f = \sqrt{2a\Delta x + v_i^2} = \sqrt{(2)(2.0 \text{ m/s}^2)(40.\text{m}) + (8.0 \text{ m/s})^2} = \sqrt{1.60 \times 10^2 \text{m}^2/\text{s}^2 + 64 \text{ m}^2/\text{s}^2}$$

$$v_f = \sqrt{224 \text{ m}^2/\text{s}^2} = \pm 15 \text{ m/s} = \boxed{15 \text{ m/s}}$$

5. $\Delta x = +9.60$ km

$a = -2.0 \text{ m/s}^2$

$v_f = 0$ m/s

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(0 \text{ m/s})^2 - (2)(-2.0 \text{ m/s}^2)(9.60 \times 10^3 \text{ m})}$$

$$v_i = \sqrt{3.84 \times 10^4 \text{m}^2/\text{s}^2} = \pm 196 \text{ m/s} = \boxed{+196 \text{ m/s}}$$

6. $a = +0.35 \text{ m/s}^2$

$v_i = 0$ m/s

$\Delta x = 64$ m

$$v_f = \sqrt{2a\Delta x + v_i^2} = \sqrt{(2)(0.35 \text{ m/s}^2)(64 \text{ m}) + (0 \text{ m/s})^2}$$

$$v_f = \sqrt{45 \text{ m}^2\text{s}^2} = \pm 6.7 \text{ m/s} = \boxed{+6.7 \text{ m/s}}$$

7. $\Delta x = 44.8$ km

$\Delta t = 60.0$ min

$a = -2.0 \text{ m/s}^2$

$\Delta x = 20.0$ m

$v_i = 12.4$ m/s

a. $$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{44.8 \times 10^3 \text{ m}}{(60.0 \text{ min})(60 \text{ s/min})} = \boxed{12.4 \text{ m/s}}$$

b. $$v_f = \sqrt{2a\Delta x + v_i^2} = \sqrt{(2)(-2.0 \text{ m/s}^2)(20.0 \text{ m}) + (12.4 \text{ m/s})^2}$$

$$v_f = \sqrt{(-80.0 \text{ m}^2/\text{s}^2) + 154 \text{ m}^2/\text{s}^2} = \sqrt{74 \text{ m}^2/\text{s}^2} = \pm 8.6 \text{ m/s} = \boxed{8.6 \text{ m/s}}$$

Givens | *Solutions*

8. $\Delta x = 2.00 \times 10^2$ m

$a = 1.20$ m/s^2

$v_f = 25.0$ m/s

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(25.0 \text{ m/s})^2 - (2)(1.20 \text{ m/s}^2)(2.00 \times 10^2 \text{ m})}$$

$$v_i = \sqrt{625 \text{ m}^2/\text{s}^2 - 4.80 \times 10^2 \text{m}^2/\text{s}^2}$$

$$v_i = \sqrt{145 \text{ m}^2/\text{s}^2} = \pm 12.0 \text{ m/s} = \boxed{12.0 \text{ m/s}}$$

9. $\Delta x = 4.0 \times 10^2$ m

$\Delta t = 11.55$

$v_i = 0$ km/h

$v_f = 2.50 \times 10^2$ km/h

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{\left[(2.50 \times 10^2 \text{ km/h})^2 - (0 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.0 \times 10^2 \text{ m})}$$

$$a = \frac{4.82 \times 10^3 \text{m}^2/\text{s}^2}{8.0 \times 10^2 \text{ m}} = \boxed{6.0 \text{ m/s}^2}$$

10. $v_i = 25.0$ km/h

$v_f = 0$ km/h

$\Delta x = 16.0$ m

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{\left[(0 \text{ km/h})^2 - (25.0 \text{ km/h})^2\right]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(16.0 \text{ m})}$$

$$a = \frac{-4.82 \text{ m}^2/\text{s}^2}{32.0 \text{ m}} = \boxed{-1.51 \text{ m/s}^2}$$

II

Additional Practice F

1. $\Delta y = -343$ m

$a = -9.81$ m/s^2

$v_i = 0$ m/s

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(-343 \text{ m}) + (0 \text{ m/s})^2} = \sqrt{6730 \text{ m}^2/\text{s}^2}$$

$$v_f = \pm 82.0 \text{ m/s} = \boxed{-82.0 \text{ m/s}}$$

2. $\Delta y = +4.88$ m

$v_i = +9.98$ m/s

$a = -9.81$ m/s^2

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(4.88 \text{ m}) + (9.98 \text{ m/s})^2} = \sqrt{-95.7 \text{ m}^2/\text{s}^2 + 99.6 \text{ m}^2/\text{s}^2}$$

$$v_f = \sqrt{3.90 \text{ m}^2/\text{s}^2} = \pm 1.97 \text{ m/s} = \boxed{\pm 1.97 \text{ m/s}}$$

3. $\Delta y = -443 \text{ m} + 221 \text{ m}$
$= -222$ m

$a = -9.81$ m/s^2

$v_i = 0$ m/s

$$v_f = \sqrt{2a\Delta y - v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(-222 \text{ m}) - (0 \text{ m/s})^2} = \sqrt{4360 \text{ m}^2/\text{s}^2}$$

$$v_f = \pm 66.0 \text{ m/s} = \boxed{-66.0 \text{ m/s}}$$

4. $\Delta y = +64$ m

$a = -9.81$ m/s^2

$\Delta t = 3.0$ s

$$\Delta y = v_i \Delta t + \tfrac{1}{2}a\Delta t^2$$

$$v_i = \frac{\Delta y - \frac{1}{2}a\Delta t^2}{\Delta t} = \frac{64 \text{ m} - \frac{1}{2}(-9.81 \text{ m/s}^2)(3.0 \text{ s})^2}{3.0 \text{ s}} = \frac{64 \text{ m} + 44 \text{ m}}{3.0 \text{ s}}$$

$$v_i = \frac{108 \text{ m}}{3.0 \text{ s}} = 36 \text{ m/s}$$

initial speed of arrow = $\boxed{36 \text{ m/s}}$

5. $\Delta y = -111$ m

$\Delta t = 3.80$ s

$a = -9.81$ m/s^2

$$\Delta y = v_i \Delta t + \tfrac{1}{2}a\Delta t^2$$

$$v_i = \frac{\Delta y - \frac{1}{2}a\Delta t^2}{\Delta t} = \frac{-111 \text{ m} - \frac{1}{2}(-9.81 \text{ m/s}^2)(3.80 \text{ s})^2}{3.80 \text{ s}} = \frac{-111 \text{ m} + 70.8 \text{ m}}{3.80 \text{ s}}$$

$$v_i = \frac{-40.2 \text{ m}}{3.80 \text{ s}} = \boxed{-10.6 \text{ m/s}}$$