NAME ______________________ DATE ____________ CLASS ____________

Motion in One Dimension

Problem E

FINAL VELOCITY AFTER ANY DISPLACEMENT

PROBLEM

A radio-controlled toy car increases speed over a distance of 15.2 m. If the car starts at rest and has a final speed of 0.76 m/s, what is the magnitude of its acceleration?

SOLUTION

1. DEFINE

Given: $\Delta x = 15.2$ m

$v_i = 0$ m/s

$v_f = 0.76$ m/s

Unknown: $a = ?$

2. PLAN

Choose the 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):

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

3. CALCULATE

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

$$a = \frac{(0.76 \text{ m/s})^2 - (0 \text{ m/s})^2}{(2)(15.2 \text{ m})}$$

$$a = \frac{0.58 \text{ m}^2/\text{s}^2 - 0 \text{ m}^2/\text{s}^2}{30.4 \text{ m}}$$

$$a = \frac{0.58}{30.4} \text{ m/s}^2$$

$$a = \boxed{1.9 \times 10^{-2} \text{ m/s}^2}$$

4. EVALUATE

The magnitude of the acceleration suggests that the car increases speed very slowly. This is confirmed by using the difference in speeds and the acceleration to calculate the time interval for the acceleration. The car reaches its final speed in 40 s.

ADDITIONAL PRACTICE

1. A dumptruck filled with sand moves 1.8 km/h when it begins to accelerate uniformly at a constant rate. After traveling 4.0×10^2 m, the truck's speed is 24.0 km/h. What is the magnitude of the truck's acceleration?

2. One of the most consistent long-jumpers is Jackie Joyner-Kersee of the United States. Her best distance in this field and track event is 7.49 m. To achieve this distance, her speed at the point where she started the jump was at least 8.57 m/s. Suppose the runway for the long jump was

19.53 m, and that Joyner-Kersee's initial speed was 0 m/s. What was the magnitude of her acceleration if it was uniform acceleration?

3. Although ungraceful on land, walruses are fine swimmers. They normally swim at 7 km/h, and for short periods of time are capable of reaching speeds of nearly 35 km/h. Suppose a walrus accelerates from 7.0 km/h to 34.5 km/h over a distance of 95 m. What would be the magnitude of the walrus's uniform acceleration?

4. Floyd Beattie set an unofficial speed record for a unicycle in 1986. He rode the unicycle through a 2.00×10^2 m speed trap, along which his speed was measured as being between 9.78 m/s and 10.22 m/s. Suppose that Beattie had accelerated at a constant rate along the speed trap, so that his initial speed was 9.78 m/s and his final speed was 10.22 m/s. What would the magnitude of his acceleration have been?

5. A fighter jet lands on an aircraft carrier's flight deck. Although the deck is 300 m long, most of the jet's acceleration occurs within a distance of 42.0 m. If the jet's velocity is reduced uniformly from +153.0 km/h to 0 km/h as it moves through 42.0 m, what is the jet's acceleration?

6. Most hummingbirds can fly with speeds of nearly 50.0 km/h. Suppose a hummingbird flying with a velocity of 50.0 km/h in the forward direction accelerates uniformly at 9.20 m/s^2 in the backward direction until it comes to a hovering stop. What is the hummingbird's displacement?

7. A thoroughbred racehorse accelerates uniformly at 7.56 m/s^2, reaching its final speed after running 19.0 m. If the horse starts at rest, what is its final speed?

8. A soccer ball moving with an initial speed of 1.8 m/s is kicked with a uniform acceleration of 6.1 m/s^2, so that the ball's new speed is 9.4 m/s. How far has the soccer ball moved?

9. A dog runs with an initial velocity of 1.50 m/s to the right on a waxed floor. It slides to a final velocity of 0.30 m/s to the right with a uniform acceleration of 0.35 m/s^2 to the left. What is the dog's displacement?

10. A hippopotamus can run up to 30 km/h, or 8.33 m/s. Suppose a hippopotamus uniformly accelerates 0.678 m/s^2 until it reaches a top speed of 8.33 m/s. If the hippopotamus has run 46.3 m, what is its initial speed?

Givens | *Solutions*

9. $v_i = 0$ m/s
$v_f = 72.0$ m/s north
$a = 1.60$ m/s^2 north
$\Delta t = 45.0$ s

a. $\Delta t = \dfrac{v_f - v_i}{a} = \dfrac{72.0 \text{ m/s} - 0 \text{ m/s}}{1.60 \text{ m/s}^2} = \boxed{45.0 \text{ s}}$

b. $\Delta x = v_i \Delta t + \dfrac{1}{2} a \Delta t^2 = (0 \text{ m/s})(45.0 \text{ s}) + \dfrac{1}{2}(1.60 \text{ m/s}^2)(45.0 \text{ s})^2 = 0 \text{ m} + 1620 \text{ m}$

$\Delta x = \boxed{1.62 \text{ km}}$

---

10. $v_i = +4.42$ m/s
$v_f = 0$ m/s
$a = -0.75$ m/s^2
$\Delta t = 5.9$ s

a. $\Delta t = \dfrac{v_f - v_i}{a} = \dfrac{0 \text{ m/s} - 4.42 \text{ m/s}}{-0.75 \text{ m/s}^2} = \dfrac{-4.42 \text{ m/s}}{-0.75 \text{ m/s}^2} = \boxed{5.9 \text{ s}}$

b. $\Delta x = v_i \Delta t + \dfrac{1}{2} a \Delta t^2 = (4.42 \text{ m/s})(5.9 \text{ s}) + \dfrac{1}{2}(-0.75 \text{ m/s}^2)(5.9 \text{ s})^2$

$\Delta x = 26 \text{ m} - 13 \text{ m} = \boxed{13 \text{ m}}$

Additional Practice E

1. $v_i = 1.8$ km/h
$v_f = 24.0$ km/h
$\Delta x = 4.0 \times 10^2$ m

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(24.0 \text{ km/h})^2 - (1.8 \text{ km/h})^2]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(4.0 \times 10^2 \text{ m})}$$

$$a = \frac{(576 \text{ km}^2/\text{h}^2 - 3.2 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{8.0 \times 10^2 \text{ m}}$$

$$a = \frac{(573 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{8.0 \times 10^2 \text{ m}} = \boxed{5.5 \times 10^{-2} \text{ m/s}^2}$$

---

2. $v_f = 0$ m/s
$v_f = 8.57$ m/s
$\Delta x = 19.53$ m

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{(8.57 \text{ m/s})^2 - (0 \text{ m/s})^2}{(2)(19.53 \text{ m})} = \frac{73.4 \text{ m}^2/\text{s}^2}{39.06 \text{ m}} = \boxed{1.88 \text{ m/s}^2}$$

---

3. $v_i = 7.0$ km/h
$v_f = 34.5$ km/h
$\Delta x = 95$ m

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(34.5 \text{ km/h})^2 - (7.0 \text{ km/h})^2]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(95 \text{ m})}$$

$$a = \frac{(1190 \text{ km}^2/\text{h}^2 - 49 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{190 \text{ m}}$$

$$a = \frac{(1140 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{190 \text{ m}} = \boxed{0.46 \text{ m/s}^2}$$

---

4. $\Delta x = 2.00 \times 10^2$ m
$v_i = 9.78$ m/s
$v_f = 10.22$ m/s

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{(10.22 \text{ m/s})^2 - (9.78 \text{ m/s})^2}{(2)(2.00 \times 10^2 \text{ m})} = \frac{104.4 \text{ m}^2/\text{s}^2 - 95.6 \text{ m}^2/\text{s}^2}{4.00 \times 10^2 \text{ m}}$$

$$a = \frac{8.8 \text{ m}^2/\text{s}^2}{4.00 \times 10^2 \text{ m}} = \boxed{2.2 \times 10^{-2} \text{ m/s}^2}$$

Givens | *Solutions*

5. $\Delta x = +42.0 \text{ m}$

$v_i = +153.0 \text{ km/h}$

$v_f = 0 \text{ km/h}$

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{[(0 \text{ km/h})^2 - (153.0 \text{ km/h})^2]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)\ (42.0 \text{ m})}$$

$$a = \frac{-(2.34 \times 10^4 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(84.0 \text{ m})} = \boxed{-21.5 \text{ m/s}^2}$$

---

6. $v_i = 50.0 \text{ km/h forward}$
$= +50.0 \text{ km/h}$

$v_f = 0 \text{ km/h}$

$a = 9.20 \text{ m/s}^2 \text{ backward}$
$= -9.20 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{[(0 \text{ km/h})^2 - (50.0 \text{ km/h})^2]\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{(2)(-9.20 \text{ m/s}^2)}$$

$$\Delta x = \frac{-(2.50 \times 10^3 \text{ km}^2/\text{h}^2)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)^2\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2}{-18.4 \text{ m/s}^2}$$

$$\Delta x = 10.5 \text{ m} = \boxed{10.5 \text{ m forward}}$$

---

7. $a = 7.56 \text{ m/s}^2$

$\Delta x = 19.0 \text{ m}$

$v_i = 0 \text{ m/s}$

$$v_f = \sqrt{v_i^2 + 2a\Delta x} = \sqrt{(0 \text{ m/s})^2 + (2)(7.56 \text{ m/s}^2)(19.0 \text{ m})}$$

$$v_f = \sqrt{287 \text{ m}^2/\text{s}^2} = \pm 16.9 \text{ m/s} = \boxed{16.9 \text{ m/s}}$$

---

8. $v_i = 1.8 \text{ m/s}$

$v_f = 9.4 \text{ m/s}$

$a = 6.1 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(9.4 \text{ m/s})^2 - (1.8 \text{ m/s})^2}{(2)(6.1 \text{ m/s}^2)} = \frac{88 \text{ m}^2/\text{s}^2 - 3.2 \text{ m}^2/\text{s}^2}{(2)(6.1 \text{ m/s}^2)}$$

$$\Delta x = \frac{85 \text{ m}^2/\text{s}^2}{(2)(6.1 \text{ m/s}^2)} = \boxed{7.0 \text{ m}}$$

---

9. $v_i = 1.50 \text{ m/s to the right}$
$= +1.50 \text{ m/s}$

$v_f = 0.30 \text{ m/s to the right}$
$= +0.30 \text{ m/s}$

$a = 0.35 \text{ m/s}^2 \text{ to the left}$
$= -0.35 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(0.30 \text{ m/s})^2 - (1.50 \text{ m/s})^2}{(2)(-0.35 \text{ m/s}^2)}$$

$$\Delta x = \frac{9.0 \times 10^{-2} \text{ m}^2/\text{s}^2 - 2.25 \text{ m}^2/\text{s}^2}{-0.70 \text{ m/s}^2}$$

$$\Delta x = \frac{-2.16 \text{ m}^2/\text{s}^2}{-0.70 \text{ m/s}^2} = +3.1 \text{ m} = \boxed{3.1 \text{ m to the right}}$$

---

10. $a = 0.678 \text{ m/s}^2$

$v_f = 8.33 \text{ m/s}$

$\Delta x = 46.3 \text{ m}$

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(8.33 \text{ m/s})^2 - (2)(0.678 \text{ m/s}^2)(46.3 \text{ m})}$$

$$v_i = \sqrt{69.4 \text{ m}^2/\text{s}^2 - 62.8 \text{ m}^2/\text{s}^2} = \sqrt{6.6 \text{ m}^2/\text{s}^2} = \pm 2.6 \text{ m/s} = \boxed{2.6 \text{ m/s}}$$

Additional Practice F

1. $v_i = 0 \text{ m/s}$

$v_f = 49.5 \text{ m/s downward}$
$= 49.5 \text{ m/s}$

$a = -9.81 \text{ m/s}^2$

$\Delta_{tot} = -448 \text{ m}$

$$\Delta x_i = \frac{v_f^2 - v_i^2}{2a} = \frac{(-49.5 \text{ m/s})^2 - (0 \text{ m/s})^2}{(2)(-9.81 \text{ m/s}^2)} = \frac{2450 \text{ m}^2/\text{s}^2}{(2)(-9.81 \text{ m/s}^2)} = -125 \text{ m}$$

$$\Delta x_2 = \Delta x_{tot} - \Delta x_1 = (-448 \text{ m}) - (-125 \text{ m}) = -323 \text{ m}$$

distance from net to ground = magnitude $\Delta x_2 = \boxed{323 \text{ m}}$