NAME ______________________ DATE ______________ CLASS ______________

Motion in One Dimension

Problem D

VELOCITY AND DISPLACEMENT WITH CONSTANT ACCELERATION

PROBLEM

A barge moving with a speed of 1.00 m/s increases speed uniformly, so that in 30.0 s it has traveled 60.2 m. What is the magnitude of the barge's acceleration?

SOLUTION

Given: $v_i = 1.00$ m/s

$\Delta t = 30.0$ s

$\Delta x = 60.2$ m

Unknown: $a = ?$

Use the equation for displacement with constant uniform acceleration.

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

Rearrange the equation to solve for a.

$$\frac{1}{2} a \Delta t^2 = \Delta x - v_i \Delta t$$

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

$$a = \frac{(2)[60.2 \text{ m} - (1.00 \text{ m/s})(30.0 \text{ s})]}{(30.0 \text{ s})^2}$$

$$a = \frac{(2)(60.2 \text{ m} - 30.0 \text{ m})}{9.00 \times 10^2 \text{ s}^2}$$

$$a = \frac{(2)(30.2 \text{ m})}{9.00 \times 10^2 \text{ s}^2}$$

$$a = \boxed{6.71 \times 10^{-2} \text{ m/s}^2}$$

ADDITIONAL PRACTICE

1. The flight speed of a small bottle rocket can vary greatly, depending on how well its powder burns. Suppose a rocket is launched from rest so that it travels 12.4 m upward in 2.0 s. What is the rocket's net acceleration?

2. The shark can accelerate to a speed of 32.0 km/h in a few seconds. Assume that it takes a shark 1.5 s to accelerate uniformly from 2.8 km/h to 32.0 km/h. What is the magnitude of the shark's acceleration?

3. In order for the Wright brothers' 1903 flyer to reach launch speed, it had to be accelerated uniformly along a track that was 18.3 m long. A system of pulleys and falling weights provided the acceleration. If the flyer was initially at rest and it took 2.74 s for the flyer to travel the length of the track, what was the magnitude of its acceleration?

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4. A certain roller coaster increases the speed of its cars as it raises them to the top of the incline. Suppose the cars move at 2.3 m/s at the base of the incline and are moving at 46.7 m/s at the top of the incline. What is the magnitude of the net acceleration if it is uniform acceleration and takes place in 7.0 s?

5. A ship with an initial speed of 6.23 m/s approaches a dock that is 255 m away. If the ship accelerates uniformly and comes to rest in 82 s, what is its acceleration?

6. Although tigers are not the fastest of predators, they can still reach and briefly maintain a speed of 55 km/h. Assume that a tiger takes 4.1 s to reach this speed from an initial speed of 11 km/h. What is the magnitude of the tiger's acceleration, assuming it accelerates uniformly?

7. Assume that a catcher in a professional baseball game catches a ball that has been pitched with an initial velocity of 42.0 m/s to the southeast. If the catcher uniformly brings the ball to rest in 0.0090 s through a distance of 0.020 m to the southeast, what is the ball's acceleration?

8. A crate is carried by a conveyor belt to a loading dock. The belt speed uniformly increases slightly, so that for 28.0 s the crate accelerates by 0.035 m/s^2. If the crate's initial speed is 0.76 m/s, what is its final speed?

9. A plane starting at rest at the south end of a runway undergoes a uniform acceleration of 1.60 m/s^2 to the north. At takeoff, the plane's velocity is 72.0 m/s to the north.

a. What is the time required for takeoff?

b. How far does the plane travel along the runway?

10. A cross-country skier with an initial forward velocity of +4.42 m/s accelerates uniformly at –0.75 m/s^2.

a. How long does it take the skier to come to a stop?

b. What is the skier's displacement in this time interval?

Additional Practice D

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1. $\Delta x = 12.4$ m upward $\Delta t = 2.0$ s $v_i = 0$ m/s	Because $v_i = 0$ m/s, $a = \dfrac{2\Delta x}{\Delta t^2} = \dfrac{(2)(12.4\text{ m})}{(2.0\text{ s})^2} = \boxed{6.2\text{ m/s}^2\text{ upward}}$
2. $\Delta t = 1.5$ s $v_i = 2.8$ km/h $v_f = 32.0$ km/h	$a = \dfrac{v_f - v_i}{\Delta t} = \dfrac{(32.0\text{ km/h} - 2.8\text{ km/h})\left(\dfrac{1\text{ h}}{3600\text{ s}}\right)\left(\dfrac{10^3\text{ m}}{\text{km}}\right)}{1.5\text{ s}}$ $a = \dfrac{(29.2\text{ km/h})\left(\dfrac{1\text{ h}}{3600\text{ s}}\right)\left(\dfrac{10^3\text{ m}}{1\text{ km}}\right)}{1.5\text{ s}} = \boxed{5.4\text{ m/s}^2}$
3. $\Delta x = 18.3$ m $\Delta t = 2.74$ s $v_i = 0$ m/s	Because $v_i = 0$ m/s, $a = \dfrac{2\Delta x}{\Delta t^2} = \dfrac{(2)(18.3\text{ m})}{(2.74\text{ s})^2} = \boxed{4.88\text{ m/s}^2}$
4. $v_i = 2.3$ m/s $v_f = 46.7$ m/s $\Delta t = 7.0$ s	$a = \dfrac{v_f - v_i}{\Delta t} = \dfrac{46.7\text{ m/s} - 2.3\text{ m/s}}{7.0\text{ s}} = \dfrac{44.4\text{ m/s}}{7.0\text{ s}} = \boxed{6.3\text{ m/s}^2}$
5. $v_i = 6.23$ m/s $\Delta x = 255$ m $\Delta t = 82$ s	$a = \dfrac{2(\Delta x - v_i\Delta t)}{\Delta t^2} = \dfrac{(2)[255\text{ m} - (6.23\text{ m/s})(82\text{ s})]}{(82\text{ s})^2}$ $a = \dfrac{(2)(255\text{ m} - 510\text{ m})}{6.7\times 10^3\text{ s}^2} = \dfrac{(2)(-255\text{ m})}{6.7\times 10^3\text{ s}^2} = \boxed{-7.6\times 10^{-2}\text{ m/s}^2}$
6. $v_i = 11$ km/h $v_f = 55$ km/h $\Delta = 4.1$ s	$a = \dfrac{v_f - v_i}{\Delta t} = \dfrac{(55\text{ km/h} - 11\text{ km/h})\left(\dfrac{1\text{ h}}{3600\text{ s}}\right)\left(\dfrac{10^3\text{ m}}{1\text{ km}}\right)}{4.1\text{ s}}$ $a = \dfrac{(44\text{ km/h})\left(\dfrac{1\text{ h}}{3600\text{ s}}\right)\left(\dfrac{10^3\text{ m}}{1\text{ km}}\right)}{4.1\text{ s}} = \boxed{3.0\text{ m/s}^2}$
7. $v_i = 42.0$ m/s southeast $\Delta t = 0.0090$ s $\Delta x = 0.020$ m/s southeast	$a = \dfrac{2(\Delta x - v_i\Delta t)}{\Delta t^2} = \dfrac{(2)[0.020\text{ m} - (42.0\text{ m/s})(0.0090\text{ s})]}{(0.0090\text{ s})^2}$ $a = \dfrac{(2)(0.020\text{ m/s} - 0.38\text{ m})}{8.1\times 10^{-5}\text{ s}^2} = \dfrac{(2)(-0.36\text{ m})}{8.1\times 10^{-5}\text{ s}^2}$ $a = \boxed{-8.9\times 10^3\text{ m/s}^2\text{, or }8.9\times 10^3\text{ m/s}^2\text{ northwest}}$
8. $\Delta t = 28$ s $a = 0.035\text{ m/s}^2$ $v_i = 0.76$ m/s	$v_f = a\Delta t + v_i = (0.035\text{ m/s}^2)(28.0\text{ s}) + 0.76\text{ m/s} = 0.98\text{ m/s} + 0.76\text{ m/s} = \boxed{1.74\text{ m/s}}$

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

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

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

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

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

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

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