NAME ______________________ DATE ____________ CLASS ______________

Motion in One Dimension

Problem B

AVERAGE ACCELERATION

PROBLEM

A basketball rolling with a velocity of +1.1 m/s comes to a stop in 8.5 s. What is the basketball's average acceleration?

SOLUTION

Given: $v_i = +1.1$ m/s

$v_f = 0$ m/s

$\Delta t = 8.5$ s

Unknown: $a_{avg} = ?$

Use the definition of average acceleration to find a_{avg}.

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

$$a_{avg} = \frac{0 \text{ m/s} - 1.1 \text{ m/s}}{8.5 \text{ s}} = \frac{-1.1 \text{ m/s}}{8.5 \text{ s}}$$

$$a_{avg} = \boxed{-0.13 \text{ m/s}^2}$$

ADDITIONAL PRACTICE

1. With a time of 6.92 s, Irina Privalova of Russia holds the women's record for running 60 m. Suppose she ran this distance with a constant acceleration, so that she crossed the finish line with a speed of 17.34 m/s. Assuming she started at rest, what was the magnitude of Privalova's average acceleration.

2. The solid-fuel rocket boosters used to launch the space shuttle are able to lift the shuttle 45 kilometers above Earth's surface. During the 2.00 min that the boosters operate, the shuttle accelerates from rest to a speed of nearly 7.50×10^2 m/s. What is the magnitude of the shuttle's average acceleration?

3. A type of firework consists of a cardboard tank mounted on plastic wheels and driven forward by a small rocket. Once the rocket ignites, the tank rolls from rest to a maximum velocity of 0.85 m/s forward, at which point the rocket burns out. If the total time that the rocket remains ignited is 3.7 s, what is the average acceleration of the tank?

4. A handball is hit toward a wall with a velocity of 13.7 m/s in the forward direction. It returns with a velocity of 11.5 m/s in the backward direction. If the time interval during which the ball is accelerated is 0.021 s, what is the handball's average acceleration?

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5. A certain type of rocket sled is used to measure the effects of extreme deceleration. The sled reaches a velocity of +320 km/h, then comes to a complete stop in 0.18 s. What is the average acceleration that takes place in this time interval?

6. In 1970, Don "Big Daddy" Garlits set what was then the world record for drag racing. With an average acceleration of 16.5 m/s^2, Garlits started at rest and reached a speed of 386.0 km/h. How much time was needed for Garlits to reach his final speed?

7. A freight train traveling with a velocity of −4.0 m/s begins backing into a train yard. If the train's average acceleration is −0.27 m/s^2, what is the train's velocity after 17 s?

8. A student on in-line roller skates travels at a speed of 4.5 m/s along the top of a hill. She then skates downhill with an average acceleration of 0.85 m/s^2. If her final speed is 10.8 m/s, how long does it take her to skate down the hill?

9. The *Impact* is the first commercial electric car to be developed in over 60 years. During tests in 1994, the car reached a top speed of nearly 296 km/h. Suppose the car started at rest and then underwent an average acceleration of 1.60 m/s^2. How long did it take the *Impact* to reach its top speed?

10. A bicyclist accelerates −0.87 m/s^2 during a 3.8 s interval. What is the change in the velocity of the bicyclist and bicycle?

Givens | *Solutions*

b. d = total distance traveled

d = magnitude Δx_1 + magnitude Δx_2 + magnitude Δx_3 + magnitude Δx_4

$d = 20.0 \text{ km} + 20.0 \text{ km} + 0 \text{ km} + 40.0 \text{ km} = 80.0 \text{ km}$

$$\text{average speed} = \frac{d}{\Delta t} = \frac{80.0 \text{ km}}{(60.0 \text{ min})\left(\frac{1 \text{ h}}{60 \text{ min}}\right)} = \boxed{80.0 \text{ km/h}}$$

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7. $v = 89.5$ km/h north

$v_{avg} = 77.8$ km/h north

$\Delta t_{rest} = 22.0$ min

$$\Delta x = v_{avg}\,\Delta t = v(\Delta t - \Delta t_{rest})$$

$$\Delta t(v_{avg} - v) = -v\Delta t_{rest}$$

$$\Delta t = \frac{v\Delta t_{rest}}{v - v_{avg}} = \frac{(89.5 \text{ km/h})(22.0 \text{ min})\left(\frac{1 \text{ h}}{60 \text{ min}}\right)}{89.5 \text{ km/h} - 77.8 \text{ km/h}} = \frac{(89.5 \text{ km/h})(22.0 \text{ min})\left(\frac{1 \text{ h}}{60 \text{ min}}\right)}{11.7 \text{ km/h}}$$

$$\Delta t = \boxed{2.80 \text{ h} = 2 \text{ h}, 48 \text{ min}}$$

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8. $v = 6.50$ m/s downward $= -6.50$ m/s

$\Delta t = 34.0$ s

$$\Delta x = v\Delta t = (-6.50 \text{ m/s})(34.0 \text{ s}) = \boxed{-221 \text{ m} = 221 \text{ m downward}}$$

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9. $v_t = 10.0$ cm/s

$v_h = 20\ v_t = 2.00 \times 10^2$ cm/s

$\Delta t_{race} = \Delta t_t$

$\Delta t_h = \Delta t_t - 2.00$ min

$\Delta x_t = \Delta x_h + 20.0 \text{ cm} = \Delta x_{race}$

$$\Delta x_t = v_t \Delta t_t$$

$$\Delta x_h = v_h \Delta t_h = v_h\,(\Delta t_t - 2.00 \text{ min})$$

$$\Delta x_t = \Delta x_{race} = \Delta x_h + 20.0 \text{ cm}$$

$$v_t\,\Delta t_t = v_h\,(\Delta t_t - 2.00 \text{ min}) + 20.0 \text{ cm}$$

$$\Delta t_t\,(v_t - v_h) = -v_h\,(2.00 \text{ min}) + 20.0 \text{ cm}$$

$$\Delta t_t = \frac{20.0 \text{ cm} - v_h\,(2.00 \text{ min})}{v_t - v_h}$$

$$\Delta t_{race} = \Delta t_t = \frac{20.0 \text{ cm} - (2.00 \times 10^2 \text{ cm/s})(2.00 \text{ min})(60 \text{ s/min})}{10.0 \text{ cm/s} - 2.00 \times 10^2 \text{ cm/s}}$$

$$\Delta t_{race} = \frac{20.0 \text{ cm} - 2.40 \times 10^4 \text{ cm}}{-1.90 \times 10^2 \text{ cm/s}} = \frac{-2.40 \times 10^4 \text{ cm}}{-1.90 \times 10^2 \text{ cm/s}}$$

$$\Delta t_{race} = 126 \text{ s}$$

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10. $\Delta x_{race} = \Delta x_t$

$vt = 10.0$ cm/s

$\Delta t_t = 126$ s

$$\Delta x_{race} = \Delta x_t = v_t \Delta t_t = (10.0 \text{ cm/s})(126 \text{ s}) = \boxed{1.26 \times 10^3 \text{ cm} = 12.6 \text{ m}}$$

Additional Practice B

1. $\Delta t = 6.92$ s

$v_f = 17.34$ m/s

$v_i = 0$ m/s

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{17.34 \text{ m/s} - 0 \text{ m/s}}{6.92 \text{ s}} = \boxed{2.51 \text{ m/s}^2}$$

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2. $v_i = 0$ m/s

$v_f = 7.50 \times 10^2$ m/s

$\Delta t = 2.00$ min

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{7.50 \times 10^2 \text{ m/s} - 0 \text{ m/s}}{(2.00 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right)} = \boxed{6.25 \text{ m/s}^2}$$

V

Givens	*Solutions*
3. $v_i = 0$ m/s $v_f = 0.85$ m/s forward $\Delta t = 3.7$ s	$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{0.85 \text{ m/s} - 0 \text{ m/s}}{3.7 \text{ s}} = \boxed{0.23 \text{ m/s}^2 \text{ forward}}$
4. $v_i = 13.7$ m/s forward $= +13.7$ m/s $v_f = 11.5$ m/s backward $= -11.5$ m/s $\Delta t = 0.021$ s	$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{(-11.5 \text{ m/s}) - (13.7 \text{ m/s})}{0.021 \text{ s}} = \frac{-25.2 \text{ m/s}}{0.021 \text{ s}}$ $a_{avg} = \boxed{-1200 \text{ m/s}^2\text{, or } 1200 \text{ m/s}^2 \text{ backward}}$
5. $v_i = +320$ km/h $v_f = 0$ km/h $\Delta t = 0.18$ s	$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{(0 \text{ km/h} - 320 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)}{0.18 \text{ s}}$ $a_{avg} = \frac{-89 \text{ m/s}}{0.18 \text{ s}} = \boxed{-490 \text{ m/s}^2}$
6. $a_{avg} = 16.5$ m/s^2 $v_i = 0$ km/h $v_f = 386.0$ km/h	$\Delta t = \frac{\Delta v}{a_{avg}} = \frac{v_f - v_i}{a_{avg}} = \frac{(386.0 \text{ km/h} - 0 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)}{16.5 \text{ m/s}^2}$ $\Delta t = \frac{107.2 \text{ m/s}}{16.5 \text{ m/s}^2} = \boxed{6.50 \text{ s}}$
7. $v_i = -4.0$ m/s $a_{avg} = -0.27$ m/s^2 $\Delta t = 17$ s	$v_f = a_{avg}\Delta t + v_i$ $v_f = (-0.27 \text{ m/s}^2)(17 \text{ s}) + (-4.0 \text{ m/s}) = -4.6 \text{ m/s} - 4.0 \text{ m/s} = \boxed{-8.6 \text{ m/s}}$
8. $v_i = 4.5$ m/s $v_f = 10.8$ m/s $a_{avg} = 0.85$ m/s^2	$\Delta t = \frac{\Delta v}{a_{avg}} = \frac{v_f - v_i}{a_{avg}} = \frac{10.8 \text{ m/s} - 4.5 \text{ m/s}}{0.85 \text{ m/s}^2} = \frac{6.3 \text{ m/s}}{0.85 \text{ m/s}^2} = \boxed{7.4 \text{ s}}$
9. $v_f = 296$ km/h $v_i = 0$ km/h $a_{avg} = 1.60$ m/s^2	$\Delta t = \frac{\Delta v}{a_{avg}} = \frac{v_f - v_i}{a_{avg}} = \frac{(296 \text{ km/h} - 0 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)}{1.60 \text{ m/s}^2} = \frac{82.2 \text{ m/s}}{1.60 \text{ m/s}^2} = \boxed{51.4 \text{ s}}$
10. $a_{avg} = -0.87$ m/s^2 $\Delta t = 3.85$	$\Delta v = a_{avg}\Delta t = (-0.87 \text{ m/s}^2)(3.85 \text{ s}) = \boxed{-3.4 \text{ m/s}}$

Additional Practice C

1. $\Delta t = 0.910$ s $\Delta x = 7.19$ km $v_i = 0$ km/s	$v_f = \frac{2\Delta x}{\Delta t} - v_i = \frac{(2)(7.19 \text{ km})}{0.910 \text{ s}} - 0 \text{ km/s} = \boxed{15.8 \text{ km/s}}$