NAME ______________________ DATE ____________ CLASS ____________

Motion in One Dimension

Problem B

AVERAGE ACCELERATION

PROBLEM

In 1977 off the coast of Australia, the fastest speed by a vessel on the water was achieved. If this vessel were to undergo an average acceleration of 1.80 m/s², it would go from rest to its top speed in 85.6 s. What was the speed of the vessel?

SOLUTION

Given: $a_{avg} = 1.80 \text{ m/s}^2$

$\Delta t = 85.6 \text{ s}$

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

Unknown: $v_f = ?$

Use the definition of average acceleration to find v_f.

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

Rearrange the equation to calculate v_f.

$$v_f = a_{avg}\,\Delta t + v_i$$

$$v_f = \left(1.80 \frac{\text{m}}{\text{s}^2}\right)\left(85.6 \text{ s}\right) + 0 \frac{\text{m}}{\text{s}}$$

$$= 154 \frac{\text{m}}{\text{s}}$$

$$= \left(154 \frac{\text{m}}{\text{s}}\right)\left(\frac{3.60 \times 10^3 \text{ s}}{1\text{h}}\right)\left(\frac{1 \text{ km}}{10^3 \text{m}}\right)$$

$$= \boxed{554 \frac{\text{km}}{\text{h}}}$$

ADDITIONAL PRACTICE

1. If the vessel in the sample problem accelerates for 1.00 min, what will its speed be after that minute? Calculate the answer in both meters per second and kilometers per hour.

2. In 1935, a French destroyer, *La Terrible*, attained one of the fastest speeds for any standard warship. Suppose it took 2.0 min at a constant acceleration of 0.19 m/s² for the ship to reach its top speed after starting from rest. Calculate the ship's final speed.

3. In 1934, the wind speed on Mt. Washington in New Hampshire reached a record high. Suppose a very sturdy glider is launched in this wind, so that in 45.0 s the glider reaches the speed of the wind. If the

glider undergoes a constant acceleration of 2.29 m/s^2, what is the wind's speed? Assume that the glider is initially at rest.

4. In 1992, Maurizio Damilano, of Italy, walked 29 752 m in 2.00 h.

a. Calculate Damilano's average speed in m/s.

b. Suppose Damilano slows down to 3.00 m/s at the midpoint in his journey, but then picks up the pace and accelerates to the speed calculated in (a). It takes Damilano 30.0 s to accelerate. Find the magnitude of the average acceleration during this time interval.

5. South African frogs are capable of jumping as far as 10.0 m in one hop. Suppose one of these frogs makes exactly 15 of these jumps in a time interval of 60.0 s.

a. What is the frog's average velocity?

b. If the frog lands with a velocity equal to its average velocity and comes to a full stop 0.25 s later, what is the frog's average acceleration?

6. In 1991 at Smith College, in Massachusetts, Ferdie Adoboe ran 1.00×10^2 m backward in 13.6 s. Suppose it takes Adoboe 2.00 s to achieve a velocity equal to her average velocity during the run. Find her average acceleration during the first 2.00 s.

7. In the 1992 Summer Olympics, the German four-man kayak team covered 1 km in just under 3 minutes. Suppose that between the starting point and the 150 m mark the kayak steadily increases its speed from 0.0 m/s to 6.0 m/s, so that its average speed is 3.0 m/s.

a. How long does it take to cover the 150 m?

b. What is the magnitude of the average acceleration during that part of the course?

8. The highest speed ever achieved on a bicycle was reached by John Howard of the United States. The bicycle, which was accelerated by being towed by a vehicle, reached a velocity of +245 km/h. Suppose Howard wants to slow down, and applies the brakes on his now freely moving bicycle. If the average acceleration of the bicycle during braking is –3.0 m/s^2, how long will it take for the bicycle's velocity to decrease by 20.0 percent?

9. In 1993, bicyclist Rebecca Twigg of the United States traveled 3.00 km in 217.347 s. Suppose Twigg travels the entire distance at her average speed and that she then accelerates at –1.72 m/s^2 to come to a complete stop after crossing the finish line. How long does it take Twigg to come to a stop?

10. During the Winter Olympic games at Lillehammer, Norway, in 1994, Dan Jansen of the United States skated 5.00×10^2 m in 35.76 s. Suppose it takes Jansen 4.00 s to increase his velocity from zero to his maximum velocity, which is 10.0 percent greater than his average velocity during the whole run. Calculate Jansen's average acceleration during the first 4.00 s.

Additional Practice B

Givens	*Solutions*
1. $v_i = 0$ km/h $= 0$ m/s $a_{avg} = 1.8$ m/s^2 $\Delta t = 1.00$ min	$v_f = a_{avg}\Delta t + v_i = (1.80 \text{ m/s}^2)(1.00 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) + 0 \text{ m/s} = \boxed{108 \text{ m/s}}$ $v_f = 108 \text{ m/s} = (108 \text{ m/s})\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)\left(\frac{1 \text{ km}}{10^3 \text{ m}}\right) = \boxed{389 \text{ km/h}}$
2. $\Delta t = 2.0$ min $a_{avg} = 0.19$ m/s^2 $v_i = 0$ m/s	$v_f = a_{avg}\Delta t + v_i = (0.19 \text{ m/s}^2)(2.0 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) + 0 \text{ m/s} = \boxed{23 \text{ m/s}}$
3. $\Delta t = 45.0$ s $a_{avg} = 2.29$ m/s^2 $v_i = 0$ m/s	$v_f = a_{avg}\Delta t + v_i = (2.29 \text{ m/s}^2)(45.0 \text{ s}) + 0 \text{ m/s} = \boxed{103 \text{ m/s}}$
4. $\Delta x = 29\,752$ m $\Delta t = 2.00$ h	**a.** $v_{avg} = \frac{\Delta x}{\Delta t} = \frac{29\,752 \text{ m}}{(2.00 \text{ h})\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)} = \boxed{4.13 \text{ m/s}}$
$v_i = 3.00$ m/s $v_f = 4.13$ m/s $\Delta t = 30.0$ s	**b.** $a_{avg} = \frac{\Delta v}{\Delta t} = \frac{4.13 \text{ m/s} - 3.00 \text{ m/s}}{30.0 \text{ s}} = \frac{1.13 \text{ m/s}}{30.0 \text{ s}} = \boxed{3.77 \times 10^{-2} \text{ m/s}^2}$
5. $\Delta x = (15 \text{ hops})\left(\frac{10.0 \text{ m}}{1 \text{ hop}}\right)$ $= 1.50 \times 10^2$ m $\Delta t = 60.0$ s $\Delta t_{stop} = 0.25$ s $v_f = 0$ m/s $v_i = v_{avg} = +2.50$ m/s	**a.** $v_{avg} = \frac{\Delta x}{\Delta t} = \frac{1.50 \times 10^2 \text{ m}}{60.0 \text{ s}} = \boxed{+2.50 \text{ m/s}}$ **b.** $a_{avg} = \frac{v_f - v_i}{\Delta t_{stop}} = \frac{0 \text{ m/s} - 2.50 \text{ m/s}}{0.25 \text{ s}} = \frac{-2.50 \text{ m/s}}{0.25 \text{ m/s}} = \boxed{-1.0 \times 10^1 \text{ m/s}^2}$
6. $\Delta x = 1.00 \times 10^2$ m, backward $= -1.00 \times 10^2$ m $\Delta t = 13.6$ s $\Delta t' = 2.00$ s $v_i = 0$ m/s $v_f = v_{avg}$	$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{-1.00 \times 1\,0^2 \text{ m}}{13.6 \text{ s}} = -7.35 \text{ m/s}$ $a_{avg} = \frac{v_f - v_i}{\Delta t'} = \frac{-7.35 \text{ m/s} - 0 \text{ m/s}}{2.00 \text{ s}} = \boxed{3.68 \text{ m/s}^2}$
7. $\Delta x = 150$ m $v_i = 0$ m/s $v_f = 6.0$ m/s $v_{avg} = 3.0$ m/s	**a.** $\Delta t = \frac{\Delta x}{v_{avg}} = \frac{150 \text{ m}}{3.0 \text{ m/s}} = \boxed{5.0 \times 10^1 \text{ s}}$ **b.** $a_{avg} = \frac{v_f - v_i}{\Delta t} = \frac{6.0 \text{ m/s} - 0 \text{ m/s}}{5.0 \times 10^1} = \boxed{0.12 \text{ m/s}^2}$

II

Givens	*Solutions*
8. $v_i = +245$ km/h $a_{avg} = -3.0$ m/s^2 $v_f = v_i - (0.200)\, v_i$	$v_i = \left(245\,\frac{\text{km}}{\text{h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{10^3\text{ m}}{1\text{ km}}\right) = +68.1\text{ m/s}$ $v_f = (1.000 - 0.200)\, v_i = (0.800)(68.1\text{ m/s}) = +54.5\text{ m/s}$ $\Delta t = \frac{v_f - v_i}{a_{avg}} = \frac{54.5\text{ m/s} - 68.1\text{ m/s}}{-3.0\text{ m/s}^2} = \frac{-13.6\text{ m/s}}{-3.0\text{ m/s}^2} = \boxed{4.5\text{ s}}$
9. $\Delta x = 3.00$ km $\Delta t = 217.347$ s $a_{avg} = -1.72$ m/s^2 $v_f = 0$ m/s	$v_i = v_{avg} = \frac{\Delta x}{\Delta t} = \frac{3.00 \times 10^3\text{ m}}{217.347\text{ s}} = 13.8\text{ m/s}$ $t_{stop} = \frac{v_f - v_i}{a_{avg}} = \frac{0\text{ m/s} - 13.8\text{ m/s}}{-1.72\text{ m/s}^2} = \frac{-13.8\text{ m/s}}{-1.72\text{ m/s}^2} = \boxed{8.02\text{ s}}$
10. $\Delta x = +5.00 \times 10^2$ m $\Delta t = 35.76$ s $v_i = 0$ m/s $\Delta t' = 4.00$ s $v_{max} = v_{avg} + (0.100)\, v_{avg}$	$v_f = v_{max} = (1.100) v_{avg} = (1.100)\left(\frac{\Delta x}{\Delta t}\right) = (1.100)\left(\frac{5.00 \times 10^2\text{ m}}{35.76\text{ s}}\right) = +15.4\text{ m/s}$ $a_{avg} = \frac{\Delta v}{\Delta t'} = \frac{v_f - v_i}{\Delta t'} = \frac{15.4\text{ m/s} - 0\text{ m/s}}{4.00\text{ s}} = \boxed{+3.85\text{ m/s}^2}$

II

Additional Practice C

1. $\Delta x = 115$ m $v_i = 4.20$ m/s $v_f = 5.00$ m/s	$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(115\text{ m})}{4.20\text{ m/s} + 5.00\text{ m/s}} = \frac{(2)(115\text{ m})}{9.20\text{ m/s}} = \boxed{25.0\text{ s}}$
2. $\Delta x = 180.0$ km $v_i = 3.00$ km/s $v_f = 0$ km/s	$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(180.0\text{ km})}{3.00\text{ km/s} + 0\text{ km/s}} = \frac{360.0\text{ km}}{3.00\text{ km/s}} = \boxed{1.2 \times 10^2\text{ s}}$
3. $v_i = 0$ km/h $v_f = 1.09 \times 10^3$ km/h $\Delta x = 20.0$ km	**a.** $\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(20.0 \times 10^3\text{ m})}{(1.09 \times 10^3\text{ km/h} + 0\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)}$ $\Delta t = \frac{40.0 \times 10^3\text{ m}}{(1.09 \times 10^3\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)} = \boxed{132\text{ s}}$
$\Delta x = 5.00$ km $v_i = 1.09 \times 10^3$ km/h $v_f = 0$ km/h	**b.** $\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(5.00 \times 10^3\text{ m})}{(1.09 \times 10^3\text{ km/h} + 0\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)}$ $\Delta t = \frac{10.0 \times 10^3\text{ m}}{(1.09 \times 10^3\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)} = \boxed{33.0\text{ s}}$