NAME ______________________ DATE ______________ CLASS ______________

Motion in One Dimension

Problem A

AVERAGE VELOCITY AND DISPLACEMENT

PROBLEM

The fastest fish, the sailfish, can swim 1.2×10^2 km/h. Suppose you have a friend who lives on an island 16 km away from the shore. If you send a message using a sailfish as a messenger, how long will it take for the message to reach your friend?

SOLUTION

Given: $v_{avg} = 1.2 \times 10^2$ km/h

$\Delta x = 16$ km

Unknown: $\Delta t = ?$

Use the definition of average speed to find Δt.

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

Rearrange the equation to calculate Δt.

$$\Delta t = \frac{\Delta x}{v_{avg}}$$

$$\Delta t = \frac{16 \text{ km}}{\left(1.2 \times 10^2 \frac{\text{km}}{\text{h}}\right)\left(\frac{1 \text{ h}}{60 \text{ min}}\right)} = \frac{16 \text{ km}}{2.0 \text{ km/min}}$$

$$= \boxed{8.0 \text{ min}}$$

ADDITIONAL PRACTICE

1. The Sears Tower in Chicago is 443 m tall. Joe wants to set the world's stair climbing record and runs all the way to the roof of the tower. If Joe's average upward speed is 0.60 m/s, how long will it take Joe to climb from street level to the roof of the Sears Tower?

2. An ostrich can run at speeds of up to 72 km/h. How long will it take an ostrich to run 1.5 km at this top speed?

3. A cheetah is known to be the fastest mammal on Earth, at least for short runs. Cheetahs have been observed running a distance of 5.50×10^2 m with an average speed of 1.00×10^2 km/h.

a. How long would it take a cheetah to cover this distance at this speed?

b. Suppose the average speed of the cheetah were just 85.0 km/h. What distance would the cheetah cover during the same time interval calculated in (a)?

4. A pronghorn antelope has been observed to run with a top speed of 97 km/h. Suppose an antelope runs 1.5 km with an average speed of 85 km/h, and then runs 0.80 km with an average speed of 67 km/h.

a. How long will it take the antelope to run the entire 2.3 km?
b. What is the antelope's average speed during this time?

5. Jupiter, the largest planet in the solar system, has an equatorial radius of about 7.1×10^4 km (more than 10 times that of Earth). Its period of rotation, however, is only 9 h, 50 min. That means that every point on Jupiter's equator "goes around the planet" in that interval of time. Calculate the average speed (in m/s) of an equatorial point during one period of Jupiter's rotation. Is the average velocity different from the average speed in this case?

6. The peregrine falcon is the fastest of flying birds (and, as a matter of fact, is the fastest living creature). A falcon can fly 1.73 km downward in 25 s. What is the average velocity of a peregrine falcon?

7. The black mamba is one of the world's most poisonous snakes, and with a maximum speed of 18.0 km/h, it is also the fastest. Suppose a mamba waiting in a hide-out sees prey and begins slithering toward it with a velocity of +18.0 km/h. After 2.50 s, the mamba realizes that its prey can move faster than it can. The snake then turns around and slowly returns to its hide-out in 12.0 s. Calculate

a. the mamba's average velocity during its return to the hideout.
b. the mamba's average velocity for the complete trip.
c. the mamba's average speed for the complete trip.

8. In the Netherlands, there is an annual ice-skating race called the "Tour of the Eleven Towns." The total distance of the course is 2.00×10^2 km, and the record time for covering it is 5 h, 40 min, 37 s.

a. Calculate the average speed of the record race.
b. If the first half of the distance is covered by a skater moving with a speed of $1.05v$, where v is the average speed found in (a), how long will it take to skate the first half? Express your answer in hours and minutes.

Motion In One Dimension

Additional Practice A

Givens	*Solutions*
1. $\Delta x = 443$ m $v_{avg} = 0.60$ m/s	$\Delta t = \dfrac{\Delta x}{v_{avg}} = \dfrac{443 \text{ m}}{0.60 \text{ m/s}} = \boxed{740 \text{ s} = 12 \text{ min, } 20 \text{ s}}$
2. $v_{avg} = 72$ km/h $\Delta x = 1.5$ km	$\Delta t = \dfrac{\Delta x}{v_{avg}} = \dfrac{1.5 \text{ km}}{\left(72 \dfrac{\text{km}}{\text{h}}\right)\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)} = \boxed{75 \text{ s}}$
3. $\Delta x = 5.50 \times 10^2$ m $v_{avg} = 1.00 \times 10^2$ km/h	**a.** $\Delta t = \dfrac{\Delta x}{v_{avg}} = \dfrac{5.50 \times 10^2 \text{ m}}{\left(1.00 \times 10^2 \dfrac{\text{km}}{\text{h}}\right)\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)\left(\dfrac{1000 \text{ m}}{1 \text{ km}}\right)} = \boxed{19.8 \text{ s}}$
$v_{avg} = 85.0$ km/h	**b.** $\Delta x = \Delta v_{avg} \Delta t$ $\Delta x = (85.0 \text{ km/h})\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)\left(\dfrac{10^3 \text{ m}}{1 \text{ km}}\right)(19.8 \text{ s}) = \boxed{468 \text{ m}}$
4. $\Delta x_1 = 1.5$ km $v_1 = 85$ km/h $\Delta x_1 = 0.80$ km $v_2 = 67$ km/h	**a.** $\Delta t_{tot} = \Delta t_1 + \Delta t_2 = \dfrac{\Delta x_1}{v_1} + \dfrac{\Delta x_2}{v_2}$ $\Delta t_{tot} = \dfrac{1.5 \text{ km}}{\left(85 \dfrac{\text{km}}{\text{h}}\right)\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)} + \dfrac{0.80 \text{ km}}{\left(67 \dfrac{\text{km}}{\text{h}}\right)\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)} = 64 \text{ s} + 43 \text{ s} = \boxed{107 \text{ s}}$ **b.** $v_{avg} = \dfrac{\Delta x_1 + \Delta x_2}{\Delta t_1 + \Delta t_2} = \dfrac{1.5 \text{ km} + 0.80 \text{ km}}{(64 \text{ s} + 43 \text{ s})\left(\dfrac{1 \text{ h}}{3600}\right)} = \dfrac{2.3 \text{ km}}{(107 \text{ s})\left(\dfrac{1 \text{ h}}{3600 \text{ s}}\right)} = \boxed{77 \text{ km/h}}$
5. $r = 7.1 \times 10^4$ km $\Delta t = 9$ h, 50 min	$\Delta x = 2\pi r$ $v_{avg} = \dfrac{\Delta x}{\Delta t} = \dfrac{2\pi(7.1 \times 10^7 \text{ m})}{\left[(9 \text{ h})\left(\dfrac{60 \text{ min}}{1 \text{ h}}\right) + 50 \text{ min}\right]\left(\dfrac{60 \text{ s}}{1 \text{ min}}\right)} = \dfrac{4.5 \times 10^8 \text{ m}}{(540 \text{ min} + 50 \text{ min})\left(\dfrac{60 \text{ s}}{1 \text{ min}}\right)}$ $v_{avg} = \dfrac{4.5 \times 10^8 \text{ m}}{(590 \text{ min})\left(\dfrac{60 \text{ s}}{1 \text{ min}}\right)}$ $v_{avg} = \boxed{1.3 \times 10^4 \text{ m/s}}$ Thus the average speed $= 1.3 \times 10^4$ m/s. On the other hand, the average velocity for this point is zero, because the point's displacement is zero.

Givens — *Solutions*

6. $\Delta x = -1.73$ km

$\Delta t = 25$ s

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{-1.73 \times 10^3 \text{ m}}{25 \text{ s}} = \boxed{-69 \text{ m/s} = -250 \text{ km/h}}$$

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7. $v_{avg,1} = 18.0$ km/h

$\Delta t_1 = 2.50$ s

$\Delta t_2 = 12.0$ s

a. $$\Delta x_1 = v_{avg,1}\Delta t_1 = (18.0 \text{ km/h})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)(2.50\text{s}) = 12.5 \text{ m}$$

$$\Delta x_2 = -\Delta x_1 = -12.5 \text{ m}$$

$$v_{avg,2} = \frac{\Delta x_2}{\Delta t_2} = \frac{-12.5 \text{ m}}{12.0 \text{ s}} = \boxed{-1.04 \text{ m/s}}$$

b. $$v_{avg,tot} = \frac{\Delta x_1 + \Delta x_2}{\Delta t_1 + \Delta t_2} = \frac{12.5 \text{ m} + (-12.5 \text{ m})}{2.50 \text{ s} + 12.0 \text{ s}} = \frac{0.0 \text{ m}}{14.5 \text{ s}} = \boxed{0.0 \text{ m/s}}$$

c. $$\textit{total distance traveled} = \Delta x_1 - \Delta x_2 = 12.5 \text{ m} - (-12.5 \text{ m}) = 25.0 \text{ m}$$

$$\textit{total time of travel} = \Delta t_1 + \Delta t_2 = 2.50 \text{ s} + 12.0 \text{ s} = 14.5 \text{ s}$$

$$\textit{average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{25.0 \text{ m}}{14.5 \text{ s}} = \boxed{1.72 \text{ m/s}}$$

II

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

$\Delta t = 5$ h, 40 min, 37 s

a. $$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{2.00 \times 10^5 \text{ m}}{\left[(5 \text{ h})\left(\frac{3600 \text{ s}}{\text{h}}\right) + (40 \text{ min})\left(\frac{60 \text{ s}}{\text{min}}\right) + 37 \text{ s}\right]} = \frac{2.00 \times 10^5 \text{m}}{20\,437 \text{ s}}$$

$$v_{avg} = \boxed{9.79 \text{ m/s} = 35.2 \text{ km/h}}$$

$v_{avg}' = (1.05)v_{avg}$

$\Delta x' = \frac{1}{2}\Delta x$

b. $$\Delta t = \frac{\Delta x'}{v_{avg}'} = \frac{\left(\frac{2.00 \times 10^5 \text{ m}}{2}\right)}{(1.05)\left(9.79 \frac{\text{m}}{\text{s}}\right)} = 9.73 \times 10^3 \text{ s}$$

$$\Delta t = (9.73 \times 10^3 \text{ s})\left(\frac{1 \text{ h}}{3600 \text{ s}}\right) = 2.70 \text{ h}$$

$$(0.70 \text{ h})\left(\frac{60 \text{ min}}{1\text{h}}\right) = 42 \text{ min}$$

$$\Delta t = \boxed{2 \text{ h, } 42 \text{ min}}$$