

### Section 3.2: Velocity Vectors in One Dimension

Speed – scalar quantity

Velocity – vector quantity

Velocity can also be represented by vectors and are added together the same way as displacement vectors.

$${}_o\vec{v}_e = {}_o\vec{v}_m + {}_m\vec{v}_e$$

where  ${}_o\vec{v}_e$  – velocity of the object with respect to the earth

${}_o\vec{v}_m$  – velocity of the object with respect to the medium

${}_m\vec{v}_e$  – velocity of the medium with respect to the earth

- 1 A train moves at 20 km/h [E]. A passenger on the train moves toward the front of the train at a velocity of 3 km/h. What is the passenger's velocity relative to a person standing on the ground?

$$\begin{array}{l} \boxed{t}V_e = 20 \text{ km/h [E]} \\ \boxed{p}V_t = 3 \text{ km/h [E]} \\ \boxed{p}V_e = ? \end{array} \quad \begin{array}{l} \boxed{p}V_t + \boxed{t}V_e = \boxed{p}V_e \\ 3 \text{ km/h} + 20 \text{ km/h} = \boxed{p}V_e \\ 23 \text{ km/h} = \boxed{p}V_e \\ 23 \text{ km/h [E]} = \boxed{p}V_e \end{array}$$

- 2 A train moves at 15 km/h. A person on the train moves toward the back at 3 km/h. What is the person's velocity relative to the ground?

$$\begin{array}{l} \boxed{t}V_e = 15 \text{ km/h} \\ \boxed{p}V_t = -3 \text{ km/h} \\ \boxed{p}V_e = ? \end{array} \quad \begin{array}{l} \boxed{p}V_t + \boxed{t}V_e = \boxed{p}V_e \\ 15 \text{ km/h} - 3 \text{ km/h} = \boxed{p}V_e \\ 12 \text{ km/h} = \boxed{p}V_e \end{array}$$

3 A goose is flying 30 km/h [S]. A hunter is driving due north at 60 km/h. Determine the:

A) velocity of the goose with respect to the hunter.

$$\begin{aligned}
 gV_e &= -30 \text{ km/h} \\
 hV_e &= 60 \text{ km/h} \\
 gV_h &
 \end{aligned}
 \qquad
 \begin{aligned}
 gV_h + hV_e &= gV_e \\
 gV_h + 60 \text{ km/h} &= -30 \text{ km/h} \\
 gV_h &= -90 \text{ km/h} \\
 gV_h &= 90 \text{ km/h [S]}
 \end{aligned}$$

B) velocity of the hunter with respect to the goose.

$$\begin{aligned}
 gV_e &= -30 \text{ km/h} \\
 hV_e &= 60 \text{ km/h} \\
 hV_g &
 \end{aligned}
 \qquad
 \begin{aligned}
 hV_g + gV_e &= hV_e \\
 hV_g - 30 \text{ km/h} &= 60 \text{ km/h} \\
 hV_g &= 90 \text{ km/h} \\
 hV_g &= 90 \text{ km/h [S]}
 \end{aligned}$$

- 4 A wildlife crew are on a moose counting expedition when they spot a herd 4.0 km [W] and running directly away from the helicopter at 10.0 m/s [W]. The helicopter follows the herd at 42 m/s [W].

A) What is the velocity of the helicopter relative to the moose?

$$\begin{array}{l}
 \boxed{m} V_e = -10 \text{ m/s} \\
 \boxed{h} V_e = -42 \text{ m/s} \\
 \boxed{h} V_m = ?
 \end{array}
 \qquad
 \begin{array}{l}
 V_{hm} + V_{me} = V_e \\
 V_{hm} - 10 \text{ m/s} = -42 \text{ m/s} \\
 V_{hm} = -32 \text{ m/s} \\
 \boxed{h} V_m = 32 \text{ m/s [W]}
 \end{array}$$

B) What is the velocity of the moose with respect to the helicopter?

$$\begin{array}{l}
 \boxed{m} V_e = -10 \text{ m/s} \\
 \boxed{h} V_e = -42 \text{ m/s} \\
 \boxed{m} V_h = ?
 \end{array}
 \qquad
 \begin{array}{l}
 V_{mh} + V_{he} = V_{me} \\
 V_{mh} - 42 \text{ m/s} = -10 \text{ m/s} \\
 \boxed{m} V_h = 32 \text{ m/s [E]}
 \end{array}$$

C) How long does it take the helicopter to reach the spot where the herd was first seen?

$$\begin{array}{l}
 V = 42 \text{ m/s [W]} \\
 d = 4000 \text{ m [W]} \\
 t = ?
 \end{array}
 \qquad
 t = \frac{d}{V} = \frac{4000 \text{ m}}{42 \text{ m/s}} = 95 \text{ s}$$

D) How long from the time of the first sighting will it take the helicopter to catch the herd?

$$\begin{array}{l}
 \boxed{h} V_m = 32 \text{ m/s [W]} \\
 d = 4000 \text{ m [W]} \\
 t = ?
 \end{array}
 \qquad
 t = \frac{d}{V} = \frac{4000 \text{ m}}{32 \text{ m/s}} = 125 \text{ s}$$

- 5 A person can swim at a speed of 5 m/s in still water. The current is 3m/s. What is the swimmer's velocity if she goes (a) downstream and (b) upstream?

(a) Still water  $sV_w = 5\text{m/s}$   
 current  $wV_e = 3\text{m/s}$   
 $sV_e = ?$

no current  
 downstream - with the current  
 upstream - against the current

$$sV_w + wV_e = sV_e$$

$$5\text{m/s} + 3\text{m/s} = sV_e$$

$$8\text{m/s} = sV_e$$

(b)  $sV_w = 5\text{m/s}$   
 $wV_e = 3\text{m/s}$   
 $sV_e = ?$

$$sV_w + wV_e = sV_e$$

$$-5\text{m/s} + 3\text{m/s} = sV_e$$

$$-2\text{m/s} = sV_e$$

$$2\text{m/s upstream} = sV_e$$

- 6 A canoe is paddled downstream with a velocity of 1.0 m/s. The river current has an average velocity of 1.5 m/s. A fly is walking on the canoe at a speed of 0.5 m/s. Determine the fly's velocity relative to the shore if it walks:

A) toward the front of the canoe (with the current)

$$cV_w = 1.0\text{m/s}$$

$$wV_e = 1.5\text{m/s}$$

$$fV_c = 0.5\text{m/s}$$

$$fV_e = ?$$

$$fV_e = fV_c + cV_w + wV_e$$

$$fV_e = 0.5\text{m/s} + 1.0\text{m/s} + 1.5\text{m/s}$$

$$fV_e = 3.0\text{m/s}$$

B) toward the back of the canoe (against the current).

$$cV_w = 1.0\text{m/s}$$

$$wV_e = 1.5\text{m/s}$$

$$fV_c = -0.5\text{m/s}$$

$$fV_e = ?$$

$$fV_e = fV_c + cV_w + wV_e$$

$$fV_e = -0.5\text{m/s} + 1.0\text{m/s} + 1.5\text{m/s}$$

$$fV_e = 2.0\text{m/s}$$