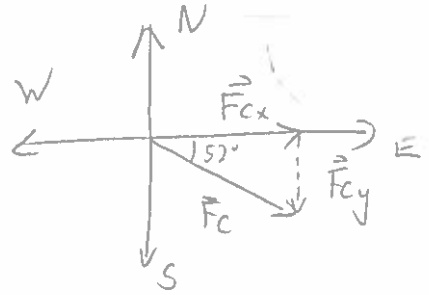


Notes

PHYSICS 12

KINEMATICS IN 2 DIMENSIONS



Example 1:

A duck has a mass of 2.5 kg. As the duck paddles, a force of 0.10 N acts on it in a direction due east. In addition, the current of the water exerts a force of 0.20 N in a direction of 52° south of east. When these forces begin to act, the velocity of the duck is 0.11 m/s in a direction due east. Find the magnitude and direction of the displacement that the duck undergoes in 3.0 s while the forces are acting.

G: $m = 2.5 \text{ kg}$

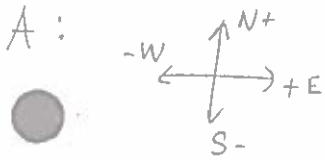
$\vec{F}_a = 0.10 \text{ N [E]}$

$\vec{F}_c = 0.20 \text{ N [52° S of E]}$

$\vec{v}_i = 0.11 \text{ m/s [E]}$

$\Delta t = 3.0 \text{ s}$

R: $d = ? \text{ [m]} \text{ and } \theta \text{ [°]}$



Find \vec{a} :

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m} = \frac{\vec{F}_a + \vec{F}_c}{m}$$

Find \vec{d} :

$$\vec{d} = \vec{v}_i t + \frac{1}{2} \vec{a} t^2$$

↑
in vector notation

S:
$$\vec{a} = \frac{[0.10, 0] + [0.1231, -0.1576]}{2.5}$$

$$\vec{a} = \frac{1}{2.5} \cdot [0.2231, -0.1576] \text{ m/s}^2$$

$$\vec{a} = [0.08924, -0.06304] \text{ m/s}^2$$

S:
$$\vec{F}_{cx} = (0.20)(\cos 52^\circ) = 0.1231 \text{ N [E]}$$

$$\vec{F}_{cy} = -(0.20)(\sin 52^\circ) = -0.1576 \text{ N [S]}$$

$$\vec{d} = [0.11, 0](3.0) + \frac{1}{2}[0.08924, -0.06304](3.0)^2$$

$$\vec{d} = [0.33, 0] + [0.40158, -0.28368]$$

$$\vec{d} = [0.73158, -0.28368] \text{ m}$$

$$\|\vec{d}\| = \sqrt{0.73158^2 + (-0.28368)^2} \quad \theta = \tan^{-1}\left(\frac{0.28368}{0.73158}\right)$$

$$= \sqrt{0.61588}$$

$$= 0.7846 \dots \text{ m}$$

$$\approx \underline{\underline{0.78 \text{ m}}}$$

$$\underline{\underline{\theta = 21^\circ}}$$

S: The duck moves $0.78 \text{ m [E } 21^\circ \text{ S]}$.

Ex 1 An alternative way.

$$\vec{a} = [0.08924, -0.06304] \text{ m/s}^2$$

$$v_f = v_i + at$$

$$\begin{aligned}\vec{v}_f &= [0.11, 0] + [0.08924, -0.06304](3.0) \\ &= [0.11 + 0.26772, 0 - 0.18912] \text{ m/s} \\ &= [0.37772, -0.18912] \text{ m/s}\end{aligned}$$

$$d = \frac{v_f^2 - v_i^2}{2a}$$

x	y	
$\vec{d}_x = \frac{0.3777^2 - 0.11^2}{2(0.08924)}$	$\vec{d}_y = \frac{(-0.18912)^2 - 0^2}{2(-0.06304)}$	$\vec{d} = [0.73158, -0.28368] \text{ m}$
$\vec{d}_x = 0.73158 \text{ m [E]}$	$\vec{d}_y = -0.28368 \text{ m [N]}$ $= 0.28368 \text{ m [S]}$	$\ \vec{d}\ = \sqrt{0.61508 \dots}$
		$\ \vec{d}\ = 0.78 \text{ m}$
		$\theta = \tan^{-1} \left(\frac{0.28368}{0.73158} \right)$
		$\theta = 21^\circ$

Example 2:

Airplane flight recorders must be able to survive catastrophic crashes. Therefore, they are typically encased in crash-resistant steel or titanium boxes that are subjected to rigorous testing. One of the tests is an impact shock test, in which the box must survive being thrown at high speeds against a barrier. A 41.0-kg box is thrown at a speed of 220 m/s and is brought to a halt in a collision that lasts for a time of 6.5 ms. What is the magnitude of the average net force that acts on the box during the collision?

$$G: m = 41.0 \text{ kg}$$

$$v_i = 220 \text{ m/s}$$

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

$$t = 6.5 \text{ ms} \rightarrow 0.0065 \text{ s}$$

$$R: F_{\text{avg}} = ? \text{ [N]}$$

$$A: F_{\text{avg}} = F_{\text{net}} = m a$$

$$a = \frac{v_f - v_i}{\Delta t}$$

$$F_{\text{avg}} = m \left(\frac{v_f - v_i}{\Delta t} \right)$$

$$S: = (41.0) \left(\frac{0 - 220}{0.0065} \right)$$

$$= 1.4 \times 10^6 \text{ N}$$

$$S: \|\vec{F}_{\text{avg}}\| = F_{\text{avg}} = 1.4 \times 10^6 \text{ N.}$$

An average net force of $1.4 \times 10^6 \text{ N}$ acts on the box during the collision.