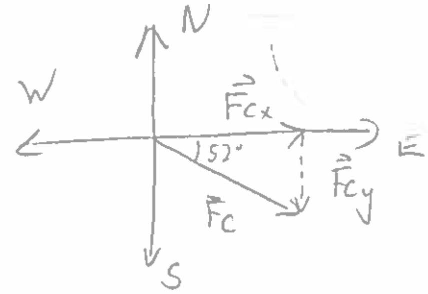
Notes



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 0.11m/s in a direction due east. Find the magnitude and direction of the displacement that the duck undergoes in 3.0s while the forces are acting.

G: $m = 2.5 kg$

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

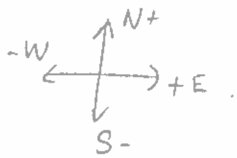
$\vec{F}_c = 0.20 N [52° S of E]$

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

$\Delta t = 3.0 s$

R: $\vec{d} = ? [m]$ and θ [°]

A:



Find $\vec{a}$:

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

Find $\vec{d}$:

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

↑ in vector notation

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

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

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

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

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

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

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

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

$$\|\vec{d}\| = \sqrt{0.73158^2 + (-0.28368)^2}$$

$$= \sqrt{0.61568..}$$

$$= 0.7846... m$$

$$\doteq 0.78 m$$

$$\theta = \tan^{-1}\left(\frac{0.28368}{0.73158}\right)$$

$$\theta \doteq 21°$$

S: The duck moves 0.78m [E 21°S].

Ex 1 An alternative way.

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

$v_f = v_i + at$

$\vec{v}_f = [0.11, 0] + [0.08924, -0.06304](3.0)$

$= [0.11 + 0.26772, 0 - 0.18912]$ m/s

$= [0.37772, -0.18912]$ m/s

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

X	Y	
$\vec{d}_x = \frac{0.3777^2 - 0.11^2}{2(0.08924)}$	$\vec{d}_y = \frac{(-0.18912)^2 - 0^2}{2(-0.06304)}$	$\vec{d} = [0.73158, -0.28368]$ m
		$\lVert\vec{d}\rVert = \sqrt{0.61508\ldots}$
$\vec{d}_x = 0.73158$ m [E]	$\vec{d}_y = -0.28368$ m [N] $= 0.28368$ m [S]	$\lVert\vec{d}\rVert \doteq 0.78$ m

$\theta = \tan^{-1}\left(\frac{0.28368}{0.73158}\right)$

$\theta \doteq 21°$

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, is which the box must survive being thrown at high speeds against a barrier. A 41.0- kg box is thrown at a speed of 220m/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: $m = 41.0\ kg$

$v_i = 220\ m/s$

$v_f = 0\ m/s$

$t = 6.5\ ms \rightarrow 0.0065\ s$

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

A: $F_{avg} = F_{net} = ma$

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

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

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

$$= 1.4 \times 10^6\ N$$

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

An average net force of 1.4×10^6 N acts on the box during the collision

Example 3:

At a time when mining asteroids has become feasible, astronauts have connected a line between their 3500-kg space tug and a 6200-kg asteroid. Using their tug's engine, they pull on the asteroid with force of 490 N. Initially the tug and the asteroid are at rest. 450 m apart. How much time does it take for the tug and the asteroid to meet?

G: $m_1 = 3500\ kg$

$m_2 = 6200\ kg$

$\|\vec{F}_{a}\| = 490\ N$

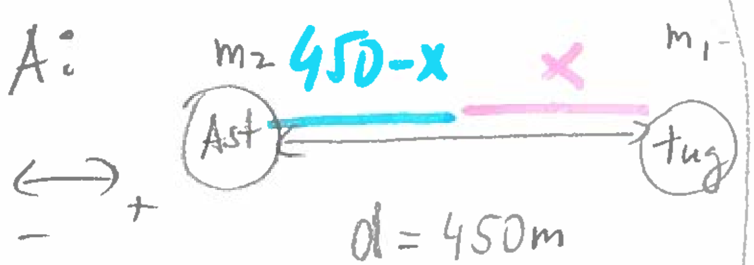
$v_{i1} = 0\ m/s$

$v_{i2} = 0\ m/s$

$d = 450m$

R: $t = ?\ [s]$

A:



By N3L : $\vec{F}_{12} = -\vec{F}_{a1}$

S: $\vec{F}_{12} = +490 N$

$\vec{F}_{a1} = -490 N$

By N2L : $\vec{a}_1 = \frac{\vec{F}_{21}}{m_1} = \frac{-490}{3500} = -0.14\ m/s^2$

$\vec{a}_2 = \frac{\vec{F}_{12}}{m_2} = \frac{490}{6200} = 0.07903\ m/s^2$

S: continued

total $\vec{d} = v_i t + \frac{1}{2} a t^2$

$450 = d_1 + d_2 \rightarrow d_1 = -x \quad d_2 = 450 - x$

$d_1 = v_i t + \frac{1}{2}(-0.14) t^2$

$-x = 0 - 0.07 t^2$

$x = 0.07 t^2$

$450 - x = v_i t + \frac{1}{2}(0.0790) t^2$

$450 - 0.07 t^2 = 0.039515 t^2$

$450 = 0.109515 t^2$

$t = \sqrt{4109.026\ldots}$

$t \doteq 64.1\ s$

S: It will take 64.1 s.