Q1.

Work is defined as the scalar product of force and displacement. Power is defined as the rate of change of work with time. The dimension of power is

A) $M L^2 T^{-3}$
B) $M L^2 T^{-2}$
C) $M L^3 T^{-2}$
D) $M L^2 T^{-1}$
E) $M L \; T^{-2}$

Ans:

$$W = \vec{F}.\vec{d} \Rightarrow [W] = [F].L = \frac{M.L}{T^2}.L = ML^2.T^{-2}$$

$$P = \frac{dW}{dt} \Rightarrow [P] = \frac{[W]}{T} = \frac{ML^2.T^{-2}}{T} = M.L^2.T^{-3}$$

Q2.

The density of iron is 7.86 g/cm^3, and the mass of an iron atom is 9.30×10^{-23} g. How many iron atoms are there in 1.00 in^3 of iron? (1 in = 2.54 cm)

A) 1.39×10^{24} atoms
B) 1.67×10^{23} atoms
C) 5.76×10^{21} atoms
D) 2.03×10^{25} atoms
E) 3.91×10^{19} atoms

Ans:

$$\text{Volume: } V = 1.00 \text{ in}^3 \times \frac{(2.54)^3 \text{cm}^3}{1.00 \text{ in}^3} = 16.4 \text{ cm}^3$$

$$\text{Volume of 1 atom: } v = \frac{m}{\rho} = \frac{9.30 \times 10^{-23}}{7.86} = 1.18 \times 10^{-23} \text{ cm}^3$$

$\therefore$ The number of atoms is:

$$N = \frac{V}{v} = \frac{16.4}{1.18 \times 10^{-23}} = 1.39 \times 10^{24} \text{ atoms}$$

Q3.

Two cars are initially at rest. Car A is at $\boldsymbol{x} = 0$, and car B is at $\boldsymbol{x} = +600$ m. They start to move, at the same time, along the same line in the positive x direction with constant accelerations: $\boldsymbol{a_A} = 4.00$ m/s^2 and $\boldsymbol{a_B} = 1.00$ m/s^2. How long does it take car A to overtake car B?

A) 20.0 s
B) 30.0 s
C) 25.0 s
D) 34.5 s
E) 17.5 s

Ans:

Let d_1 = distance moved by A

Let d_2 = distance moved by B

When they meet: $d_1 = d_2 + 600 \longrightarrow (1)$

$$d_1 = \cancelto{0}{v_0} t + \frac{1}{2} a_A t^2 = \frac{1}{2} \times 4.00 \times t^2 = 2t^2 \longrightarrow (2)$$

$$d_2 = v_0 t + \frac{1}{2} a_B t^2 = \frac{1}{2} \times 1.00 \times t^2 = \frac{1}{2} t^2 \longrightarrow (3)$$

From (2) and (3), back to (1):

$$2t^2 = \frac{1}{2} t^2 + 600 \Rightarrow \frac{3}{2} t^2 = 600$$

$$t^2 = \frac{2}{3} \times 600 = 400 \Rightarrow t = 20.0 \text{ s}$$

Q4.

Which of the following statements is **WRONG**?

A) A body can have constant velocity and still have a varying speed. ***Not Possible***
B) A body can have a constant speed and still have a varying velocity. *uniform circular motion*
C) A body can have zero velocity and still be accelerating. *free fall at max. height*
D) A body can have a constant acceleration and a variable velocity. by definition
E) A body can have an upward velocity while experiencing a downward acceleration. free fall

Ans:

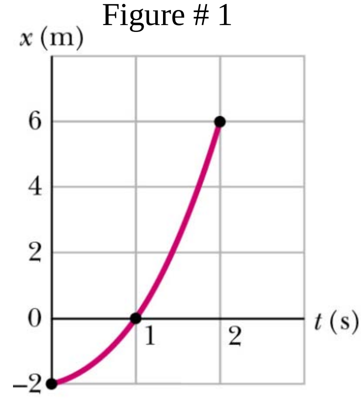
A

Q5.

FIGURE 1 shows the motion of a particle moving along an *x* axis with constant acceleration. What is the magnitude of the acceleration of the particle?

A) 4 m/s^2
B) 6 m/s^2
C) 3 m/s^2
D) 2 m/s^2
E) 5 m/s^2

Figure # 1



Ans:

$$x_0 = x(0) = -2\text{ m}$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2$$

$$x + 2 = v_0 t + \frac{1}{2}at^2$$

$$\text{at } t = 1\text{ s: } 0 + 2 = v_0 + \frac{a}{2} \Rightarrow v_0 = 2 - \frac{a}{2}$$

$$\text{at } t = 6\text{ s: } 6 + 2 = \left(2 - \frac{a}{2}\right)(2) + 2a$$

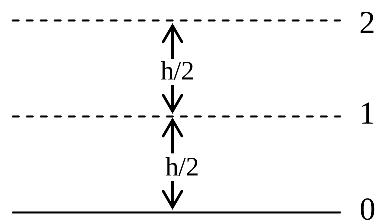
$$8 = 4 - a + 2a \Rightarrow 4 = a$$

$$\Rightarrow a = 4\text{ m/s}^2$$

Q6.

An object is thrown vertically upward from the ground. When it reaches half of its maximum height, it has a speed of 19.6 m/s. What is the maximum height reached?

A) 39.2 m
B) 49.4 m
C) 44.0 m
D) 23.0 m
E) 30.7 m



Ans:

$$v^2 = v_i^2 - 2g(y - y_i)$$

Apply this equation to points 1 and 2:

$$v_2^2 = v_1^2 - 2g(y_2 - y_1)$$

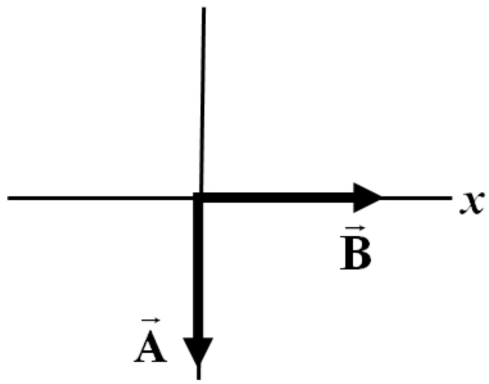
$$0 = (19.6)^2 - (19.6)\left(h - \frac{h}{2}\right)$$

$$\Longrightarrow h = 2 \times 19.6 = 39.2\text{ m}$$

Q7.

The two vectors shown in **FIGURE 2** lie in the *xy* plane. Which of the following vectors has positive *x* and *y* components?

Figure # 2



A) $\vec{\mathbf{B}} - \vec{\mathbf{A}}$ ✓
B) $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ *second quadrant*
C) $\vec{\mathbf{B}} + \vec{\mathbf{A}}$ fourth quadrant
D) $\vec{\mathbf{A}} - 2\vec{\mathbf{B}}$ second quadrant
E) $2\vec{\mathbf{A}} - \vec{\mathbf{B}}$ second quadrant

Ans:

A

Q8.

A vector $\vec{\mathbf{A}}$ is defined by $\vec{\mathbf{A}} = 1.50\hat{\mathbf{i}} + 1.50\hat{\mathbf{j}}$. Find a vector $\vec{\mathbf{B}}$ that makes an angle of 60.0° with $\vec{\mathbf{A}}$ in the counterclockwise direction, and has a magnitude of 4.00 units.

A) $\vec{\mathbf{B}} = -1.04\hat{\mathbf{i}} + 3.86\hat{\mathbf{j}}$
B) $\vec{\mathbf{B}} = 3.86\hat{\mathbf{i}} + 1.04\hat{\mathbf{j}}$
C) $\vec{\mathbf{B}} = 1.04\hat{\mathbf{i}} + 3.86\hat{\mathbf{j}}$
D) $\vec{\mathbf{B}} = -1.04\hat{\mathbf{i}} - 3.86\hat{\mathbf{j}}$
E) $\vec{\mathbf{B}} = 3.86\hat{\mathbf{i}} - 1.04\hat{\mathbf{j}}$

Ans:

Since $A_x = A_y \Rightarrow \theta_A = 45°$ (first quadrant)

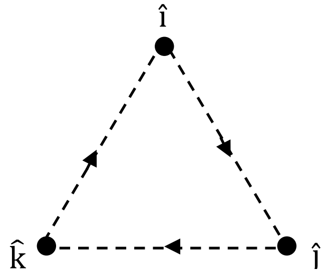
$\therefore \theta_B = 60 + 45 = 105^{\circ}$

$B_x = B.\cos\theta_B = 4.00 \times \cos 105° = -1.04$

$B_y = B.\sin\theta_B = 4.00 \times \cos 105° = +3.86$

Q9.

Three vectors are given by $\vec{\mathbf{A}} = 1.0\hat{\mathbf{i}} + 1.0\hat{\mathbf{j}}$, $\vec{\mathbf{B}} = -1.0\hat{\mathbf{j}} + 1.0\hat{\mathbf{k}}$, and $\vec{\mathbf{C}} = -1.0\hat{\mathbf{i}} + 1.0\hat{\mathbf{k}}$. Find $\vec{\mathbf{A}} \cdot (\vec{\mathbf{B}} \times \vec{\mathbf{C}})$.



A) – 2.0
B) – 4.0
C) + 2.0
D) + 4.0
E) 0

Ans:

$$\vec{B} \times \vec{C} = (-\hat{j} + \hat{k}) \times (-\hat{i} + \hat{k}) = (\hat{j} \times \hat{i}) - (\hat{j} \times \hat{k}) - (\hat{k} \times \hat{i})$$

$$= -\hat{k} - \hat{i} - \hat{j}$$

$$\vec{A}.(\vec{B} \times \vec{C}) = (\hat{i} + \hat{j}).(-\hat{i} - \hat{j} - \hat{k})$$

$$= -1.0 - 1.0 = -2.0$$

Q10.

At time t = 0, a particle moving in the xy plane leaves the origin with a velocity of $\vec{\mathbf{v}}_{\mathbf{o}} = 3.0\hat{\mathbf{i}} + 5.0\hat{\mathbf{j}}$ (m/s). The particle moves with a constant acceleration of $\vec{\mathbf{a}} = 1.0\hat{\mathbf{i}} - 5.0\hat{\mathbf{j}}$ (m/s^2). What is the position vector of the particle at t = 4.0 s?

A) $20\hat{\mathbf{i}} - 20\hat{\mathbf{j}}$ m
B) $1.5\hat{\mathbf{i}} + 2.5\hat{\mathbf{j}}$ m
C) $7.0\hat{\mathbf{i}} - 15\hat{\mathbf{j}}$ m
D) $0.75\hat{\mathbf{i}} + 1.3\hat{\mathbf{j}}$ m
E) $4.0\hat{\mathbf{i}}$ m

Ans:

Constant acceleration:

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

$$= 0 + (3\hat{i} + 5\hat{j})(4) + (\hat{i} - 5\hat{j})(8)$$

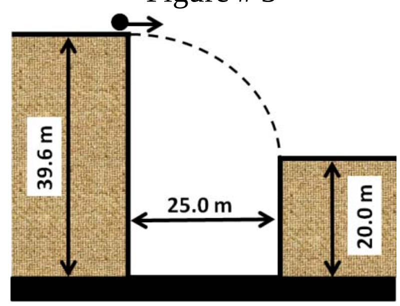
$$= 12\hat{i} + 20\hat{j} + 8\hat{i} - 40\hat{j}$$

$$= 20\hat{i} - 20\hat{j}\ \text{m}$$

Q11.

A ball is thrown horizontally from the edge of the top of a building of height 39.6 m. The ball just reaches the top of another building of height 20.0 m that is at a horizontal distance of 25.0 m away (see **FIGURE 3**). What is the initial speed of the ball?

Figure # 3



A) 12.5 m/s
B) 10.2 m/s
C) 50.4 m/s
D) 9.80 m/s
E) 19.9 m/s

Ans:

Vertical: $y - y_0 = v_{0y}t - \frac{1}{2}gt^2$

$20.0 - 39.6 = 0 - 4.9\,t^2$

$\Rightarrow t = 2.00\ s$

Horizontal: $x = v_{0x}t$

$\Rightarrow v_0 = v_{0x} = \frac{x}{t} = \frac{25.0}{2.00} = 12.5\ m/s$

Q12.

A particle is moving with constant speed around a circle that is centered at the origin. At time *t* = 0, the particle is at (3.0 , 0) m. At *t* = 3.0 s, the particle reaches the point (-3.0 , 0) m for the first time. What is the magnitude of the acceleration of the particle?

A) 3.3 m/s^2
B) 1.0 m/s^2
C) 13 m/s^2
D) 8.8 m/s^2
E) 14 m/s^2

Ans:

In the given time, the particle has moved half a circle.

$\therefore$ Period $= T = 2 \times 3.0 = 6.0\ s$

$a = \frac{v^2}{R} \longrightarrow (1)$

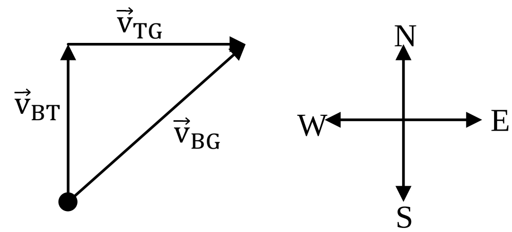
$T = \frac{2\pi R}{v} \Rightarrow v = \frac{2\pi R}{T}\ (2)$

From $(2) \longrightarrow (1)$: $a = \frac{1}{R} \cdot \frac{4\pi^2 R^2}{T^2} = \frac{4\pi^2 R}{T^2} = 3.3\ m/s^2$

Q13.

A train moves due East at 6.00 m/s along a level, straight track. A boy on the train rolls a ball along the floor with a speed of 3.00 m/s relative to the train. The ball is rolled directly across the width of the train from South to North. What is the speed of the ball relative to a stationary observer on the ground?

A) 6.71 m/s
B) 3.46 m/s
C) 5.20 m/s
D) 9.00 m/s
E) 3.00 m/s



Ans:

T: train; B: ball; G: ground

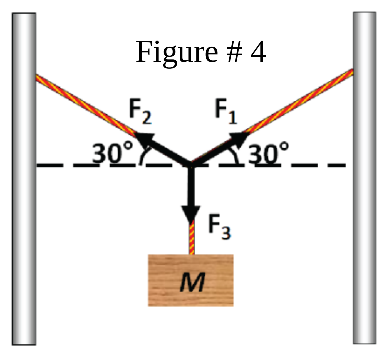
$$V_{BG} = \sqrt{v_{TG}^2 + v_{BT}^2}$$

$$= \sqrt{36.0 + 9.00} = 6.71\ \mathrm{m/s}$$

Q14.

A block of mass *M* is hung by ropes as shown in **FIGURE 4**. The system is in equilibrium. Which of the following statements is **CORRECT** concerning the magnitudes of the three forces?

A) $F_1 = F_2 = F_3$
B) $F_2 = 2\,F_3$
C) $F_2 < F_3$
D) $F_1 = F_2 = F_3/2$
E) $F_1 > F_3$



Ans:

$$x - \text{component: } F_{1x} - F_{2x} = 0$$

$$\Rightarrow F_{1x} = F_{2x} \Rightarrow F_1.\cos 30° = F_2.\cos 30°$$

$$\Rightarrow F_1 = F_2$$

$$y - \text{component: } F_{1y} + F_{2y} - F_3 = 0$$

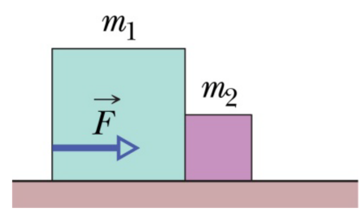
$$F_3 = F_{1y} + F_{2y} = F_{1y} + F_{1y} = 2F_{1y}$$

$$= 2F_1.\sin 30° = F_1$$

Q15.

Two blocks, with $\boldsymbol{m_1}$ = 2.5 kg and $\boldsymbol{m_2}$ = 1.5 kg, are in contact on a horizontal frictionless table. A horizontal force $\boldsymbol{F}$ is applied to the larger block, as shown in **FIGURE 7**. If the magnitude of the force between the two blocks is 1.2 N, what is the magnitude of the applied force $\boldsymbol{F}$?

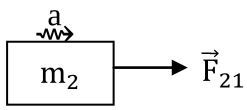
Figure # 7



A) 3.2 N
B) 2.0 N
C) 2.4 N
D) 5.6 N
E) 1.2 N

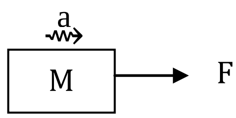
Ans:

$*$ consider m_2 :



$$m_2 a = F_{21} \Rightarrow a = \frac{F_{21}}{m_2} = \frac{1.2}{1.5} = 0.80\ m/s^2$$

$*$ Now, consider the system :



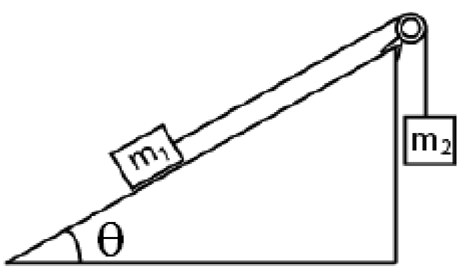
$$F = M.a = (2.5 + 1.5)(0.80) = 3.2\ N$$

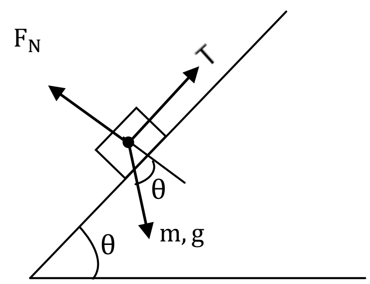
Q16.

FIGURE 5 shows a system of two masses, with $\boldsymbol{m_1}$ = 5.00 kg and $\boldsymbol{m_2}$ = 2.00 kg. Calculate the angle $\boldsymbol{\theta}$ for which the system is at rest. Assume the pulley to be massless and frictionless. The incline is frictionless.

Figure # 5

A) 23.6°
B) 35.2°
C) 63.5°
D) 45.0°
E) 50.3°





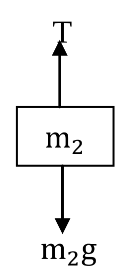
Ans:

For m_1: $T = m_1 g . \sin\theta \longrightarrow (1)$

For m_2: $T = m_2 g \qquad \longrightarrow (2)$

Equate (1)and (2): $m_1 g . \sin\theta = m_2 g$

$$\Rightarrow \sin\theta = \frac{m_2}{m_1} = \frac{2.00}{5.00} = 0.400 \Rightarrow \theta = 23.6°$$

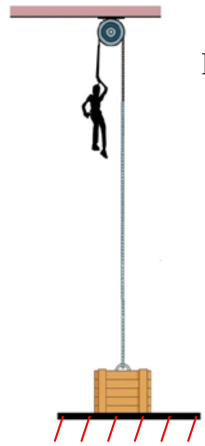


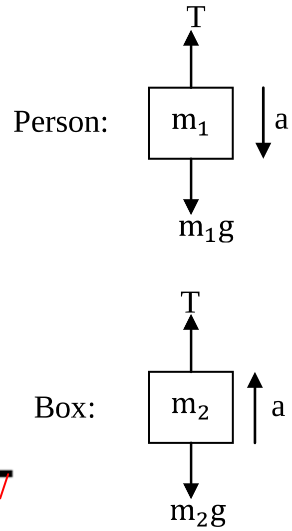
Q17.

A 75 kg person lowers himself from rest to the ground by means of a rope that passes over a frictionless pulley and is attached to a 60 kg box, as shown in **FIGURE 6**. The person and the box move along vertical lines. What is the magnitude of the acceleration of the person?

A) 1.1 m/s^2
B) 9.8 m/s^2
C) 5.4 m/s^2
D) 3.6 m/s^2
E) 4.6 m/s^2

Figure # 6





Ans:

person: $-m_1 a = T - m_1 g$

$\Rightarrow m_1 a = -T + m_1 g \longrightarrow (1)$

box: $m_2 a = T - m_2 g \longrightarrow (2)$

Add (1)and (2):

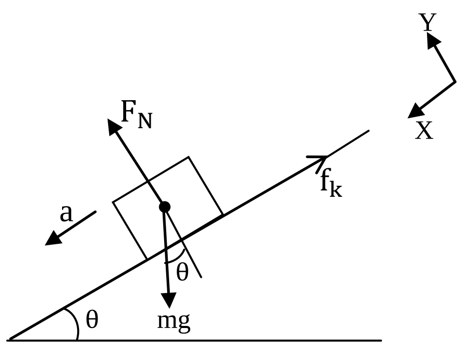
$(m_1 + m_2)a = (m_1 - m_2)g$

$$\Rightarrow a = \frac{m_1 - m_2}{m_1 + m_2} . g = \frac{75 - 60}{75 + 60} \times 9.8 = 1.1\ m/s^2$$

Q18.

A 3.00 kg block starts from rest at the top of a 30.0° incline and slides a distance of 2.00 m down the incline in 1.50 s. Calculate the magnitude of the frictional force acting on the block.

A) 9.37 N
B) 13.5 N
C) 1.50 N
D) 14.7 N
E) 8.98 N



Ans:

Calculate a:

$$x = \cancel{v_0}^{\,0} t + \frac{1}{2} a t^2$$

$$\Rightarrow a = \frac{2x}{t^2} = \frac{2 \times 2}{2.25} = 1.78\ m/s^2$$

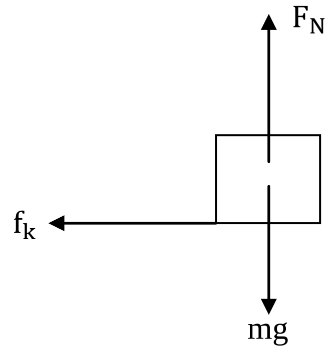
Now, apply Newton's 2nd law:

$ma = mg\sin\theta - f_k$

$\Rightarrow f_k = m(g\sin\theta - a) = 9.37\ N$

Q19.

An object is given an initial speed of 10 m/s and slides on a horizontal rough surface. It moves a distance of 40 m before coming to rest. During deceleration, the only horizontal force acting on the object is the force of friction. What is the coefficient of kinetic friction between the object and the surface?



A) 0.13
B) 0.83
C) 0.31
D) 1.3
E) 0.04

Ans:

Calculate a:

$$v_f^2 \to 0 = v_i^2 - 2ax$$

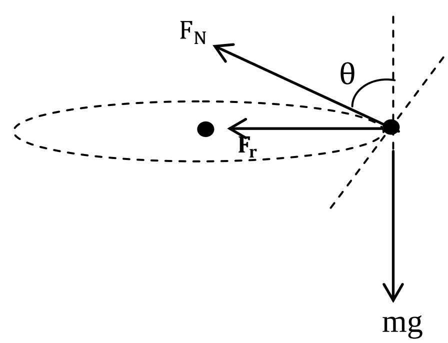
$$\Rightarrow a = \frac{v_i^2}{2x} = \frac{100}{80} = 1.25 \ m/s^2$$

Apply Newton's 2nd law:

$$ma = f_k \Rightarrow ma = \mu_k . F_N = \mu_k . mg \Rightarrow \mu_k = \frac{a}{g} = \frac{1.25}{9.8} = 0.13$$

Q20.

A highway curve has a radius of 100 m and is designed for a speed of 50.0 km/h. At what angle should the curve be banked so that a car rounding the curve will not slip?



A) 11.1°
B) 39.0°
C) 15.7°
D) 16.3°
E) 12.6°

Ans:

$$v = 50.0 \frac{km}{h} . \frac{1 h}{3600s} . \frac{100 m}{1 km} = 13.9 \ m/s$$

$$F_r = F_N . \sin\theta \quad \longrightarrow (1)$$

$$mg = F_N . \cos\theta \quad \longrightarrow (2)$$

$$\text{Divide}(1)\text{by }(2): \frac{F_r}{mg} = \tan\theta$$

$$\Rightarrow \tan\theta = \frac{1}{mg} . \frac{mv^2}{R} = \frac{v^2}{Rg} = \frac{(13.9)^2}{100 \times 9.8} = 0.197$$

$$\Rightarrow \theta = 11.1°$$
