

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)  $ML^2T^{-3}$
- B)  $ML^2T^{-2}$
- C)  $ML^3T^{-2}$
- D)  $ML^2T^{-1}$
- E)  $MLT^{-2}$

$$P = \frac{W}{T} = \frac{N \cdot m}{s} = \frac{kg \cdot m}{s^2} \cdot \frac{m}{s}$$

$$= \frac{kg \cdot m^2}{s^3} = \frac{ML^2}{T^3}$$

Q2.

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

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

$$\rho = 7.86 \text{ g/cm}^3$$

$$m = 9.3 \times 10^{-23} \text{ g}$$

$$V = 1 \text{ in}^3 = \frac{2.54^3 \text{ cm}^3}{\text{in}^3} = 16.4 \text{ cm}^3$$

$$\rho = \frac{M}{V} \Rightarrow M = \rho V = 7.86 \text{ g/cm}^3 (16.4 \text{ cm}^3) = 128.904 \text{ g}$$

$$\text{number of atoms} = \frac{128.904}{9.3 \times 10^{-23}} = 1.39 \times 10^{24} \text{ atoms}$$

Q3.

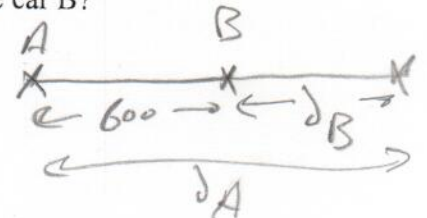
Two cars are initially at rest. Car A is at  $x = 0$ , and car B is at  $x = +600 \text{ m}$ . They start to move, at the same time, along the same line in the positive  $x$  direction with constant accelerations:  $a_A = 4.00 \text{ m/s}^2$  and  $a_B = 1.00 \text{ m/s}^2$ . How long does it take car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

$$d_A = d_B + 600 \quad (1)$$

$$d_A = v_0 t + \frac{1}{2} a t^2 = 2t^2 \quad (2)$$

$$d_B = v_0 t + \frac{1}{2} a t^2 = \frac{1}{2} t^2 \quad (3)$$



$$(2) \text{ and } (3) \text{ in } (1) \Rightarrow 2t^2 = \frac{1}{2} t^2 + 600 \Rightarrow t = 20 \text{ s}$$

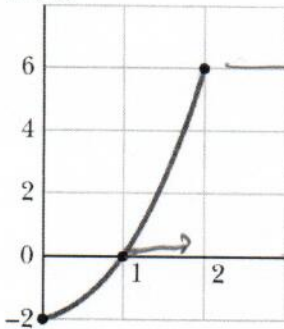
Q4.

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

- A) A body can have constant velocity and still have a varying speed.
- B) A body can have a constant speed and still have a varying velocity.
- C) A body can have zero velocity and still be accelerating.
- D) A body can have a constant acceleration and a variable velocity.
- E) A body can have an upward velocity while experiencing a downward acceleration.

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?

Fig#  
 $x$  (m)

- A)  $4 \text{ m/s}^2$   
 B)  $6 \text{ m/s}^2$   
 C)  $3 \text{ m/s}^2$   
 D)  $2 \text{ m/s}^2$   
 E)  $5 \text{ m/s}^2$

$$x_0 = -2 \text{ m}$$

$$6 + 2 = v_0(2) + \frac{1}{2}(a)(2)^2$$

$$0 - (-2) = v_0(1) + \frac{1}{2}a(1)^2$$

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

Q6.

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

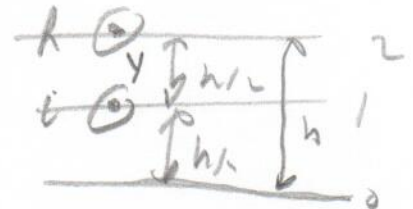
- A)  $39.2 \text{ m}$   
 B)  $49.4 \text{ m}$   
 C)  $44.0 \text{ m}$   
 D)  $23.0 \text{ m}$   
 E)  $30.7 \text{ m}$

$$v_i = 19.6 \text{ m/s}$$

$$v_f = 0$$

$$a = -9.8 \text{ m/s}^2$$

$$h = 1$$



$$h = v_0 t + \frac{1}{2} a t^2$$

$$v^2 = v_0^2 + 2aX$$

$$0 = (19.6)^2 + 2(-9.8)h$$

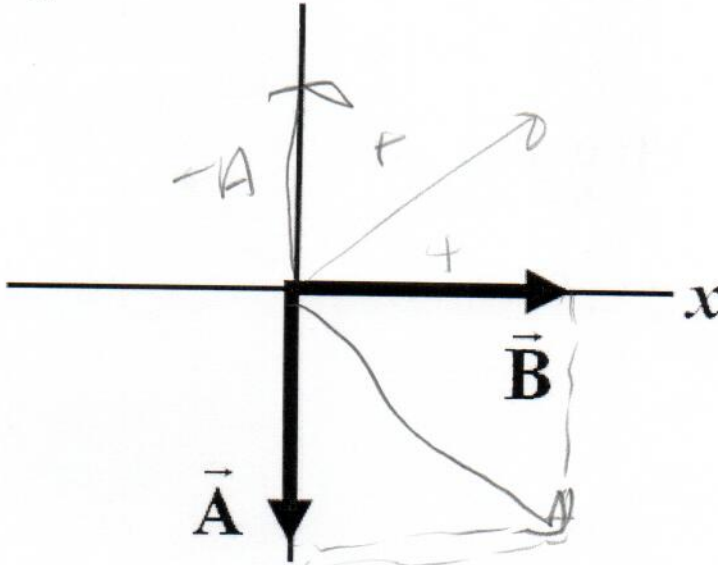
$$X = 19.6 \text{ m}$$

$$\therefore h = 2X = 39.2 \text{ m}$$

Q7.

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

Fig#



- A)  $\vec{B} - \vec{A}$   
 B)  $\vec{A} - \vec{B}$   
 C)  $\vec{B} + \vec{A}$   
 D)  $\vec{A} - 2\vec{B}$   
 E)  $2\vec{A} - \vec{B}$

Q8.

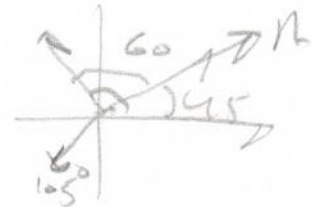
A vector  $\vec{A}$  is defined by  $\vec{A} = 1.50\hat{i} + 1.50\hat{j}$ . Find a vector  $\vec{B}$  that makes an angle of  $60.0^\circ$  with  $\vec{A}$  in the counterclockwise direction, and has a magnitude of 4.00 units.

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

$$\theta_{AB} = \tan^{-1}\left(\frac{1.5}{1.5}\right) = 45^\circ$$

$$B_x = 4 \cos 105 = -1.04$$

$$B_y = 4 \sin 105 = 3.86$$





Q9. Three vectors are given by  $\vec{A} = 1.0\hat{i} + 1.0\hat{j}$ ,  $\vec{B} = -1.0\hat{j} + 1.0\hat{k}$ , and  $\vec{C} = -1.0\hat{i} + 1.0\hat{k}$ . Find  $\vec{A} \cdot (\vec{B} \times \vec{C})$ .

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

Q10. At time  $t = 0$ , a particle moving in the  $xy$  plane leaves the origin with a velocity of  $\vec{v}_0 = 3.0\hat{i} + 5.0\hat{j}$  (m/s). The particle moves with a constant acceleration of  $\vec{a} = 1.0\hat{i} - 5.0\hat{j}$  (m/s<sup>2</sup>). What is the position vector of the particle at  $t = 4.0$  s?

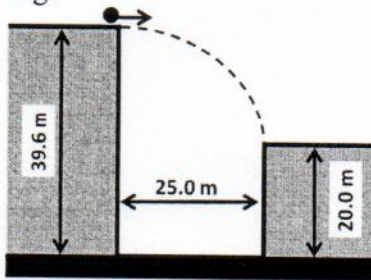
- A)  $20\hat{i} - 20\hat{j}$  m  
B)  $1.5\hat{i} + 2.5\hat{j}$  m  
C)  $7.0\hat{i} - 15\hat{j}$  m  
D)  $0.75\hat{i} + 1.3\hat{j}$  m  
E)  $4.0\hat{i}$  m

$$\begin{aligned} \vec{r} &= \vec{r}_0 + \vec{v}_0 t + \frac{1}{2} \vec{a} t^2 \\ &= 0 + (3\hat{i} + 5\hat{j})(4) + \frac{1}{2}(1\hat{i} - 5\hat{j})(4)^2 \\ &= 20\hat{i} - 20\hat{j} \end{aligned}$$

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?

Fig#



- 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

$$\begin{aligned} & \text{X-direction} \\ & u_x = u_0 \\ & u_x = u_0 \\ & a = 0 \\ & X = 25 \text{ m} \\ & X = u_0 t + 0 \\ & u_0 = \frac{X}{t} \\ & = \frac{25}{2} = 12.5 \text{ m/s} \end{aligned}$$

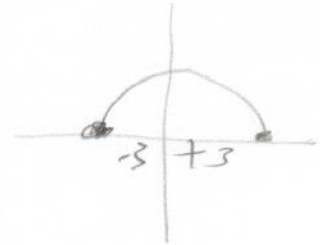
$$\begin{aligned} & \text{Y-direction} \\ & u_y = 0 \\ & u_y = ? \\ & a = -9.8 \\ & Y = -19.6 \text{ m} \\ & t = ? \\ & Y = u_y t + \frac{1}{2} a t^2 \\ & -19.6 = \frac{1}{2} (-9.8) t^2 \\ & t = 2 \text{ s} \end{aligned}$$

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)  $3.3 \text{ m/s}^2$   
 B)  $1.0 \text{ m/s}^2$   
 C)  $13 \text{ m/s}^2$   
 D)  $8.8 \text{ m/s}^2$   
 E)  $14 \text{ m/s}^2$

$$\begin{aligned} a &= \frac{v^2}{R} \\ &= \frac{\pi^2}{3} \\ &= 3.3 \text{ m/s}^2 \end{aligned} \quad \left\{ \begin{aligned} v &= \frac{\Delta r}{t} \\ &= \frac{\pi R / 2}{3} \\ &= \frac{\pi \cdot 3 / 3}{3} = \pi \end{aligned} \right.$$

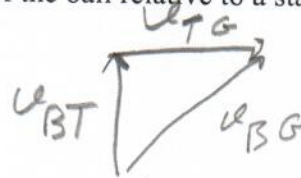


Q13.

A train moves due East at  $6.00 \text{ m/s}$  along a level, straight track. A boy on the train rolls a ball along the floor with a speed of  $3.00 \text{ m/s}$  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)  $6.71 \text{ m/s}$   
 B)  $3.46 \text{ m/s}$   
 C)  $5.20 \text{ m/s}$   
 D)  $9.00 \text{ m/s}$   
 E)  $3.00 \text{ m/s}$

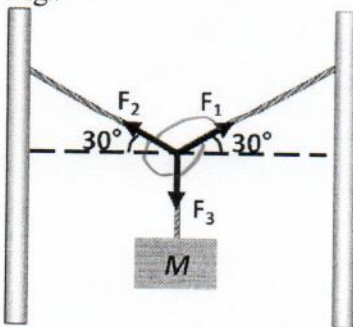
$$\begin{aligned} \vec{v}_{BG} &= \vec{v}_{BT} + \vec{v}_{TG} \\ &= \sqrt{6^2 + 3^2} \\ &= 6.71 \text{ m/s} \end{aligned}$$



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?

Fig#



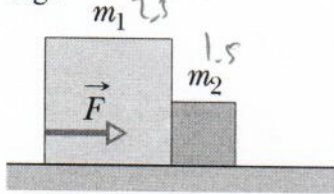
$$\begin{aligned} \theta_1 &= \theta_2 = \theta_3 = 120^\circ \\ \Rightarrow F_1 &= F_2 = F_3 \end{aligned}$$

- 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)  $F_1 > F_3$

Q15.

Two blocks, with  $m_1 = 2.5$  kg and  $m_2 = 1.5$  kg, are in contact on a horizontal frictionless table. A horizontal force  $F$  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  $F$ ?

Fig#



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

$$F_{12} \rightarrow \boxed{2}$$

$$F_{net} = ma$$

$$F_{12} = m_2 a$$

$$1.2 = 1.5 a$$

$$\therefore a = 0.8 \text{ m/s}^2$$

$$F_{net} = ma$$

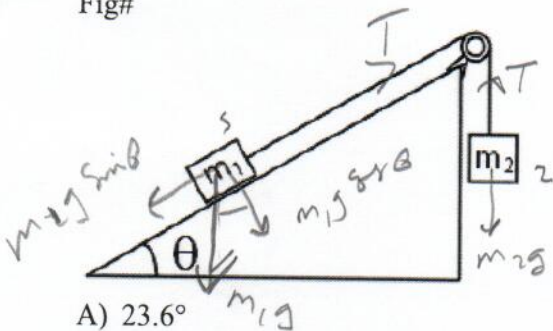
$$= (2.5 + 1.5) (0.8)$$

$$\boxed{F = 3.2 \text{ N}}$$

Q16.

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

Fig#



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

$$-m_1 g \sin \theta + T = 0 \quad (1)$$

$$T - m_2 g = 0 \quad (2)$$

$$\therefore m_1 g \sin \theta = m_2 g$$

$$\sin \theta = \frac{m_2}{m_1} = \frac{2}{5}$$

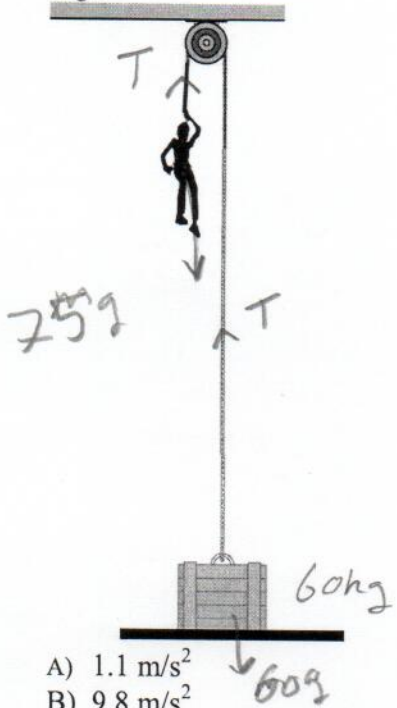
$$\therefore \theta = 23.6^\circ$$



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?

Fig#



$$T - 75g = -75a \quad (1)$$

$$T - 60g = +60a \quad (2)$$

$$(1) - (2) \Rightarrow$$

$$-15g = -135a$$

$a = 1.1 \text{ m/s}^2$

- A) 1.1 m/s<sup>2</sup>
- B) 9.8 m/s<sup>2</sup>
- C) 5.4 m/s<sup>2</sup>
- D) 3.6 m/s<sup>2</sup>
- E) 4.6 m/s<sup>2</sup>

Q18.

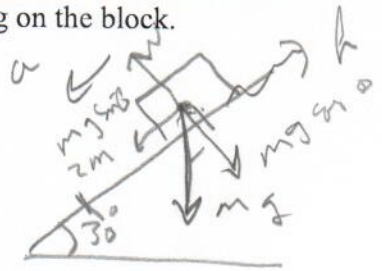
A 3.00 kg block starts from rest at the top of a 30.0° incline and slides a distance of 2.00 m down the incline in 1.50 s. Calculate the magnitude of the frictional force acting on the block.

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

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

$$2 = \frac{1}{2} (a) (1.5)^2$$

$\therefore a = 1.78 \text{ m/s}^2$



$$F_{\text{net}} = ma$$

$$3g \sin 30 - f = 3a$$

$$3g \sin 30 - (f/3) = 3(1.78)$$

$$f = 3g \sin 30 - 3(1.78)$$


$f = 9.37 \text{ N}$

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

$$\begin{aligned}
 & u_i = 10 \text{ m/s} \\
 & x = 40 \text{ m} \\
 & u_f = 0 \\
 & M \text{ is } \sim \\
 & F_{\text{net}} = ma \\
 & f = ma \\
 & \mu_k mg = ma \\
 & \mu_k = \frac{a}{g} = 0.13
 \end{aligned}$$



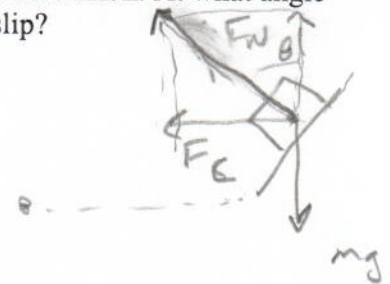
$$\begin{aligned}
 u_f^2 &= u_i^2 + 2ax \\
 0 &= 100 + 2(a)(40) \\
 a &= \frac{-100}{80} = -1.25 \text{ m/s}^2
 \end{aligned}$$

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°

$$\begin{aligned}
 & R = 100 \text{ m} \\
 & u = 50 \text{ km/h} \\
 & \theta = ?
 \end{aligned}$$



$$u = \frac{50 \text{ km}}{\text{h}} = \frac{50}{3.6} = 13.9 \text{ m/s}$$

$$F_N \cos \theta = mg \quad (1)$$

$$F_N \sin \theta = F_c \quad (2)$$

$$F_c = m \frac{u^2}{R}$$

$$\frac{(2)}{(1)} \Rightarrow \tan \theta = \frac{F_c}{mg} = \frac{m u^2}{R} \frac{1}{mg}$$

$$\tan \theta = \frac{u^2}{Rg} = \frac{13.9^2}{(100)(9.8)} = 0.197$$

$$\therefore \theta = 11.1^\circ$$