Q1.

The velocity of a particle is given by v = $At^2 + (B/A)\,t$, where v is in m/s and t is in seconds. The dimension of B is:

A) $L^2\,T^{-5}$
B) $L^3\,T^{-3}$
C) $L^2\,T^3$
D) $L^4\,T^4$
E) $L^5\,T^{-6}$

Ans:

The dimension of A is LT^{-3}. The dimension of B is L^2T^{-5}

Q2.

The position of a particle as a function of time is given by x(t) = $3.0t^3 - 10.0t^2 + 9.0t$, where x is in meters and t is in seconds. Find the velocity at the time when the acceleration is zero.

A) – 2.1 m/s
B) + 2.1 m/s
C) + 5.0 m/s
D) – 5.0 m/s
E) + 3.5 m/s

Ans:

The first derivative gives the velocity: $v = 9t^2 - 20t + 9$
The second derivative gives the acceleration: $a = 18t - 20$. The time at which the acceleration is zero is t=20/18 s. At this time, the velocity is -2.1 m/s

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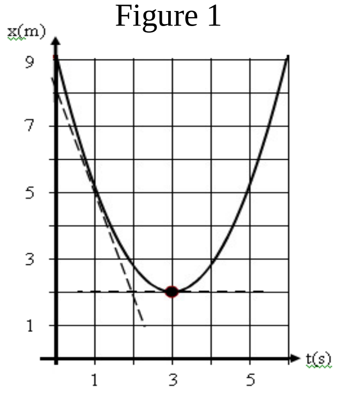
Q3.

The position-time curve for a particle moving along the x-axis is shown in **Figure 1**. The dashed straight lines are tangent to the curve at t = 1.0 s and t = 3.0 s. Find the magnitude of the average acceleration in the time interval t = 1.0 s and t = 3.0 s.

Figure 1



A) 1.5 m/s^2
B) 5.0 m/s^2
C) 1.0 m/s^2
D) 2.0 m/s^2
E) 2.5 m/s^2

Ans:

The velocity is the slope of the tangent line. At t=1 s, the slope gives v_1=3 m/s, and at t= 3 s, the slope gives v_2=0. From the definition of the average acceleration, the magnitude is 1.5 m/s^2

Q4.

Two objects A and B are thrown from the top of a building with the same magnitude of velocity. Object A is thrown upward but object B is thrown downward. When they reach the ground (ignore air resistance):

A) The two objects have the same velocity.
B) Object A has a higher velocity than object B.
C) Object B has a higher velocity than object A.
D) The velocities will depend on the masses of the objects.
E) The velocities will depend on the shapes of the objects.

Ans:

A

Q5.

A ball starts from rest and slides down a hill with a constant acceleration for 10.0 s. If it travels 50.0 m during the first 5.00 seconds of its motion, how far will it travel during the next 5.00 seconds of its motion?

A) 150 m
B) 98.0 m
C) 75.0 m
D) 200 m
E) 25.0 m

Ans:

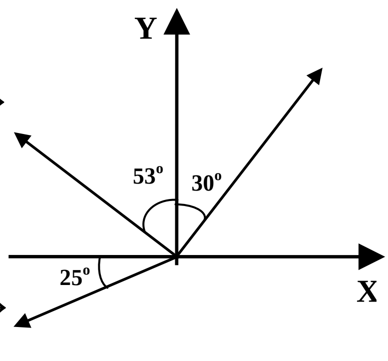
Find the acceleration in the first interval: $50 = \frac{1}{2}a(5)^2 \Rightarrow a = 4\ m/s^2$

The distance for the whole trip is $x = \frac{1}{2} \times 4 \times (10)^2 = 200\ m.$ And for the second interval will be 150 m.

Q6.

Figure 2 shows three vectors **A**, **B** and **C**, whose magnitudes are 15 m, 10 m and 12 m respectively. Find both the magnitude and direction of the resultant of theses vectors. The y-component of the sum of vectors is:

Figure 2



A) 18.0 m, 129° from the positive x-axis
B) 14.0 m, 150° from the positive x-axis
C) 12.0 m, 53° from the positive x-axis
D) 20.0 m, 163° from the positive x-axis
E) 10.0 m, 110° from the positive x-axis

Ans:

The x-component of the sum of vectors is:

$\vec{S} = A\sin 30\hat{i} + A\cos 30\hat{j} - B\sin 53\hat{i} + B\cos 53\hat{j} - C\cos 25\hat{i} - C\sin 25\hat{j}$

$\vec{S} = -11.36\hat{i} + 13.94\hat{j}$

Q7.

If vector **A** = b (3.0 **i** + 4.0 **j**), where b is a constant. Find the value of b that makes vector **A** a unit vector.

A) 0.20
B) 0.10
C) 0.30
D) 0.50
E) 0.40

Ans:

For $\left|\vec{A}\right| = 1,\ b = \frac{1}{\sqrt{3^2 + 4^2}} = 0.2$

Q8.

Two vectors $\vec{A}$ and $\vec{B}$ have magnitudes 3.0 and 4.0 respectively. Their vector product is $\vec{A} \times \vec{B} = -5.0\hat{k} + 2.0\hat{i}$. Find the angle between $\vec{A}$ and $\vec{B}$.

A) 27^o
B) 22^o
C) 39^o
D) 11^o
E) 16^o

Ans:

$$\left|\vec{A} \times \vec{B}\right| = \sqrt{5^2 + 2^2} = 5.39 = \left|\vec{A}\right|\left|\vec{B}\right| \sin\theta = 3 \times 4 \times \sin\theta \Rightarrow \theta = 27^\circ$$

Q9.

A player running in an open field has components of velocity v_x = 2.60 m/s and v_y = – 1.80 m/s at t = 10.0 s. For the time interval from t = 10.0 s to t = 20.0 s, the magnitude of its average acceleration is 0.45 m/s^2 and makes an angle of 31.0^o with the positive x-axis. Find the velocity (in units m/s) of the player at t = 20.0 s.

A) 6.46 **i** + 0.518 **j**
B) 5.32 **i** + 3.52 **j**
C) 4.52 **i** + 5.60 **j**
D) 2.46 **i** + 2.52 **j**
E) 9.60 **i** + 5.30 **j**

Ans:

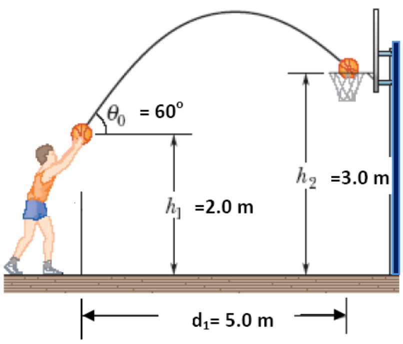
$$v_x = v_{x0} + a_x t = 2.6 + (0.45\cos 31)10 = 6.46\ m/s$$

$$v_y = v_{y0} + a_y t = -1.8 + (0.45\sin 31)10 = 0.518\ m/s$$

Q10.

A basketball player would like to throw a ball at an angle of $\theta_0 = 60^o$ above the horizontal such that the ball just goes through the center of the rim of the basket that is h_2 = 3.0 m high from the floor and it is at a horizontal distance of d_1 = 5.0 m from the player's hand (see **Figure 3**). At the instant the ball leaves the player's hand, his hand is h_1 = 2.0 m above the floor. Find the magnitude of the initial velocity of the ball.

Figure 3



A) 8.0 m/s
B) 5.0 m/s
C) 9.8 m/s
D) 3.2 m/s
E) 7.0 m/s

Ans:

$$d = v_{0x}t = (v_0 \cos 60)t \Rightarrow t = \frac{d}{v_0 \cos 60}$$

$$h = v_{0y}t - \tfrac{1}{2}g\ ^2 \Rightarrow h = v_0 \sin 60 \times \frac{d}{v_0 \cos 60} - \tfrac{1}{2}g\left(\frac{d}{v_0 \cos 60}\right)^2$$

$$h = d\ \tan 60 - \tfrac{1}{2}g\left(\frac{d}{v_0 \cos 60}\right)^2 \Rightarrow v_0 = 8\ m/s$$

Q11.

A particle rotates clockwise with a constant speed in a horizontal circle whose center is at the origin. It completes one revolution in 2.0 s. At t = 0.0, the particle is at (0.0, 1.5) m. What is the magnitude of the average acceleration of the particle in the interval between t = 3.0 and t = 8.0 seconds?

A) 1.9 m/s^2
B) 4.7 m/s^2
C) 0
D) 1.0 m/s^2
E) 0.60 m/s^2

Ans:

At t=8, $\vec{v}_2 = \frac{2\pi r}{T}\hat{i}$ m/s, and at t=3s, $\vec{v}_2 = -\frac{2\pi r}{T}\hat{i}$ m/s $\Rightarrow \left|\vec{a}_{avg}\right| = \frac{4\pi r}{T}/5 = 1.9 m/s^2$

Q12.

A 100-m wide river flows due east at a uniform speed of 3.0 m/s. A boat with a speed of 8.0 m/s relative to the water leaves the south bank pointed in a direction 60^o west of north. What is the boat's velocity relative to the ground? [**i** and **j** are unit vectors along the east and north directions respectively**]**

A) – 3.9 **i** + 4.0 **j** m/s
B) – 3.0 **i** + 8.0 **j** m/s
C) – 3.0 i + 4.0 **j** m/s
D) + 11 **i** + 5.0 **j** m/s
E) – 11 **i** + 5.0 **j** m/s

Ans:

$$\vec{v}_{BG} = \vec{v}_{BR} + \vec{v}_{RG} = 8\cos 60\,\hat{j} - 8\sin 60\,\hat{i} + 3\hat{i} = -3.9\hat{i} + 4.0\hat{j}$$

Q13.

Which one of the following statements is CORRECT?

A) It is possible to be accelerating while traveling at constant speed.
B) It is not possible to be accelerating while traveling at constant speed.
C) It is possible to round a curve with zero acceleration.
D) It is not possible to round a curve with a constant magnitude of acceleration.
E) The acceleration of a particle moving in a circle with constant speed is constant.

Ans:

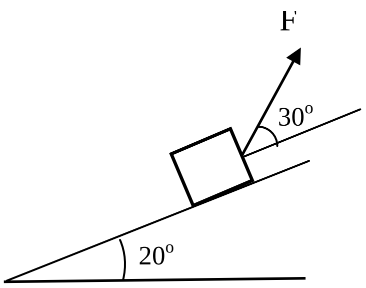
A

Q14.

As shown in **Figure 4**, a man is pulling a 60.0 N box up an inclined frictionless plane with a force F = 23.7 N whose direction makes an angle 30.0^o with inclined plane. The inclined plane makes an angle of 20.0^o with the horizontal. Find the magnitude of the acceleration of the box.

A) Zero
B) 3.35 m/s^2
C) 9.80 m/s^2
D) 4.80 m/s^2
E) 6.50 m/s^2

Figure 4



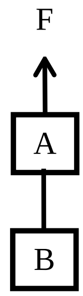
Ans:

$$ma = F\cos 30 - mg\sin 20 = 0$$

Q15.

Two boxes A and B, are connected to the ends of a light vertical cord, as shown in **Figure 5**. A constant upward force F = 80.0 N is applied to box A. Starting from rest, box B descends 12.0 m in 4.00 s. Find the mass of box B if the tension in the cord is 36.0 N.

Figure 5



A) 4.34 kg
B) 3.42 kg
C) 24.0 kg
D) 15.3 kg
E) 12.7 kg

Ans:

$$|a| = \left|\frac{2(y-y_0)}{t^2}\right| = 1.5\ m/s^2 \Rightarrow T - m_B g = -m_B a \Rightarrow m_B = \frac{T}{g-a} = 4.34\ kg$$

Q16.

With what force will the feet of a person of mass 60.0 kg press downward on an elevator floor when the elevator has an upward acceleration of 1.20 m/s^2?

A) 660 N
B) 600 N
C) 516 N
D) 588 N
E) 980 N

Ans:

$$N - mg = ma \Rightarrow N = m(g+a) = 660\ N$$

Q17.

A 0.15 kg ball is thrown at an angle of 30^o above the horizontal with an initial speed of 12 m/s. At its highest point, the net force on the ball is:

A) 1.5 N, down
B) 9.8 N, 30^o below horizontal
C) 0
D) 9.8N, up
E) 9.8 N, down

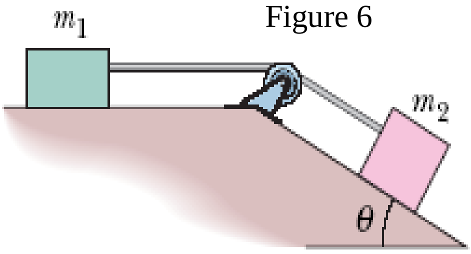
Ans:

$$F_{net} = mg = 0.15 \times 9.8 = 1.5\ N$$

Q18.

As shown in **Figure 6**, blocks m_1 and m_2 have masses of 4.00 kg and 8.00 kg, respectively. The coefficient of kinetic friction between m_1 and the horizontal surface is 0.500. The incline plane ($\theta = 30^o$) is frictionless. Find the acceleration of the system. (Assume that the pulley is massless and frictionless).

Figure 6



A) 1.63 m/s²
B) 3.48 m/s²
C) 4.80 m/s²
D) 0
E) 0.430 m/s²

Ans:

$$m_2 g \sin\theta - T = m_2 a$$

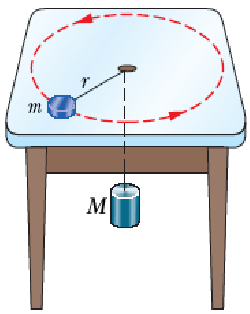
$$T - \mu m_1 g = m_1 a$$

$$m_2 g \sin\theta - m_1 a - \mu m_1 g = m_2 a \Rightarrow a = \frac{m_2 g \sin\theta - \mu m_1 g}{m_1 + m_2} = 1.63\ m/s^2$$

Q19.

Figure 7 shows an object of mass m = 0.10 kg tied to a rope rotating in a horizontal circle of radius r=0.25 m, on a frictionless table top. It rotates at constant speed of 4.0 m/s while the mass M is stationary. Find the value of mass M.

Figure 7



A) 0.65 kg
B) 0.87 kg
C) 0.25 kg
D) 0.98 kg
E) 1.0 kg

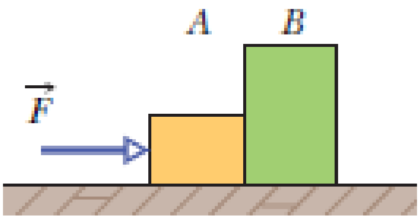
Ans:

$$T = Mg = m\frac{v^2}{r} \Rightarrow M = 0.65\ kg$$

Q20.

Figure 8 shows a constant horizontal force F = 20.0 N applied to block A (mass = 2.00 kg) which pushes against block B (mass = 3.00 kg) to the right. The coefficient of kinetic friction between the surface and object A is 0.220 and between the surface and object B is 0.350. Find the magnitude of the contact force between object A and object B.

Figure 8



A) 13.5 N
B) 20.0 N
C) 5.40 N
D) 11.4 N
E) 15.0 N

Ans:

The acceleration of the system A+B is $a = \dfrac{F - \mu_A m_A g - \mu_B m_B g}{m_A + m_B} = 1.08\ m/s^2$

For block B: $F_C - \mu_B m_B g = m_B a \Rightarrow F_C = 13.5\ N$