Q1.

A position of a particle at time *t* is given by: $x = ab(1 - e^{-bt})$. The dimensions of *a* and *b* are, respectively:

A) LT and T^{-1}
B) LT^{-1} and L
C) LT^{-1} and LT^{-1}
D) T^{-1} and LT^{-1}
E) MT^{-1} and LT^{-1}

Ans:

$$bT = 1$$

$$b = T^{-1}$$

$$ab = L \Rightarrow a = \frac{L}{b} = LT$$

Q2.

A uniform solid cylinder with a radius of 2.30 cm and a height of 55.0 inches has a mass of 690 g. Find its density. (1 inch = 2.54 cm)

A) 297 kg/m^3
B) 230 kg/m^3
C) 145 kg/m^3
D) 400 kg/m^3
E) 520 kg/m^3

Ans:

$$\rho = \frac{m}{\pi R^2 h} = \frac{690\ g \times \frac{1\ kg}{1000\ g}}{3.14 \times (2.3)^2 cm^2 \times \frac{1\ m^2}{(100)^2 cm^2} \times 55\ in \times \frac{2.54\ cm}{1\ in} \times \frac{1\ m}{100\ cm}}$$

$$\Rightarrow \rho = 297\ kg/m^3$$

Q3.

A car starts from rest at time *t* = 0; accelerates at a constant rate of 4.0 m/s^2 in a straight road and reaches a speed of 20 m/s. Then the car slows down at a constant rate until it stops at *t* = 9.0 s. Find the total distance travelled by the car for the entire motion.

A) 90 m
B) 50 m
C) 60 m
D) 40 m
E) 80 m

Ans:

$v_{01} = 0;\ v_1 = 20;\ a_1 = 4\,m/s^2$

$$v_1^2 = 2ax_1 + v_{01}^2 \Rightarrow x_1 = \frac{20 \times 20}{2 \times 4} = 50\ m$$

$$v_1 = v_{01} + at_1 \Rightarrow t_1 = \frac{20}{4} = 5s$$

$t_2 = 9 - 5 = 4\ s$

$v_2 = 0;\ v_{02} = 20$

$v_2 = v_{02} + a_2 t_2$

$$a_2 = -\frac{20}{4} = -5s$$

$$v_2^2 = v_{02}^2 + 2a_2x_2 \Rightarrow x_2 = \frac{-20 \times 20}{-2 \times 5} = 40\ m$$

$X = X_1 + X_2 = 90\ m$

Q4.

The coordinate of an object is given as a function of time by $x = 7t - 4t^2$, where x is in meters and t is in seconds. The ratio of its instantaneous velocity at $t = 2$ s to its average velocity over the interval from $t = 0$ to $t = 2$ s is:

A) 9
B) 6
C) 1
D) 4
E) 5

Ans:

$$x = 7t - 4t^2$$

$$v(t) = 7 - 8t \Rightarrow v(2) = 7 - 16 = -9\ m/s$$

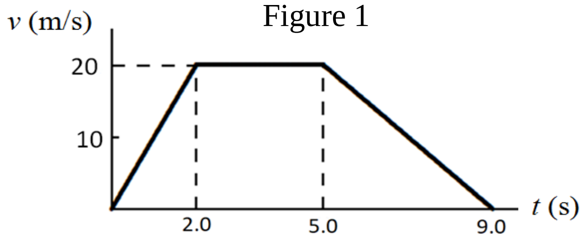
$$v_{av} = \frac{X(2) - X(10)}{2} = \frac{14 - 16 - 0}{2} = \frac{-2}{2} = -1$$

$$\frac{v_{ins}}{v_{av}} = \frac{-9}{-1} = 9$$

Q5.

The graph in **Figure 1** represents the straight-line motion of a car. Find the acceleration of the car at 7.1 s.

Figure 1



A) -5.0 m/s^2
B) $+5.0$ m/s^2
C) -10 m/s^2
D) $+10$ m/s^2
E) zero

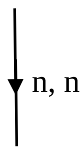
Ans:

$$a = \frac{0 - 20}{9 - 5} = \frac{-20}{4} = -5.0\ m/s^2$$

Q6.

The speed of a freely falling particle under the gravity is increasing with time. Its velocity and acceleration are:

A) negative and negative, respectively
B) negative and positive, respectively
C) positive and negative, respectively
D) negative and zero, respectively
E) positive and zero, respectively



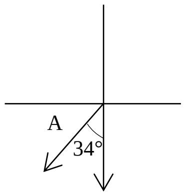
Ans:

A

Q7.

Vector $\vec{A}$ is in the direction 34.0° clockwise from the negative y-axis. The magnitude of x-component of $\vec{A}$ is 16.0 m. What is the magnitude of $\vec{A}$?

A) 28.6 m
B) 11.3 m
C) 15.4 m
D) 23.8 m
E) 32.5 m



Ans:

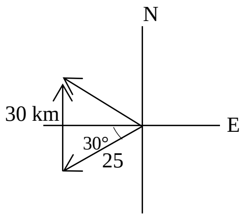
$$-A\sin 34° = A_x = 16$$

$$|A| = \frac{16}{sin34°} = 28.6$$

Q8.

Starting from one oasis, a camel walks 25 km in a direction 30° south of west and then walks 30 km toward the north to a second oasis. What is the direction from the first oasis to the second oasis?

A) 51° West of North
B) 33° North of West
C) 27° West of North
D) 12° North of West
E) 45° West of North



Ans:

$$R_x = 25\cos 30°$$

$$R_y = 30 - 25\sin 30°$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = 39°\ North\ of\ West = (90 - 39) = 51\ West\ of\ North$$

Q9.

If the vector $\vec{A} = 2.0\hat{i} + 3.0\hat{j}$, vector $\vec{B} = 4.0\hat{j} + 3.0\hat{k}$ and vector $\vec{C} = 5.0\hat{i} - 5.0\hat{k}$, find the value of $(\vec{A}\times\vec{B})\cdot\vec{C}$.

A) 5
B) 4
C) 2
D) 1
E) 7

Ans:

$$\vec{A}\times\vec{B} = (2\,\hat{\imath} + 3\,\hat{\jmath}) \times (4\,\hat{\jmath} + 3\,\hat{k}) = 8\,\hat{k} + 9\hat{\imath} - 6\hat{\jmath}$$

$$(\vec{A}\times\vec{B})\cdot\vec{C} = (9\,\hat{\imath} - 6\,\hat{\jmath} + 8\hat{k})\cdot(5\,\hat{\imath} - 5\,\hat{k}) = 45 - 40 = 5$$

Q10.

Vectors $\vec{A}$ and $\vec{B}$ each have magnitude 10 units. If the magnitude of $(\vec{A}\cdot\vec{B})$ is 50 units. Find the magnitude of $(\vec{A}\times\vec{B})$.

A) 87
B) 55
C) 26
D) 43
E) 38

Ans:

$$|\vec{A}| = 10, |\vec{B}| = 10$$

$$|\vec{A}\cdot\vec{B}| = |A|\,|B|\cos\theta$$

$$50 = 100\cos\theta$$

$$\theta = \cos^{-1}\left(\frac{1}{2}\right) = \frac{\pi}{3}$$

$$|\vec{A}\times\vec{B}| = |A|\,|B|\sin\theta = 100\times\sin\left(\frac{\pi}{3}\right) = 86.6$$

Q11.

A plane traveling east at 200 m/s turns and then travels south at 200 m/s. The magnitude of change in its velocity is:

A) 283 m/s
B) 200 m/s
C) 156 m/s
D) 400 m/s
E) zero

Ans: Considering $\hat{\imath}$ = east and $\hat{\jmath}$ = North

$$v_0 = 200\,\hat{\imath} + 0\hat{\jmath}\,;\, v = 0\hat{\imath} - 200\,\hat{\jmath}$$

$$\Delta v = v - v_0 = -200\,\hat{\jmath} - 200\,\hat{\imath}$$

$$|\Delta v| = \sqrt{200^2 + 200^2} = 282.8 \cong 283\ m/s$$

Q12.

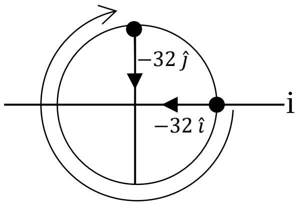
An object is moving on circle in xy-plane with a uniform speed of 8.0 m/s. At time t = 0 its acceleration is –32 m/s$^2\,\hat{\imath}$. If at around t = 1.2 s (approximate time) its acceleration is –32 m/s$^2\,\hat{\jmath}$, which one of the following statements is **TRUE**?

A) The object is going around clockwise direction.
B) The object is going around counter-clockwise direction.
C) The velocity and acceleration of the object are along the same direction.
D) The velocity and position vector of the object are along the same direction.
E) The position vector and acceleration are perpendicular to each other.

Ans:

$$\frac{v^2}{R} = a \Rightarrow \frac{64}{32} = R \Rightarrow 2\ m$$

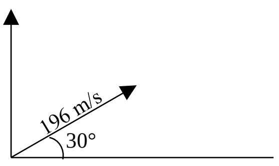
$$T = \frac{2\pi R}{v} = 1.6 \Longrightarrow t = 1.6 \times \frac{3}{4} = 1.2$$



Q13.

A projectile is fired from the leveled ground at an angle of 30.0° above the horizontal with the initial speed of 196 m/s. Find the speed of the projectile when it reaches half of its maximum height. (Ignore air resistance)

A) 183 m/s
B) 155 m/s
C) 109 m/s
D) 132 m/s
E) 267 m/s



Ans: considering x = horizontal and y = vertical

$v_x = 196\cos 30° = 169.7;\ v_{oy} = 196\sin 30° = 98\ m/s$

$v_y = 0$

$$y_{max} = \frac{v_{oy}^2}{2g} = \frac{98 \times 98}{2 \times 9.8} = 490\ m$$

$$y = \frac{490}{2} = 245\ m$$

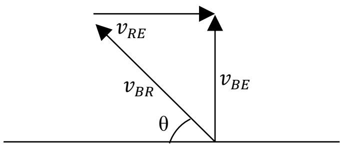
$$v_y^2 = 98^2 - 2 \times 9.8 \times 245 = 69.3\ m/s$$

$$|v| = \sqrt{169.7^2 + 69.32} = 183.3\ m/s$$

Q14.

A 0.20-km wide river has a uniform flow speed of 3.0 m/s toward the east. A boat with a speed of 8.0 m/s relative to the water leaves the south bank and heads in such a way that it crosses to a point directly north of its departure point. How long does it take the boat to cross the river?

A) 27 s
B) 30 s
C) 45 s
D) 60 s
E) 70 s



Ans: considering x = East and y = North

$$v_{BEX} = v_{BRX} + v_{REX}$$

$$0 = v_{BRX} + 3\ m/s \Rightarrow v_{BRX} = -3\ m/s$$

$$-8cos\theta = 3 \Longrightarrow \theta = \cos^{-1}\left(\frac{3}{8}\right)$$

$$v_{BEY} = v_{BRY} + v_{REY}$$

$$v_{BE} = 8\ sin\theta = 7.41$$

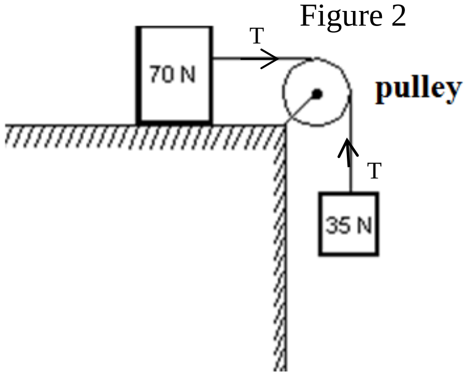
$$t = \frac{200}{7.41} = 27\ s$$

Q15.

A 70 N block and a 35 N block are connected by a massless string as shown in **Figure 2**. If the pulley is massless-frictionless and the surface is frictionless, the magnitude of the acceleration of the 35-N block is

A) 3.3 m/s^2
B) 1.7 m/s^2
C) 4.9 m/s^2
D) 6.5 m/s^2
E) 9.8 m/s^2

Figure 2



Ans:

$$T = \frac{70}{9.8}\,a$$

$$T - 35 = -\frac{35}{9.8}\,a$$

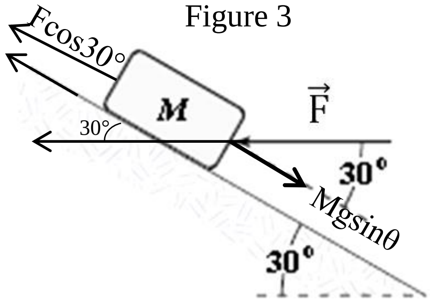
$$\frac{70}{9.8}\,a + \frac{35}{9.8}\,a = 35$$

$$a = \frac{35 \times 9.8}{105} = 3.3$$

Q16.

A block is pushed up a frictionless 30° incline by an applied force $\vec{F}$, which is parallel to the horizontal as shown in **Figure 3**. If the magnitude of $\vec{F}$ is 25 N and M = 3.0 kg, what is the magnitude of the resulting acceleration of the block?

Figure 3



A) 2.3 m/s^2
B) 3.5 m/s^2
C) 6.4 m/s^2
D) 4.8 m/s^2
E) 5.2 m/s^2

Ans:

$$Mgsin\theta - \mathrm{F}\sin 30° = -\mathrm{Ma}$$

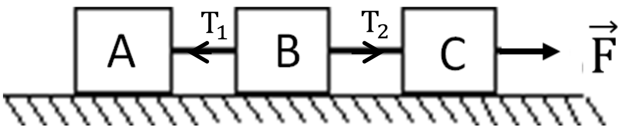
$$\frac{3 \times 9.8 sin30° - 25\cos 30°}{-3} = \mathrm{a}$$

$$\mathrm{a} = 2.31\, m/s$$

Q17.

Three blocks (A, B, C), each having the same mass M, are connected by strings as shown in **Figure 4**. Block C is pulled to the right by a force $\vec{F}$ that causes the entire system to accelerate. Neglecting friction, the net force acting on block B is:

Figure 4



A) $\vec{F}/3$
B) $\vec{F}$
C) $\vec{F}/2$
D) $2\vec{F}/3$
E) zero

Ans:

$$F - T_2 = Ma$$

$$T_2 = F - \frac{F}{3} = \frac{2F}{3}$$

$$T_1 = Ma = \frac{F}{3}$$

$$3MA = a \Rightarrow Ma = \frac{F}{3}$$

$$T_2 - T_1 = \mathrm{F}_{B,Net}$$

$$\Rightarrow \mathrm{F}_{B,Net} = \frac{2F}{3} - \frac{F}{3} = \frac{F}{3}$$

Q18.

A 0.10 kg stone is tied to the end of a 1.0-m long rope. The stone is moved in a circle in the vertical plane with a constant speed. Which one of the following statements is **TRUE**?

A) The magnitude of the tension at the highest point is minimum
B) The magnitude of tension at the lowest point is minimum
C) The magnitude of the tension at the highest point is maximum
D) The magnitude of tension at the lowest point is zero
E) The magnitude of tension is same everywhere

Ans:

A

Q19.

A 2.5 kg block is initially at rest on a horizontal surface. A horizontal force $\vec{F}$ of magnitude 6.0 N and a vertical force $\vec{P}$ are then applied to the block as shown in **Figure 5**. The coefficients of friction for the block and surface are μ_s = 0.40 and μ_k = 0.25. Determine the magnitude of the frictional force acting on the block if the magnitude of $\vec{P}$ is 8.0 N

A) 6.0 N
B) 6.6 N
C) 4.1 N
D) 8.0 N
E) 9.8 N

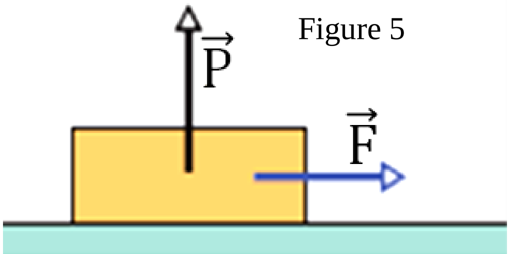


Figure 5

Ans:

$$F_N + \mathrm{P} = \mathrm{mg}$$

$$F_N = mg - P = 2.5 \times 9.8 - 8 = 16.5\ N$$

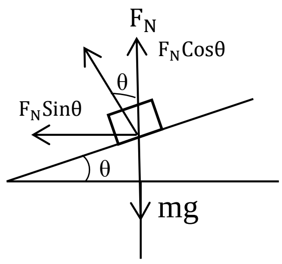
$$f_{s,max} = \mu_s F_N = 16.5 \times 0.4 = 6.6\ N$$

$$f_{s,max} > F, So, f_s = 6N$$

Q20.

At what angle should the circular roadway of 50 m radius, be banked to allow cars to round the curve without slipping at 12 m/s? (Ignore friction)

A) 16°
B) 10°
C) 33°
D) 27°
E) 90°



Ans:

$$\frac{F_N sin\theta}{F_N cos\theta} = \frac{mv^2}{Rmg}$$

$$Tan\theta = \frac{v^2}{Rg} \Rightarrow \theta = \tan^{-1}\left(\frac{12 \times 12}{50 \times 4.8}\right) = 16.3°$$