Q1.

The volume V of an object as a function of time is calculated by V = (A/B) t^4 + Bt, where t is measured in seconds and V is in cubic meters. Determine the dimension of the constant A.

A) $L^6 T^{-5}$
B) $L^{-5} T^6$
C) $L^{-1} T^3$
D) $L^{-3} T^4$
E) $L^3 T^{-1}$

Ans:

$$[B] = \frac{[V]}{[t]} = L^3T^{-1};\ [A] = \frac{[V]\times[B]}{[t^4]} = \frac{L^3\times L^3T^{-1}}{T^4}$$

$$[A] = L^6T^{-5}$$

Q2.

Copper has a density of 8.96 g/cm3, and the mass of a copper atom is 1.06×10^{-25} kg. If the atoms are spherical and tightly packed, what is the radius of a copper atom?

A) 1.41×10^{-10} m
B) 2.41×10^{-11} m
C) 5.44×10^{-10} m
D) 7.45×10^{-10} m
E) 3.41×10^{-9} m

Ans:

$$\rho = \frac{m}{V} = \frac{m}{\frac{4\pi}{3}R^3} \Rightarrow R = \left(\frac{m}{\frac{4\pi}{3}\rho}\right)^{\frac{1}{3}}$$

$$R = \left(\frac{3}{4\pi}\times\frac{1.06\times10^{-25}}{8.96\times10^{-3}}\right)^{\frac{1}{3}} = 1.41\times10^{-10}m$$

Q3.

A ball is thrown vertically upwards with an initial velocity of 20 m/s. It takes 4.0 s for the ball to come back to its original position. What is the magnitude of the average velocity of the ball for the whole trip? (Neglect air resistance)

A) 0.0 m/s
B) 10 m/s
C) 4.0 m/s
D) 2.0 m/s
E) 5.0 m/s

Ans:

$$v_{avg} = \frac{\Delta y}{\Delta t} = \frac{y_f - y_i}{\Delta t} = 0(y_f = y_i)$$

Q4.

The position of a particle moving along an x-axis is given by x = 6.00 t^2 – 3.00 t^3, where x is in meters and t is in seconds. What is the acceleration of the particle at its maximum x-position?

A) – 12.0 m/ s^2
B) 15.1 m/ s^2
C) – 11. 2 m/ s^2
D) 9. 51 m/ s^2
E) –19. 5 m/ s^2

Ans:

For max. x-position $v_x = 0$ $but\ v_x = \frac{dx}{dt} = 12\ t - 9t^2$

If $v_x = 0$ then $12t - 9t^2 = 0 \Rightarrow 4 - 3t = 0 \Longrightarrow t = \frac{4}{3} = 1.33\,\text{sec} \Rightarrow time\ for\ v_x = 0$

$$a_x = \frac{d^2x}{dt^2} = 12 - 18t$$

$$a_x(t = 1.33\ sec) = 12 - 18 \times 1.33 = -11.99\ m/s^2 \ \cong -12.0\ m/s^2$$

Q5.

A particle is moving along an x-axis with a constant acceleration of –3.0 m/s^2. The velocity of the particle is given by the equation *v* (t) = 4.0 – 3.0t, where *v* is in m/s and t is in seconds. Find the displacement of the particle during the time interval t = 0 to t = 2.0 s.

A) 2.0 m
B) 2.8 m
C) 1.4 m
D) 3.1 m
E) 7.7 m

Ans:

$$v_f^2 = v_i^2 + 2a\Delta x \Rightarrow \Delta x = \frac{v_f^2 - v_i^2}{2a};\ v_f = v(t = 2.0\ s);\ v_i = v(t = 0\ s)$$

$$v_f(t = 2.0) = 4.0 - 3t = 4 - 6 = -2m/s$$

$$v_i(t = 0) = 4$$

$$\Delta x = \frac{(-2)^2 - (4)^2}{2 \times (-3.0)} = \frac{-12}{-6.0} = 2.0\ m$$

Q6.

A stone is thrown vertically upwards with an initial speed of 4.0 m/s from a window which is 8.0 m above the ground. With what speed will the stone hit the ground? (Neglect air resistance)

A) 13 m/s
B) 1.0 m/s
C) 4.0 m/s
D) 22 m/s
E) 12 m/s

Ans:

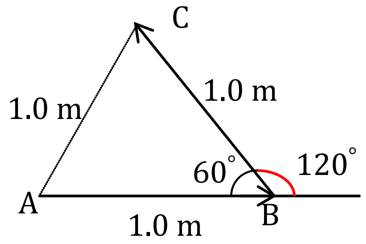
$$v_{fy}^2 = v_{iy}^2 - 2|g|y = (-4)^2 - 2 \times 9.8 \times (-8) = 172.8\ \frac{m^2}{s^2}$$

$$v_{fy} = \sqrt{172.8} = 13.14\ m/s \text{ vertically downward}$$

Q7.

Initially an object moves 1.00 m in a straight-line from point A to point B. Then, it changes direction and moves another 1.00 m in a straight-line until it reaches point C. Point C is at a distance of 1.00 m from point A. Through what angle did the object changes its direction with respect to its initial direction of motion?

A) 120°
B) 70.0°
C) 100°
D) 135°
E) 140°



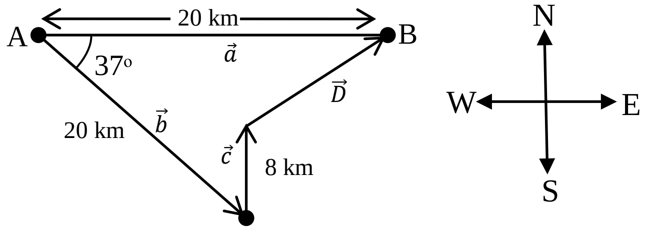
Ans:

A

Q8.

Oasis B is 20 km due east of oasis A. Starting from Oasis A, a camel walks 20 km in a direction 37° south of east and then walks 8.0 km due north. How far is the camel then from oasis B?

A) 5.7 km
B) 4.0 km
C) 6.6 km
D) 2.7 km
E) 1.4 km



Ans:

$$\vec{D} = \vec{a} - \vec{b} - \vec{c}$$

$$= 20\vec{\imath} - b\cos 37°\vec{\imath} + b\sin 37°\vec{\jmath} - c\vec{\jmath}$$

$$= 20\vec{\imath} - 15.97\vec{\imath} + 12.04\vec{\jmath} - 8\vec{\jmath}$$

$$\vec{D} = 4.03\vec{\imath} + 4.04\vec{\jmath} \Rightarrow |D| = \sqrt{(4.03)^2 + (4.04)^2} = 5.7\ km$$

Q9.

Vector $\vec{A}$ has a magnitude of 5.0 units and vector $\vec{B}$ has a magnitude of 10 units. Which of the following values is not possible for the scalar product of vectors $\vec{A}$ and $\vec{B}$?

A) 55
B) 45
C) 35
D) Zero
E) 25

Ans:

$|A.B|_{max} = 50; |A.B|_{min} = 0$

Q10.

Vector $\vec{A} = 1.00\hat{i} + 3.00\hat{j}$, vector $\vec{B} = 4.00\hat{i} - 1.00\hat{j}$ and the vector $\vec{C} = 2.00\hat{k}$. Find the angle (in degrees) between vector $\vec{A}$ and vector $\vec{B} \times \vec{C}$.

A) 176
B) 103
C) 76.0
D) 1.1
E) 24.0

Ans:

$$\vec{D} = \vec{B} \times \vec{C} \text{ then angle between } \vec{A} \text{ and } \vec{D} = \theta = \cos^{-1}\left(\frac{A_x D_x + A_y D_y}{|A||B|}\right)$$

$$\vec{D} = \vec{B} \times \vec{C} = (4\vec{i} - 1.0\vec{j}) \times 2\vec{k} = -8\vec{j} - 2\vec{i}$$

$$|D| = \sqrt{68} = 8.25; \ |A| = \sqrt{10} = 3.16$$

$$\theta = \cos^{-1}\left(\frac{-2 - 24}{8.25 \times 3.16}\right) = 175.8° \cong 176°$$

Q11.

A soccer ball is kicked from the ground and follows a parabolic path before landing on the ground. Which one of the following statements is **True**? (Neglect air resistance)

A) The horizontal component of the velocity of the ball is the same throughout its flight
B) The acceleration of the ball decreases as the ball moves upward
C) The velocity of the ball is zero when the ball is at its maximum height
D) The acceleration of the ball is zero when the ball is at its maximum height
E) The vertical component of the velocity of the ball is zero just before hitting the ground

Ans:

A

Q12.

A particle starts from the origin at $t = 0$ with a velocity of (6.0 m/s) $\hat{i}$ and moves in the xy plane with a constant acceleration of (–2.0 m/s^2) $\hat{i}$ + (4.0 m/s^2) $\hat{j}$. At the instant the particle reaches its maximum positive x-coordinate, what is its corresponding y-coordinate?

A) 18 m
B) 36 m
C) 11 m
D) 27 m
E) 15 m

Ans:

At maximum positive x-coordinate, $v_{fx} = 0 \; but \; v_{fx} = v_{ix} + a_x t$

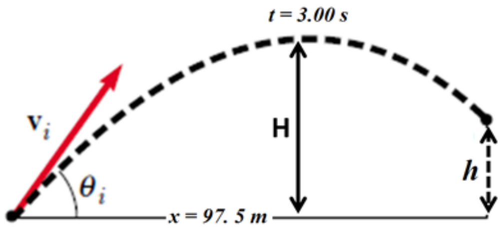
$Then \; v_{fx} = 0 = 6 - 2.0\,t \;\Rightarrow at\; t = 3\; sec;\; and\; corresponding\; y - coordinate\; is:$

$$y = v_{iy} + \frac{1}{2}a_y t^2 = 0 + \frac{1}{2} \times 4 \times (3)^2 = 18.0\, m$$

Q13.

A baseball is hit at ground level as shown in **Figure 1**. The ball is observed to reach its maximum height above ground level 3.00 s after being hit. And 2.50 s after reaching this maximum height, the ball is observed to barely clear a fence of height h that is at a horizontal distance of 97.5 m from the point where it was hit. What is the height h of the fence? (Neglect air resistance)

Figure 1



A) 13.5 m
B) 30.6 m
C) 2.80 m
D) 44.1 m
E) 4.90 m

Ans:

At t = 3.00 s ; $v_{iy} = 0$

For downward motion:

$$Height\; H = v_{iy}t - \frac{1}{2}|g|t^2 - \frac{1}{2}|g|t^2$$

$$H = -\frac{1}{2} \times 9.8 \times (3)^2 = -44.1\, m$$

$$H - h = v_{iy}t - \frac{1}{2}|g|t^2 = -\frac{1}{2}|g|t^2$$

$$H - h = -\frac{1}{2} \times 9.8 \times (2.5)^2 = -30.63\, m$$

$$h = H + 30.63 = -44.1 + 30.63$$

$$h = -13.47$$

$$|h| = 13.47 = 13.5\, m$$

Q14.

A star with a diameter of 40.0 km rotates about its central axis making two revolutions per second. What is the speed (km/s), of an object on the star's equator?

A) 251
B) 628
C) 400
D) 100
E) 450

Ans:

$T = 0.5\ sec$

$$v = \frac{2\pi R}{T} = \frac{2\pi \times 20 \times 10^3}{0.5} = 251327.4\ m/s = 2.51 \times 10^2\ km/s$$

Q15.

A boat is traveling upstream towards the east at 10 km/h with respect to the water of a river. The water is flowing at 5.0 km/h with respect to the ground. A man on the boat walks from front to rear at 3.0 km/h with respect to the boat. What are the magnitude and direction of the man's velocity with respect to the ground?

A) 2.0 km/h, towards the east
B) 2.0 km/h, towards the west
C) 8.0 km/h, towards the east
D) 12 km/h, towards the east
E) 18 km/h, towards the west

Ans:

$v_{mg} = v_{mb} + v_{bw} + v_{wg}$

$= -3 + 10 - 5$

$v_{mg} = +2\ km/h$