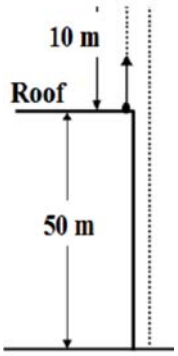
Q5. An object is thrown vertically upward from the roof of a building that is 50 m high. It rises to a maximum height of 10 m above the roof (**Figure 1**). When is it 20 m below the roof? Ans: 3.9 s

Figure 1



Answer:

Take the launch point as the origin and the upward direction is positive:

First: Calculate the initial velocity:

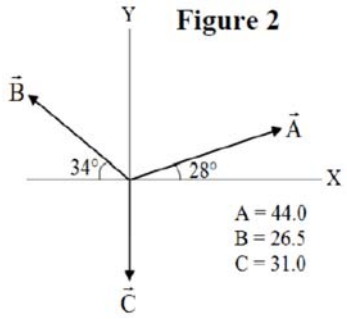
$$v_f^2 = v_i^2 + 2(-g)(10-0) \quad \Rightarrow \quad v_i = \sqrt{20\times 9.8} = 14 \text{ m/s}$$

Then, calculate the time to reach -20 m from the top of the building:

$$x_f - 0 = v_i t + \frac{1}{2}(-g)t^2 \quad \Rightarrow \quad -20 = (-14)t - 4.9t^2 \Rightarrow t = 3.9 \text{ s}$$

Q7. For the three vectors ($\vec{A}$, $\vec{B}$, $\vec{C}$) shown in **Figure 2**, find $\vec{C}\times(\vec{B}\times\vec{A})$. Ans: $3.19\cdot 10^4(-\hat{i})$

Figure 2



Answer:

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & 0 \\ B_x & B_y & 0 \end{vmatrix} = \left(A_xB_y - B_xA_y\right)\hat{k}$$

$$\begin{aligned} \vec{C}\times\left(\vec{A}\times\vec{B}\right) &= -C_y\hat{j}\times\left(A_xB_y - B_xA_y\right)\hat{k} \\ &= C_y\left(A_xB_y - B_xA_y\right)(-\hat{i}) \\ &= (31)\left[44.0*\cos(28^\circ)*26.5\text{Sin}(34^\circ) - \{-26.5*\cos(34^\circ)\}*44.0\cdot\sin(28^\circ)\right](-\hat{i}) \\ &= 3.19\cdot 10^4(-\hat{i}) \end{aligned}$$

Q8. What is the angle between two vectors $\vec{A} = 20\,\hat{i}$ and $\vec{B} = -25\,\hat{i} + 30\,\hat{j}$?

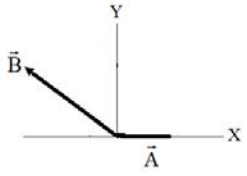
Ans: 130°

Answer:

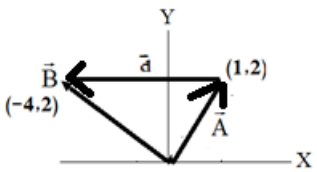
$$\vec{B}\cdot\vec{A} = \vec{A}\cdot\vec{B} = \left|\vec{B}\right|\left|\vec{A}\right|\cos\theta$$

$$\Rightarrow \cos\theta = \frac{A_xB_x + A_yB_y + A_zB_z}{\left|\vec{B}\right|\left|\vec{A}\right|} = \frac{(20)(-25)+(0)(3)+(0)(0)}{781} = -\frac{500}{781}$$

$$\Rightarrow \theta = \cos^{-1}(0.64) \approx 130^\circ$$



Q9. A body moves from a position with coordinates (1.0, 2.0) m to (– 4.0, 2.0) m. Its displacement vector is given by: Ans: 5.0 m at 180°



Answer:

$$\vec{r}_A = \hat{i} + 2\,\hat{j}, \quad \vec{r}_B = -4\hat{i} + 2\,\hat{j} \quad \Rightarrow \quad \vec{d} = \vec{r}_B - \vec{r}_A = \left(-5.0\,\hat{i} + 0\,\hat{j}\right) \text{ m}$$

$\Rightarrow$ $\vec{d}$ makes an angle of 180° and has a magnitude of 5.0 m.

Q13. A particle undergoes counterclockwise uniform circular motion around a circle of radius 5.0 m with a period of 3.2 s, as shown in **Figure 3**. In a quarter of a period, as the particle moves from A to B, what is the magnitude of the average velocity of the particle? Ans: 8.8 m/s

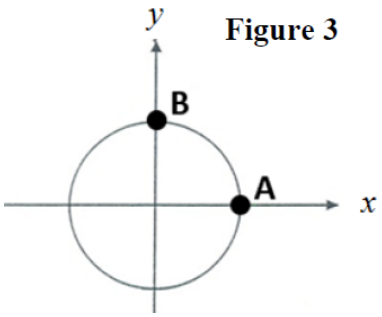


Figure 3

Answer:

Define the coordinates of each point as:

$$\vec{r}_A = 5.0\,\hat{i}, \quad \vec{r}_B = 5.0\,\hat{j}$$

Then calculate the displacement $\vec{d}$:

$$\vec{d} = \vec{r}_B - \vec{r}_A = \left(5.0\,\hat{j} - 5.0\,\hat{i}\right) \text{ m}$$

Note that the time travelling from A to be is $\Delta T = \frac{T}{4} = \frac{3.2}{4} = 0.8$ s, which is equal to the fourth of the periodic time.

Consequently,

$$\vec{v}_{average} = \frac{\vec{d}}{\Delta T} = \left(6.25\,\hat{j} - 6.25\,\hat{i}\right) \text{ m/s} \Rightarrow \left|\vec{v}_{average}\right| = 8.8 \text{ m/s}$$

Q19. Which of the following statements is **TRUE**?

a) A particle can be in equilibrium and yet moving.
b) A stone that has been thrown vertically upward reverses its acceleration as it reaches the top of its trajectory.
c) Two vectors of unequal magnitudes can add up to zero.
d) On a displacement-time graph, a straight line with positive slope indicates motion at increasing speed.
e) The action and reaction forces act on the same object.

Q20. Which of the following statements is **TRUE**?

a) A car can be accelerating while moving at constant speed.
b) If an object is released from rest, it falls 9.8 m during the first second of its motion.

c) The velocity of a projectile equals its initial velocity added to a constant horizontal velocity.
d) A particle can move with uniform velocity along a circular path.
e) The velocity of a projectile at the top of its trajectory is zero.