Q1.

The velocity of a particle is time dependent and is given by the equation:

$v = At^2 + \frac{B}{A}$. Where, *t* is time and *A* and *B* are unknown quantities. Find the dimension of *B*.

A) L^2/T^4
B) T/L
C) T^3/L^3
D) L/T^4
E) L^2T^2

Ans:

$$At^2 = v \Rightarrow At^2 = \frac{L}{T} \Rightarrow A = \frac{L}{T^3}$$

$$\frac{B}{A} = \frac{L}{T} \cdot A \Rightarrow B = \frac{L}{T} \cdot \frac{L}{T^3}$$

$$\therefore B = \frac{L^2}{T^4}$$

Q2.

When can we be certain that the average velocity of an object is always equal to its instantaneous velocity?

A) only when the velocity is constant
B) never
C) always
D) only when the acceleration is constant
E) only when the acceleration is changing at a constant rate

Ans:

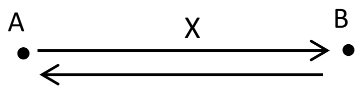
A

Q3.

A person walks first at a constant speed of 18.0 km/h along a straight line from point A to point B and then back along the line from B to A at a constant speed of 10.8 km/h. The values of **average velocity** and **average speed** over the entire trip are **respectively**:

A) 0 and 3.75 m/s
B) 3.75 m/s and 4.25 m/s
C) 4.00 m/s and 0
D) 0 and 1.35 m/s
E) 2.67 m/s and 2.67 m/s

Ans:



$$v_0 = \frac{18 \times 1000}{60 \times 60} = 5\ \text{m/s}$$

$$v = \frac{10.8 \times 1000}{60 \times 60} = 3\ \text{m/s}$$

$$\text{Average velocity} = \frac{\Delta x}{\Delta t} = \frac{x - x}{\Delta t} = 0\ \ \text{m/s}$$

$$\text{Average speed} = \frac{x + x}{t_0 + t} = \frac{2x}{\frac{x}{v_0} + \frac{x}{v}} = \frac{2x}{\frac{x}{5} + \frac{x}{3}} = \frac{2 \times 15}{8}$$

$$\therefore \text{Average speed} = \frac{15}{4} = 3.75\ \text{m/s}$$

Q4.

Starting from the origin, a body moves from rest along the positive x-axis. It accelerates with 6.00 m/s^2 for the first 4.00s, and then travels with constant speed for another 4.00s. The total distance covered by the particle is:

A) 144 m
B) 319 m
C) 96.5 m
D) 912 m
E) 588 m

Ans:

$$v_1 = v_{01} + at_1$$

$$v_1 = 0 + 6 \times 4 \ \Rightarrow v_1 = 24\ \text{m/s}$$

$$x_1 = v_{01}t + \frac{1}{2}at_1 = 0 + \frac{1}{2} \times 6 \times 4^2 = 48\ \text{m}$$

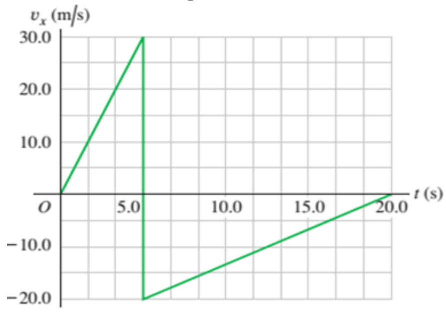
$$x_1 = v_2 t_2 = v_1 t_2 = 24 \times 4 = 96\ \text{m}$$

$$\therefore x = \ x_1 + x_2 = 48 + 96 = 144\ \text{m}$$

Q5.

A rigid ball traveling in a straight line along the positive *x*-axis hits a solid wall and suddenly rebounds during a brief instant. The ball's velocity as a function of time is shown in **Figure 1**. Find the displacement of the ball for the first 20.0s.

Figure 1



A) -75.0 m
B) 150 m
C) 25.0 m
D) -150 m
E) 325 m

Ans:

$$\overrightarrow{\Delta X} = \text{Area under the curve}$$

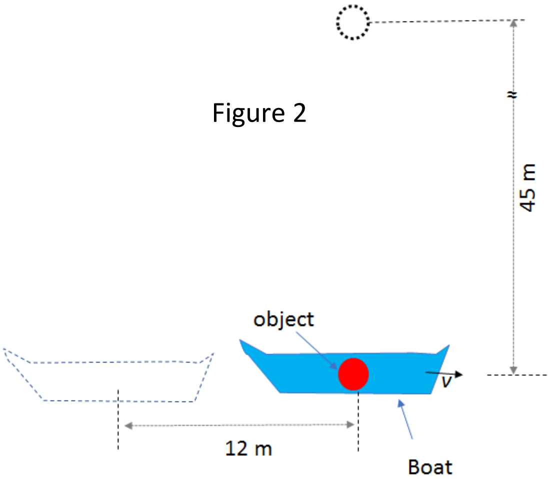
$$= \frac{1}{2} \times 5 \times 30 + \frac{1}{2} \times (20-5)(-20) = 75 - 150$$

$$\overrightarrow{\Delta X} = -75 \text{ m}$$

Q6.

An object falls from a bridge that is 45 m above the water. It falls directly into a small boat, moving with constant speed *v* as shown in **Figure 2**. The boat was 12 m away from the point of impact (the point at which the object falls on the boat) when the object was released. What is the speed *v* of the boat? [Ignore air resistance.]

Figure 2



A) 4.0 m/s
B) 8.0 m/s
C) 6.0 m/s
D) 5.0 m/s
E) 2.5 m/s

Ans:

Object Motion

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

$$-45 = 0 + \frac{1}{2}(-9.8)t^2$$

$$t = \sqrt{\frac{90}{9.8}}$$

Boat Motion

$$v = \frac{x}{t} = \frac{12}{\sqrt{\frac{90}{9.8}}} = 4.0 \text{ m/s}$$

Q7.

A horse in an open field runs 12.0 m east and then 28.0 m in a direction 50.0° west of north. How far and in what direction must the horse then run to end up 10.0 m south of its original starting point?

A) 29.6 m and 18.6° east of south
B) 33.0 m and 18.6° east of south
C) 28.0 m and 28.6° east
D) 42.0 m and 28.6° south
E) 39.0 m and 18.6° east of south

Ans:

$12\ \mathrm{m} - 28\sin 50° + x = 0$

$x = -12 + 28\sin 50° = 9.45\ \mathrm{m}$

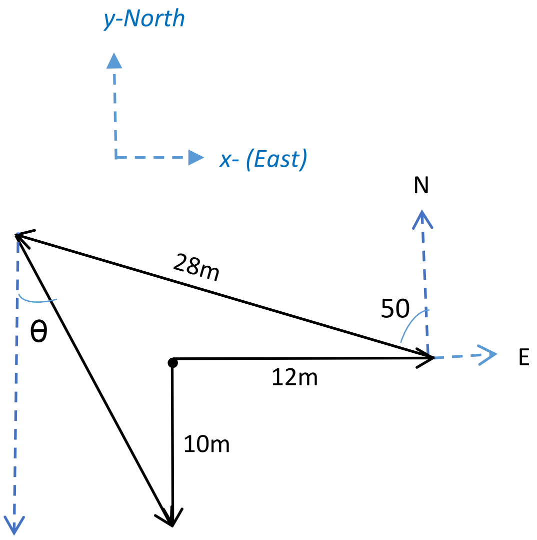
$0 + 28\cos 50° + y = -10$

$y = -10 - 28\cos 50° = -28.0\ \mathrm{m}$

$\vec{r} = 9.45\,\hat{i} - 28.0\,\hat{j}$

$|\vec{r}| = \sqrt{9.45^2 + (-28)^2} = 29.6\ \mathrm{m}$

$\theta = \tan^{-1}\left(\frac{9.45}{28}\right) = 18.6°$



Q8.

Consider two non-zero vectors $\vec{A}$ and $\vec{B}$. If $|\vec{A}-\vec{B}| = |\vec{A}| + |\vec{B}|$, then:

A) $\vec{A}$ and $\vec{B}$ are parallel and in the opposite direction
B) $\vec{A}$ and $\vec{B}$ are parallel and in the same direction
C) the angle between $\vec{A}$ and $\vec{B}$ is 45°
D) the angle between $\vec{A}$ and $\vec{B}$ is 60°
E) $\vec{A}$ is perpendicular to $\vec{B}$

Ans:

A

Q9.

Consider vectors $\vec{A}=5.0\hat{i} - 6.5\hat{j}$ and $\vec{B}= -3.5\hat{i} + 7.0\hat{j}$. A third vector $\vec{C}$ lies in the *xy*-plane and is perpendicular to the vector $\vec{A}$. If the scalar product of $\vec{C}$ with $\vec{B}$ is 15.0, find the vector $\vec{C}$.

A) $8.0\hat{i} + 6.1\hat{j}$
B) $3.0\hat{i} + 4.3\hat{j}$
C) $7.2\hat{i} + 1.4\hat{j}$
D) $1.0\hat{i} + 1.0\hat{j}$
E) $4.5\hat{i} + 9.3\hat{j}$

Ans:

$$\vec{C} = C_X\hat{\imath} + C_y\hat{\jmath}$$

$$\vec{A}\cdot\vec{C} = 0$$

$$5C_X - 6.5C_y = 0$$

$$C_X = \frac{6.5}{5}C_y = 1.3\ C_y$$

$$\vec{C}\cdot\vec{B} = 15\ \Rightarrow -3.5C_X + 7C_y = 15$$

$$-3.5\times 1.3C_y + 7C_y = 15 \Rightarrow 2.45C_y = 15 \Rightarrow C_y = 6.1$$

$$C_X = \ 1.5\times 3.1 = 8.0$$

Q10.

Vector $\vec{A}$ has magnitude of 12.0 units and vector $\vec{B}$ has magnitude 16.0 units. If $\vec{A}.\vec{B}$ = 90.0 units, what is the magnitude of the vector product between these two vectors?

A) 170
B) 180
C) 120
D) 140
E) 130

Ans:

$$|\vec{\mathrm{A}}||\vec{\mathrm{B}}|\cos\theta = 90 \Rightarrow 12\times 16\cos\theta = 90$$

$$\theta = \cos^{-1}\left(\frac{90}{12\times 16}\right) = 1.08\ \mathrm{rad}$$

$$|\vec{\mathrm{A}}\times\vec{\mathrm{B}}| = |\mathrm{A}||\mathrm{B}|\cos\theta$$

$$|\vec{\mathrm{A}}\times\vec{\mathrm{B}}| = 12\ \times 16\cos\theta = 170$$

Q11.

A particle moves so that its position (in meters) as a function of time (in seconds) is: $\vec{r} = 3.0t^2\,\hat{i} + 2.0t^3\,\hat{j} + 5.0t\,\hat{k}$. Find the magnitude of average acceleration for the interval t = 0 s to t = 3.0 s.

A) 19 m/s^2
B) 27 m/s^2
C) 6.0 m/s^2
D) 12 m/s^2
E) 8.1 m/s^2

Ans:

$$\vec{r}(t) = 3t^2\hat{i} + 2t^3\hat{j} + 5t\hat{k}$$

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = 6t\hat{i} + 6t^2\hat{j} + 5\hat{k}$$

$$\vec{a} = \frac{v(3) - v(0)}{3 - 0} = \frac{18\hat{i} + 54\hat{j} + 5\hat{k} - 5\hat{k}}{3}$$

$$\vec{a} = 6\hat{i} + 18\hat{j} \Rightarrow |\vec{a}| = \sqrt{6^2 + 18^2} = 19\ \text{m/s}^2$$

Q12.

A particle starts from the origin at time t = 0 s with a velocity $\vec{v} = 7.0\hat{i}$ m/s. It moves in the xy-plane with a constant acceleration $\vec{a} = (-9.0\,\hat{i} + 3.0\,\hat{j}\,)$ m/s^2. At the time the particle reaches the maximum x-coordinate, what is its position vector?

A) $(2.7\,\hat{i} + 0.91\,\hat{j}\,)$ m
B) $(3.5\,\hat{i} + 1.1\,\hat{j}\,)$ m
C) $(-9.0\,\hat{i} + 3.0\,\hat{j}\,)$ m
D) $7.0\,\hat{i}$ m
E) $(2.7\,\hat{i} + 3.0\,\hat{j}\,)$ m

Ans:

$$v_x = v_{0x} + a_x t$$

$$0 = 7 - 9t \Rightarrow t = \frac{7}{9}\,\text{s}$$

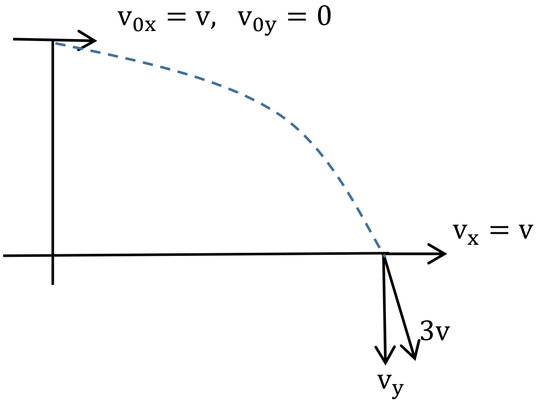
$$x = v_{0x}t + \frac{1}{2}at^2 = 7 \times \frac{7}{9} + \frac{1}{2} \times (-9) \times \frac{7^2}{9^2} = 2.7\ \text{m}$$

$$y = v_{0y}t + \frac{1}{2}a_y t^2 = 0 + \frac{1}{2} \times 3 \cdot \frac{7^2}{9^2} = 0.91\ m$$

Q13.

A ball is thrown horizontally from a height of 26 m and hits the ground with a speed that is three times its initial speed. What is the initial speed of the ball? [Ignore air resistance.]

A) 8.0 m/s
B) 3.0 m/s
C) 11 m/s
D) 26 m/s
E) 5.3 m/s



Ans:

$$v_x^2 + v_y^2 = (3v)^2$$

$$v^2 + v_y^2 = 9v^2 \Rightarrow v_y^2 = 9v^2 - v^2$$

$$v_y^2 = 8v^2$$

Vertical Motion:

$$v_y^2 = v_0^2 + 2a\Delta g$$

$$8v^2 = 0 + 2(-9.8)(-26)$$

$$v = \sqrt{\frac{2 \times 9.8 \times 26}{8}} = 8.0 \text{ m/s}$$

Q14.

A particle undergoes a uniform circular motion. Which one of the following statements is **False** in regards to the particle and its motion?

A) The velocity is constant.
B) The velocity and acceleration are always perpendicular to each other.
C) The acceleration is always directed towards the center.
D) The magnitude of change in velocity in half time-period is two times the speed.
E) The displacement for half time-period is maximum.

Ans:

A

Q15.

A person walks up a stalled (not moving) escalator of length L in 90 s. When standing on the same escalator, now moving, the person is carried up in 60 s. How much time would it take that person to walk up the moving escalator?

A) 36 s
B) 25 s
C) 46 s
D) 57 s
E) 19 s

Ans:

$$v_{PE} = \frac{L}{90}$$

$$v_{EG} = \frac{L}{60}$$

$$v_{PE} = v_{PG} - v_{EG}$$

$$v_{PG} = v_{PG} + v_{EG} = \frac{L}{90} + \frac{L}{60}$$

$$v_{PG} = \frac{2L + 3L}{180} = \frac{5L}{180}$$

$$\therefore t = \frac{L}{v_{PG}} = \frac{L \times 180}{5L} = 36\ s$$