Q1.

Consider two uniform solid spheres A and B made of the same material and having radii r_A and r_B, respectively. Find the ratio r_B / r_A if the mass of sphere B is five times the mass of sphere A.

A) 1.7
B) 2.2
C) 2.7
D) 1.2
E) 3.3

Ans:

$$m_B = 5m_A$$

$$\rho V_B = 5\rho V_A \Rightarrow \frac{4\pi}{3} R_B{}^3 = 5\,\frac{4\pi}{3} R_A{}^3$$

$$R_B = (5)^{\frac{1}{3}} R_A$$

$$\frac{R_B}{R_A} = 5^{\frac{1}{3}} = 1.71$$

Q2.

The position x of a particle is given by

$$x = Rt^3 + \frac{H}{R}t^2$$

where x is in meters and t is in seconds. The dimension of H is

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

Ans:

$$[H] = \frac{L \times [R]}{T^2}, [R] = \frac{L}{T^3} = LT^{-3}$$

$$= \frac{L \times LT^{-3}}{T^2} = L^2T^{-5}$$

Q3.

The velocity of a train is 80.0 km/h , due west. One and a half hour later its velocity decreases to 65.0 km/h, due west. What is the train's average acceleration ?

A) 10.0 km/h^2 due east
B) 10.0 km/h^2 due west
C) 43.3 km/h^2 due west
D) 43.3 km/h^2 due east
E) 53.3 km/h^2 due east

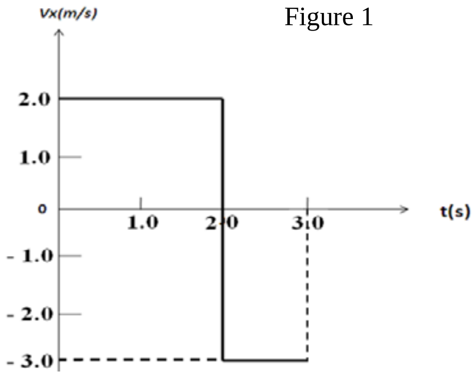
Ans:

$$a_{avg} = \frac{65 - 80}{1.5} = -10\ \text{km/h}^2 \text{ due west}$$

Q4.

A ball moves in a straight line along the x-axis and **Figure 1** shows its velocity as a function of time t. What is the ball average velocity and average speed, respectively, over a period of
3.00 s.

Figure 1



A) 0.330 m/s, 2.33 m/s
B) 2.33 m/s , 0.330 m/s
C) 2.33 m/s , 2.33 m/s
D) 1.66 m/s, 2.33 m/s
E) 2.33 m/s, 1.66 m/s

Ans:

$$\text{Average Velocity} = \frac{\Delta x}{\Delta t} = \frac{2 \times 2 - 1 \times 3}{3}$$

$$= \frac{4 - 3}{3} = 0.330\ \text{m/s}$$

$$\text{Average Speed} = \frac{\Delta s}{\Delta t} = \frac{2 \times 2 + 1 \times 3}{3}$$

$$= \frac{7}{3} = 2.33\ \text{m/s}$$

Q5.

The position of an object moving along the *x*-axis is given by $x = 6.0 + 6.0\,t - 3.0\,t^2$, where *x* is in meters and *t* in seconds. Which statement about this object is ***correct***?

A) The object is momentarily at rest at $t = 1.0$ s.
B) The object position is negative at t = 0 s.
C) The acceleration of the object is zero at t = 0 s.
D) The acceleration of the object is positive at all times.
E) The object is momentarily at rest at t = 2.0 s.

Ans:

$x = 6 + 6t - 3t^2 \mathrm{m}$

$v = \frac{dx}{df} = 6 - 6t\ \mathrm{m/s}$

$\text{For } v = 0\,, 6 - 6t = 0, \text{Then } v = 0, \text{at } t = 1 \text{ sec}$

$a = \frac{dv}{dt} = -6\ \mathrm{m/s^2}$

$x(t = 0) = +6.0\ \mathrm{m}$

Q6.

A rock is thrown vertically upward from ground level at time *t* =0.0 s. At *t* =1.5 s it passes the top of a tall tower, and then 1.0 s later it reaches its maximum height. What is the height of the tower?

A) 26 m
B) 62 m
C) 36 m
D) 16 m
E) 20 m

Ans:

$\text{Tower Height } H = v_{iy}t - \frac{1}{2}gt^2$

$\text{but } v_{fy} = v_{iy} - gt$

$\text{for maximum heigh } v_{fy} = 0, \text{and } t = 1.5 + 1.0 = 2.5 \text{ sec}$

$\text{then } v_{iy} = g \times t = 9.8 \times 2.5 = 24.5\ \mathrm{m/s}$

$H = v_{iy}t - \frac{1}{2}gt^2$

$v_{iy} = 24.5\ \mathrm{m/s}, t = 1.5 \text{ sec}$

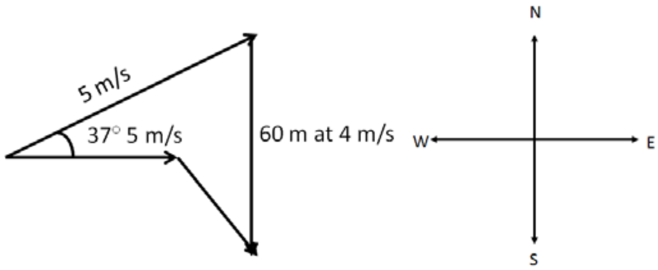
$H = 24.5 \times 1.5 - \frac{1}{2} \times 9.8 \times (1.5)^2$

$H = 25.7\ \mathrm{m} = 26\ \mathrm{m}$

Q7.

A man walks 50 m in a direction 37° north of east at 5.0 m/s, then 60 m south at 4.0 m/s. How long would it take him to get back to his starting point at 5.0 m/s by the shortest path?

A) 10 s
B) 15 s
C) 20 s
D) 5.0 s
E) 3.5 s



Ans:

$$\Delta x = 50\cos 37 = 39.9 \text{ m}$$

$$\Delta y = 50\sin 37 - 60 = 30.09 - 60 = -29.9$$

$$r = \sqrt{(\Delta x)^2 + (\Delta y)^2} = 49.9 \text{ m}, t = \frac{r}{v} = \frac{49.9}{5} = 9.98 \text{ sec}$$

Q8.

Vector $\vec{A}$ has a magnitude of 35.0 m and makes an angle of 37.0° with the positive x axis. Find a vector $\vec{B}$ that is in the direction opposite to vector $\vec{A}$ and is one fifth the magnitude of $\vec{A}$.

A) $-(5.59 \text{ m})\ \hat{i} - (4.21\text{m})\ \hat{j}$
B) $(5.59 \text{ m})\ \hat{i} + (4.21 \text{ m})\ \hat{j}$
C) $(0.798 \text{ m})\ \hat{i} - (0.602 \text{ m})\ \hat{j}$
D) $-(1.56 \text{ m})\ \hat{i} - (5.06 \text{ m})\ \hat{j}$
E) $-(0.798 \text{ m})\ \hat{i} + (0.602 \text{ m})\ \hat{j}$

Ans:

$$\vec{B} = -\frac{\vec{A}}{5}$$

$$\vec{A} = 35\cos 37\vec{\imath} + 35\sin 37\vec{\jmath}$$

$$\vec{A} = 27.95\vec{\imath} + 21.06\vec{\jmath}$$

$$\vec{B} = -\frac{1}{5}(27.95\vec{\imath} + 21.06\vec{\jmath})$$

$$= -5.59\vec{\imath} - 4.21\vec{\jmath}$$

Q9.

If $\vec{A} = 2\hat{i} + 3\hat{j}$, $\vec{B} = \hat{i} - \hat{j}$ and $\vec{C} = \hat{i} + \hat{j}$, find $(\vec{A} \times \vec{B}) \cdot \vec{C}$.

A) 0
B) –6
C) +6
D) $-3\hat{k}$
E) $+2\hat{i}$

Ans:

$C = \vec{i} + \vec{j}$; $\vec{D} = \vec{A} \times \vec{B} = \vec{k}$

$\vec{D}.\vec{C} = 0$

Q10.

The scalar product of vectors $\vec{A}$ and $\vec{B}$ is 6.00 and the magnitude of their vector product is 9.00. Find the angle between these two vectors.

A) 56.3°
B) 43.0°
C) 23.4°
D) 37.5°
E) 90.0°

Ans:

$AB\cos\theta = A.B = 6$, $|A \times B| = 9.0 = AB\sin\theta$

$$\tan\theta = \frac{A.B}{|A \times B|} = \frac{9}{6} = 1.5$$

$\theta = \tan^{-1}(1.5) = 56.3°$

Q11.

The position of a particle is given by $\vec{r} = (4t - t^2)\,\hat{i} + t^3\,\hat{j}$, where $\vec{r}$ is in meters and t in seconds. Find the average acceleration (in m/s^2) of the particle in the time interval between t = 2 s and t = 4 s.

A) $-2\hat{i} + 18\hat{j}$
B) $-4\hat{i} - 6\hat{j}$
C) $-5\hat{i} - 10\hat{j}$
D) $-7\hat{i} - 12\hat{j}$
E) $-10\hat{i} - 6\hat{j}$

Ans:

$$v = \frac{dr}{dt} = (4 - 2t)\hat{\imath} + 3t^2\hat{\jmath}$$

$v(t = 2s) = (4 - 4)\hat{\imath} + 12\hat{\jmath} = 12\hat{\jmath}$

$v(t = 4s) = (4 - 8)\hat{\imath} + 48\hat{\jmath} = -4\hat{\imath} + 48\hat{\jmath}$

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{-4\hat{\imath} + 48\hat{\jmath} - 12\hat{\jmath}}{2} = \frac{-4\hat{\imath} + 36\hat{\jmath}}{2} = -2\hat{\imath} + 18\hat{\jmath}$$

Q12.

A projectile is thrown from the ground into the air with an initial speed v_0. Its velocity, 1.50 s after it was thrown, is 42.3 m/s making an angle 30.4^0 above the horizontal. Determine the initial velocity v_0 of the projectile.

A) 51.3 m/s at 44.7^0 above the horizontal
B) 43.1 m/s at 34.2^0 above the horizontal
C) 21.6 m/s at 49.2^0 above the horizontal
D) 32.5 m/s at 23.5^0 above the horizontal
E) 12.2 m/s at 54.5^0 above the horizontal

Ans:

$$v_y(t = 1.5\text{ sec}) = v\sin\theta = 42.3\sin(30.4) = 21.4\text{ m/s}$$
$$v_{0x} = v\cos\theta = 42.3\cos(30.4) = 36.48\text{ m/s}$$
$$v_{0y} = v_y + gt = 21.41 + 9.8 \times 1.5 = 36.11\text{m/s}$$
$$v_0 = \sqrt{{v_{0x}}^2 + {v_{0y}}^2} = \sqrt{36.11^2 + 36.48^2} = (51.3\ \text{m})/\text{s},$$
$$\theta = \tan^{-1}\left(\frac{v_{0y}}{v_{0x}}\right) = \tan^{-1}\left(\frac{36.11}{36.48}\right) = 44.7°$$

Q13.

A 0.150 kg ball, attached to the end of a string, is revolving uniformly in a horizontal circle of radius 0.600 m. The ball makes 10.0 revolutions in 5.00 seconds. Calculate the centripetal acceleration of the ball?

A) 94.8 m/s^2
B) 25.7 m/s^2
C) 12.6 m/s^2
D) 9.81 m/s^2
E) zero

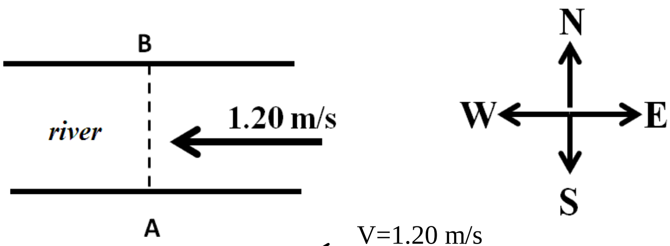
Ans:

$$a = \frac{v^2}{R};\ v = \frac{2\pi R}{T};\ T = \frac{5\text{ sec}}{10\text{ rev}} = \frac{1}{2}\text{ sec}$$
$$v = \frac{2\pi \times 0.6}{0.5} = 7.54\text{ m/s}$$
$$a = \frac{(7.54)^2}{0.6} = 94.8\text{ m/s}$$

Q14.

A boat is to travel from point A to point B directly across a river. The water in the river flows with a velocity of 1.20 m/s toward the west, as shown in **Figure 3**. If the speed of the boat in still water is 1.85 m/s, at what angle from the north must the boat head?

Figure # 3

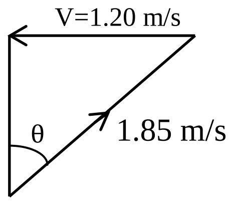


A) 40.4^0 east of north
B) 30.2^0 west of north
C) 10.5^0 east of north
D) 90.0^0 west of north
E) 55.0^0 west of north

Ans:

$\theta = \sin^{-1}\left(\frac{1.2}{1.85}\right)$

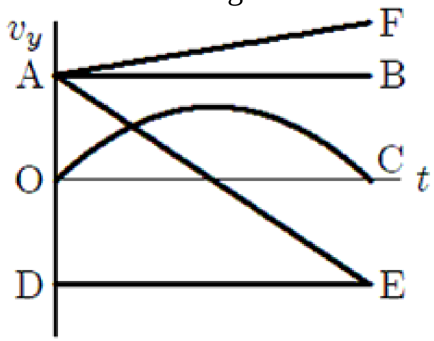
$= 40.44°$ of north



Q15.

Which one of the curves shown in **Figure 2** best represents the vertical component of the velocity v_y versus time t for a projectile fired at an angle of 45^0 above the horizontal?

Figure 2



A) AE
B) AB
C) OC
D) DE
E) AF

Ans:

$v_y = v_{iy} - gt$

$\frac{\partial y}{\partial t} = -g$, line with $-$ ve slope