Q1.

A car moves North at a speed of 90 km/h for 1 hour. Then it turns East and travel at 110 km/h for 3 hours. The car then turns South and travels for 2 hours at 60 km/h. What is the average speed of the car in the whole interval?

A) 25 m/s
B) 15 m/s
C) 35 m/s
D) 45 m/s
E) 50 m/s

Ans:

Total distance: $x = v_1 t_1 + v_2 t_2 + v_3 t_3 = 540\ km$

$$S = \frac{x}{t} = \frac{540\ km}{6\ hr} = 25\ \mathrm{m/s}$$

Q2.

The position of a particle is given by the function $x = 2.0t^3 - 9.0t^2 + 42$ where x is in meters and t is in seconds. Find the position x when the particle momentarily stops.

A) 15 m
B) 22 m
C) 35 m
D) 12 m
E) 24 m

Ans:

The particle stops when $v = 0$

$v = 6.0\,t^2 - 18\,t = 0 \Rightarrow t = 3.0\ s$

$x(t = 3.0) = 15\ m$

Q3.

A car starts moving from rest at a traffic light. It accelerates at 4.0 m/s^2 for 6.0 s. It then travels at constant speed for 20 seconds, and then slows down at a rate of 3.0 m/s^2 to stop at the next traffic light. How far apart are the traffic lights?

A) 650 m
B) 920 m
C) 320 m
D) 740 m
E) 600 m

Ans:

$x = x_1 + x_2 + x_3$

$$= \frac{1}{2} \times 4 \times 6^2 + (4 \times 6) \times 20 + \left[\frac{(4 \times 6)^2 - 0}{-2 \times (-3.0)}\right] = 649\ m$$

Q4.

A man throws a ball vertically upward from the window of a building with a speed of 15 m/s. The window is 2.0 m above the ground. How long is the ball in air before it hits the ground?

A) 3.2 s
B) 2.7 s
C) 2.5 s
D) 1.7 s
E) 4.4 s

Ans:

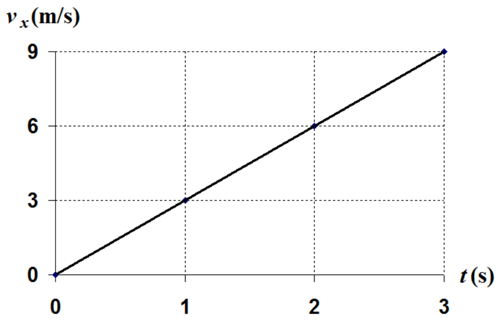
$$y = v_0 t - \frac{1}{2} g t^2 \;\Rightarrow\; -2.0 = 15t - 4.9t^2 \;\Rightarrow t = 3.2\, s$$

Q5.

Figure 1 shows the velocity graph of a particle moving along the *x*-axis. Its initial position at *t* = 0.0 is *x* = 2.0 m. What is the position of the particle at *t* = 2.0 s.

A) 8.0 m
B) 6.0 m
C) 7.0 m
D) 12 m
E) 9.0 m

Figure 1



Ans:

$$\text{From the plot, slope} = a = 3\frac{m}{s^2}$$

$$x - 2.0 = v_0 t + \frac{1}{2} a t^2 = 0.0 + 6.0 \;\Rightarrow x = 8.0\, m$$

Q6.

Ships A and B leave port at the same time. Ship A travels at 20 km/h in a direction 30° west of north, while ship B travels 20° east of north at 25 km/h. What is the distance between the two ships two hours after they depart?

A) 39 km
B) 17 km
C) 22 km
D) 26 km
E) 31 km

Ans:

$$\vec{r}_A = \vec{v}_A t = 20[-\sin 30\,\hat{\imath} + \cos 30\,\hat{\jmath}] \times 2 = -20.0\hat{\imath} + 34.6\,\hat{\jmath}$$

$$\vec{r}_B = \vec{v}_B t = 25[\sin 20\,\hat{\imath} + \cos 20\,\hat{\jmath}] \times 2 = 17.1\,\hat{\imath} + 47\,\hat{\jmath}$$

$$R = |\vec{r}_B - \vec{r}_A| = 39.1 \text{ km}$$

Q7.

Vector $\vec{A}$ has a magnitude of 12.0 units. Vector $\vec{B}$ has a magnitude of 14.0 units. Find the magnitude of $\vec{A}\times\vec{B}$ if $\vec{A}\cdot\vec{B} = 67.0$ units.

A) 154 units
B) 122 units
C) 102 units
D) 87.0 units
E) 138 units

Ans:

$$\vec{A}\cdot\vec{B} = A\,B\ \cos\theta = 67 \ \Rightarrow\ \theta = 66.5^{\circ}$$

$$\vec{A}\times\vec{B} = A\,B\ \sin\theta = 12\times 14\times \sin 66.5^{\circ}\ = 154$$

Q8.

The force $\vec{F}$ applied on a charged particle moving in a magnetic field $\vec{B}$ is given by the equation $\vec{F} = q\vec{v}\times\vec{B}$, where:

$\vec{F} = 6.0\hat{i} + 30.0\hat{j} + 8\hat{k}$, $\vec{v} = 2.0\hat{i} - 2.0\hat{j} + 6.0\hat{k}$, $\vec{B} = 2.0\hat{i} + 2.0\hat{j} + B_z\hat{k}$ and q = 1. Find the value of B_z.

A) – 9.0
B) – 3.0
C) 3.0
D) 6.0
E) 4.0

Ans:

$$q\vec{v}\times\vec{B} = (-2B_z - 12)\hat{\imath} - (2B_z - 12)\hat{\jmath} + 8\hat{k} = \vec{F} = 6.0\hat{\imath} + 30.0\hat{\jmath} + 8\hat{k}$$

$$-2B_z - 12 = 6.0 \ \Rightarrow B_z = -9.0$$

Q9.

A ball thrown horizontally at 2.5 m/s travels a horizontal distance of 1.6 m before hitting the ground. From what height was the ball thrown?

A) 2.0 m
B) 4.9 m
C) 1.4 m
D) 3.2 m
E) 1.8 m

Ans:

$$v_{0x} = 2.5\frac{m}{s}, v_{0y} = 0.0$$

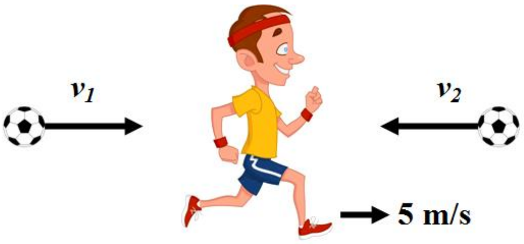
$$t = \frac{x}{v_{0x}} = 0.64\ s\ \Rightarrow y = v_{0y}t - \frac{1}{2}gt^2 = -2.0\ m$$

Q10.

A student is running to the right at 5 m/s as shown in **Figure 2**. Two balls are thrown towards the student from two opposite directions. The student sees that both balls are approaching him at 10 m/s. What are the speeds (in units of m/s) of the two balls?

A) $v_1 = 15, v_2 = -5$
B) $v_1 = -5, v_2 = 15$
C) $v_1 = -15, v_2 = 15$
D) $v_1 = 15, v_2 = 15$
E) $v_1 = 5, v_2 = -5$

Figure 2



Ans:

$$v_{1G} = v_{SG} + v_{1S} = 5 + 10 = 15\ m/s$$

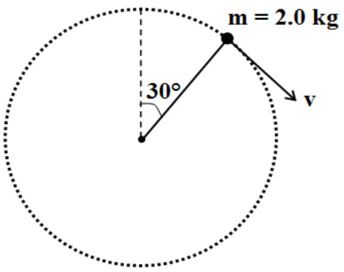
$$v_{2G} = v_{SG} + v_{2S} = 5 - 10 = -5\ m/s$$

Q11.

A 2.0 kg ball swings in a vertical circle on the end of an 80-cm long string. See **Figure 3**. The tension in the string is 20 N when its angle from the highest point on the circle is 30°. What is the speed of the ball at this position?

A) 3.8 m/s
B) 2.5 m/s
C) 2.9 m/s
D) 3.2 m/s
E) 3.0 m/s

Figure 3



Ans:

$$mg\cos 30^o + T = m\frac{v^2}{r} \Rightarrow T = 3.8\ \text{N}$$

Q12.

A particle in uniform circular motion about the origin of an xy coordinate system, moving clockwise with a period of 10 s. At one instant, its position vector (measured from the origin) is $\vec{r} = (-4.0\hat{i} + 3.0\,\hat{j})\,\text{m}$. At that instant, what is the velocity (in m/s) of the particle?

A) $\vec{v} = 1.9\hat{i} + 2.5\,\hat{j}$

B) $\vec{v} = -2.5\hat{i} + 1.9\,\hat{j}$

C) $\vec{v} = -0.4\hat{i} + 0.3\,\hat{j}$

D) $\vec{v} = 2.5\hat{i} - 1.9\,\hat{j}$

E) $\vec{v} = -1.9\hat{i} - 2.5\,\hat{j}$

Ans:

$r = 5\,m, \theta = 143^o$

$$v = \frac{2\pi r}{T} = \pi\,\frac{m}{s}$$

The velocity makes an angle 53° with the horizontal: $v_x = v\cos 53 = 1.9\,m/s, v_y = 2.5\,m/s$

Q13.

An iceboat sails across the surface of a frozen lake with constant acceleration produced by the wind. At a certain instant, the boats velocity is $\vec{v} = 6.30\hat{i} - 8.42\,\hat{j}$ m/s. Three seconds later, the boat is instantaneously at rest. What is the average acceleration (in m/s^2) for this 3.00 s interval?

A) $(-2.10\hat{i} + 2.81\hat{j})$

B) $(2.10\hat{i} - 2.81\hat{j})$

C) $(2.10\hat{i} + 2.81\hat{j})$

D) $(-2.10\hat{i} - 2.81\hat{j})$

E) zero

Ans:

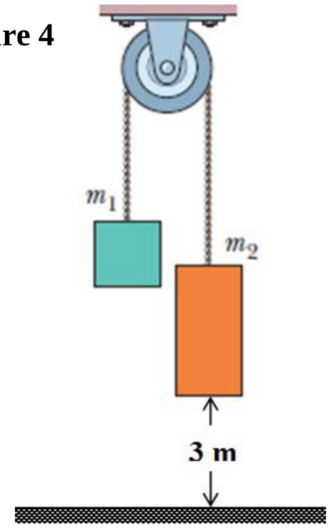
$\vec{a} = \frac{\Delta\vec{v}}{t} = (-2{,}10\,\hat{\imath} + 2.81\,\hat{\jmath}\,)\ m/s^2$

Q14.

The system in **Figure 4** is initially held at rest where the mass m_2 = 48 kg is 3.0 m from the floor. When released, mass m_2 starts moving downward and reaches the floor in 2.6 s. What is the mass m_1?

A) 40 kg
B) 31 kg
C) 34 kg
D) 37 kg
E) 44 kg

Figure 4



Ans:

$$a = \frac{2y}{t^2} = 0.89\ m/s^2$$

$$T - m_2 g = -m_2 a$$

$$T - m_1 g = m_1 a$$

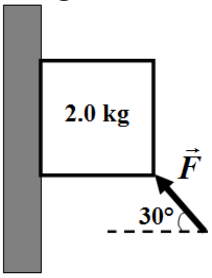
$$\Rightarrow m_1 = \frac{g - a}{g + a} m_1 = 40.0\ kg$$

Q15.

The 2.0 kg box in **Figure 5** slides down a vertical wall while you push it with a force $\vec{F}$ at a 30° angle from the horizontal. What magnitude of the force $\vec{F}$ should you apply to cause the box to slide down at a constant speed? (Assume no friction).

A) 39 N
B) 23 N
C) 12 N
D) 44 N
E) 33 N

Figure 5



Ans:

$$F \sin 30 = mg \Rightarrow F = \frac{mg}{\sin 30} = 39.2\ N$$

Q16.

A small car of mass m is pushing a truck of mass 2m that has a dead battery. See **Figure 6**. Which one of the following statements is **TRUE**?

Figure 6

A) The car exerts the same amount of force on the truck as the truck exerts on the car
B) The car exerts a force on the truck, but the truck doesn't exert a force on the car
C) The force exerted by the car on the truck is double the force exerted by the truck on the car.
D) The force exerted by the truck on the car is double the force exerted by the car on the truck.
E) The truck exerts a force on the car, but the car doesn't exert a force on the truck

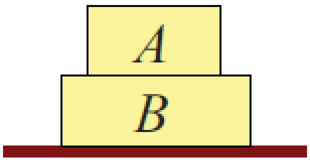
Ans:

A

Q17.

Two blocks, A and B are at rest on a table as shown in **Figure 7**. The mass of block A is 1.0 kg. The magnitude of the normal force from the table on block B is 39.2 N. What is the mass (in kg) of block B?

Figure 7



A) 3
B) 1
C) 2
D) 4
E) 5

Ans:

$$F_N = (m_A + m_B)g = 39.2\ N \Rightarrow m_B = 3\ kg$$

Q18.

A 1.5 kg box is placed on a horizontal moving belt. The coefficients of friction between the belt and the box are μ_s = 0.52 and μ_k = 0.38. What is the maximum acceleration (in m/s^2) the belt can have without the box slipping?

A) 5.1
B) 3.7
C) 6.2
D) 7.6
E) 6.8

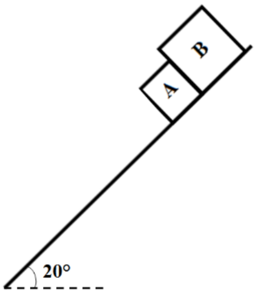
Ans:

The box is accelerated by the force of friction. But when the acceleration of the belt exceeds the corresponding maximum value for the force of friction $f_s = \mu_s F_N$, the box will slip. So $max.\ a = \mu_s F_N / m = 5.1$ m/s2

Q19.

Two boxes, A and B, are sliding down the 20° ramp, shown in **Figure 8**. Box A has a mass of 5.0 kg and a kinetic coefficient of friction 0.2. Box B has a mass of 10 kg and a coefficient of kinetic friction 0.15. What is the acceleration (in m/s^2) of block A?

Figure 8



A) 1.8
B) 2.0
C) 1.6
D) 1.5
E) 1.4

Ans:

$$(m_1 + m_2) g \sin 20 - g \cos 20\ (\mu_1 m_1 + \mu_2 m_2) = (m_1 + m_2) a$$

$$a = g \frac{(m_1 + m_2) g \sin 20 - (\mu_1 m_1 + \mu_2 m_2) \cos 20}{(m_1 + m_2)} = 1.8\ m/s^2$$

Q20.

A 1500 kg car drives around a flat 200-m radius circular road. What is the coefficient of static friction between the car and the road when the speed is 25 m/s?

A) 0.32
B) 0.41
C) 0.50
D) 0.54
E) 0.47

Ans:

$$f_s = \mu_s F_N = m\frac{v^2}{r} \Rightarrow \mu_s = \frac{m}{F_N}\frac{v^2}{r} = \frac{v^2}{gr} = 0.319$$