Q1.

The speed-time relation of a moving particle is given by: $v = \frac{1}{2}at + \frac{b}{t+c}$, where v is the speed, t is the time and a, b, c are constants. The dimensional formulae of the constants, a, b and c are respectively:

$$c = [T],$$

$$b = vt = \frac{L}{T}T = [L],$$

$$a = \frac{v}{t} = \frac{L}{T^2}$$

A) $\frac{L}{T^2}, L,$ and T

B) $LT^2, L,$ and T

C) $\frac{L}{T}, L,$ and T

D) $\frac{L}{T}, L^2,$ and T

E) $L, L,$ and T^2

Q2.

A 0.19 kg solid sphere has a radius of 21 mm. Its density is:

$$\rho = \frac{m}{V} = \frac{0.19}{\frac{4}{3}\pi(21\times10^{-3})^3} = 4.9\times10^3 \text{ kg/m}^3$$

A) 4.9×10^3 kg/m^3
B) 2.1×10^3 kg/m^3
C) 1.2×10^3 kg/m^3
D) 3.9×10^3 kg/m^3
E) 1.9×10^3 kg/m^3

Q3.

You are given the two vectors $\vec{A}$ and $\vec{B}$. If $\vec{A}\cdot\vec{B} = 4.00$ and $\left|\vec{A}\times\vec{B}\right| = 3.00$, then the angle between $\vec{A}$ and $\vec{B}$ is:

$$\left.\begin{aligned}\vec{A}\cdot\vec{B} &= 4.00 = \left|\vec{A}\right|\left|\vec{B}\right|\cos\theta \\ \left|\vec{A}\times\vec{B}\right| &= 3.00 = \left|\vec{A}\right|\left|\vec{B}\right|\sin\theta\end{aligned}\right\} \Rightarrow \tan\theta = \frac{3}{4} = 36.9°$$

A) 36.9°
B) 26.5°

C) 45.0°
D) 86.2°
E) 96.0°

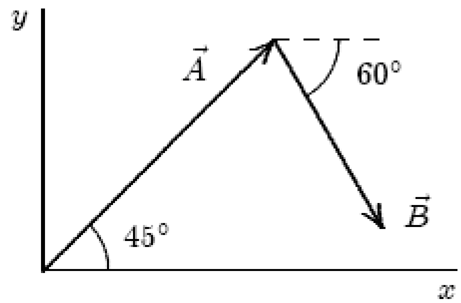
Q4.
If the magnitude of the sum of two vectors is less than the magnitude of either vector, then:

A) the scalar product of the vectors must be negative
B) the scalar product of the vectors must be positive
C) the vectors must be parallel and in opposite directions
D) the vectors must be parallel and in the same direction
E) the vectors must be perpendicular to each other.

Q5.
In **Figure 1**, $\vec{A}$ has a magnitude of 10.0 m and $\vec{B}$ has a magnitude of 8.0 m. The x-component of $\left(\vec{A}+\vec{B}\right)$ is:

$$\left(\vec{A}+\vec{B}\right)_x = 8\cos 60^\circ + 10\cos 45^\circ = 11 \text{ m}$$

Fig# 1



A) 11 m
B) 8.0 m
C) 15 m
D) 7.3 m
E) 19 m

Q6.
.A car travels 80.0 km to the north at 40.0 km/h, then travels 60.0 km to the south at 30.0 km/h. What is the difference between the average speed and the magnitude of the average velocity on this trip?

Total distance = 140 Km, Total displacement = 80-60=20 Km, Total time = 4

Average velocity on this trip = $\left|\frac{20}{4} - \frac{140}{4}\right| = 30$ km/h

A) 30 km/h
B) 39 km/h
C) 32 km/h
D) 24 km/h
E) 27 km/h

Q7.
The position of a particle moving along the x-axis is given by: $x = 3.0\,t^2 - 2.0\,t^3$, where x is in meters and t is in seconds. At what time is its acceleration zero?

$$x = 3.0t^2 - 2.0t^3 \quad \Rightarrow \quad v = 6.0t - 6.0t^2 \quad \Rightarrow \quad a = 6.0 - 12.0t$$

$$a = 0 \quad \Rightarrow \quad t = 0.5 \text{ s}$$

A) 0.50 s
B) 1.0 s
C) 1.5 s
D) 0.67 s
E) 0.25 s

Q8.
A ball is released from rest at the top of a building. The time it takes the ball to fall halfway to the ground is 1.2 s. Find the total time it takes for the ball to fall from the top of the building to the ground.

$$d = v_o t + \frac{1}{2} g t^2 \quad \Rightarrow \quad \frac{d}{2} = \frac{1}{2} 9.8 (1.2)^2 \quad \Rightarrow \quad d = 14.112$$

$$\Rightarrow 14.112 = \frac{1}{2} 9.8 t^2 \quad \Rightarrow \quad t = 1.7 \text{ s}$$

A) 1.7 s
B) 1.8 s
C) 1.5 s
D) 1.9 s
E) 2.4 s

Q9.
A particle starts from the origin at $t = 0$ s with velocity of $6.0\,\hat{i}$ m/s and moves in *xy* plane with constant acceleration of $\left(-2.0\,\hat{i} + 4.0\,\hat{j}\right)$m/s^2. What are the (x, y) coordinates of the particle at the instant, when it reaches its maximum *x* coordinate?
at the instant, when it achieves its maximum *x* coordinate?

$$x = v_o t + \frac{1}{2} a t^2 = 6.0\hat{i} + \frac{1}{2}\left(-2.0\hat{i} + 4.0\hat{j}\right)t^2$$

at max. height $\frac{dx}{dt} = 0 \quad \Rightarrow \quad t = 3$ s

$$x = 18 + \frac{1}{2}(-2)3^2 = 9 \text{ m},$$

$$y = \frac{1}{2}(4)3^2 = 18 \text{ m}$$

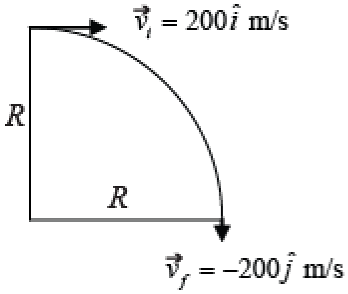
A) x = 9.0 m, y = 18 m
B) x = 18 m, y = 9.0 m
C) x = 4.5 m, y = 9.0 m
D) x = 27 m, y = 18 m
E) x = 9.0 m, y = 27 m

Q10.
What is the magnitude of the acceleration of an aircraft, which enters a horizontal circular turn of radius R with velocity $\vec{v}_i = 200\,\hat{i}$ m/s and 15.0 s later leaves the turn with a velocity $\vec{v}_f = -200\,\hat{j}$ m/s ? (see **Figure 2**)

$$a = \frac{v^2}{R} \Rightarrow \frac{T}{4} = 15 \Rightarrow \frac{2\pi R}{4v} = 15 \Rightarrow R = \frac{60v}{2\pi},$$

$$a = \frac{v^2}{R} = \frac{v^2}{\frac{60v}{2\pi}} = \frac{2\pi v}{60} = \frac{2\pi\left(200\right)}{60} = 20.9 \text{ m/s}^2$$

Fig# 2



A) 20.9 m/s^2
B) 24.4 m/s^2
C) 11.4 m/s^2
D) 15.5 m/s^2
E) 18.9 m/s^2

Q11.

A ball is thrown upward with a speed v_o at an angle of 45° above the horizontal. It reaches a maximum height of 8.0 m. What is the maximum height this ball would go if it is thrown upward with a speed (2 v_o) at an angle of 45° above the horizontal?

$$\frac{h_1}{h_2} = \frac{v_{01}^2}{v_{02}^2} \quad \Rightarrow \quad \frac{8}{h_2} = \left(\frac{v_0}{2v_o}\right)^2 \Rightarrow h_2 = 8 \times 4 = 32m,$$

note that $h = \dfrac{v_0^2 \sin^2\theta}{2g}$

A) 32 m
B) 8.0 m
C) 16 m
D) 64 m
E) 4.0 m

Q12.
A car has a velocity (relative to the ground) of 16.0 m/s directed due north. A truck has a velocity (relative to the car) of 24.0 m/s, directed 52.0° north of east. What is magnitude of the truck velocity relative to the ground?

Take East as x axis and North as y axis. Thus,

V_c=16 j, V_{tc}=24 cos 52 $\hat{i}$+24 sin 52 $\hat{j}$

$V_{tc} = V_t - V_c$ ➔ $V_t = V_{tc} + V_c$ = 24 cos 52 $\hat{i}$+24 sin 52 $\hat{j}$ + 16 $\hat{j}$ = 14.8 $\hat{i}$+34.9 $\hat{j}$

⇨ $V_t = [14.8^2+34.9^2]^{1/2}$ = 37.9 m/s

A) 37.9 m/s
B) 22.7 m/s
C) 11.3 m/s
D) 19.7 m/s
E) 15.1 m/s

Q13.
Three forces act on a particle of mass m = 1.0 kg that moves with **constant velocity** $\vec{v} = \left(5.0\hat{i} + 8.0\hat{j}\right)$m/s. Two of the forces are $\vec{F}_1 = \left(6.0\hat{i} + 4.0\hat{j} - 2.0\hat{k}\right)$N and $\vec{F}_2 = \left(-8.0\hat{i} + 4.0\hat{j} - 5.0\hat{k}\right)$N. What is the third force?

Constant velocity means that total applied forces = 0

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \left(6.0\hat{i} + 4.0\hat{j} - 2.0\hat{k}\right) + \left(-8.0\hat{i} + 4.0\hat{j} - 5.0\hat{k}\right) + \vec{F}_3 = 0$$

$$\Rightarrow \vec{F}_3 = -\left(\vec{F}_1 + \vec{F}_2\right) = -\left[\left(6.0\hat{i} + 4.0\hat{j} - 2.0\hat{k}\right) + \left(-8.0\hat{i} + 4.0\hat{j} - 5.0\hat{k}\right)\right] = \left(2.0\hat{i} - 8.0\hat{j} + 7.0\hat{k}\right)\text{N}$$

A) $\left(2.0\hat{i} - 8.0\hat{j} + 7.0\hat{k}\right)$N
B) $\left(-3.0\hat{i} + 1.6\hat{j} + 4.0\hat{k}\right)$N
C) $\left(2.0\hat{i} - 3.0\hat{j} - 2.0\hat{k}\right)$N
D) $\left(8.0\hat{i} - 4.0\hat{j} + 7.0\hat{k}\right)$N
E) 0

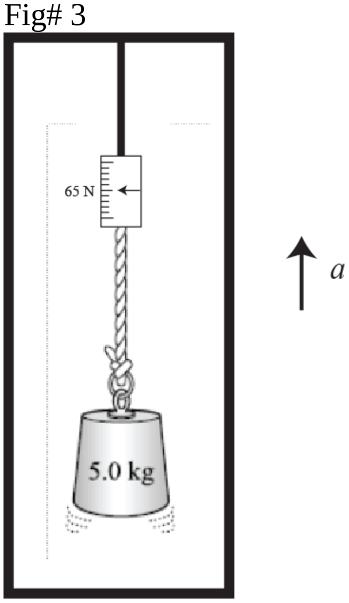
Q14.
Consider a particle in motion. Which of the following statements is **correct**?

A) If the sum of the external forces acting on the particle is zero, then the particle is moving with constant velocity.
B) If the particle is moving with constant speed, then the sum of the external forces acting on it must always be zero.
C) If the sum of the external forces acting on the particle is zero, then it will come to rest after some time.
D) The velocity of the particle is always in the direction of the resultant external force.
E) If the sum of the external forces acting on the particle is zero, then it has an acceleration of 9.8 m/s^2

Q15.
A 5.0 kg object is hung from a spring balance attached to the ceiling of an elevator cab (see **Figure 3**). The balance reads 65 N. What is the acceleration of the elevator?
Equation of motion in moving upward is given by:

$$ma = T - mg \Rightarrow a = \frac{65 - (5 \times 9.8)}{5} = 3.2 \text{ m/s}^2$$

Fig# 3



A) 3.2 m/s^2
B) 1.6 m/s^2
C) 4.8 m/s^2
D) 5.6 m/s^2
E) 23 m/s^2

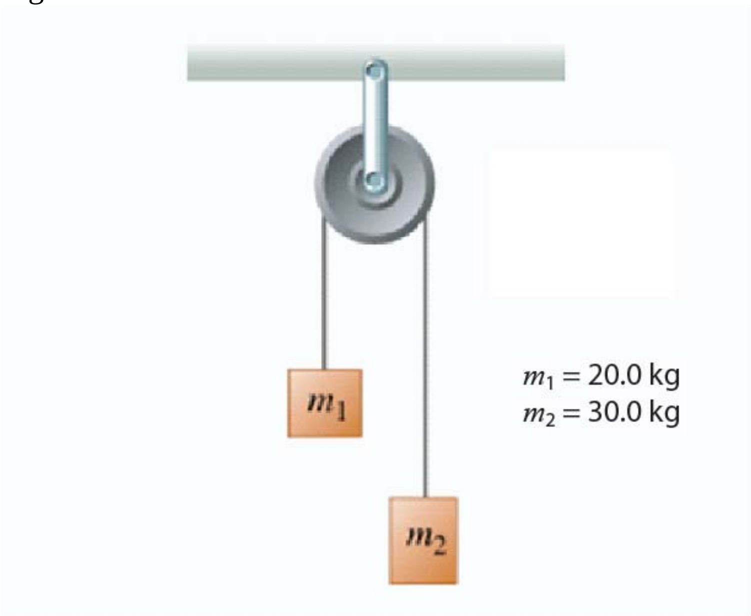
Q16.
Two blocks with masses m_1= 20.0 kg and m_2= 30.0 kg respectively, are connected by a string that passes over a frictionless pulley with negligible mass as shown in **Figure 4**. The tension in the string is:
The equations of motion of each mass are:

$$m_2 a = m_2 g - T\,, \quad m_1 a = T - m_1 g$$

$$\Rightarrow \quad a = \left(\frac{m_2 - m_1}{m_2 + m_1}\right) g = 1.96 \text{ m/s}^2$$

$$T = (g - a) m_2 = 235 \text{ N}$$

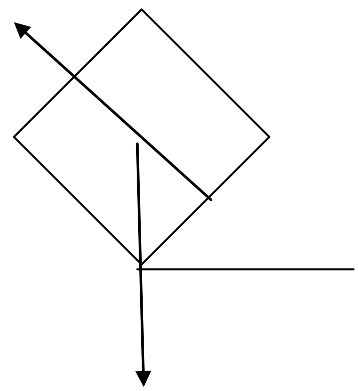
Fig#



A) 235 N
B) 490 N
C) 980 N
D) 122 N
E) 378 N

Q17.

A 1125 kg car is traveling on a banked circular road that has a radius R = 225 m and is banked at angle θ. What should be this angle θ so that this car traveling at speed v = 29.1 m/s can safely go round the turn without sliding off the road? (Ignore frictional forces)



N sin θ = mv^2/R (1)
N cos θ = mg (2)
(1) / (2) gives

tan θ = v^2/(R g) = (29.1)^2/[(225)(9.8)]= 0.384

θ = 21.0°

A) 21.0°
B) 15.2°
C) 9.24°
D) 11.8°
E) 7.45°

Q18.
Three blocks of masses m_1=1.5 kg, m_2=2.0 kg, and m_3=1.0 kg are pushed by a horizontal force F of magnitude 9.0 N as shown in **Figure 5**. The coefficient of kinetic friction between each block and the table is μ_k = 0.20. What is the magnitude F_{32} of the force on mass m_3 from mass m_2?

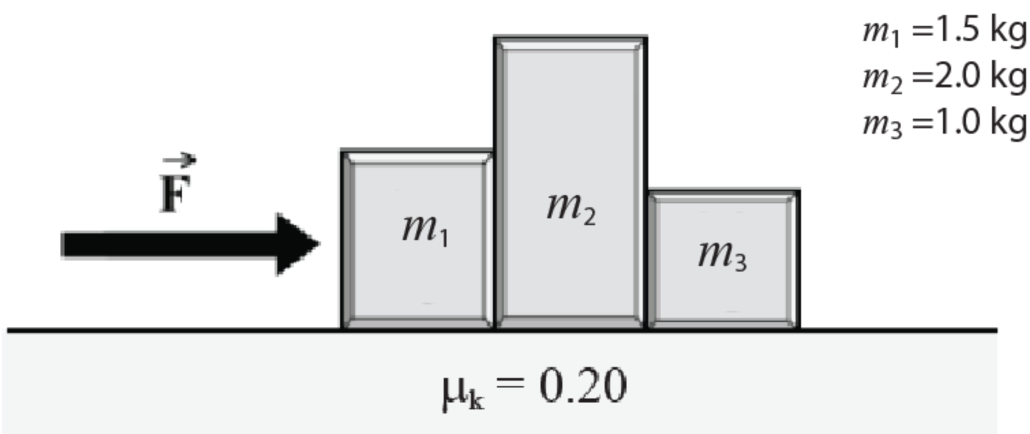
The equation of motion of the system is:

$$(m_1+m_2+m_3)a = F-\mu(m_1+m_2+m_3)g \Rightarrow a=\frac{9-(0.2\times 4.5\times 9.8)}{4.5}=0.04 \text{ m/s}^2$$

For the third mass:

$$m_3 a = F_{32}-F_{23} \Rightarrow F_{32} = 1\times 0.04+1\times 0.2\times 9.8 = 2 \text{ N}$$

Fig# 5



A) 2.0 N
B) 8.2 N
C) 3.7 N
D) 7.0 N
E) 0 N

Q19.
In **Figure 6**, a 10.0 kg block is pushed at a **constant speed** up an inclined plane (θ = 45°) with a horizontal force $\vec{F}$. The coefficient of kinetic friction between block and the plane is $\mu_k = 0.50$. What is the magnitude of F?
The normal force is:

$$N = mg\cos\theta + F\sin\theta$$

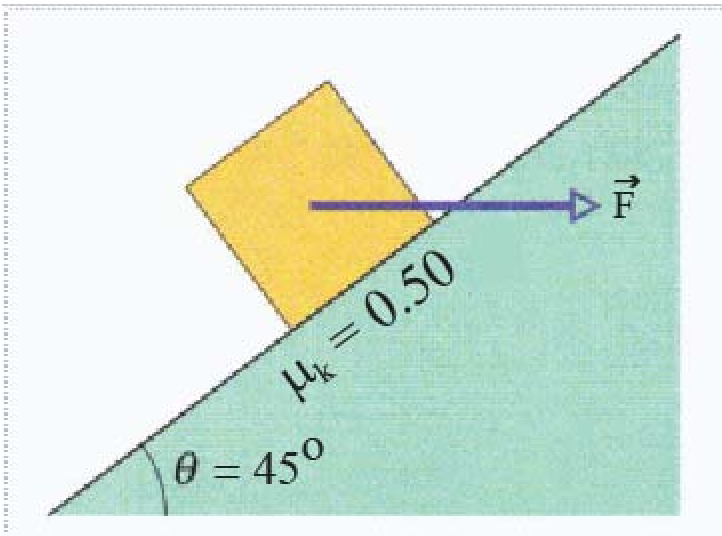
The equation of motion down the inclined plane is:

$$ma = F\cos\theta - mg\sin\theta - \mu N = 0$$ since we have constant speed.

The above equations give:

$$F = \frac{mg(1+\mu)}{(1-\mu)} \approx 290$$

Fig# 6



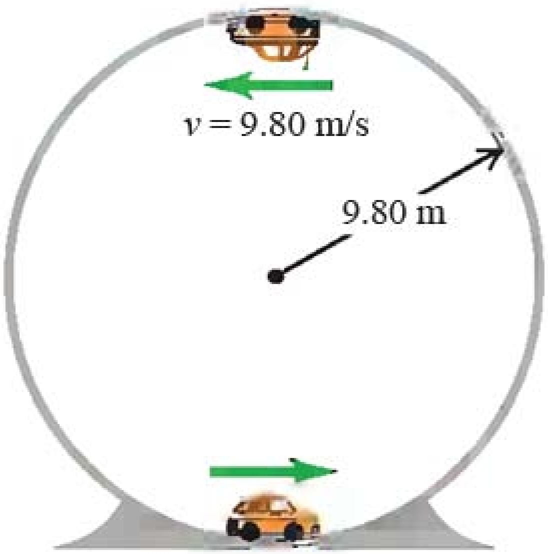
A) 290 N
B) 490 N
C) 980 N
D) 170 N
E) 0 N

Q20.
A small remote control car with mass 1.60 kg moves in a vertical circle inside a hollow metal cylinder that has a radius of 9.80 m, as shown in the **Figure 7**. The speed at the highest point B is v = 9.80 m/s. What is the magnitude of the normal force exerted on the car by the walls of the cylinder at point B (at the top of the vertical circle?)

The equation of motion at B is:

$$m\left(\frac{v^2}{r}\right) = mg + R \quad \Rightarrow \quad R = m\left(\frac{v^2}{r}\right) - mg = 0$$

Fig# 7



A) 0 N
B) 13.5 N
C) 95.2 N
D) 63.3 N
E) 75.6 N