Q1.

A ball with a weight of 4.5 N is thrown at an angle of 30^o above the horizontal with an initial speed of 10 m/s. Neglecting air resistance, at its highest point, the net force on the ball is:

A) 4.5 N, vertically downward
B) Zero
C) 1.5 N, 30° below horizontal
D) 9.8 N, vertically downward
E) 9.8 N, 30° below horizontal

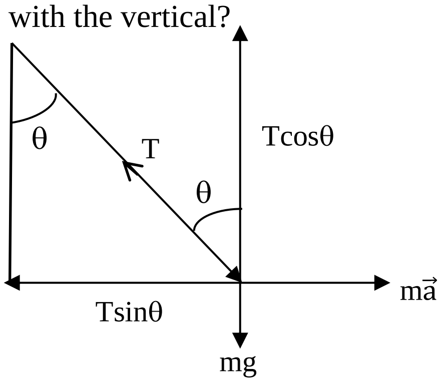
Ans:

A

Q2.

A ball is suspended by a string from the ceiling of a car. The car moves horizontally with a constant acceleration of 2.5 m/s^2 with respect to the ground. The ball is at rest with respect to the car. What angle does the string make with the vertical?

A) 14^o
B) Zero
C) 25^o
D) 45^o
E) 90^o



Ans:

$T\sin\theta = ma = m \times 2.5$

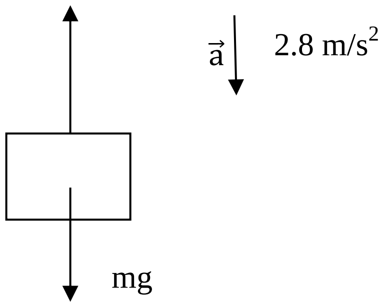
$T\cos\theta = mg = m \times 9.8$

$\theta = \tan^{-1}\left(\frac{2.5}{9.8}\right) = 14.31^\circ \approx 14°$

Q3.

A 5.0 kg block is lowered with a downward acceleration of 2.8 m/s^2 by means of a rope. Find the force exerted by the block on the rope.

A) 35 N, downward
B) 14 N, downward
C) 35 N, upward
D) 14 N, upward
E) 49 N, upward



Ans:

$T - mg = -ma$

$T = m(g - a)$

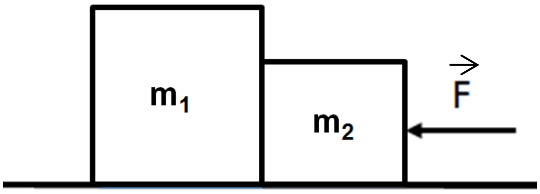
$= 5(9.8 - 2.8)$

$T = 35$ N

Q4.

Two blocks of masses m_1= 2.0 kg and m_2 = 1.0 kg are in contact with each other on a frictionless surface as shown in **Figure 1**. A horizontal force $\vec{F}$ of magnitude 3.0 N is applied to the block of mass m_2 as shown. Find the magnitude of the force that m_1 exerts on m_2.

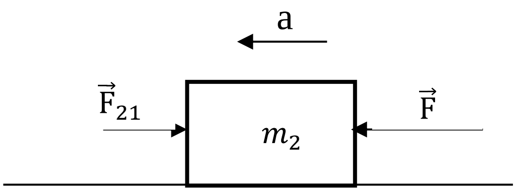
Figure 1



A) 2.0 N
B) 9.8 N
C) 1.0 N
D) 6.0 N
E) 3.0 N

Ans:

$$a = \frac{F}{m_1 + m_2} = \frac{3}{2+1} = 1.0\, m/s^2$$



$$\vec{F}_{21} - \vec{F} = -m_2\vec{a}$$

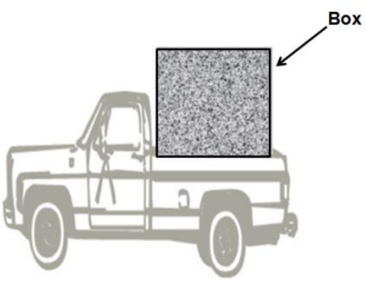
$$F_{21} = \vec{F} - m_2\vec{a}$$

$$= 3 - 1 \times 1 = 2\, N$$

Q5.

A pickup truck carries a box on its back as shown in **Figure 2**. The truck starts from rest. When the truck attains an acceleration of 2.00 m/s^2, the box starts to slip towards the end of the truck. The coefficient of friction between the box and the truck's back surface is **?**

Figure 2



A) μ_s= 0.20
B) μ_s= 0.15
C) μ_s= 0.37
D) μ_s=0.11
E) μ_s= 0.30

Ans:

$$a = 2.0\, m/s^2$$

$$f_s = F = ma$$

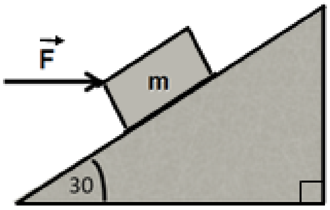
$$f_s = \mu_s \not{m} g = \not{m} a$$

$$\mu_s = \frac{a}{g} = \frac{2}{9.8} = 0.204 \approx 0.20$$

Q6.

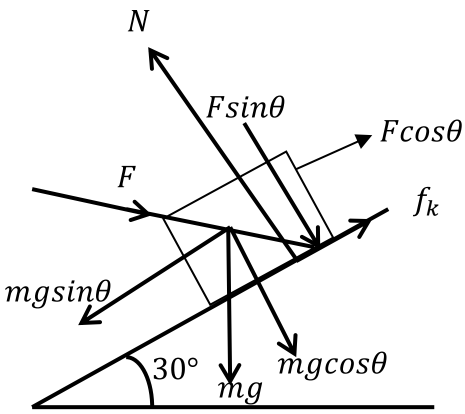
A block is sliding down a rough inclined plane that makes an angle of 30° with the horizontal. When a horizontal force $\vec{F}$ of magnitude 10 N is applied to the block, as shown in **Figure 3**, the block slides down at a constant speed. If the coefficient of kinetic friction between the block and the inclined plane is 0.30, find the mass of the block.

Figure 3



A) 4.3 kg
B) 1.5 kg
C) 4.7 kg
D) 2.0 kg
E) 3.9 kg

Ans:



$$N - Fsin\theta - mgcos\theta = 0$$

$$N = Fsin\theta + mgcos\theta$$

$$mgsin\theta - Fcos\theta - f_k = 0$$

$$mgsin\theta - Fcos\theta - \mu_k(Fsin\theta + mgcos\theta) = 0$$

$$m(gsin\theta - \mu_k gcos\theta) = Fcos\theta + \mu_k Fsin\theta$$

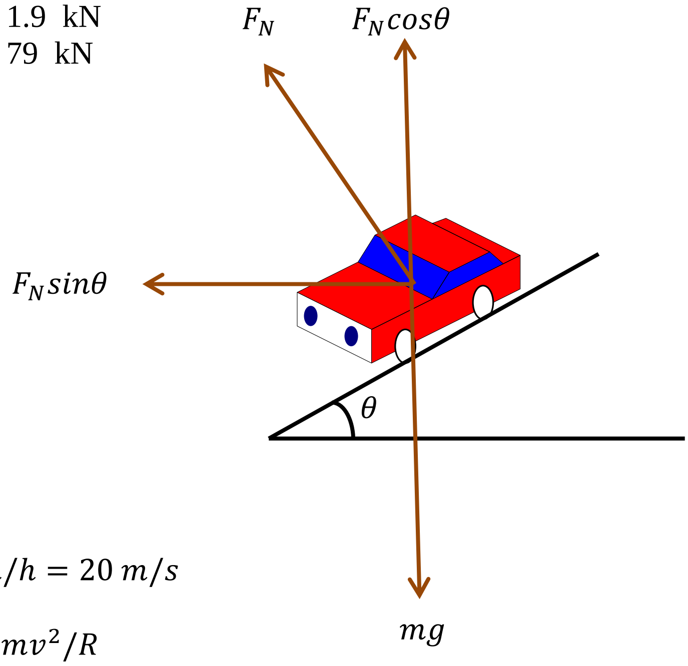
$$m = \frac{Fcos\theta + \mu_k Fsin\theta}{gsin\theta - \mu_k gcos\theta} = \frac{F(cos\theta + \mu_k sin\theta)}{g(sin\theta - \mu_k cos\theta)} = \frac{10(cos30 + 0.3 \times sin30)}{9.8(sin30 - 0.3cos30)}$$

$$m = 4.32\ kg \cong 4.32\ kg$$

Q7.

A car of mass 500 kg can go around a banked circular road of radius 60 m at the maximum speed of 72 km/h without slipping. Find the normal force on the car from the banked surface (Ignore the friction force from the road).

A) 5.9 kN
B) 6.4 kN
C) 39 kN
D) 1.9 kN
E) 79 kN



Ans:

$v = 72km/h = 20\ m/s$

$F_N sin\theta = mv^2/R$

$$\theta = \tan^{-1}\left(\frac{v^2}{Rg}\right) = \tan^{-1}\left(\frac{20 \times 20}{500 \times 9.8}\right) = 34.23°$$

$$F_N = \frac{mg}{cos\theta} = \frac{500 \times 9.8}{\cos(34.23)} = 5926.6\ N = 5.9\ kN$$

Q8.

A block is dropped from a high tower and is falling freely under the influence of gravity. Which one of the following statements is **true**? (Ignore air resistance).

A) The kinetic energy increases by equal amounts over equal distances.
B) As the block falls, the net work done by all of the forces acting on the block is zero joules.
C) The kinetic energy of the block increases by equal amounts in equal times.
D) The potential energy of the block decreases by equal amounts in equal times.
E) The total energy of the block increases by equal amounts over equal distances.

Ans:

A

Q9.

A massless spring hangs from the ceiling. How much does its potential energy increase if a 30 kg mass is attached to it? The spring constant is 4800 N/m.

A) 9.0 J
B) 1.9 J
C) 5.3 J
D) 12 J
E) 15 J

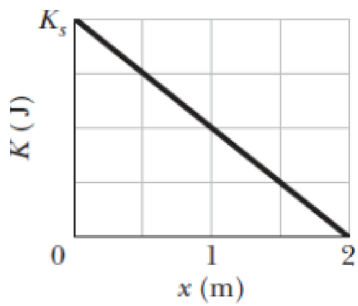
Ans:

$$x = \frac{mg}{k} = 0.061\ m\ ;\ U_s = \frac{1}{2}kx^2 = 0.5 \times 4800 \times (0.061)^2;\ U_s = 9.0\ J$$

Q10.

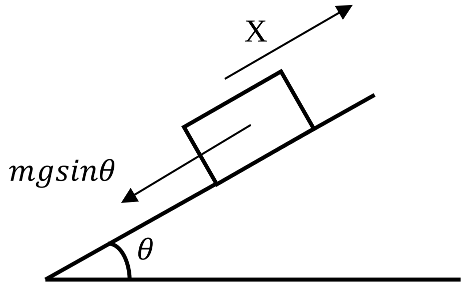
A 10 kg block is sent up a frictionless ramp along which an x axis extends upward. **Figure 4** gives the kinetic energy of the block as a function of position x; the scale of the figure's vertical axis is set by K_s = 80 J. What is the angle of the inclination of the ramp with respect to the horizontal surface?

Figure 4



A) 24°
B) 31°
C) 19°
D) 33°
E) 11°

Ans:



$$Work = W = Fd = mgsin\theta \times x$$

$$\Delta K = W = mgsin\theta \cdot x$$

$$slope\ of\ graph = \frac{\Delta K}{x} = \frac{W}{x} = \frac{mgsin\theta x}{x} = \text{mgsin}\theta$$

$$\theta = \sin^{-1}\left(\frac{slope\ of\ graph}{mg}\right)$$

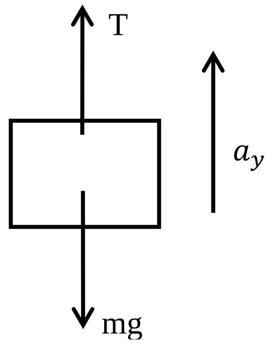
$$slope\ of\ graph = \frac{80}{2} = 40$$

$$\theta = \sin^{-1}\left(\frac{40}{10 \times 9.8}\right) = 24.1°$$

Q11.

Starting from rest, an elevator with a mass of 1.00×10^3 kg moves 100 m vertically upward in 50.0 s. At what average rate does the force from the cable do work on the elevator?

A) 19.8 kW
B) 11.1 kW
C) 29.7 kW
D) 31.3 kW
E) 15.6 kW



Ans:

$$y = v_1 + \frac{1}{2}a_y + 2 = \frac{1}{2}a_y t^2$$

$$a_y = \frac{2y}{t^2} = \frac{2\times100}{(50)^2} = 0.08\,m/s^2$$

$$T - mg = ma_y$$

$$T = m(g - a_y) = 10^3(9.8 + 0.08)$$

$$P = \frac{T\times d}{t} = \frac{9880\times100}{50} = 19.8\,kW$$

Q12.

Two balls are launched from the same spring-loaded cannon with the spring compressed the same distance each time. Ball A has a 40 kg mass and ball B has a 60 kg mass. The relation between their speeds at the instant of launch is:

A) $v_A = \sqrt{(3/2)}\ v_B$
B) $v_A = v_B$
C) $v_A = (3/2)v_B$
D) $v_B = \sqrt{(3/2)}\ v_A$
E) $v_B = (3/2)v_A$

Ans:

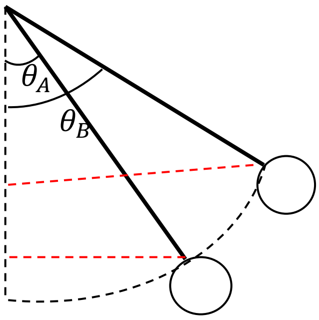
$$U_s = K_A = K_B$$

$$= \frac{1}{2}m_A V_A^2 = \frac{1}{2}m_B V_B^2$$

$$V_A = \sqrt{\frac{m_B}{m_A}}\cdot V_B = \sqrt{\frac{60}{40}}V_B = \sqrt{\frac{3}{2}}\,V_B$$

Q13.

In a simple pendulum a 2.00 kg mass is attached to a 2.00 m long massless string. The mass has a speed of 3.00 m/s when the string makes an angle of 30.0° with the vertical. What is the speed of the mass when the string makes an angle of 45° with the vertical?



A) 1.66 m/s
B) 2.64 m/s
C) 5.22 m/s
D) 26.6 m/s
E) 0.720 m/s

Ans:

$$E = \frac{1}{2}mv_A^2 + mgl(1 - cos\theta_A) = \frac{1}{2}mv_B^2 + mgl(1 - cos\theta_B)$$

$$v_B^2 = v_A^2 + lg(cos\theta_B - cos\theta_A)$$

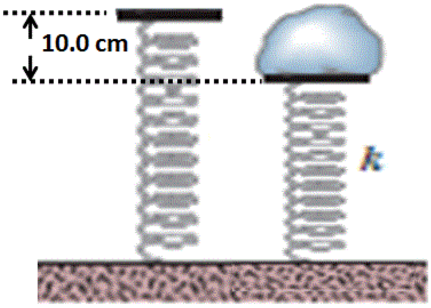
$$v_B^2 = (3)^2 + 2 \times 9.8(cos45 - cos30) = 2.77\ m^2/s$$

$$v_B = \sqrt{2.77} = 1.66\ m/s$$

Q14.

Figure 5 shows a 10.0 kg stone resting on a spring. The spring is compressed 10.0 cm by the stone. The stone is further pushed down an additional 40.0 cm and then released. The stone rises vertically to a maximum height of 1.00 m from its release point. What is the magnitude of the work done by non-conservative forces (air resistance) on the stone during its flight to the maximum height?

Figure 5



A) 24.5 J
B) 14.7 J
C) 34.9 J
D) 9.25 J
E) 41.5 J

Ans:

$$k = \frac{mg}{x} = \frac{10 \times 9.8}{0.1} = 980\ N/m$$

$$W_{nc} + mgy = \frac{1}{2}kx^2$$

$$W_{nc} = \frac{1}{2}kx^2 - mgy$$

$$= \frac{1}{2} \times 980 \times (0.5)^2 - 10 \times 9.8 \times 1$$

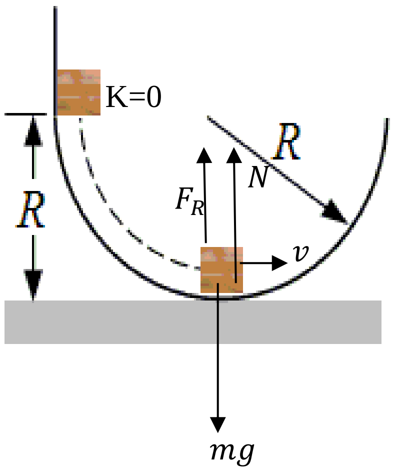
$$W_{nc} = 122.5 - 98 = 24.5\ J$$

Q15.

Starting from rest, a 2.00 kg block slides downward inside a frictionless circular hoop of radius R = 0.50 m, as shown in **Figure 6**. What is the magnitude of the normal force exerted on the block by the hoop when the block reaches the bottom of the hoop?

A) 58.8 N
B) 88.5 N
C) 30.1 N
D) 72.4 N
E) 31.7 N

Figure 6



Ans:

$$N - mg = \frac{mv^2}{R}$$

$$N = mg + \frac{mv^2}{R}$$

But $\frac{1}{2}mv^2 = mgR \Rightarrow mv^2 = 2mgR$

$$N = mg + \frac{2mg\cancel{R}}{\cancel{R}} = mg + 2\,mg$$

$$N = 3mg = 3 \times 2 \times 9.8 = 58.8\ N$$