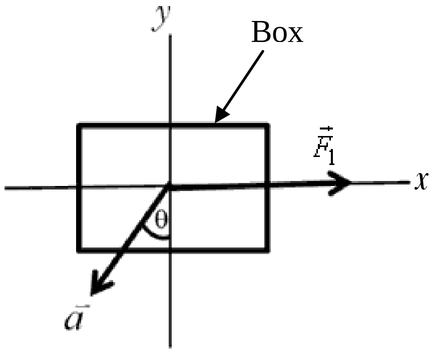
Q1.

Two forces are acting on a 2.00 kg box. In the overhead view of **Figure 1** only one force $\vec{F}_1$ and the acceleration $\vec{a}$ of the box are shown. Find the magnitude and direction of the second force if $\vec{F}_1$ = 25.0 N, $\vec{a}$ = 15.0 m/s^2 and θ = 30.0°.

Figure 1



A) 47.7 N, making an angle of 213° with the positive x-axis.
B) 42.0 N, making an angle of 300° with the positive x-axis.
C) 50.0 N, making an angle of 30.0° with the positive x-axis.
D) 30.0 N, making an angle of 60.0° with the positive x-axis.
E) 50.0 N, making an angle of 50.0° with the positive x-axis

Ans:

$$F_{net} = \vec{F}_1 + \vec{F}_2 = m\vec{a}$$

$$\vec{F}_2 = m\vec{a} - \vec{F}_1 = 2(a\cos\theta\vec{\imath} + a\sin\theta\vec{\jmath}) - \vec{F}_1$$

$$\vec{F}_2 = -15\vec{\imath} - 25.98\,\vec{\jmath} - 25\vec{\imath} = -40\vec{\imath} - 25.98\,\vec{\jmath}$$

$$|F_2| = \sqrt{(-40)^2 + (-25.98)^2} = 47.7\text{ N}$$

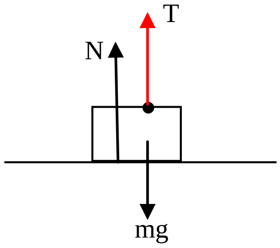
$$\theta = \tan^{-1}\left(\frac{-25.98}{-40}\right) = 33^{\circ}, \text{both x and y} - \text{ve components}$$

$$\theta = 180 + 33 = 213°$$

Q2.

A block of 5.0 N weight is at rest on a horizontal surface. A 2.0 N upward force is applied to the block by means of a vertical string attached to its center. Find the magnitude and direction of the force of the block on the horizontal surface.

A) 3.0 N downward
B) 3.0 N upward
C) 7.0 N upward
D) 7.0 N downward
E) 5.0 N downward



Ans:

$$N + T - mg = 0$$

$$N = mg - T$$

$$N = 5 - 2 = 3.0\ \text{N}$$

Force of the block on the horizontal surface equal and opposite to N

Q3.

As shown in **Figure 2**, two boxes A and B are connected to each end of a light vertical rope. A constant upward force **F** of magnitude 80.0 N is applied to box A. Starting from rest, box B descends 12.0 m in 4.00 s. Find the mass of box B if the tension in the rope is 36.0 N.

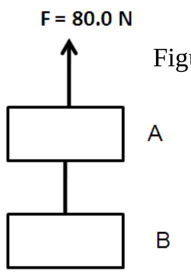
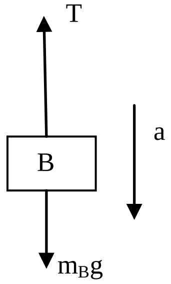


Figure 2

A) 4.34 kg
B) 3.18 kg
C) 5.67 kg
D) 1.45 kg
E) 6.43 kg

Ans:



$$T - m_B g = -m_B a$$

$$m_B = \frac{T}{(g - a)}$$

To find a: $y = v_{iy} t + \frac{1}{2} a t^2$

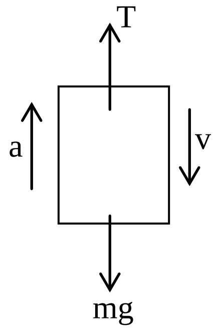
For $v_{iy} = 0$, $a = \frac{2y}{t^2} = \frac{24}{16} = 1.5\ \text{m/s}^2$

$$m_B = \frac{T}{(g - a)} = \frac{36}{(9.8 - 1.5)} = 4.34\ \text{kg}$$

Q4.

An elevator and its load have a combined mass of 2.00 x 10^3 kg. Find the tension in the supporting cable when the elevator, initially moving downward at 15.0 m/s, is brought to rest with constant acceleration in a distance of 50.0 m.

A) 2.41 x 10^4 N
B) 1.51 x 10^4 N
C) 3.20 x 10^3 N
D) 6.32 x 10^3 N
E) 7.45 x 10^4 N



Ans:

$T - mg = ma$

$T = m(g + a)$

For calculation of a: $v_{fy}{}^2 = v_{iy}{}^2 - 2a_y$

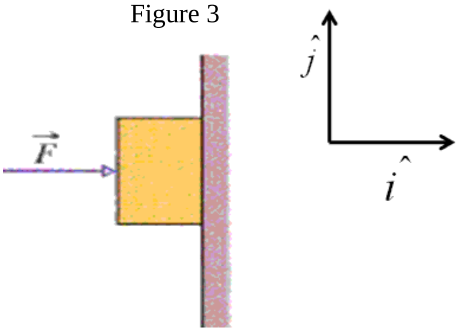
For $v_{fy} = 0, a = \dfrac{v_{iy}{}^2}{2y} = \dfrac{(15)^2}{2 \times 50} = 2.25 \text{m/s}$

$T = m\,(g + a) = 2000\,(9.8 + 2.25) = 2.41 \times 10^4$ N

Q5.

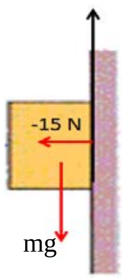
A 15 N horizontal force F pushes a block weighing 5.0 N against a vertical wall as shown in **Figure 3**. The coefficient of static friction between the wall and the block is 0.60 and the coefficient of kinetic friction is 0.40. In unit vector notation, find the force (in Newtons) on the block from the wall.

Figure 3



A) -15 $\hat{i}$ + 5.0 $\hat{j}$
B) -15$\hat{i}$ + 9.0 $\hat{j}$
C) 15$\hat{i}$ – 4.0 $\hat{j}$
D) 15$\hat{i}$ + 4.0 $\hat{j}$
E) 5.0$\hat{i}$ – 9.0 $\hat{j}$

Ans:



$f_s\ (= \mu_s N = \mu_s|F| = 0.6 \times 15 = 9.0\text{ N}) \gg mg,$
block will not slip then $|f_s| = |mg|$

Force on the block $F = -|F|\vec{i} + |f_s|\vec{j}$

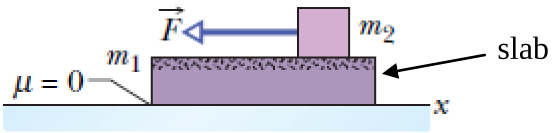
$= -|F|\vec{i} + |mg|\vec{j}$

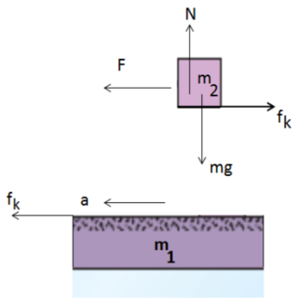
$= -15\hat{i} + 5\,\hat{j}$

Q6.

A slab of mass m_1 = 50.0 kg rests on a frictionless floor. A block of mass m_2 = 15.0 kg rests on top of the slab as shown in **Figure 4.** The coefficient of static friction between the block and the slab is 0.600 and their coefficient of kinetic friction is 0.400. The 15.0 kg block is pulled leftward by a horizontal force **F** of magnitude 100 N. Find the acceleration of the slab.

Figure 4





A) 1.18 m/s^2 leftward
B) 3.92 m/s^2 rightward
C) 1.18 m/s^2 rightward
D) 3.92 m/s^2 leftward
E) 2.34 m/s^2 rightward

Ans:

For slab $f_k = m_1 a$

$a = \frac{f_k}{m_1}$ but $f_k = \mu_k m_2 g = 0.4 \times 15 \times 9.8 = 58.8$ N

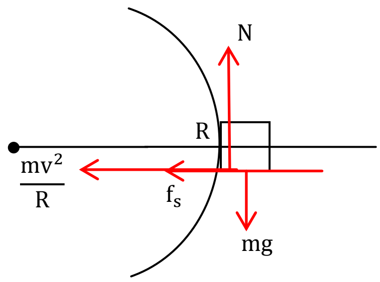
$a = \frac{28.8}{50} = 1.18 m/s^2$ toward left

Q7.

Find the smallest radius of a circular flat horizontal track around which a bicyclist can travel if his speed is 30 km/hour and the coefficients of static and kinetic friction between the tires and the track are 0.32 and 0.25, respectively.

A) 22 m
B) 15 m
C) 30 m
D) 35 m
E) 10 m

Ans:



$\not{-}f_s = \not{-}\mu_s \cancel{m} g = \not{-}\frac{\cancel{m}v^2}{R}$

$\mu_s g = \frac{v^2}{R} \Rightarrow R = \frac{v^2}{\mu_s g}$

but $v = 30$ km/hr $= 8.33$ m/s

Then $R = \frac{v^2}{\mu_s g} = \frac{(8.33)^2}{0.32 \times 9.8} = 22$ m

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Q8.

A truck carrying a 66.0 kg box accelerates uniformly from rest at 1.17 m/s^2 for 15.0 s. Calculate the work done on the box during this time interval.

A) 1.02 x 10^4 J
B) 1.02 x 10^3 J
C) 2.90 x 10^3 J
D) 2.90 x 10^4 J
E) 1.90 x 10^4 J

Ans:

$$W = \Delta K = \frac{1}{2} m(v_f{}^2 - v_i{}^2) \quad v_f = v_i + at \text{ but } v_i = 0 \text{ then } v_f = at$$

$$= \frac{1}{2} m \times (at)^2$$

$$W = \frac{1}{2} \times 66 \times (1.17 \times 15)^2 = 1.02 \times 10^4 \text{ J}$$

Q9.

An elevator supported by a single cable descends at a constant speed. The only forces acting on the elevator are the tension in the cable and the gravitational force. Which one of the following statements is **true**?

A) The net work done by the two forces is zero.
B) The magnitude of the work done by the force of tension is larger than that done by the gravitational force.
C) The magnitude of the work done by the gravitational force is larger than that done by the force of tension.
D) The kinetic energy of the elevator increases.
E) The tension force does positive work.

Ans:

A

Q10.

A spring of spring constant $k = 2.0 \times 10^2$ N/m is suspended with its upper end supported vertically from a ceiling. With the spring hanging in its equilibrium configuration, an object of mass m = 2.0 kg is attached to the lower end and released from rest. What is the speed of the object after it has fallen 4.0 cm?

A) 79 cm/s
B) 90 cm/s
C) 96 cm/s
D) 83 cm/s
E) 57 cm/s

Ans:

$$\Delta K + \Delta U_g + \Delta U_S = 0$$

$$\frac{1}{2}\, m v_f^{\,2} - mgh + \frac{1}{2}\, kh^2 = 0$$

$$v_f = \sqrt{2gh - \frac{k}{m}h^2} = \sqrt{2 \times 9.8 \times 0.04 - \frac{200}{2}(0.04)^2}$$

$$v_f = 0.79\ \mathrm{m/s} = 79\ \mathrm{cm/s}$$

Q11.

A pump is required to lift 800 kg of water **per minute** from a well 14.0 m deep and eject it with a speed of 18.0 m/s. What must be the average power output of the pump?

A) 3.99 kW
B) 9.93 kW
C) 1.93 kW
D) 5.22 kW
E) 2.15 kW

Ans:

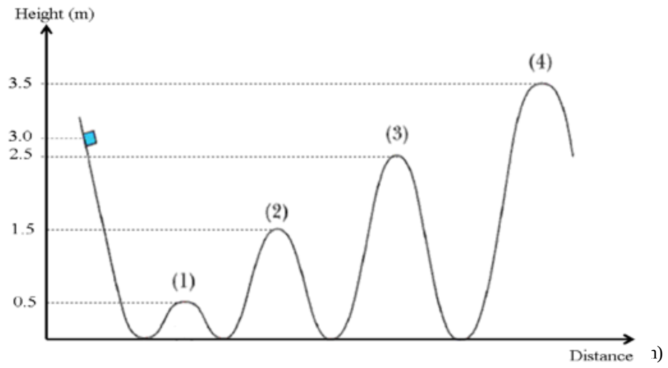
$$P_{avg} = \frac{W}{t} = \frac{\Delta K + \Delta U_g}{t} = \frac{\frac{1}{2}\, m v_f^{\,2} + mgh}{t}$$

$$P_{avg} = \frac{\frac{1}{2} \times 800 \times (18)^2 + 800 \times 9.8 \times 14}{60} = 3989.3\ \mathrm{W}$$

$$P_{avg} = 3.99\ \mathrm{kW}$$

Q12.

As shown in **Figure 5** (**not to the scale**), a small block is released from rest on a frictionless ramp at a height of 3.0 m. The hill heights along the ramp are as shown. The hills have identical circular tops and the block does not fly off any hill. At which two hill tops values of the normal force on the block will be **maximum and minimum**, respectively?



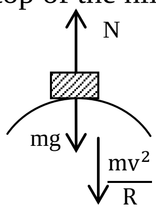
A) 3, 1
B) 4, 1
C) 2, 3
D) 1,4
E) 3, 2

Ans:

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

$$N = m\left(g - \frac{v^2}{R}\right)$$

at the top of the hill



N is **maximum** when v is **minimum** at hill # 3

N is **minimum** when v is **maximum** at hill # 1

Q13.

Starting from rest, a firefighter of mass 100 kg slides down a vertical pole. The average frictional force exerted on him by the pole has a magnitude of 820 N, and his speed at the bottom of the pole is 3.40 m/s. How far did he slide down the pole?

A) 3.61 m
B) 6.31 m
C) 1.16 m
D) 2.22 m
E) 4.15 m

Ans:

$$\Delta K + \Delta U = W_f$$

$$\frac{1}{2}mv_f^2 - mgh = -f_k h$$

$$h(mg - f_k) = \frac{mv_f^2}{2}$$

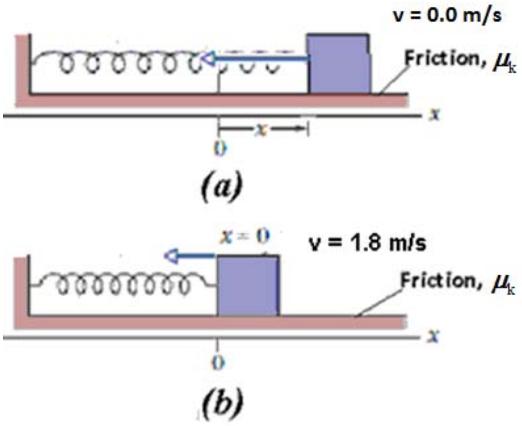
$$h = \frac{mv^2}{2(mg - f_k)} = \frac{100 \times (3.4)^2}{2(100 \times 9.8 - 820)} = 3.61\ \text{m}$$

Q14.

A 2.0 kg block sliding on a rough horizontal surface is attached to one end of a horizontal spring (k = 2.5x10^2 N/m) which has its other end fixed. The block is pulled to the right by a distance x = 0.20 m from equilibrium and released from rest as shown in **Figures 6(a) and 6(b)**. What is the coefficient of kinetic friction between the block and the horizontal surface if the block passes through the equilibrium position with a speed of 1.8 m/s?

A) 0.45
B) 0.32
C) 0.58
D) 0.19
E) 0.26

Figure 6



Ans:

$$\Delta K + \Delta U_s = W_f = -f_k x$$

$$\frac{1}{2}mv_f^2 - \frac{1}{2}kx^2 = -\mu_k mgx$$

$$\mu_k = \frac{1}{mgx}\left[\frac{1}{2}kx^2 - \frac{1}{2}mv_f^2\right]$$

$$\mu_k = \frac{1}{2 \times 9.8 \times 0.2}\left[\frac{1}{2} \times 250 \times (0.2)^2 - \frac{1}{2} \times 2 \times (1.8)^2\right] = 0.45$$

Q15.

An object moves from point A to point B under the influence of only two forces. Between points A and B, one force is **conservative** and does +150 J of work while the other force is **non-conservative** and does –100 J of work. Which **one of the** following statement**s** describes the situation correctly?

A) the kinetic energy of the object increases and its mechanical energy decreases.
B) both the kinetic energy and the mechanical energy of the object increase.
C) the kinetic energy of the object decreases and its mechanical energy increases.
D) both the kinetic energy and mechanical energy of the object decrease.
E) the change in its potential energy is 50.0 J.

Ans:

$$W_{cons} = +150\ J, \qquad W_{non-cons} = -100\ J$$

$$\Delta \mathbf{K} = W_{cons} + W_{non-consc} = 150 - 100 = \mathbf{+50\ J}$$

$$\Delta \mathbf{E} = \Delta K + \Delta U = W_{non-cons} = \mathbf{-100\ J}$$

Therefore object kinetic energy Δ**K** increases and its mechanical energy Δ**E** decreases.
