Phy 101

Chapter 8

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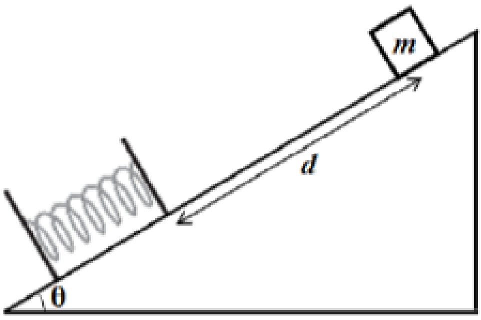
Q5.

A block of mass m = 3.5 kg slides from rest down a frictionless incline of angle θ = 30°. See Figure 2. After sliding a distance d along the incline, it compresses a relaxed spring of spring constant 430 N/m. The block monetarily stops after compressing the spring by 20 cm. What is the distance d ?

Figure 2

A) 30 cm
B) 40 cm
C) 50 cm
D) 55 cm
E) 60 cm



Ans:

Conservation of energy:

$$mg(d + X)sin\theta = \frac{1}{2}\, hx^2$$

$$d + X = 0.50\ m$$

$$d = 0.30\ m$$

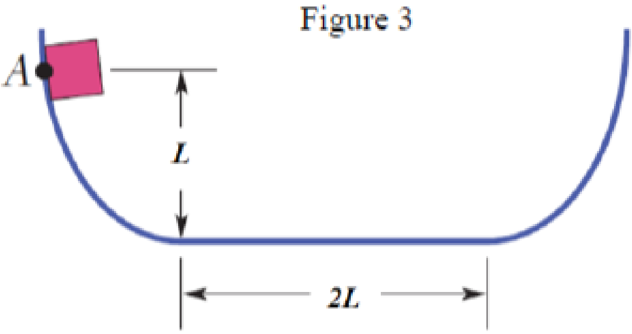
191, Major 2, Q5

Q6.

A box can slide along a track with elevated curved ends and a flat central part, as shown in Figure 3. The flat part has length $2L$. The curved portions of the track are frictionless, but for the flat part the coefficient of kinetic friction is $\mu_k = 0.25$. The box is released from rest at point A on the left curved portion, which is at a height L. Find the maximum height that the box will reach at the right curved portion.

A) $L/2$
B) L
C) $3L/2$
D) $2L/3$
E) $L/3$

Figure 3



Ans:

Conservation of energy:

$$mgL' = mgL - \mu mg(2L)$$

$$L' = L - \mu(2L) = 0.5\ L$$

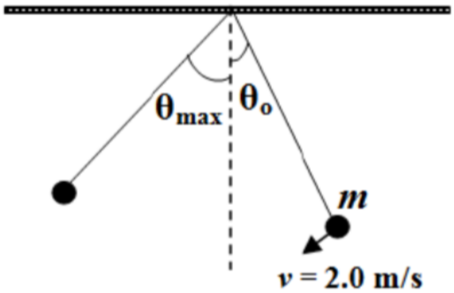
191, Major 2, Q6

Q7.

A pendulum consists of a small mass $m = 0.15$ kg attached to a massless rod with length 2.0 m. At $\theta_o = 15°$, the mass has a speed of 2.0 m/s (see Figure 4). Find the maximum angle θ_{max} that the pendulum will make with the vertical. (Ignore air resistance)

A) 30°
B) 37°
C) 27°
D) 45°
E) 60°

Figure 4



Ans:

U = 0 at initial position
H_i = height at initial position
H_f = height at final position

H= H_i - H_f

$$\frac{1}{2} mv_i^2 = mgh \Rightarrow h = 0.2\,m$$

$$H_i = L cos\theta_0, H_f = L cos\theta_{max}$$

$$\frac{h}{L} = \frac{H_i - H_f}{L} = cos\theta_0 - cos\theta_{max} \Longrightarrow \theta_{max} = 30°$$

191, Major 2, Q7

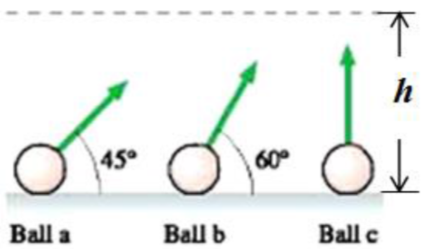
Q9.
A crate (mass = 14 kg) initially moving with speed of 0.60 m/s is pushed into a horizontal rough floor with a constant force F = 40 N. After a straight-line displacement of magnitude d = 0.50 m, the speed of the crate decreases to 0.20 m/s. Find the increase in the thermal energy of the crate and the floor.

A) 22 J
B) 16 J
C) 28 J
D) 36 J
E) 40 J

Solution:
$$\Delta K = W_F + W_{th} \;\; \Rightarrow \Delta E_{th} = -W_{th} = W_F - \Delta K = 22.2\,J$$

191, Final, Q9

Q10.
The three balls (a, b, and c) in Figure 4, have equal masses. They are fired from the same initial height with the same speeds but with different launching angles. Rank in order, from largest to smallest, the speeds of the balls v_a, v_b, and v_c, as they cross the dashed horizontal line at height h.



Solution:
Use conservation of energy

A) All the balls will have the same speed
B) v_a, v_b, v_c
C) v_a, v_c, v_b
D) v_b, v_a, v_c
E) v_c, v_a, v_b

191, Final, Q10

Q5.

A particle is moved from point A to point B under the action of two forces. One of the forces is conservative and the other one is non-conservative, but none of the forces is a frictional force. The kinetic energies of the particle at points A and B are equal if

A) the sum of the works of the two forces is zero.
B) the work of the conservative force is equal to the work of the non-conservative force.
C) the work of the conservative force is zero.
D) the work of the non-conservative force is zero.
E) None of these answers

Ans:

$$\Delta K - W_C = W_N$$

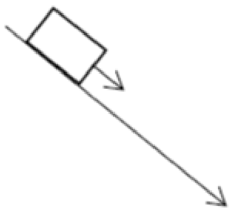
$$\Delta K = W_C + W_N$$

182, Major 2, Q5

Q6.

A child whose weight is 267 N slides down a 6.10 m long slide that makes an angle of 20.0° with the horizontal. The coefficient of kinetic friction between the slide and the child is 0.100. If the child starts at the top with a speed of 0.457 m/s, what is the child's speed at the bottom? (Ignore air resistance)

A) 5.46 m/s
B) 2.35 m/s
C) 4.00 m/s
D) 1.41 m/s
E) 2.32 m/s



Ans:

$$\Delta K + \Delta U_g = W_a + W_4$$

$$\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 - mgsin20° = -mgcos\theta\mu X$$

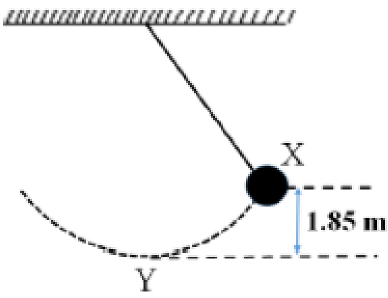
$$v = \sqrt{v_0^2 + 2gx(sin20 - cos20\mu)} = 5.46\, m/s$$

182, Major 2, Q6

Q7.

A simple pendulum consists of a 2.00 kg mass attached to a string. The mass is released from rest at X as shown in Figure 2. If the height of X from the lowest point Y is 1.85 m, find the speed of the mass at point Y. (Ignore air resistance)

Figure 2



A) 6.02 m/s
B) 9.00 m/s
C) 8.45 m/s
D) 2.87 m/s
E) 3.53 m/s

Ans:

$$\Delta K + \Delta v_g = 0$$

$$K - K_0 + v_g - V_{0g} = 0$$

$$\frac{1}{2}mv^2 - mgh = 0$$

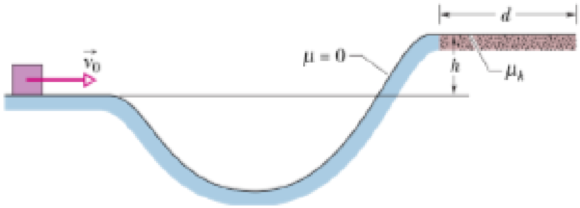
$$v = \sqrt{2mgh} = \sqrt{2 \times 9.8 \times 1.85} = 6.02\, m/s$$

182, Major 2, Q7

Q8.

In Figure 3, a block slides along a track from one level to a higher level after passing through a valley. The track is frictionless until the block reaches the higher level. On the rough surface, a frictional force stops the block in a distance d. The block's initial speed v_0 is 6.0 m/s, the height difference h is 1.1 m, and μ_k is 0.60. Find d. (Ignore air resistance)

Figure 3



A) 1.2 m
B) 4.5 m
C) 2.6 m
D) 3.4 m
E) 5.7 m

Ans:

$$\Delta K + \Delta V_g = W_a + W_f$$

$$K - K_0 + V_g - V_{vg} = -mg\mu_k d$$

$$-\frac{1}{2}mv_0^2 + mgh = -mg\mu_k d$$

$$d = \frac{\frac{1}{2}v_0^2 - gh}{g\mu_k} = 1.2\, m$$

182, Major 2, Q8

Q6.

Camping equipment weighing 6.0×10^3 N is pulled by campers across a frozen lake using a horizontal rope. The coefficient of kinetic friction is 0.050. The work done by the campers in pulling the equipment 1.0×10^3 m at constant velocity is:

A) 3.0×10^5 J
B) 1.0×10^5 J
C) 2.0×10^5 J
D) 4.0×10^5 J
E) 5.0×10^5 J

Ans:

$$\Delta K + \Delta U_g = W_a + (W_f)$$

$$W_a = \Delta K + W_f = \frac{1}{2}mv^2 + \mu mg\Delta X$$

$$= 0.05\times6000\times1000 = 3.0\times10^5\ J$$

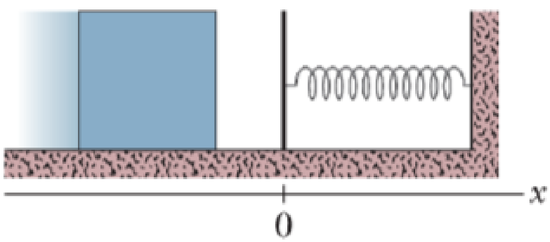
182, Final, Q6

Q7.

A block of mass m = 2.5 kg slides on a horizontal rough surface head on into a spring of spring constant k = 320 N/m, as shown in Figure 1. When the block stops, it has compressed the spring by 7.5 cm. The coefficient of kinetic friction between block and floor is 0.25. What is the block's speed just as it reaches the spring?

A) 1.0 m/s
B) 2.0 m/s
C) 3.0 m/s
D) 4.0 m/s
E) 5.0 m/s

Figure 1



Ans:

$$\Delta U_s + \Delta K = W_f$$

$$\frac{1}{2}kx^2 + \frac{1}{2}mv_0^2 = -\mu mgX$$

$$v_0 = \sqrt{2\mu gX + \frac{K}{m}X^2} = \sqrt{2\times0.25\times9.8\times0.075 + \frac{320}{2.5}\times0.075^2} = 1.0\ \text{m/s}$$

182, Final, Q7

Q8.

A projectile of mass 0.500 kg is fired with an initial speed of 10.0 m/s at an angle of 60.0° above the horizontal. The potential energy of the projectile-Earth system when the projectile is at its highest point (relative to the potential energy when the projectile is at ground level) is:

A) 18.8 J
B) 27.7 J
C) 32.5 J
D) 46.2 J
E) 55.3 J

Ans:

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

$$K - K_0 + U - U_0 = 0$$

$$U = \frac{1}{2}mv_0^2 - \frac{1}{2}m(v_0 cos60°)^2$$

$$U = \frac{1}{2} \times 0.5 \times 10^2 - \frac{1}{2} \times 0.5\left(10 \times \frac{1}{2}\right)^2 = 18.8 \ J$$

182, Final, Q8

Q3.

A 20 kg child slides 3.5 m down a vertical pole to the house floor, starting from rest. What is the kinetic energy of the child as he reaches the floor if the frictional force on him from the pole is negligible?

A) 6.9×10^2 J
B) 4.1×10^2 J
C) 2.5×10^2 J
D) 7.9×10^2 J
E) 8.2×10^2 J

181, Major 2, Q3

Ans:

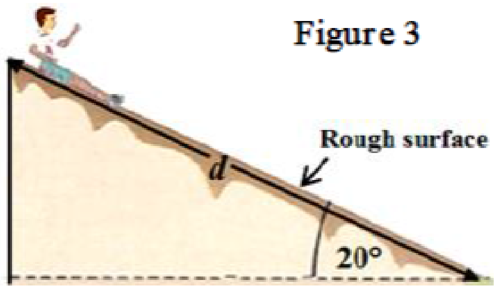
$$K_i + U_i = K_f + U_f \Rightarrow U_i = K_f \left(K_i = U_f = 0\right)$$

$$K_f = U_i = mgh = 20 \times 9.8 \times 3.5 = 686 \, J = 6.9 \times 10^2 \, J$$

Q6.

A child whose weight is 267 N moves down a distance $d = 6.10$ m along a slide that makes an angle of 20.0° with the horizontal, as shown in **Figure 3**. If coefficient of kinetic friction between slide and child is 0.100, what is change in kinetic energy of the child over the distance "d"?

Figure 3



A) 404 J
B) 355 J
C) 222 J
D) 511 J
E) 659 J

Ans:

$$\Delta K + \Delta U = W_f = -f_k d$$

$$\Delta K = -\Delta U - f_k d = U_i - f_k d$$

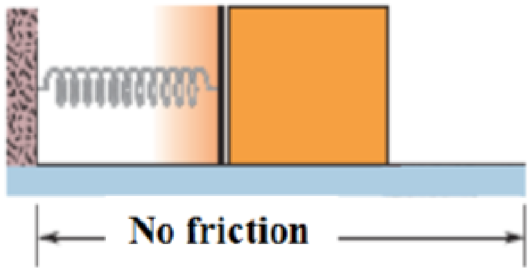
$$= mgd(sin\theta - \mu_k cos\theta) = 267 \times 6.1(sin20 - 0.1 \times cos20) = 404.00 \text{ J}$$

181, Major 2, Q6

Q7.

In **Figure 4**, a 3.5 kg block is accelerated over a horizontal frictionless floor from rest by a compressed spring with negligible mass and a spring constant of 9.7×10^2 N/m. The block leaves the spring at its relaxed length with a speed of 1.5 m/s. What was the compression distance of the spring?

Figure 4



A) 9.0 cm
B) 6.7 cm
C) 3.5 cm
D) 11 cm
E) 13 cm

Ans:

$$K_i + U_{si} = K_f + U_{sf} \Rightarrow U_{si} = K_f (K_i = U_{sf} = 0)$$

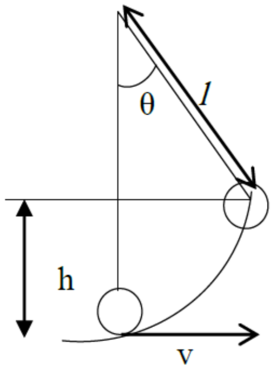
$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

$$x = \sqrt{\frac{mv^2}{k}} = = \sqrt{\frac{3.5 \times (1.5)^2}{9.7 \times 10^2}} = 0.090\ m$$

181, Major 2, Q7

Q8.

A stone attached to end of 3.8 m long string is swinging in a vertical plane. If the string makes a maximum angle of 39° with the vertical, find maximum speed of the swinging stone? (Ignore air resistance)



A) 4.1 m/s
B) 2.4 m/s
C) 1.9 m/s
D) 5.3 m/s
E) 6.1 m/s

Ans:

$h = l(1 - cos\theta$

$h = 3.8(1 - cos39) = 0.85$

$K_i + U_i = K_f + U_f \; (U_i = K_f = 0)$

$\frac{1}{2}mv^2 = mgh$

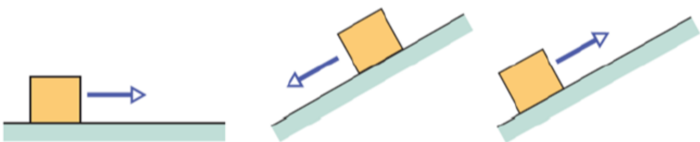
$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.85} = 4.074 \; m/s$

181, Major 2, Q8

Q16.

Figure 7 shows three cases involving a block sliding along the rough plane. The block begins with the same speed in all three cases and slides until the kinetic frictional force has stopped it. Rank the situations according to the increase in thermal energy due to the sliding, **greatest first**.

Figure 7



A) 2, 1, 3
B) 3, 2, 1
C) 1, 2, 3
D) 2, 3, 1
E) All ties

Ans:

$\Delta K + \Delta U + \Delta E_{th} = 0$

$\Delta E_{th} = -\Delta K - \Delta U$

$\Delta E_{th} = K_i - U_f + U_i$

For (1) $\Delta E_{th} = K_i (U_i = 0)$

For (2) $\Delta E_{th} = K_i + U_i = K_i + mgh$

For (3) $\Delta E_{th} = K_i - U_f = K_i - mgh$

181, Major 2, Q16

Q26.

A 5.0 g marble is fired vertically upward using a spring gun. The spring must be compressed 5.0 cm if the marble is to just reach a target 17 m above the marble's position on the compressed spring. What is the spring constant of the spring? (Ignore the air resistance and spring mass).

A) 6.7×10^2 N/m
B) 7.0×10^2 N/m
C) 5.3×10^2 N/m
D) 4.0×10^2 N/m
E) 8.0×10^2 N/m

Ans:

$$K_i + U_{gi} + U_{si} = K_f + U_{gf} + U_{sf}$$

$$U_{si} = U_{gf}\left(K_i = K_f = U_{gi} = U_{sf} = 0\right)$$

$$\frac{1}{2}kx^2 = mgh$$

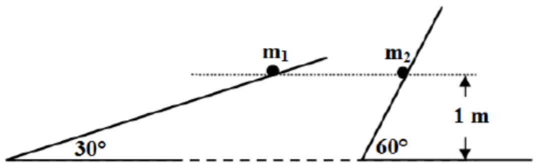
$$k = \frac{2mgh}{x^2} = \frac{2\times5\times9.8\times17\times10^{-3}}{(0.05)^2} = 666.4\ \mathrm{N/m}$$

181, Final, Q26

Q2.

Two masses m_1 and $m_2 = 2m_1$ start from rest from the same height from the top of two frictionless inclines of angles 30° and 60° (see **Figure 1**). When the masses reach the bottom of the inclines:

Figure 1



A) Both masses are moving with the same speed.
B) m_1 moves faster than m_2.
C) m_2 moves faster than m_1.
D) Both masses have the same kinetic energy.
E) m_1 has more kinetic energy than m_2.

Ans:

$$\Delta K + \Delta U_g = W_{ext}^{\ 0}$$

$$\Delta K = -\Delta U_g$$

$$\frac{1}{2}mv^2 = -(-mgh)$$

$$\Rightarrow v = \sqrt{2gh}$$

Independent of mass

173, Major 2, Q2

Q3.

A 500 kg elevator is pulled upward with a constant force of 5500 N for a distance of 50 m. What is the net work done on the elevator by all forces acting on it?

A) $+3.0 \times 10^4$ J
B) -5.2×10^5 J
C) -3.6×10^5 J
D) $+2.1 \times 10^5$ J
E) $+1.7 \times 10^4$ J

Ans:

$$W_F = 5500 \times 50 = 275 \times 10^3 \text{ J}$$

$$W_g = -500 \times 9.8 \times 50 = -245 \times 10^3 \text{ J}$$

$$W_{net} = W_F + W_g = +30 \times 10^3 \text{ J} = +3.0 \times 10^4 \text{ J}$$

173, Major 2, Q3

Q4.

A simple pendulum is 1.30 m long. The mass at its end is pulled to one side until the pendulum makes an angle of 29.0° with the vertical and then released from rest. If the kinetic energy of the mass at the lowest point of its motion is 0.360 J, what is the value of the mass?

A) 0.225 kg
B) 0.106 kg
C) 0.140 kg
D) 0.980 kg
E) zero

Ans:

Take the lowest point as the reference of gravitational potential energy.

$$U_i + \cancelto{0}{K_i} = \cancelto{0}{U_f} + K_f \quad \{i \longrightarrow \text{release};\ f \longrightarrow \text{lowest point}\}$$

$$mgh = K_f \Longrightarrow mgL\,(1 - cos\theta_i) = K_f$$

$$m = \frac{K_f}{gL(1 - cos\theta_i)} = \frac{0.36}{9.8 \times 1.3 \times (1 - \cos 29^o)} = 0.225 \text{ kg}$$

173, Major 2, Q4

Q5.

A ball falls from the top of a building to the floor. At the moment when it is 0.70 m above the floor, its gravitational potential energy equals its kinetic energy. What is the speed of the ball at that moment? Take the floor as the reference of gravitational potential energy.

A) 3.7 m/s
B) 6.9 m/s
C) 9.8 m/s
D) 14 m/s
E) zero

Ans:

$$\left.\begin{aligned} U_g &= mgh \\ K &= \frac{1}{2}mv^2 \end{aligned}\right\} U_g = K: \cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.7} = 3.7 \text{ m/s}$$

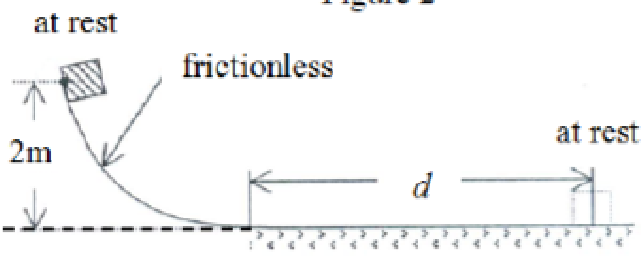
173, Major 2, Q5

Q6.

A block slides along the track shown in **Figure 2**. The curved portion of the track is frictionless, but for the horizontal part the coefficient of kinetic friction is 0.40. The block is released from rest from a height of 2.0 m above the horizontal part of the track. Find the distance d that the block moves on the horizontal part before it stops. Treat the block as a particle.

A) 5.0 m
B) 0.80 m
C) 2.4 m
D) 7.5 m
E) 1.5 m

Figure 2



Ans:

$$\Delta U_g + \cancelto{0}{\Delta K} = W_{ext}$$

$$-mgh = W_f = -f_k \cdot d$$

$$mgh = \mu_k mg \cdot d$$

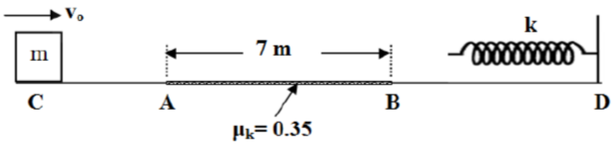
$$d = \frac{h}{\mu_k} = \frac{2.0}{0.40} = 5.0 \text{ m}$$

173, Major 2, Q6

Q7.

As shown in **Figure 3**, a 4.0-kg block has speed 8.5 m/s at point C. Tracks CA and BD are frictionless, but track AB (of length 7.0 m) is rough ($\mu_k = 0.35$). The block runs into and compresses a spring ($k = 2400$ N/m) until it momentarily stops. By what distance is the spring compressed when the block stops?

Figure 3



A) 0.20 m
B) 0.45 m
C) 0.35 m
D) 0.57 m
E) 0.15 m

Ans:

$$\Delta K + \Delta U_s = W_{ext}$$

$$K_f^{\;0} - K_i + \frac{1}{2}kd^2 = W_f$$

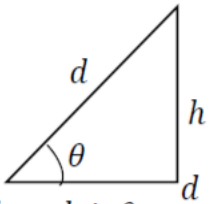
$$-\frac{1}{2}mv^2 + \frac{1}{2}kd^2 = -\mu_k mgx$$

$$1200\,d^2 = -96.04 + 144.5 \Rightarrow d = 0.2 \text{ m}$$

173, Major 2, Q7

Q9.

A 2.0 kg block is projected down a rough inclined plane that makes an angle of 30° above the horizontal with an initial kinetic energy of 2.0 J. If the coefficient of kinetic friction between the block and the incline is 0.60, how far will the block slide down the incline before coming to rest?



$$h = d\sin\theta = \frac{d}{2}$$

A) 5.2 m
B) 1.8 m
C) 3.0 m
D) 1.0 m
E) 2.3 m

Ans:

$$\Delta K + \Delta U_g = W_{ext}$$

$$-K_i - mgh = -f_x \cdot d$$

$$-K_i - \frac{1}{2}mgd = -\mu_x\, mg\, cos30°\, d$$

$$(\mu_x\, cos30° - 0.5)\, mgd = K_i$$

$$0.384\, d = 2.0 \Rightarrow d = 5.2 \text{ m}$$

173, Final, Q9

Q5.

At time t = 0, a 1.0 kg ball is thrown from the top of a 100 m tall tower with initial velocity $\vec{\mathbf{v}}_0 = \left(16\hat{i} + 24\hat{j}\right)$ m/s. At what height from the ground will the kinetic energy of the ball be three times its initial kinetic energy? (Ignore the air resistance)?

A) 15 m
B) 10 m
C) 20 m
D) 25 m
E) 40 m

Ans:

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

$$U - U_0 + K - K_0 = 0$$

$$mgh - mg \times 100 + 3K_0 - K_0 = 0$$

$$mgh - mg100 + 2 \times \frac{1}{2} m v_0^2 = 0$$

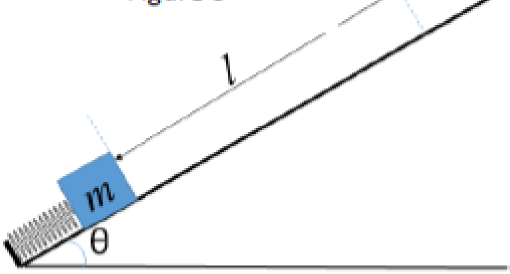
$$h = 100g - v_0^2 = 15\, m$$

172, Major 2, Q5

Q6.

A block with mass m = 2.00 kg is placed against a spring on a rough incline with angle θ = 30.0° and coefficient of kinetic friction μ_k = 0.215 as shown in **Figure 3** (The block is not attached to the spring). The spring, which is compressed 20.0 cm from its relaxed position, is then released from rest and the block travels distance l = 1.20 m from the release point on the incline before coming to rest. Find the value of spring constant k of the spring.

Figure 3



A) 807 N/m
B) 578 N/m
C) 256 N/m
D) 980 N/m
E) 663 N/m

Ans:

$$\cancel{\Delta K}^{0} + \Delta U_g + \Delta U_s = W_f$$

$$U_g - U_{0g} + U_s - U_{0s} = -\mu_k F_N l$$

$$mgh - 0 + 0 - \frac{1}{2} kx^2 = -\mu_k mgcos\theta l$$

$$mglsin\theta - \frac{1}{2} kx^2 = -\mu_k mgcos\theta l \Rightarrow k = \frac{2mgl(sin\theta + \mu_k cos\theta)}{x^2} = 807\, N/m$$

172, Major 2, Q6

Q7.

If only conservative forces are acting on a body then the work done by conservative forces

A) does not change the total mechanical energy.
B) does not change the potential energy.
C) does not change the kinetic energy.
D) is always equal to zero.
E) is always negative.

Ans:

A

172, Major 2, Q7

Q8.

An 18-kg object is released from rest and moves vertically downward from a height of 80 m above the ground. It reaches the ground with a speed of 15 m/s. How much work was done by the non-conservative forces on the object?

A) – 12 kJ
B) – 16 kJ
C) + 12 kJ
D) + 16 kJ
E) – 14 kJ

Ans:

$$W_f = \Delta K + \Delta U_g = K - \cancelto{0}{K_0} + \cancelto{0}{U} - U_0$$

$$W_f = \frac{1}{2}mv^2 - mgh = m\left(\frac{1}{2}v^2 - gh\right) = -12k\,\mathrm{J}$$

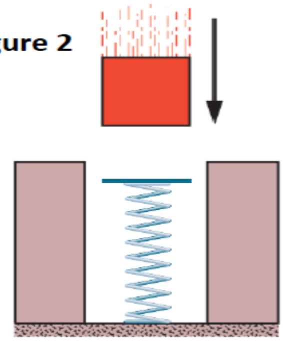
172, Major 2, Q8

Q3.

A 0.80 kg block is dropped onto a relaxed vertical spring that has a spring constant of k = 250 N/m as shown in **Figure 2**.The block compresses the spring 0.12 m before momentarily stopping. Find the maximum speed of the block just before it hits the spring. (Assume that friction and air resistance are negligible.)

A) 1.5 m/s
B) 2.1 m/s
C) 3.2 m/s
D) 4.6 m/s
E) 5.0 m/s

Figure 2



Ans:

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

$$\left(0 - \frac{1}{2}mv_0^2\right) + (0 - mgx) + \left(\frac{1}{2}kx^2 - 0\right) = 0$$

$$v_0 = \sqrt{\frac{kx^2}{m} - 2gx} = 1.5\ m/s$$

172, Major 2, Q3

Q7.

A 2.0-kg block with an initial velocity of $\vec{v} = 3.0\hat{i} - 4.0\hat{j}$ (m/s) slides on a horizontal xy- rough surface with coefficient of kinetic friction $\mu_k = 0.12$. Find the total distance traveled by the block before it comes to rest.

A) 11 m
B) 17 m
C) 25 m
D) 30 m
E) 47 m

Ans:

$$\Delta K + \Delta U_g = W_f$$

$$K - K_0 = \mu_k F_N d\cos 180°$$

$$0 - \frac{1}{2}mv^2 = -\mu_k mgd$$

$$\Rightarrow d = \frac{v^2}{2\mu_k g} = \frac{5^2}{2 \times 0.12 \times 9.8} = 10.6 \approx 11\,m$$

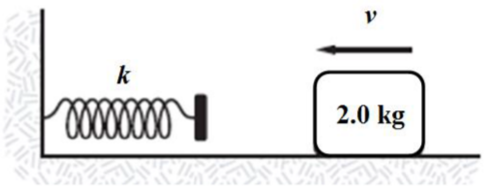
172, Final, Q7

Q4.

Figure 1 shows a block of mass 2.0 kg moving on a horizontal frictionless surface and an uncompressed spring with one end attached to a wall. The speed of the block before it touches the spring is 6.0 m/s. How fast is the block moving at the instant the spring has been compressed 15 cm? The spring constant *k* of the spring is 2.0 kN/m.

A) 3.7 m/s
B) 4.4 m/s
C) 9.2 m/s
D) 5.4 m/s
E) 1.2 m/s

Figure 1



Ans:

$$\Delta K + \Delta U_s = 0$$

$$\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 + \frac{1}{2}kx^2 = 0$$

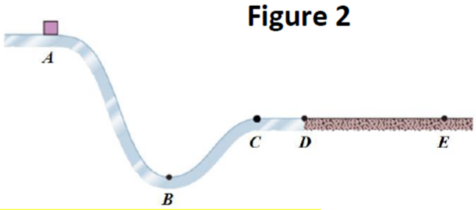
$$v = \sqrt{v_0^2 - \frac{k}{m}x^2} = \sqrt{6^2 - \frac{2000}{2} \times \left(\frac{15}{100}\right)^2} = 3.7\,m/s$$

171, Major 2, Q4

Q6.

In **Figure 2**, a block slides from *A* to *D* along a frictionless ramp, and then passes through horizontal region *DE*, where a frictional force acts on it. Which one of the following statements about the block is **FALSE**?

Figure 2



A) Its mechanical energy remains constant in region DE
B) Its kinetic energy increases in region AB
C) Its mechanical energy remains constant in region AB
D) Its kinetic energy remains constant in region CD
E) Its mechanical energy remains constant in region BC

Ans:

A

171, Major 2, Q6

Q7.

The summit (the highest point) of Mount Everest is 8.9×10^3 m above sea level and an 85 kg climber climbs to the summit starting from sea level. How many candy bars, at 1.3×10^5 J per bar, would supply an energy equivalent to the energy spent (lost) by the climber against the gravitational force on him?

A) 57
B) 84
C) 32
D) 74
E) 12

Ans:

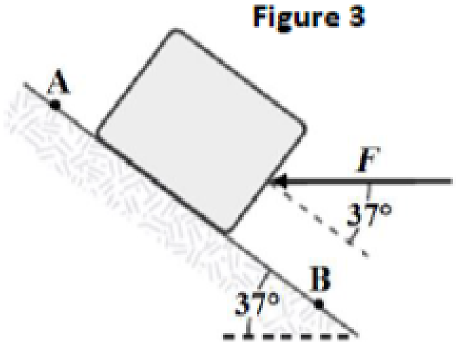
$$\# \, candy \, bars = \frac{mgh}{1.3\times10^5} = \frac{85\times9.8\times8900}{1.3\times10^5} = 57$$

171, Major 2, Q7

Q8.

A 4.0-kg block is lowered down a 37° rough incline a distance of 5.0 m from point A to point B. A force $\vec{F}$ of magnitude 10 N is applied to the block between A and B as shown in **Figure 3**. The kinetic energy of the block at A is 10 J and at B is 20 J. How much work is done on the block by the force of friction between A and B?

Figure 3



A) – 68 J
B) – 58 J
C) – 95 J
D) – 83 J
E) – 43 J

Ans:

$$W_a + W_f = \Delta K + \Delta U_g$$

$$\vec{d}\cdot\vec{F} + W_f = (20-10) + U_g - U_{og} \quad (U_g = 0)$$

$$-50cos37° + W_f = 10 - mgh$$

$$W_f = 50cos37° + 10 - 4\times9.8\times5sin37° = -68°$$

171, Major 2, Q8

Q7.

A block is attached to the end of an ideal spring and moved from coordinate x_i to coordinate x_f. The relaxed position is at $x = 0$. For which values of x_i and x_f is the work done by spring on the block positive?

A) $x_i = -6$ cm and $x_f = -4$ cm
B) $x_i = -4$ cm and $x_f = 6$ cm
C) $x_i = 4$ cm and $x_f = 6$ cm
D) $x_i = -4$ cm and $x_f = -4$ cm
E) $x_i = -6$ cm and $x_f = 7$ cm

Ans:

$$W_s = -\Delta U_s = U_{os} - U_s$$

$$W_s = \frac{1}{2}k\left(x_i^2 - x_f^2\right)$$

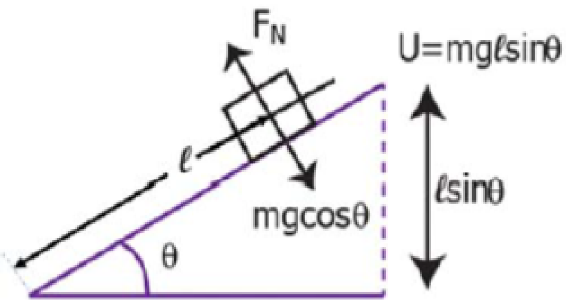
171, Final, Q7

Q8.

A 5.00-kg box starts to slide up a 30.0° incline with 275 J of kinetic energy. How far will it slide up the incline if the coefficient of kinetic friction between the box and the incline is 0.350?

A) 6.99 m
B) 2.25 m
C) 8.80 m
D) 5.23 m
E) 3.43 m

Ans:



$$\Delta K + \Delta U_g = W_f$$

$$\cancel{K}^{\,0} - K_0 + U_g - \cancel{U_{0g}}^{\,0} = -fl$$

$$-275 + mglsin\theta = -\mu_k mglcos\theta$$

$$l = \frac{275}{mg(sin\theta + \mu_k cos\theta)}$$

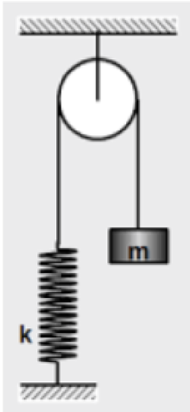
$$l = \frac{275}{5 \times 9.8(sin30° + 0.35cos30°)} = 6.99\ m$$

171, Final, Q8

Q3.

A 20-kg mass is attached to a massless spring (k = 380 N/m) that passes over a frictionless massless pulley, as shown in Figure 3. The mass is released from rest with the spring unstretched. What is the speed of the mass at the instant when it has dropped a vertical distance of 0.40 m?

Figure 3



A) 2.2 m/s
B) 2.8 m/s
C) 1.5 m/s
D) 4.8 m/s
E) 3.6 m/s

Ans:

$$\Delta K = K_f - \overset{0}{\cancel{K_i}} = K_f = \frac{1}{2}mv^2$$

$$\Delta U_g = -mgh$$

$$\Delta U_s = \frac{1}{2}kh^2$$

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

$$\frac{1}{2}mv^2 + \frac{1}{2}kh^2 - mgh = 0$$

$$v^2 = 2gh - \frac{k}{m}h^2$$

$$= (2 \times 9.8 \times 0.4) - \left(\frac{380}{20} \times 0.16\right) = 4.8\ (\mathrm{m/s})^2$$

$$\Rightarrow v = 2.2\ \mathrm{m/s}$$

163, Major 2, Q3

Q4.

A particle moves from the point (1.0, 2.0) m to the point (– 4.0, – 2.0) m while being acted on by a constant force $\vec{F} = 4.0\,\hat{i} + 2.0\,\hat{j}$ (N). What is the work done on the particle by this force?

A) – 28 J
B) + 10 J
C) + 23 J
D) + 17 J
E) – 78 J

Ans:

$$\vec{d} = \vec{r}_f - \vec{r}_i = -5\hat{i} - 4\hat{j} \quad (m)$$

$$W = \vec{F}\cdot\vec{d} = (4\hat{i} + 2\hat{j})\cdot(-5\hat{i} - 4\hat{j}) = -20 - 8 = -28\,J$$

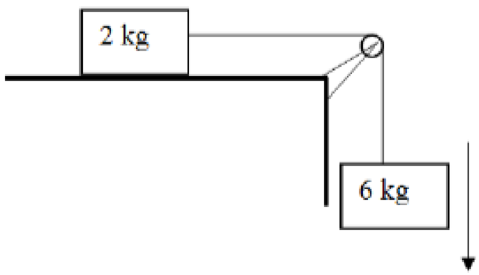
163, Major 2, Q4

Q5.

Two masses are connected and move as shown in Figure 4. The coefficient of kinetic friction between the 2.00-kg mass and the surface is 0.400. The system starts from rest. What is the speed of the 6.00-kg mass at the instant when it has fallen 1.50 m? Assume that the pulley is massless and frictionless.

A) 4.37 m/s
B) 3.54 m/s
C) 6.00 m/s
D) 5.05 m/s
E) 5.42 m/s

Figure 4



Ans:

Let $m_1 = 2kg, m_2 = 6kg, M = m_1 + m_2$

$$\Delta K = K_f - \cancel{K_i}^{\,0} = \frac{1}{2}mv^2$$

$$\Delta U_g = -m_2 gh$$

$$W_{ext} = W_f = -f_k \cdot d = -\mu_k m_1 gh$$

$$\Delta K + \Delta U_g = W_{ext}:$$

$$\frac{1}{2}mv^2 - m_2 gh = -\mu_k m_1 gh$$

$$4v^2 - 88.2 = -11.76 \Rightarrow v = 4.37\,m/s$$

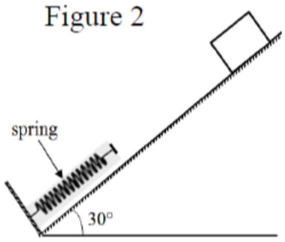
163, Major 2, Q5

Q8.

A 3.0-kg block starts from rest and slides down a frictionless 30° incline, where it collides with a massless spring of force constant 400 N/m, as shown in **Figure 2**. The block slides a total distance of 0.65 m on the incline until it is stopped by the spring. By how much is the spring compressed?

A) 0.22 m
B) 0.37 m
C) 0.13 m
D) 0.48 m
E) 0.31 m

Figure 2



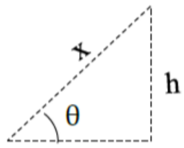
Ans:

$$\cancelto{0}{\Delta K} + \Delta U_g + \Delta U_s = 0$$

$$-mgh + \frac{1}{2}kd^2 = 0$$

$$\Rightarrow d = \sqrt{\frac{2mgh}{k}} = \sqrt{\frac{mgx}{k}}$$

$$= \sqrt{\frac{3 \times 9.8 \times 0.65}{400}} = 0.22 \text{ m}$$



$$\sin\theta = \frac{h}{x} \Rightarrow h = x \cdot \sin\theta = \frac{x}{2}$$

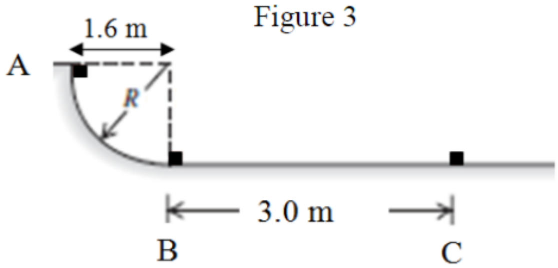
163, Final, Q8

Q9.

In **Figure 3**, a block is released from rest at point A and comes to rest at point C. The track from A to B is frictionless, while the track from B to C is rough. What is the coefficient of kinetic friction between the block and track BC?

A) 0.53
B) 0.34
C) 0.21
D) 0.72
E) 0.43

Figure 3



Ans:

$$\cancelto{0}{\Delta K} + \Delta U_g = W_{ext}$$

$$-\cancel{m}\cancel{g}R = -\mu_k \cancel{m}\cancel{g}d$$

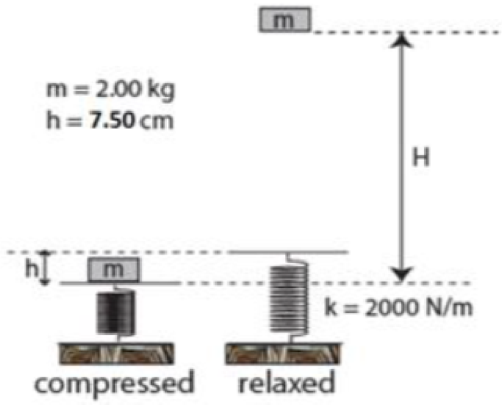
$$\mu_k = \frac{R}{d} = \frac{1.6}{3} = 0.53$$

163, Final, Q9

Q10.

A vertical spring is compressed at distance h = 7.50 cm from its relaxed position and a 2.00 kg block is placed on top of it. When the spring is released, the block will move up with maximum speed v_{max} and it will stop at maximum height H. The maximum height H is measured from the compressed position of the spring as shown in **Figure 6**. Provided the spring constant $k = 2.00\times10^3$ N/m, the values of v_{max} and H **respectively** are: [Ignore air resistance]

Figure 6



A) 2.04 m/s and 28.7 cm
B) 1.05 m/s and 11.8 cm
C) 9.65 m/s and 28.7 cm
D) 5.35 m/s and 11.8 cm
E) 7.08 m/s and 77.6 cm

Ans:

$$\frac{1}{2}kh^2 = \frac{1}{2}mv_{max}^2 + mgh$$

$$v_{max} = \sqrt{\frac{k}{m}h^2 - 2gh}$$

$$v_{max} = \sqrt{\frac{2000}{2}\left(\frac{7.5}{100}\right)^2 - 2\times 9.8\times\frac{7.5}{100}} = 2.04\ m/s$$

$$\frac{1}{2}kh^2 = mgH$$

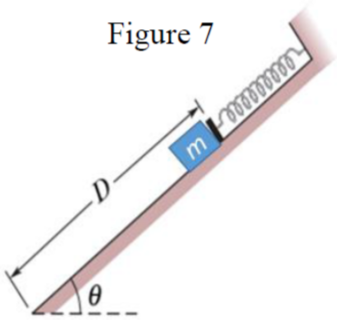
$$H = \frac{1}{2}\frac{kh^2}{mg} = \frac{1}{2}\,\frac{2000\times\left(\frac{7.5}{100}\right)^2}{2\times 9.8} = 28.7\text{ cm}$$

162, Major 2, Q10

Q12.

In **Figure 7**, a spring with $k = 550$ N/m is at the top of a frictionless incline of angle $\boldsymbol{\theta} = 37.0°$. The lower end of the incline is distance $D = 1.00$ m from the end of the spring, which is at its relaxed length. What is the speed of the object when it reaches the lower end of the incline? [Ignore air resistance]

Figure 7



A) 4.50 m/s
B) 1.70 m/s
C) 6.13 m/s
D) 2.50 m/s
E) 7.00 m/s

Ans:

$$\Delta U + \Delta K = 0$$

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

$$-\frac{1}{2}kx^2 - mg\sin\theta(D + x) + \frac{1}{2}mv^2 = 0$$

$$v = \sqrt{\frac{k}{m}x^2 + 2g(D + x)\sin\theta} = \sqrt{\frac{550}{3.6}0.2^2 + 28.8(1.2)\sin37°} = 4.5\text{ m/s}$$

162, Major 2, Q12

Q14.

Which one of the following statements is **True**?

A) The work done by a conservative force on a body does not depend on path followed by the body.
B) The work done by a non-conservative force on a body does not depend on path followed by the body.
C) Spring force is an example of a non-conservative force.
D) Gravitational force is an example of non-conservative force.
E) Friction force is an example of conservative force.

Ans:

A

162, Major 2, Q14

Q15.

A 0.50 kg ball is thrown vertically upward from a point 1.1 m above the ground with a speed of 12 m/s. When it has reached a height of 2.1 m above the ground, its speed is 10 m/s. The change in mechanical energy of the ball is:

A) - 6.1 J
B) + 6.1 J
C) - 4.5 J
D) + 4.5 J
E) zero

Ans:

$$\mathrm{E} - \mathrm{E}_0 = \mathrm{K} + \mathrm{U} - K_0 - U_0$$

$$= \frac{1}{2}\mathrm{m}(v^2 - v_0^2) + mg\,(2.1 - 1.1)$$

$$= \frac{1}{2} \times \frac{1}{2}\,[100 - 144] + \frac{1}{2} \times 9.8 \times 1$$

$$= -\frac{44}{4} + 4.9 = -11 + 4.9 = -6.1\ \mathrm{J}$$

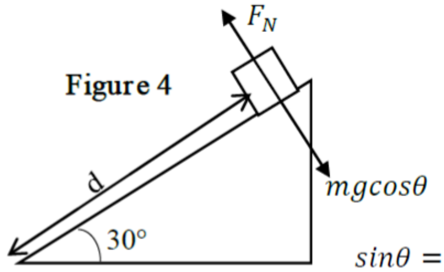
162, Major 2, Q15

Q7.

A 5.0 kg block initially at rest, slides down the ramp of an inclined plane of angle 30°, from the height of 5.0 m. Find the speed of the block at the end of the ramp if the coefficient of kinetic friction between the block and the surface of the ramp is 0.23.

A) 7.7 m/s
B) 4.2 m/s
C) 3.5 m/s
D) 1.6 m/s
E) 2.3 m/s

Figure 4



$sin\theta = \frac{h}{d}$

Ans:

$$\Delta k + \Delta U = W_f$$

$$\frac{1}{2}mv^2 - mgh = -f_k d$$

$$\frac{1}{2}mv^2 - mgh = -\mu_k mgdcos\theta$$

$$v = \sqrt{2g\left(h - \mu_k \frac{h}{sin\theta}cos\theta\right)}$$

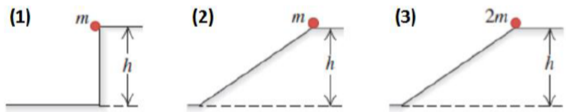
$$v = \sqrt{2 \times 9.8 \times 5(1 - 0.23 \times cot30^\circ)} = 7.7\ m/s$$

162, Final, Q7

Q9.

In the three cases shown in **Figure 7,** an object is released from rest at the top, and experiences no friction or air resistance. Rank the cases according to the speed of the object at the bottom, **greatest first**. (*m* in the figure represents mass).

A) All tie
B) (1 and 2 tie), then 3
C) 3 then (1 and 2 tie)
D) (2 and 3 tie), then 1
E) 1 then (2 and 3 tie)



Ans:

$v_f = \sqrt{2gh}$,   all tie

161, Major 2, Q9

Q12.

A 2.5-kg block rests on a rough horizontal floor where it compresses a horizontal spring by a distance of 0.030 m. The force constant of the spring is 850 N/m. The block is then released and slides on the floor. The coefficient of kinetic friction between the block and floor is 0.40. What is the speed of the block after it has moved a distance of 0.020 m?

A) 0.34 m/s
B) 0.26 m/s
C) 0.54 m/s
D) 0.11 m/s
E) 0.29 m/s

Ans:

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

$$\frac{1}{2}mv_f^2 + \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2 = -\mu_k mgd$$

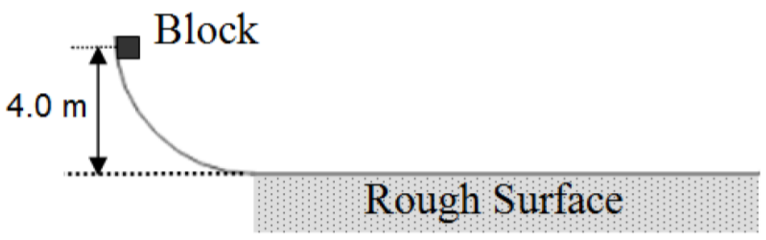
$$v_f = \sqrt{\frac{k}{m}x_i^2 - kx_f^2 - 2\mu_k gd} = 0.34$$

161, Major 2, Q12

Q13.

A 2.00-kg block slides on the surface shown in **Figure 8**. The curved surface is frictionless, but the horizontal surface is rough and has a coefficient of kinetic friction of 0.200 with the block. The block starts from rest 4.00 m above the rough surface. What is the distance travelled by the block on the rough surface before coming to rest.

A) 20.0 m
B) 15.0 m
C) 10.0 m
D) 18.2 m
E) 23.5 m



Ans:

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

$$mgh = \mu_k mgd$$

$$d = \frac{h}{\mu_k} = \frac{4}{0.2} = 20\ m$$

161, Major 2, Q13

Q7.

A 60 kg skier starts from rest at height $H = 20$ m above the end of a ski-jump ramp (see **Figure 4**) and leaves the ramp at angle $\theta = 28°$. Neglect the effects of air resistance and assume the ramp is frictionless. What is the maximum height (h) of his jump above the end of the ramp?

A) 4.4 m
B) 8.5 m
C) 16 m
D) 5.7 m
E) 3.6 m

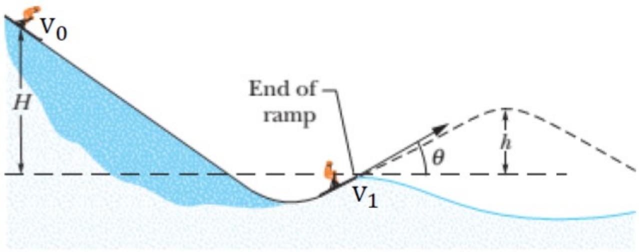


Figure 4

Ans:

Using the conservation of energy

$$mgh = \frac{1}{2}mv_1^2 \Rightarrow v_1 = \sqrt{2gh} = 19.8\ \text{m/s}$$

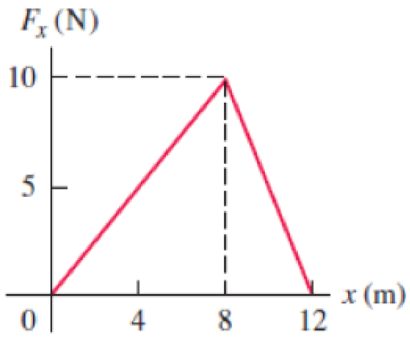
$$h = \left(\frac{v_1 \sin\theta}{2g}\right)^2$$

$$= \frac{(9.8\sin 28)^2}{2 \times 9.8} = 4.4\ \text{m}$$

161, Final, Q7

Q1.

A force F_x is applied to a 5.0-kg box moving it along the x-axis. The force varies with distance as shown in **FIGURE 1**. If the box starts from rest at the origin, what is its speed at $x = 12$ m?



A) 4.9 m/s
B) 4.0 m/s
C) 2.8 m/s
D) zero
E) 3.9 m/s

Answer:

$$W = \text{area under the curve} = \frac{1}{2} \times 12 \times 10 = 60\ \text{J}$$

$$\Delta k = W: K_{12} - K_0 = W$$

$$\frac{1}{2}mv^2 - 0 = W$$

$$\Rightarrow v = \frac{\sqrt{2W}}{m}$$

$$= \sqrt{\frac{2\times 60}{5.0}} = 4.9\ \text{m/s}$$

153, Major 2, Q1

Q3.
A rough inclined plane has a height of 1.00 m, and makes an angle of 45.0° above the horizontal. An object of mass 1.00 kg is released from rest at the top of the incline, and has a speed of 3.50 m/s at the bottom of the incline. Calculate the magnitude of the work done by the frictional force.

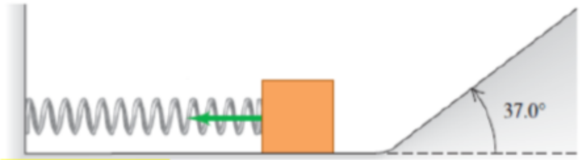
A) 3.68 J
B) 5.31 J
C) 8.21 J
D) 2.50 J
E) 4.94 J

Answer:

$$\Delta K = K_f - K_i = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = \frac{1}{2} \times 1.00 \times (12.25 - 0) = 6.125 \text{ J}$$
$$\Delta U_g = -mgh = -1.00 \times 9.8 \times 1.00 = -9.8 \text{ J}$$
$$\Delta K + \Delta U_g = W_{ext}: W_f = \Delta K + \Delta U_g = 6.125 - 9.8 = -3.675 \text{ J}$$

153, Major 2, Q3

Q5.
A 3.0-kg block is pushed against a spring of force constant k = 500 N/m, compressing it 0.25 m. When the block is released from rest, it moves along a frictionless horizontal surface and then up a frictionless plane inclined at 37° above the horizontal (see **FIGURE 3**). What is the speed of the block after it has moved 0.50 m up along the incline? Ignore air resistance. The block is not connected to the spring.



A) 2.1 m/s
B) 0.79 m/s
C) 4.1 m/s
D) 4.5 m/s
E) 2.9 m/s

Answer:

$$\Delta K + \Delta U_g = 0$$
$$\frac{1}{2}mv^2 - \frac{1}{2}kx^2 + mgh = 0$$
$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 - mgh$$
$$v^2 = \frac{k}{m}x^2 - 2gh = \left(\frac{500}{3}\right)(0.25)^2 - (19.6)(0.30) = 4.2 \Rightarrow v = 2.1 \text{ m/s}$$

153, Major 2, Q5

Q6.
The only force acting on a particle is conservative force $\vec{F}$. If the particle is at point A, the potential energy of the system is + 40 J, If the particle moves from point A to point B, the

work done on the particle by $\vec{F}$ is + 15 J. What is the potential energy of the system at point B?

A) + 25 J
B) – 25 J
C) + 55 J
D) – 55 J
E) – 15 J

Answer:

For a conservative force : $\Delta U = -W$

$\Delta U = -W$

$U_B - U_A = -W$

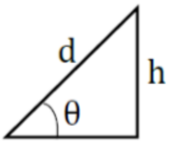
$U_B = U_A - W = 40 - 15 = +25$ J

153, Major 2, Q6

Q9.

A 5.0-kg block is sent up a plane inclined at 30° with an initial speed of 6.0 m/s. The block comes to rest after travelling 2.0 m along the plane. What is the change in the mechanical energy of the block during its motion on the plane?

A) – 41 J
B) + 140 J
C) + 49 J
D) – 90 J
E) + 14 J



Ans:

$\Delta K = K_f^{\,0} - K_i = -\frac{1}{2}mv_i^2 = -\frac{1}{2}\times 5\times 36 = -90$ J

$\sin\theta = \dfrac{h}{d} \Rightarrow h = d\cdot \sin\theta$

$= 2\times\dfrac{1}{2} = 1.0$ m

$\Delta U_g = mgh = 5\times 9.8\times 1.0 = +49$ J

$\Delta E_{mec} = \Delta K + \Delta U_g = -90 + 49 = -41$ J

153, Final, Q9

Q2.

A ball is thrown vertically upward. Neglecting air resistance, which one of the following statements is **FALSE**.

A) The potential energy of the earth-ball system decreases as the ball is going up.

B) The kinetic energy of the ball decreases while the ball is going up.

C) The sum of the kinetic energy of the ball and potential energy of ball-earth system is constant.

D) The potential energy of the earth-ball system decreases as the ball is coming down.

E) The kinetic energy of the ball increases when the ball is coming down.

152, Major 2, Q2

Q13.

In **Figure 8**, A 2.00 kg block situated on a rough incline is connected to a spring of negligible mass and spring constant 100 N/m. The block is released from rest when the spring is unstretched. If the pulley is massless and frictionless and the block moves 20.0 cm down the incline before coming to rest, then find the coefficient of kinetic friction between the block and incline.

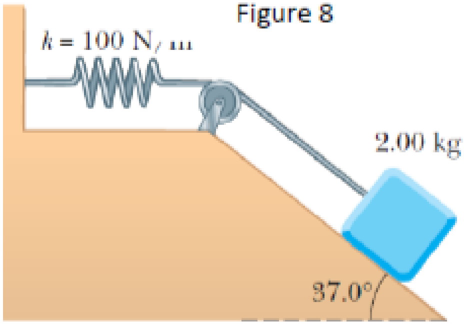
A) 0.115

B) 0.235

C) 0.498

D) 0.403

E) 0.495



Ans:

$$\Delta K + \Delta U_g + \Delta U_s = W_{nc}$$

$$\Delta K = 0$$

$$\Delta U_g = -mgd\sin 37 = -2.36$$

$$\Delta U_s = \frac{1}{2}kx^2 = 2$$

$$\Delta U_s = \frac{1}{2}kx^2 = 2$$

$$W_{nc} = -\mu_k mg\cos\theta d = -3.13\ \mu_k$$

$$\Rightarrow \mu_k = 0.115$$

152, Major 2, Q13

Q14.

A horizontal spring is fixed at one end. If it requires 6.0 J of work to stretch the spring by 2.0 cm from its equilibrium length, how much more work will be required to stretch it an additional 4.0 cm?

A) 48 J

B) 54 J

C) 6.0 J

D) 12 J

Ans:

$$U_s = 6 = \frac{1}{2}kx^2 \Rightarrow k = 3 \times 10^4\ N/m$$

$$W_s = \frac{1}{2}k\left(x_f^2 - x_i^2\right) = 48\ J$$

152, Major 2, Q14

Q15.

A 3.00 kg box starts from rest and slides down an incline. The incline is 0.500 m high and the angle of inclination is 30.0°. If the box experiences a constant friction force of magnitude 5.00 N, then find the speed of the box as it reaches the bottom of the incline.

A) 2.54 m/s

B) 6.47 m/s

C) 3.96 m/s

D) 5.58 m/s

E) 8.76 m/s

Ans:

$$\Delta K + \Delta U_g = W_{nc}$$

$$\frac{1}{2}mv^2 - mgh = -F\frac{h}{sin30}$$

$$\Rightarrow v = 2.54\, m/s$$

152, Major 2, Q15

Q7.

A light-weight object and a heavy-weight object are sliding with equal speeds along a horizontal frictionless surface and then they both slide up the same frictionless hill. Which one of the following statements is correct. [Ignore air resistance]

A) Both objects will slide up to the same height.
B) The heavyweight object will reach higher height because it has greater kinetic energy.
C) The lightweight object will reach higher height because it has smaller kinetic energy.
D) The lightweight object will reach higher height because it weighs less.
E) The heavyweight object will reach higher height because it has greater momentum.

Ans:

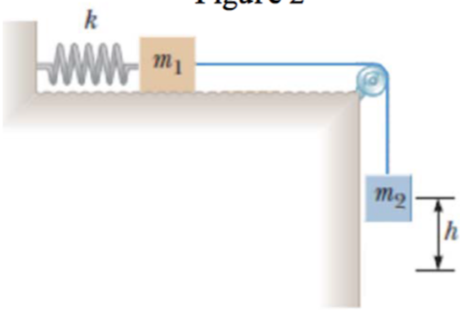
$$\frac{1}{2}\mathrm{mv}^2 = \mathrm{mgh}$$

152, Final, Q7

Q8.

Figure 2 shows two blocks connected by a massless string that passes over a frictionless pulley. The block of mass $m_1 = 5.00$ kg is connected to a spring of force constant 400 N/m. Initially, the system is released from rest when the spring is unstretched. If the hanging block of mass $m_2 = 3.00$ kg falls a distance $h = 0.100$ m before coming to rest, calculate the coefficient of kinetic friction between the block of mass m_1 and the surface.

Figure 2



A) 0.192
B) 0.235
C) 0.154
D) 0.289
E) 0.350

Ans:

$$\cancel{\Delta K}^{\,0} + \Delta U + \Delta U_s = W_{nc}$$

$$0 - m_2gh + \frac{1}{2}kx^2 = -\mu_k m_1 g(0.1)$$

$$-2.94 + 2 = -4.9\mu_k$$

$$\mu_k \cong 0.192$$

152, Final, Q8