Total Number of Points is 15 (Multiple Choice and Workout Problems). Multiple Choice Problems are 1 Point per Question.

1.) A toy car moving at constant speed completes one lap around a circular track (a distance of 200 m) in 25.0 s. If the mass of the car is 1.50 kg, what is the magnitude of the force that keeps it in a circle?

A) 0.48 N  \hspace{1cm} B) 1.51 N  \hspace{1cm} C) 3.02 N  \hspace{1cm} D) 12.0 N  \hspace{1cm} E) 96.0 N

\[ F = ma = m \frac{v^2}{r} = m \frac{(l/t)^2}{l/2\pi} \]

\[ = m \frac{2\pi l}{t^2} = 3.02 \text{ N} \]

2.) The coefficient of static friction is 0.800 between the soles of a sprinter’s running shoes and the level track on which she is running. Determine the maximum acceleration that she can achieve.

A) 0.80 m/s²  \hspace{1cm} B) 7.84 m/s²  \hspace{1cm} C) 9.80 m/s²  \hspace{1cm} D) 12.3 m/s²  \hspace{1cm} E) 38.7 m/s²

\[ F_{\text{net,}x} = ma_x = 0 \quad \Rightarrow \quad N = mg \]

\[ F_{\text{net,}x} = ma_x \quad \Rightarrow \quad ma_x = -\mu_s N = -\mu_s mg \]

\[ \Rightarrow \quad |a_x| = \mu_s g = 7.84 \text{ m/s}^2 \]

3.) A sled of mass \( m \) is given a kick on a frozen pond. The kick imparts to it an initial speed \( v_i = 2.00 \text{ m/s} \). The coefficient of kinetic friction between the sled and the ice is \( \mu_k = 0.100 \). Utilizing energy considerations, find the distance the sled moves before it stops.

A) 0.20 m  \hspace{1cm} B) 0.98 m  \hspace{1cm} C) 2.04 m  \hspace{1cm} D) 4.08 m  \hspace{1cm} E) 20.0 m

\[ \Delta E_{\text{mech}} + \Delta E_{\text{th}} = 0 \quad \Rightarrow \quad \Delta K + \Delta E_{\text{th}} = 0 \]

\[ \Rightarrow \quad \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2 + f_k d = 0 \quad \Rightarrow \quad \frac{1}{2} mv_i^2 = \mu_k mgd \]

\[ d = \frac{v_i^2}{2\mu_k g} = 2.04 \text{ m} \]
4.) If a ski lift raises 100 passengers averaging 660 N in weight to a height of 150 m in 60 s, at constant speed, what average power is required of the force making the lift?

A) 0.264 kW  
B) 1.65 kW  
C) 26.4 kW  
D) 66.0 kW  
E) 165.0 kW

\[ P = Fv = n \overline{W}_{\text{passenger}} \left( \frac{h}{\Delta t} \right) = 165 \text{ kW} \]

5.) A force of 800 N stretches a certain spring a distance of 0.200 m. What is the potential energy of the spring when it is stretched 5.00 cm?

A) 5 J  
B) 10 J  
C) 100 J  
D) 200 J  
E) 4000 J

\[ U(x) = \frac{1}{2} kx^2 = \frac{1}{2} \left( \frac{F}{d} \right) x^2 = 5 \text{ J} \]

6.) A 140 g mass on a 2.5 m-long pendulum string is pulled 8° to one side and released. What is its velocity when it reaches 4° on the opposite side?

A) 0.025 m/s  
B) 0.158 m/s  
C) 0.358 m/s  
D) 0.598 m/s  
E) 32.8 m/s

\[ h = R(1 - \cos \theta) \quad \Rightarrow \quad \Delta h = R(\cos 4^\circ - \cos 8^\circ) \]
\[ \Delta K + \Delta U = 0 \quad \Rightarrow \quad mg\Delta h = \frac{1}{2}mv^2 \]
\[ v = \sqrt{2g\Delta h} = 0.598 \text{ m/s} \]

7.) Which of the following statements about the Conservation of Energy is NOT true?

A) The total energy \( E \) of an isolated system cannot change.  
B) The total energy \( E \) of a system can change only by amounts of energy that are transferred to or from the system.  
C) An applied force can transfer energy into or out of the system  
D) The total mechanical energy \( E_{\text{mech}} \) of a system remains constant in any isolated system of objects that interact only through conservative forces.  
E) The work done by the friction force on a particle moving through any closed path is zero.
8.) A block of mass 0.250 kg is placed on top of a light vertical spring of constant  
\( k = 4800 \text{ N/m} \) and is pushed downward so that the spring is compressed 6.6 cm. After the  
block is released, it travels upward and leaves the spring. To what maximum height above  
the point of release does it rise?

A) 2.13 m  
B) 4.27 m  
C) 8.53 m  
D) 20.9 m  
E) 129 m  

\[ \Delta K + \Delta U = 0 \Rightarrow U_{e,i} = U_{e,f} \]
\[ mgh = \frac{1}{2}kx^2 \Rightarrow h = \frac{kx^2}{2mg} = 4.27 \text{ m} \]

9.) A bullet \((m_b = 9.78 \text{ g})\) is fired into a stationary block of wood \((m_w = 4.52 \text{ kg})\), coming  
quickly to rest inside the block. The speed of the bullet-wood combination after the  
collision is 0.512 m/s. What was the original speed of the bullet?

A) 11 m/s  
B) 121 m/s  
C) 237 m/s  
D) 335 m/s  
E) 463 m/s

\[ m_b v_i = (m_b + m_w) v_f \]
\[ v_i = \frac{m_b + m_w}{m_b} v_f = 237 \text{ m/s} \]

10.) The mass of the Earth is \(5.98 \times 10^{24} \text{ kg}\), and the mass of the Moon is \(7.36 \times 10^{22} \text{ kg}\). The  
distance between Earth and Moon is \(3.84 \times 10^8 \text{ m}\) (measured between their centers).  
Locate the center of mass of the Earth-Moon system as measured from the center of the Earth.

\[ x_{\text{com}} = \frac{m_{\text{Earth}}x_{\text{Earth}} + m_{\text{Moon}}x_{\text{Moon}}}{m_{\text{Earth}} + m_{\text{Moon}}} \]
\[ = \frac{m_{\text{Moon}}x_{\text{Moon}}}{m_{\text{Earth}} + m_{\text{Moon}}} = 4670 \text{ km} \]

A) \(4.67 \times 10^3 \text{ km}\)  
B) \(6.39 \times 10^3 \text{ km}\)  
C) \(4.26 \times 10^4 \text{ km}\)  
D) \(1.92 \times 10^5 \text{ km}\)  
E) \(3.75 \times 10^5 \text{ km}\)
Workout Problem 1 (3 points)

A 12.0 kg block is released from rest on a 30° rough incline. The kinetic coefficient of friction is \(\mu_k = 0.10\). Below the block is a spring that can be compressed 3.00 cm by a force of 250 N. The kinetic energy of the block just before it hits the spring is 250 J.

A) Draw a Free Body Diagram while the block is compressing the spring!
B) What is the kinetic frictional force \(f_k\)?
C) By how much is the spring compressed when the block momentarily stops?

\[
F_s + f_k - mg \sin \theta = 0 \\
N - mg \cos \theta = 0 \\
\Rightarrow f_k = \mu_k N = \mu_k mg \cos \theta = 10.2 \text{ N} \\
W_s + W_g = \Delta K + \Delta E_{th} \\
-\frac{1}{2}kx^2 + mgx \sin \theta = -K_i + f_k x \\
\frac{1}{2}kx^2 + (f_k - mg \sin \theta)x - K_i = 0 \\
\Rightarrow x = \frac{1}{k}((mg \sin \theta - f_k)) + \sqrt{(mg \sin \theta - f_k)^2 + 2K_i} = 0.25 \text{ m}
\]
Workout Problem 2 (2 points)

A 300 g bird flying along at 6.00 m/s sees a 10 g insect heading straight toward the bird with a speed of 30.0 m/s. The bird opens the mouth wide and enjoys a nice lunch.

A) What is the bird’s speed immediately after swallowing?
B) Is this an elastic or inelastic collision? Explain!
C) Is the kinetic energy of the bird-insect system conserved? Explain!

This is a completely inelastic collision, since bird and insect are “stuck” together and move now with the same velocity.

The kinetic energy is not conserved, since some of the kinetic energy is converted to thermal energy or energy related to the deformation of the insect/the bird’s stomach.

\[ m_b v_b - m_i v_i = (m_b + m_i) v_{bi} \]
\[ \Rightarrow v_{bi} = \frac{m_b v_b - m_i v_i}{m_b + m_i} = 4.84 \text{ m/s} \]