1. Andrew Baxter throws a stone of weight $w$ vertically upward into the air from ground level with initial speed $v_0$. Karen Mcvay observes that a constant force $f$ due to air drag acts on the stone throughout its flight.
   a) Bill Moomaw, also observing this event, said it should be possible to compute the maximum height reached by the stone in terms of $v_0$, $f$, $g$, and $w$.
   b) He also wants to know the speed just before it hits the ground in terms of $v_0$, $w$, and $f$.

   a) $W_{other} = \Delta \text{TME}$

   $fL - mg - fh = wh - \frac{1}{2} mv_0^2$

   $h(w+f) = \frac{1}{2} mv_0^2$

   $h = \frac{1}{2} mv_0^2 = \frac{w}{w+f} \frac{v_0^2}{2g(w+f)}$

   or $h = \frac{v_0^2}{2g(1+f/w)}$

   b) $W_{other} = \Delta \text{TME}$

   $-2fh = \frac{1}{2} mv^2 - \frac{1}{2} mv_0^2$

   $V^2 = v_0^2 - 4f \frac{h}{m} = v_0^2 - 4f \frac{v_0^2}{m} \frac{2g(1+f/w)}{2g(1+f/w)}$

   $= v_0^2 \left[1 - \frac{4f}{2w(1+f/w)} \right] = v_0^2 \left[1 - \frac{2f}{w+f} \right]$

   $= v_0^2 \left[\frac{w+f-2f}{w+f} \right] = v_0^2 \frac{[w-f]}{w+f}$

   $V = v_0 \left[\frac{v_0-f}{w+f}\right]^{\frac{1}{2}}$
2. A particle of mass \( m_0 \), travelling at speed \( v_0 \), strikes a stationary particle of mass \( 2m_0 \). As a result, the particle of mass \( m_0 \) is deflected through \( 45^\circ \) and has a final speed of \( v_0/2 \).

a) Find the speed and direction of the particle of mass \( 2m_0 \) after the collision

b) Was this an elastic collision? Explain your answer.

\[ \begin{align*}
\text{Before} & \quad \text{After} \\
\begin{array}{c}
m_0 \quad V_0 \\
1 \\
2m_0 \\
2
\end{array} & \quad \begin{array}{c}
m_0 \\
45^\circ \quad V_1' = v_0/2 \\
2m_0 \\
\end{array}
\end{align*} \]

2. Momentum in x direction before = after

\[ m_0 \cdot v_0 = \frac{m_0 \cdot v_0}{2} \cos 45^\circ + 2m_0 \cdot v_1' \cos \theta \]  \hspace{1cm} (1)

3. Momentum in y direction

\[ 0 = \frac{m_0 \cdot v_0}{2} \sin 45^\circ = 2m_0 \cdot v_1' \sin \theta \]  \hspace{1cm} (2)

\[ 2v_1' \sin \theta = \frac{V_0}{2\sqrt{2}} \Rightarrow v_1' \sin \theta = \frac{V_0}{4\sqrt{2}} \]  \hspace{1cm} (3)

From (1), \( 2v_1' \cos \theta = V_0 - \frac{V_0}{2\sqrt{2}} \) \quad \( v_1' \cos \theta = \frac{V_0 (1 - \frac{1}{2\sqrt{2}})}{2} \) \hspace{1cm} (4)

Divide (3) by (4)

\[ \tan \theta = \frac{2}{2 \cdot \sqrt{2} \cdot (1 - \frac{1}{2\sqrt{2}})} = \frac{1}{2\sqrt{2} - 1} \]

\[ V_2' = \frac{V_0}{4\sqrt{2} \sin 28.7^\circ} \]

\[ V_2' = 0.368V_0 \]

\[ \theta = \tan^{-1} \left( \frac{1}{2\sqrt{2} - 1} \right) = 28.7^\circ \]

b) KE before = \( \frac{1}{2} m_0 v_0^2 \) \quad KE after = \( \frac{1}{2} m_0 v_0^2 + m_0 \cdot \frac{136}{4} v_0^2 \)

\[ = 0.5 m_0 v_0^2 \cdot \text{KE after} = 0.261 m_0 v_0^2 \quad \text{inelastic} \]
3. Yinwei Zhang has set up the following experiment. A pendulum bob of mass m, at the end of a string of length L, starts from rest at the position shown in the figure, with the string at 60° to the vertical. At the lowest point of the arc, the bob strikes a previously stationary block, of mass nm, that is on a frictionless horizontal surface. The collision is perfectly elastic.

Express parts a), b), and c) in terms of g, L, m, and n.

a) What is the speed of the bob just before the impact occurs?

b) What is the tension in the string at this instant?

c) What velocity is given to the block by the impact?

d) What maximum angle θ does the string make with the vertical after the collision?

*Express the answer as cos(θ) = some function of just n.*
4. A 920 kg sports car collides into the rear end of a 2300 kg SUV stopped at a red light on Texas avenue. The bumpers lock, the brakes are locked and the two cars skid 2.8 m before coming to a stop. Sonja Loy happened to be a witness to this tragedy and she told the police officer she studied physics at TAMU and if he could give her the coefficient of kinetic friction between the tires and the pavement she could calculate the speed of the sports car. The officer looked through a table and said $\mu_k = 0.80$. What was the speed of the sports car before the collision?

\[
920 V = 3220 V'
\]

\[
V' = \frac{920}{3220} V = 0.286 V
\]

\[
2.8m \quad f_k = \mu_k N = \mu_k mg
\]

\[
= 0.8 \times 3220 \times 9.8
\]

\[
= 2.52 \times 10^4 N
\]

\[
\frac{1}{2} m V''^2 = 7.07 \times 10^4
\]

\[
\frac{3220 (0.286 V)^2}{2} = 7.07 \times 10^4
\]

\[
0.286 V^2 = 24.90
\]

\[
0.286 V = 6.63 m/s
\]

\[
V = 23.2 \text{ m/s}
\]
5. A single conservative force acting on a particle within a system varies as \( \vec{F} = (-Ax + Bx^2)\hat{i} \)
where \(A\) and \(B\) are constants, \(\vec{F}\) is in Newton’s, and \(x\) is in meters.

a) Calculate the potential energy function \(U(x)\) associated with this force for the system, taking \(U = 0\) at \(x = 0\).

b) Find the change in potential energy as the particle moves from \(x = 2.00\) m to \(x = 3.00\) m.

c) Find the change in kinetic energy as the particle moves from \(x = 2.00\) m to \(x = 3.00\) m

\[
\vec{F} = (-Ax + Bx^2)\hat{i}
\]
\[
F_x = - \frac{dU}{dx} = -Ax + Bx^2
\]
\[
\frac{dU}{dx} = Ax - Bx^2
\]
\[
U = \int Ax\,dx - \int Bx^2\,dx
\]
\[
U = \frac{Ax^2}{2} - \frac{Bx^3}{3} + C
\]
\[
\text{At } x = 0, U = 0 \implies C = 0
\]

2) \[
\boxed{U = \frac{Ax^2}{2} - \frac{Bx^3}{3}}
\]

3) \[
\text{At } x = 3, U = \frac{9A}{2} - \frac{B\cdot27}{3} = \frac{9A}{2} - 9B = 9\left(\frac{A}{2} - B\right)
\]
\[
\text{At } x = 2, U = \frac{4A}{2} - \frac{8B}{3} = 2A - \frac{8B}{3}
\]
\[
\Delta U = U_x - U_i = \frac{9A}{2} - 2A - 9B + \frac{8B}{3} = \frac{5A}{2} - \frac{19B}{3}
\]
\[
\text{Since } W = \Delta KE = \Delta U
\]
\[
\text{Then } \Delta KE = -\Delta U
\]
\[
\Delta KE = -\frac{5A}{2} + \frac{19B}{3}
\]
\[
= -2.5A + 6.33B
\]