1. A 2.5 kg projectile is launched towards a brick wall as shown.

\[ \begin{align*} 
V_y &= 14 \times \sin 40^\circ \\
&= 9.0 \text{ m/s} \\
V_x &= 14 \times \cos 40^\circ \\
&= 10.7 \text{ m/s} 
\end{align*} \]

**a) What are horizontal and vertical components of the launch velocity?**

**ANSWER:**
- horizontal component: 10.7 m/s
- vertical component: 9.0 m/s

\[ \begin{align*} 
L &= \frac{dx}{V_x} \\
&= \frac{15 \text{ m}}{9.0 \text{ m/s}} \\
&= 1.40 \text{ s} 
\end{align*} \]

**b) How much time does it take for the projectile to reach the wall?**

**ANSWER:**
- time: 1.40 s
c) What is the projectile's impact speed with the wall? (3 marks)

\[ v_x = \text{constant} = 10.7 \text{ m/s} \rightarrow \]

\[ v_{y_f} = v_{f_i} + at \]
\[ = 9.0 + (-9.81)(1.40) \]
\[ = -4.734 \text{ m/s} \downarrow \]

\[ \begin{align*}
10.7 & \quad \quad \quad -4.734 \\
10.7 & \quad \quad \quad \downarrow \\
\sqrt{10.7^2 + (-4.734)^2} & \quad \quad \quad \downarrow \\
\sqrt{104.89 + 22.42} & \quad \quad \quad \downarrow \\
\sqrt{127.31} & \quad \quad \quad \downarrow \\
\sqrt{127.31} & \quad \quad \quad \downarrow \\
11.7 \text{ m/s} & \quad \quad \quad \downarrow \\
\end{align*} \]

\[ v_f = 11.7 \text{ m/s} \]

ANSWER:

c) impact speed: \[ 11.7 \text{ m/s} \]

OVER
2. A 5.30 kg wagon is moving at 2.00 m/s to the right. A 0.180 kg blob of putty moving at 32.0 m/s also to the right strikes the wagon and sticks to it.

a) With what speed will the wagon and the putty move after the collision? (5 marks)

\[
P_b = P_a
\]

\[
m_B v_B + m_w v_w = (m_B + m_w) v
\]

\[
(0.180 \times 32) + (5.30 \times 2.00) = (0.180 + 5.30) v
\]

\[
5.76 + 10.6 = 5.48 v
\]

\[
\frac{16.36}{5.48} = v
\]

\[
3.00 \text{ m/s} = v
\]

**ANSWER:**

a) final speed of wagon: \(3.00 \text{ m/s}\)
b) Suppose the wagon had instead been struck by a ball with the same mass and speed as the putty and the ball rebounded to the left after the collision. How would the speed of the wagon compare with your answer to a)? Using principles of physics, give an explanation for your prediction.

\[ \text{Speed of wagon would have increased since } P_b = P_a \]

\[ \text{ball has negative momentum after collision (going in opposite direction)} \]

\[ \text{the wagon must have more } + \text{ momentum than before collision} \]

\[ \text{hence the wagon would travel faster } v = \frac{P}{m} \text{ if mass remained constant}. \]
3. (5 marks)

A 1.5 kg ball was moving east at 72 m/s and collided with a stationary 8.3 kg wooden sphere. The ball rebounded at 43 m/s in the direction 55° north of west. What were the speed and direction of the wooden sphere after the collision?

\[
P_b = 1.5 \times 72 = 108 \text{ kg m/s}
\]

\[
P_a = 1.5 \times 43 = 64.5 \text{ kg m/s}
\]

\[
P_{ws} = \sqrt{P_b^2 + P_a^2 - 2 \times P_b \times P_a \times \cos 125°}
\]

\[
P_{ws} = \sqrt{108^2 + 64.5^2 - (2 \times 108 \times 64.5 \times \cos 125°)}
\]

\[
P = \sqrt{23815.25}
\]

\[
P = 154
\]

\[
\frac{P}{m} = \frac{154}{8.3} = 18.6 \text{ m/s}
\]

\[
27 \sin \theta = \frac{\sin 125°}{64.5} \Rightarrow \theta = 20°
\]

\[
\left[ v = 19 \text{ m/s} \right] \text{ at } 20° \text{ southeast}
\]
A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. If a 25 kg mass is suspended from the end of the pole, what is the tension in the horizontal cable?

(7 marks)

\[ F_T \times \cos 40^\circ \times 4.0 = F_{g_m} \times \cos 30^\circ \times 4.0 + F_{g_b} \times \cos 30^\circ \times 2.0 \]

\[ F_T \times 3.064 = 25 \times 9.8 \times \cos 30^\circ \times 4.0 + 15 \times 9.8 \times \cos 30^\circ \times 2.0 \]

\[ F_T = 3.064 = 630.574 \]

\[ F_T = \frac{819.7466}{3.064} \]

\[ F_T = 267.5 = 270 N \]
A 1.5 m-long uniform beam supports a 120 kg load. The beam is suspended by a wire connected as shown. This wire is under a tension of 3700 N.

What is the mass of the beam?

\[ \tau_{cc} = \tau_c \]

\[ 3700 \times \cos 72^\circ \times 1.5 = m \times 9.81 \times \cos 20^\circ \times 0.75 + 120 \times 9.81 \times \cos 18^\circ \times 1.5 \]

\[ 1715.044 = m \times 6.9138 + 1659.30 \]

\[ m = \frac{(1715.044 - 1659.30)}{6.9138} \]

\[ m = 8.1 \text{ kg} \]
A 7.5 \times 10^4 \text{ kg} space vehicle leaves the surface of the earth with a speed of 1.3 \times 10^4 \text{ m/s}.
What will its speed be when it is infinitely far from the earth? (7 marks)

\[ E_{k_i} = E_{p_e} + E_{ke} \]

\[ \frac{1}{2} m v^2 = -\frac{G M m}{R} + \frac{1}{2} m v_i^2 \]

\[ \frac{1}{2} \times 7.5 \times 10^4 \times v^2 = -\frac{6.67 \times 10^{-11} \times 5.98 \times 10^5 \times 7.5 \times 10^4}{6.38 \times 10^6} + \frac{1}{2} \times 7.5 \times 10^4 \times (1.3 \times 10^3)^2 \]

\[ 37500 \times v^2 = -4.63 \times 10^{12} + 6.33 \times 10^{12} \]

\[ v^2 = \frac{1.64 \times 10^{12}}{37500} \]

\[ v = \sqrt{4.466/333.3} \]

\[ v = 6682 \text{ m/s} \]
A 1.0 \times 10^{-3} \text{ kg} \text{ styrofoam ball carrying } 50 \mu\text{C} \text{ of charge is released from rest from position A as shown in the diagram below. } (1 \mu\text{C} = 1 \times 10^{-6} \text{ C})

a) Determine the change in electric potential energy, \Delta E_p, of the ball as it moves from position A to position B. \hspace{1cm} (5 \text{ marks})

\[
\Delta E_p = E_{p_2} - E_{p_1} = \frac{kQq}{R_2} - \frac{kQq}{R_1}
\]

\[
= \frac{9.0 \times 10^9 \times -40 \times 10^{-6} \times 50 \times 10^{-6}}{5.0} - \frac{9.0 \times 10^9 \times -40 \times 10^{-6} \times 50 \times 10^{-6}}{2.0}
\]

\[
= -3.6 - (-9)
\]

\[
\Delta E_p = 5.4 \text{ J}
\]

b) What is the speed of the ball as it reaches position B? \hspace{1cm} (v_i = 0 \text{ at A}) \hspace{1cm} (2 \text{ marks})

\[
E_k = \frac{1}{2} mv^2 = \Delta E_p
\]

\[
\frac{1}{2} \times m \times v^2 = 5.4
\]

\[
v = \sqrt{\frac{2 \times 5.4}{1.0 \times 10^{-3}}} = 104 \text{ m/s}
\]
8 (6 marks)
A battery having an emf of 12.0 V is connected to the circuit as shown.

\[ I = 0.77 \, \text{A} \]

\[ \text{Emf} = 12.0 \, \text{V} \]

\[ R = 20.0 \, \Omega \]

\[ R = 40.0 \, \Omega \]

What is the terminal voltage of the battery?

\[ V_T = \varepsilon - IR \]
\[ V_T = I \times R_p \]

\[ \frac{1}{R_p} = \frac{1}{20} + \frac{1}{40} = \frac{3}{40} \]

\[ R_p = \frac{40.0}{\frac{3.0}{13.33} = 10.3 \, \text{V}} \]

\[ V_T = 0.77 \times 13.33 = 10.3 \, \text{V} \]

Explain what happens to the terminal voltage of this battery when switch S is opened.

If S is opened the \( R_p \) increases and current decreases since \( V_T = \varepsilon - IR \).

If current decreases then \( V_T \) must increase, as \( \varepsilon + R \) are constant.

"32"
The internal resistance of the battery shown in the circuit below dissipates 10 W of power. Determine the current through the 13 Ω resistor.

\( P = I^2 R \)
\[ I = \sqrt{\frac{P}{R}} \]
\[ = \sqrt{\frac{10 \text{ W}}{1.8 \Omega}} \]
\[ I = 2.357 \text{ A} \]

\[ V_{5Ω} = IR \]
\[ = 2.357 \times 5.0 \]
\[ = 11.7 \text{ V} \]

\[ V_p = IR \]
\[ = 2.357 \times 5.346 \]
\[ = 12.65 \text{ V} \]

\[ I_{13} = \frac{V}{R} = \frac{12.65 \text{ V}}{23 \Omega} \]
\[ I_{13} = 0.55 \text{ A} \]