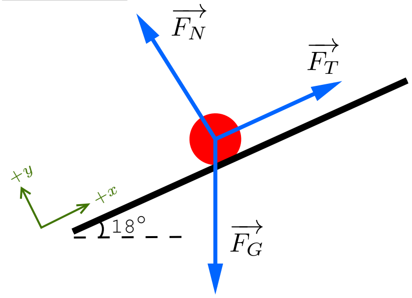
SPH4U: Dynamics Assignment

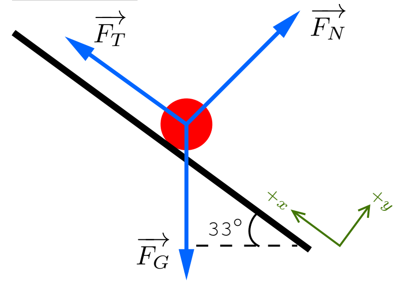
Q01. Two heavy boxes, m_1 and m_2, lie stationary on different inclines, as shown. A rope runs over a pulley and connects the boxes. Mass 1, m_1 is 380 kg. Assuming that each incline is frictionless and the system is in equilibrium, answer the following:

(a) **Draw FBD(s).**

m_1 FBD:



m_2 FBD:



(b) **Find the magnitude of the tension in the cable.**

***m_1*:**

$$
\begin{aligned}
\vec{F_{net_{1x}}} &= 0\\
0 &= \vec{F_{gx}} + |F_T|\\
0 &= m_1 g \sin 18^\circ + |F_T|\\
0 &= 380(-9.8)\sin 18^\circ + |F_T|\\
|F_T| &= 1150.78\text{N}\\
|F_T| &= 1200 \text{ N}
\end{aligned}
$$

$\therefore$ The magnitude of tension in the string is 1200 N.

(c) **Calculate the mass of m_2 needed to keep the system in equilibrium.**

$$
\begin{aligned}
F_{net_{2x}} &= 0\\
0 &= \vec{F_{gx}} \sin 33^\circ + 1150.78\\
0 &= m_2 g \sin 33^\circ + 1150.78\\
m_2 &= \frac{-1150.78}{-9.8\sin 33^\circ}\\
m_2 &= 215.6\text{kg}\\
m_2 &= 220 \text{ kg}
\end{aligned}
$$

$\therefore$ The mass of the second box (m_2) is 220 kg.

Q02. A girl applies a 140 N force to a 35.0 kg bale of hay at an angle of 28° above the horizontal. The force of friction acting on the bale is 55 N.

(a) **What will be the horizontal acceleration of the bale?**

$$
\begin{aligned}
\vec{F_{net_x}} &= \vec{F_{a_x}} - \vec{F_f}\\
&= 140\cos 28^\circ - 55\\
&= 66.81 \text{ N[forward]}
\end{aligned}
\qquad
\begin{aligned}
\vec{F_{net_x}} &= m\vec{a}\\
66.81 &= 35\vec{a}\\
\vec{a} &= 1.96\text{m/s}^2\text{[forward]}\\
\vec{a} &= 2.0 \text{ m/s}^2\text{[forward]}
\end{aligned}
$$

$\therefore$ The horizontal acceleration of the bale is 2.0 m/s^2[forward].

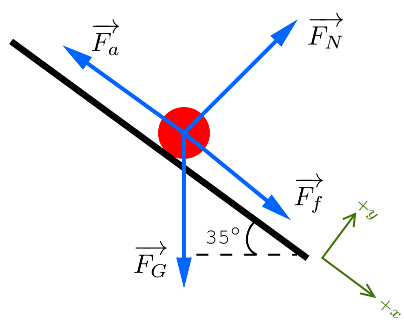
(b) **What is the coefficient of friction between the bale and the ground?**

$$\begin{aligned}
\vec{F_f} &= \mu_f \vec{F_N} \\
55 &= \mu_f(\vec{F_g} - \vec{F_{a_y}}) \\
\mu_f &= \frac{55}{\vec{F_g} - \vec{F_{a_y}}} \\
\mu_f &= \frac{55}{35(9.8) - 140\sin 28^\circ} \\
\mu_f &= 0.198 \\
\mu_f &= 0.20
\end{aligned}$$

$\therefore$ The coefficient of friction between the bale and ground is 0.20.

Q03. A 15kg box is pushed up a 35° ramp. A force of 110 N exists between the box and the ramp.

(a) **Draw an FBD showing a tilted coordinate system (label positive x-direction)**



(b) **What minimum force, *F*, would be necessary to move the box up the ramp at a constant speed?**

$$\begin{aligned}
\vec{F_{net_x}} &= \vec{F_a} + \vec{F_{g_x}} + \vec{F_f} \\
0 &= \vec{F_a} + 15(-9.8)\sin 35^\circ - 110 \\
0 &= \vec{F_a} - 194.31 \\
\vec{F_a} &= 194.31 \text{ N[uphill]} \\
\vec{F_a} &= 190 \text{ N[uphill]}
\end{aligned}$$

$\therefore$ Since constant speed implies no acceleration in this scenario ($\vec{F_{net}} = 0$), the force required to move the box at constant speed must also result in 0 net force, meaning the minimum force required is 190 N[uphill].

Q04. The apparatus shown in the diagram consists of a box of books connected by a string to a hanger plate loaded with masses. The mass, m_1, is for the box and books and the mass, m_2 is for the hanger with masses. The box is moving up the incline 35° to the horizontal with constant speed. What is the coefficient of friction between the box and the incline?

m_1:

$$\vec{F_{net_x}} = \vec{F_g}\sin 35^\circ + \vec{F_T} - \vec{F_f}$$
$$0 = 0.45(-9.8)\sin 35^\circ + \vec{F_T} + \vec{F_f}$$
$$0 = -2.53 + \vec{F_T} + \vec{F_f}$$
$$\vec{F_T} = \vec{F_f} + 2.53 \text{ N[uphill]}$$

m_2:

$$\vec{F_{net_y}} = \vec{F_g} - \vec{F_T}$$
$$0 = 0.35 \times 9.8 - \vec{F_T}$$
$$\vec{F_T} = 3.43 \text{ N[up]}$$

Set Equations for F_T Equal:

$$3.43 = \vec{F_f} + 2.53$$
$$\vec{F_f} = 0.9 \text{ N[downhill]}$$

Solve for Friction Coefficient:

$$\vec{F_f} = \mu_f \vec{F_N}$$
$$0.9 = \mu_f \times 0.45(9.8)\cos 35^\circ$$
$$\mu_f = \frac{0.9}{0.45(9.8)\cos 35^\circ}$$
$$\mu_f = 0.249$$
$$\mu_f = 0.25$$

$\therefore$ The coefficient of friction between the box and incline is 0.25.