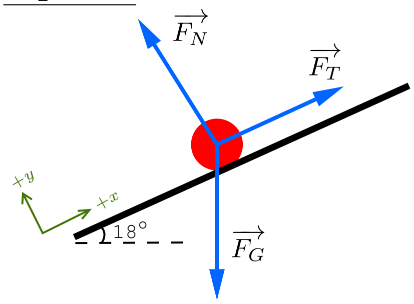
SPH4U: Dynamics Assignment

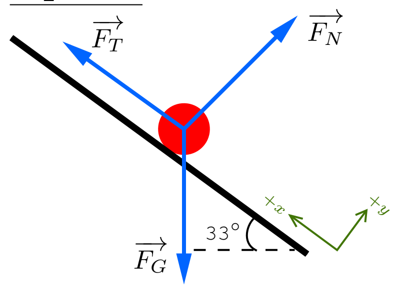
Q01. Two heavy boxes, m_1 and m_2, lie stationary on different inclines, as shown. A rope runs over a pulley and connects the boxes. Mass 1, m_1 is 380kg. Assuming that each incline is frictionless and the system is in equilibrium, answer the following:

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

$\boldsymbol{m_1}$ FBD:



$\boldsymbol{m_2}$ FBD:



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

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

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

(c) **Calculate the mass of $\boldsymbol{m_2}$ needed to keep the system in equilibrium.**

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

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

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

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

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

$\therefore$ The horizontal acceleration is 2.0m/s^2[right]

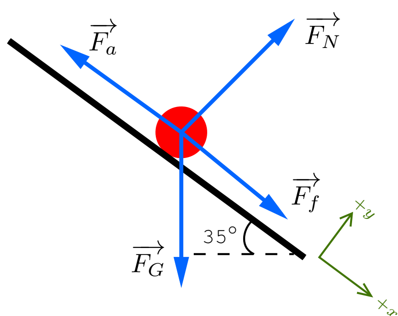
(b) **What is the coefficient of friction between the bale and the ground?**

$$\begin{aligned}
\vec{F_f} &= \mu_f \vec{F_N} \\
55 &= \mu_f(\vec{F_g} - \vec{F_{a_y}}) \\
\mu_f &= \frac{55}{35 \times 9.8 - 140 \sin 35^\circ} \\
\mu_f &= 0.21
\end{aligned}$$

$\therefore$ The coefficient of friction between the bale and ground is 0.21.

Q03. A 15kg box is pushed up a 35° ramp. A force of 110N 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?**

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

$\therefore$ Since 194.31N is the force required to keep the object at rest, the minimum force for constant speed must be greater than 194.31N.

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?

$\boldsymbol{m_1}$**:**

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

$\boldsymbol{m_2}$**:**

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

Set Equations for $\boldsymbol{F_T}$ Equal:

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

Solve for Friction Coefficient:

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

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