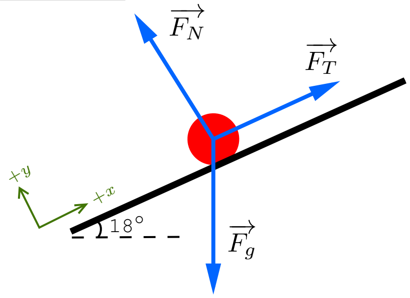
SPH4U: Dynamics Assignment

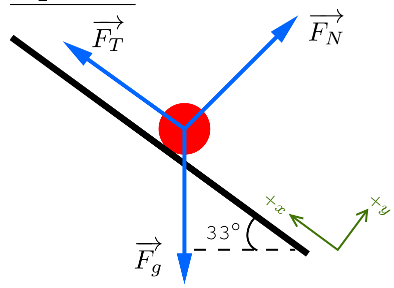
Q01.

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

m_1 FBD:



m_2 FBD:



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

m_1:

$$\begin{aligned}
\vec{F_{net_{1x}}} &= 0 \\
0 &= \left|\vec{F_T}\right| - \vec{F_{g_x}} \\
0 &= \left|\vec{F_T}\right| - 380(9.81)\sin 18° \\
\left|\vec{F_T}\right| &= 380(9.81)\sin 18° \\
\left|\vec{F_T}\right| &= 1151.95 \text{ N} \\
\left|\vec{F_T}\right| &= 1200 \text{ N}
\end{aligned}$$

∴ The magnitude of tension in the string is **1200 N**.

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

$$\begin{aligned}
\vec{F_{net_{2x}}} &= 0 \\
0 &= \vec{F_T} - \vec{F_{g_x}} \\
0 &= 1151.95 - m_2(9.81)\sin 33° \\
m_2 &= \frac{1151.95}{9.81\sin 33°} \\
m_2 &= 215.6 \text{ kg} \\
m_2 &= 220 \text{ kg}
\end{aligned}$$

∴ The mass of the second box (m_2) is **220 kg**.

Q02.

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

$$\begin{aligned}
\vec{F_{net_x}} &= \vec{F_{a_x}} - \vec{F_f} \\
&= 140\cos 28° - 55 \\
&= 68.81 \text{ N[forward]}
\end{aligned}$$

$$\begin{aligned}
\vec{F_{net_x}} &= m\vec{a} \\
68.81 &= 35\vec{a} \\
\vec{a} &= 1.96\text{m/s}^2\text{[forward]} \\
\vec{a} &= 2.0 \text{ m/s}^2\text{[forward]}
\end{aligned}$$

∴ The horizontal acceleration of the bale is **2.0 m/s^2[forward].**

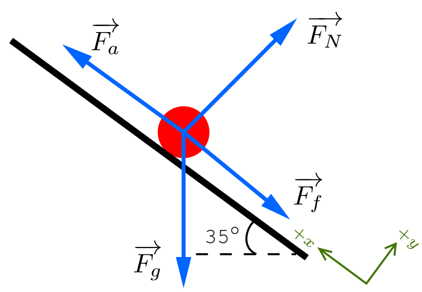
(b) **What is the coefficient of friction between the bale and the ground?**

$$\begin{aligned}
\vec{F_f} &= \mu_f \vec{F_N} \\
55 &= \mu_f(\vec{F_g} - \vec{F_{a_y}}) \\
\mu_f &= \frac{55}{\vec{F_g} - \vec{F_{a_y}}} \\
\mu_f &= \frac{55}{35(9.81) - 140 \sin 28^\circ} \\
\mu_f &= 0.198 \\
\mu_f &= 0.20
\end{aligned}$$

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

Q03.

(a) **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?**

$$\begin{aligned}
\vec{F_{net_x}} &= \vec{F_a} - \vec{F_{g_x}} - \vec{F_f} \\
0 &= \vec{F_a} - 15(9.81)\sin 35^\circ - 110 \\
\vec{F_a} &= 15(9.81)\sin 35^\circ + 110 \\
\vec{F_a} &= 194.4 \text{ N[uphill]} \\
&\boxed{\vec{F_a} = 190 \text{ N[uphill]}}
\end{aligned}$$

$\therefore$ 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.

m_1:

$$\vec{F_{net_x}} = \vec{F_T} - \vec{F_f} - \vec{F_{g_x}}$$
$$0 = \vec{F_T} - \vec{F_f} - 0.45(9.81)\sin 35°$$
$$\vec{F_T} = \vec{F_f} + 0.45(9.81)\sin 35°$$
$$\vec{F_T} = \vec{F_f} + 2.53 \text{ N[uphill]}$$

m_2:

$$\vec{F_{net_y}} = \vec{F_g} - \vec{F_T}$$
$$0 = 0.35 \times 9.81 - \vec{F_T}$$
$$\vec{F_T} = 3.43 \text{ N[up]}$$

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:

$$\vec{F_f} = \mu_f \vec{F_N}$$
$$0.9 = \mu_f \times 0.45(9.81)\cos 35°$$
$$\mu_f = \frac{0.9}{0.45(9.81)\cos 35°}$$
$$\mu_f = 0.249$$
$$\mu_f = 0.25$$

$\boxed{\therefore \text{ The coefficient of friction between the box and incline is } \mathbf{0.25}.}$