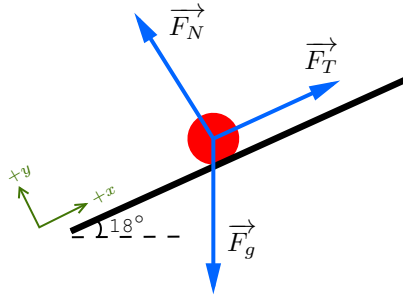


SPH4U: Dynamics Assignment

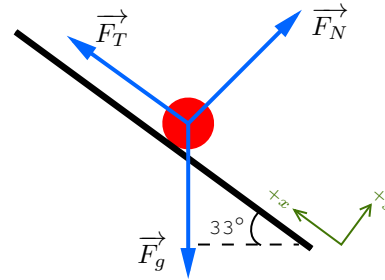
Q01. Two heavy boxes, m_1 and m_2 , lie stationary on different inclines, as shown. A rope runs over a pulley and connects the boxes. Mass 1, m_1 is 380 kg. Assuming that each incline is frictionless and the system is in equilibrium, answer the following:

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

m_1 FBD:



m_2 FBD:



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

m_1 :

$$\begin{aligned}
 F_{net1x}^{\rightarrow} &= 0 \\
 0 &= |F_T| - F_{gx}^{\rightarrow} \\
 0 &= |F_T| - 380(9.8) \sin 18^\circ \\
 |F_T| &= 1150.78 \text{ N} \\
 |F_T| &= 1200 \text{ N}
 \end{aligned}$$

\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.**

$$\begin{aligned}
 F_{net2x}^{\rightarrow} &= 0 \\
 0 &= F_T^{\rightarrow} - F_{gx}^{\rightarrow} \\
 0 &= 1150.78 - m_2(9.8) \sin 33^\circ \\
 m_2 &= \frac{1150.78}{9.8 \sin 33^\circ} \\
 m_2 &= 215.6 \text{ kg} \\
 m_2 &= 220 \text{ kg}
 \end{aligned}$$

\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?**

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

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

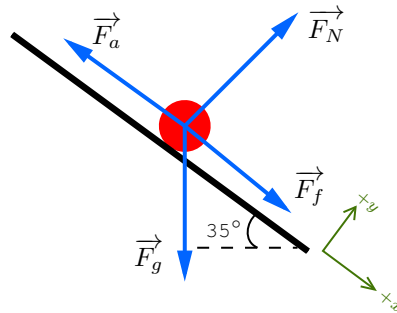
(b) What is the coefficient of friction between the bale and the ground?

$$\begin{aligned}
 \vec{F}_f &= \mu_f \vec{F}_N \\
 55 &= \mu_f (\vec{F}_g - \vec{F}_{a_y}) \\
 \mu_f &= \frac{55}{\vec{F}_g - \vec{F}_{a_y}} \\
 \mu_f &= \frac{55}{35(9.8) - 140 \sin 28^\circ} \\
 \mu_f &= 0.198 \\
 \mu_f &= 0.20
 \end{aligned}$$

\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?

$$\begin{aligned}
 \vec{F}_{netx} &= \vec{F}_a + \vec{F}_{gx} + \vec{F}_f \\
 0 &= \vec{F}_a + 15(-9.8) \sin 35^\circ - 110 \\
 0 &= \vec{F}_a - 194.31 \\
 \vec{F}_a &= 194.31 \text{ N[uphill]} \\
 \vec{F}_a &= 190 \text{ N[uphill]}
 \end{aligned}$$

\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 :

$$F_{net_x}^{\rightarrow} = \vec{F}_g \sin 35^\circ + \vec{F}_T - \vec{F}_f$$

$$0 = 0.45(-9.8) \sin 35^\circ + \vec{F}_T + \vec{F}_f$$

$$0 = -2.53 + \vec{F}_T + \vec{F}_f$$

$$\vec{F}_T = \vec{F}_f + 2.53 \text{ N[uphill]}$$

 m_2 :

$$F_{net_y}^{\rightarrow} = \vec{F}_g - \vec{F}_T$$

$$0 = 0.35 \times 9.8 - \vec{F}_T$$

$$\vec{F}_T = 3.43 \text{ N[up]}$$

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.