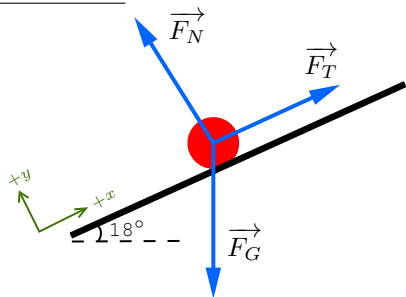


## SPH4U: Dynamics Assignment

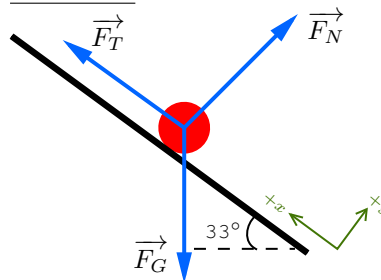
**Q01.** Two heavy boxes,  $m_1$  and  $m_2$ , lie stationary on different inclines, as shown. A rope runs over a pulley and connects the boxes. Mass 1,  $m_1$  is 380 kg. Assuming that each incline is frictionless and the system is in equilibrium, answer the following:

(a) Draw FBD(s).

$m_1$  FBD:



$m_2$  FBD:



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

$$\begin{aligned}
 F_{net1x} &= 0 \\
 0 &= \vec{F}_g \sin 18^\circ + |F_T| \\
 0 &= m_1 g \sin 18^\circ + |F_T| \\
 0 &= 380(-9.8) \sin 18^\circ + |F_T| \\
 |F_T| &= 1150.78 \text{ N} \\
 |F_T| &= 1200 \text{ N}
 \end{aligned}$$

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

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

$$\begin{aligned}
 F_{net2x} &= 0 \\
 0 &= \vec{F}_g \sin 33^\circ + 1150.78 \\
 m_2 &= \frac{-1150.78}{-9.8 \sin 33^\circ} \\
 m_2 &= 215.6 \text{ kg} \\
 m_2 &= 220 \text{ kg}
 \end{aligned}$$

$\therefore$  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  $28^\circ$  above the horizontal. The force of friction acting on the bale is 55 N.

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

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

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

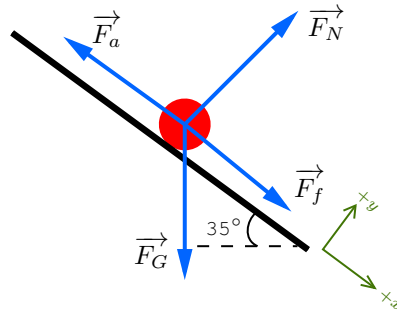
(b) What is the coefficient of friction between the bale and the ground?

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

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

**Q03.** A 15kg box is pushed up a  $35^\circ$  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?

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

$\therefore$  Since constant speed implies no acceleration ( $F_{net} = 0$ ), 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.

**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  $35^\circ$  to the horizontal with constant speed. What is the coefficient of friction between the box and the incline?

$m_1$ :

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

$m_2$ :

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

Set Equations for  $F_T$  Equal:

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

**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.