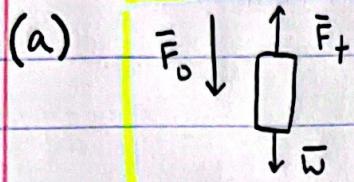


Midterm #2 Algebra Based Physics

2 Ch. 4: Dynamics, Force + Newton's Laws

- ① $5 \times 10^5 \text{ kg}$ rocket accel forward, thrusters up force = $1.25 \times 10^7 \text{ N}$
 air resistance force = $4.5 \times 10^6 \text{ N}$ down



(b) gravity = 9.8 m/s^2 (N)

$$9.81 \text{ m/s} \cdot 5 \times 10^5 \text{ kg} = 4.9 \times 10^6 \text{ kg m/s}^2 = 4.9 \times 10^6 \text{ N}$$

$$4.90 \times 10^6 \text{ N} + 4.50 \times 10^6 \text{ N} = 9.4 \times 10^6 \text{ N}$$

(air drag)

$$\text{tot. thrust avail.} - \text{total drag} \Rightarrow 1.25 \times 10^7 \text{ N} - 9.4 \times 10^6 \text{ N}$$

$$= 12.50 \times 10^6 - 9.4 \times 10^6$$

$$N = \text{kg m/s}^2 (+ \text{kg}) = 3.10 \times 10^6 \text{ N} \quad (\text{effective thrust})$$

\downarrow

works against mass of $5 \times 10^5 \text{ kg}$

$$\text{thrust} \div \text{mass} = 3.10 \times 10^6 \text{ kg m/s}^2 / 5 \times 10^5 \text{ kg}$$

$$= 0.62 \times 10^1 \text{ m/s}^2 \Rightarrow 6.20 \text{ m/s}^2$$

- ② football player mass = 70 kg pushes player mass = 90 kg

- (a) exerts force = 700 N on other player, force of other player exerts on first player = ?

$$m_1 = 70 \text{ kg} \quad m_2 = 90 \text{ kg} \quad f_1 = 700 \text{ N}$$

Every action = equal + opp. reaction

700 N in pos. direction BUT neg. for second player

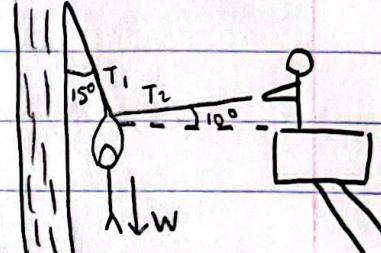
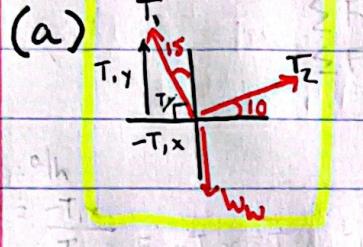
$\hookrightarrow -700 \text{ N}$

- ③ rocket sled decel at rate = 200 m/s^2 , mass = 2000 kg
 const. air resist force = 1000 N . Find additional force required
 to give the rocket the decel.?

$$\begin{aligned} f &= m \cdot a \\ &= (2000 \text{ kg}) \cdot (200 \text{ m/s}^2) \\ &= 400,000 \end{aligned}$$

additional force needed = $4.00 \times 10^5 \text{ N}$

- ④ 76.0 kg lady pulled away from burning building



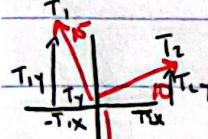
(b) expression for F_{net}, x

$$F_{\text{net}}, x = T_2 \cos \theta_2 - T_1 \sin \theta_1$$

(c) expression for F_{net}, y

$$F_{\text{net}}, y = T_2 \sin \theta_2 + T_1 \cos \theta_1 - \bar{w}$$

(d) $\bar{F}_{\text{net}} = 0$, find tension in two ropes



$$\begin{aligned} w_w &= 76 \times 9.80 \\ w_w &= 745 \text{ N} \end{aligned}$$

$$\begin{aligned} \sum F_x &= m a_x = 0 & \cos \theta = a/h & \cos \theta = a/h & \cos 10^\circ = \frac{T_2 x}{T_2} \\ \sum F_y &= m a_y = 0 & \cos 75^\circ = -\frac{T_1 x}{T_1} & \cos 75^\circ = -\frac{T_1 \cos 75^\circ}{T_1} & \cos 10^\circ = \frac{T_2 x}{T_2} + w_w = 0 \\ \sin \theta &= 0/h & \cos 75^\circ = \frac{T_1 y}{T_1} & \cos 75^\circ = \frac{T_1 \sin 75^\circ}{T_1} & \cos 10^\circ = \frac{T_2 y}{T_2} \\ \sin 75^\circ &= T_1 y / T_1 & \sin 75^\circ = \frac{T_1 \sin 75^\circ}{T_1} & \sin 75^\circ = \frac{T_1 \sin 75^\circ}{T_1} & \sin 10^\circ = \frac{T_2 y}{T_2} \rightarrow T_2 y = T_2 \sin 10^\circ \end{aligned}$$

$$\begin{aligned} T_1 y &= T_1 \sin 75^\circ \\ T_1 &= T_1 \sin 75^\circ \end{aligned}$$

$$\begin{aligned} T_1 x &= T_1 \cos 75^\circ \\ T_1 &= T_1 \cos 75^\circ \end{aligned}$$

$$\begin{array}{c|c} x & y \\ \hline T_1 - T_1 \cos 75^\circ & T_1 \sin 75^\circ \\ T_2 - T_2 \cos 10^\circ & T_2 \sin 10^\circ \\ \hline -745 & \end{array}$$

work on next page

$$(d \text{ cont.}) \quad T_2 \cos 10 - T_1 \cos 75 = 0$$

$$T_2 \cos 10 = T_1 \cos 75$$

$$T_1 \sin 75 + T_2 \sin 10 - 745 = 0$$

$$\Downarrow \quad \frac{T_2 \cos 10}{\cos 75} = T_1 \quad \xrightarrow{\text{plug}} \quad T_1 \sin 75 + T_2 \sin 10 - 745 = 0$$

$$\left[\frac{T_2 \cos 10}{\cos 75} \right] \sin 75 + T_2 \sin 10 - 745 = 0 \\ +745 \quad +745$$

$$3.67 T_2 + 0.174 T_2 = 745$$

$$\frac{3.84 T_2}{3.84} = \frac{745}{3.84}$$

Tension #2

$$T_2 = 194 \text{ N}$$

$$\frac{194 (\cos 10)}{\cos 75} = T_1$$

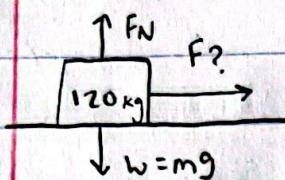
$$T_1 = 738 \text{ N}$$

Tension #1

3 Ch. 5 : Friction, Drag, Elasticity

- ① 120 kg woodcrate on floor, coef. of static + kinetic
 friction = 0.5 and 0.3

(a) max force can exert horiz. w/o moving it



$$M_s = 0.5 \quad f_s \leq M_s F_N$$

$$\sum F_y = m a_y \quad f_s \leq 0.5(1,180)$$

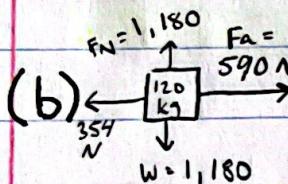
$$F_N + W = 0 \quad f_s \leq 590 \text{ N}$$

$$F_N - 1,180 = 0$$

$$W = 120(9.8) = 1,180 \text{ N}$$

$$F_N = 1,180$$

(b)



$$M_k = 0.3 \quad \sum F_x = m a$$

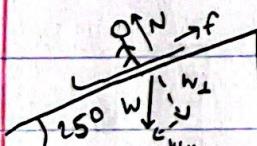
$$f_k = M_k F_N \quad \frac{590 - 354}{120} = \frac{120(a)}{120}$$

$$f_k = 0.3(1,180) \quad a = 1.97 \text{ m/s}^2$$

$$f_k = 354 \text{ N}$$

- ② Skid down slope with incline 25°

coeff. of kinetic frict = 0.1, what is accel?



$$\sin \theta = o/h \quad f_k = M_k F_N$$

$$\sin 25^\circ = \frac{w_y}{w} \quad f_k = 0.1(w_y)$$

$$w_x = w \sin 25 \quad f_k = 0.1(w \cos 25)$$

$$\sum F_x = m a_x$$

$$\cos \theta = a/h$$

$$w_y - f_k = m a_x$$

$$\cos 25 = \frac{-w_y}{w}$$

$$w \sin 25 - (0.1(w \cos 25)) = m a_x$$

$$w_y = -w \cos 25$$

$$w [\sin 25 - 0.1 \cos 25] = m a_x$$

$$mg [\sin 25 - 0.1 \cos 25] = m a_x$$

$$g [\sin 25 - 0.1 \cos 25] = a_x$$

$$9.81 - 0.090$$

$$9.81 [0.332] = a_x$$

$$3.25 = a_x$$

$$\text{m/s}^2$$

③ Drag Force: skier reaches top speed 40 m/s, area = 0.75 m^2 ,

density of air = 1.225 kg m^{-3} , $C = 0.75$

find magnitude of drag (N)

$$F_D = \frac{1}{2} C_p A v^2$$

$$F_D = \frac{1}{2} (1.225 \text{ kg m}^{-3}) (0.75) (0.75 \text{ m}^2) (40 \text{ m/s})^2$$

$$F_D = 551.25 \text{ N}$$

④ mass = 2300 kg on top of 10 m wood, radius = 4 cm

length of beam decreased by 3 mm, what is Young's modulus of the wood? (units?)

$$\bar{F} = mg$$

$$m = 2300 \text{ kg}$$

$$3 \text{ mm} \rightarrow r = 0.003 \text{ m}$$

$$r = 0.04 \text{ m}$$

$$4 \text{ mm} \rightarrow r = 0.04 \text{ m} \quad A = \pi r^2 = 5 \times 10^{-3} \text{ m}^2$$

$$\bar{F} = mg$$

$$F/A = Y(\Delta L/L)$$

$$\bar{F} = 2300 \text{ kg} \cdot 9.81 \text{ m/s}^2$$

$$\frac{F/A}{\Delta L/L} = Y$$

$$= 22563 \text{ N}$$

$$\downarrow$$

$$Y = \frac{22563 \text{ N}}{0.003 \text{ m}} / 10 \text{ m}^{-3} \text{ m}^2$$

$$Y = 1.5 \times 10^{10} \text{ N/m}^2$$

4 Ch. 6: Uniform Circular Motion + Gravitation

- ① A pitcher in baseball pitches a ball at 144 km per hr, ball rotates around arm at 0.5 m radius
 Angular velo of ball as throws (in rad/s)?

$$\text{ang. velo} = v = r\omega \rightarrow \frac{144 \text{ km/hr}}{0.5} = \frac{(0.5 \text{ m})(\omega)}{0.5}$$

$$\text{ang. accel} = a = r\alpha$$

$$\frac{144 \text{ km}}{\text{hr}} \cdot \frac{1 \text{ hr}}{3600 \text{ s}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \frac{144 \text{ km/hr}}{0.5 \text{ m}} \cdot \frac{40 \text{ m/s}}{0.5 \text{ m}} = \omega$$

$$= 40 \text{ m/s}$$

$$\omega = 80 \text{ rad/s}$$

- ② What is the ideal banking for gentle turn of 0.9 km radius on highway w/ a 120 km/hr speed limit, assuming everyone travels at the limit?

$$120 \text{ km/h} \rightarrow \text{m/s}$$

$$\tan \theta = \frac{v^2}{rg} \quad \frac{120 \text{ km}}{\text{hr}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{3600 \text{ s}} = 33.3 \text{ m/s}$$

$$\tan \theta = \frac{33.3^2}{900(9.8)}$$

$$\frac{1108.89}{8820}$$

$$0.9 \text{ km} = 900 \text{ m}$$

$$\tan \theta = 0.1257$$

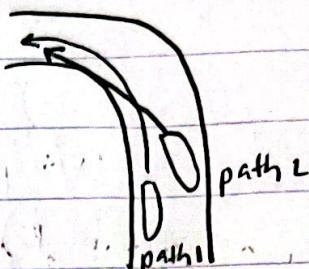
$$\theta = \tan^{-1}(0.1257)$$

$$\theta = 7.16^\circ \approx \boxed{\theta = 7.16^\circ}$$

1.20.0.

0.90.0

- ③ Two race car drivers routinely navigate a turn as shown
 (a) which path may be taken at a higher speed, if both paths correspond to same force of friction and centripetal force?



Path 2

- (b) suppose path 1 has radius of curve of 400m and path 2 has radius of curve 800m. The coeff. of friction = 1.0. If the force of friction balances the centripetal force, what are the tangential velo. of each race car?

$$F_c = \frac{mv^2}{r} = M_m g$$

$$\frac{v^2}{r} = Mg \quad v = \sqrt{rMg}$$

$$\text{Path } \#1 = v = \sqrt{1 \cdot 9.81 \text{ m/s}^2 \cdot 400 \text{ m}} = 62.6 \text{ m/s}$$

$$\text{Path } \#2 = v = \sqrt{1 \cdot 9.81 \text{ m/s}^2 \cdot 800 \text{ m}} = 88.6 \text{ m/s}$$

④ TWO Bonus Points

planet pluto

(a) $a_c = \frac{Gm}{r^2}$

$$a_c = \frac{6.673 \times 10^{-4} (1.4 \times 10^{22})}{(4.50 \times 10^{12})^2}$$

$$a_c = 4.61 \times 10^{-14} \text{ m/s}^2$$

(b) $a_c = \frac{Gm}{r^2}$

$$a_c = \frac{6.673 \times 10^{-4} (8.62 \times 10^{25})}{(2.50 \times 10^{12})^2}$$

$$a_c = 9.2 \times 10^{-10} \text{ m/s}^2$$

$$\text{Compare} = \frac{9.2 \times 10^{-10}}{4.61 \times 10^{-4}}$$

$$= \underline{\underline{20,000}}$$

Uranus' centrip. accel. is 20,000 greater than centrip. accel. due to pluto