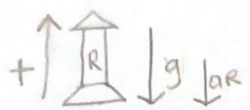
## Chapter 4: Dynamics, force and Newton's Laws of Motion

① A $5 \times 10^5$ kg rocket is accelerating straight up. The thrusters produce an upward force of $1.25 \times 10^7$ N, and the force of air resistance is $4.5 \times 10^6$ N downwards. (a) Draw a free-body diagram including the weight of the rocket, the thrust, and air resistance, (b) What is the rockets acceleration?

a)




b) rocket's acceleration

$$\frac{F_{net}}{m} = \frac{m\vec{a}}{m} \; ; \; F_{net} = T - aR - mg \; ; \; N = \frac{kg\,m}{s^2}$$

weight force $= -mg\hat{\imath}$

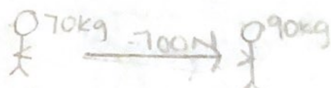
$$= 1.25 \times 10^7 N - 4.5 \times 10^6 N - (5 \times 10^5 kg)(9.8\ m/s^2)$$
$$= 3.1 \times 10^6 N$$

$$a = \frac{F_N}{m} \Rightarrow \frac{3.1 \times 10^6 N}{5 \times 10^5 kg} = \boxed{6.2\ m/s^2} \quad \frac{kg\,m}{s^2} \cdot \frac{1}{kg}$$

② a football player with mass 70kg pushes a player with mass 90kg (a) According to Newton's 3rd Law, if the 1st player exerts a force of 700 N on the second player, what is the force the second player exerts on the first player?

Newton's 3rd law:

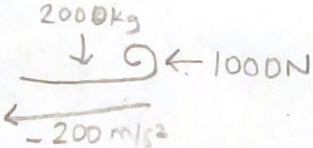
$\vec{F}_{AB} = -\vec{F}_{AB}$




70kg 700N ⟶ ⟵ 90kg -700N

$= -6.3 \times 10^4$ N kg

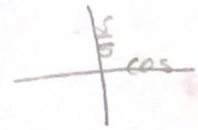
③ a rocket sled is decelerated at a rate $200\ m/s^2$, and it has a mass of 2000 kg. There is a constant air resistance force of 1000N. What additional force is required to give the rocket the deceleration?



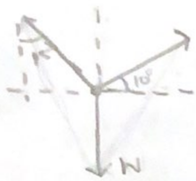

$$F_{net} = ma$$
$$= 2000\,kg \cdot -200\,m/s^2$$
$$= -4 \times 10^5 N + -1000 N$$
$$= -4 \times 10^5 N$$

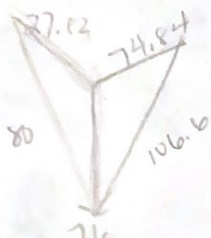
$F_N = p - ma$

4) A 76.0-kg person is being pulled away from a burning as shown in Fig. 1
(a) Draw a free-body Diagram including the two tension vectors and the woman's weight
(b) write down an expression for $F_{net,x}$.
(c) Write down an expression for $F_{net,y}$
(d) Assuming $\vec{F}_{net} = 0$, calculate the tension in the two ropes

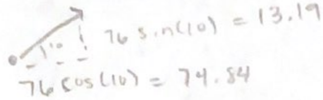



a) free body diagram




b) $F_{net,x}$





$W = mg$

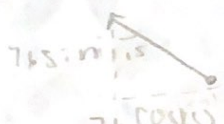
$76kg \cdot 9.8$

$744.8N$

$F_{net,x}$

$= \sqrt{(76\sin(10))^2 + (76\cos(10))^2} = 75.998$

c) $F_{net,y}$




$F_{net,y} =$

$\sqrt{(76\sin(15))^2 + (76\cos(15))^2}$

$= 27.82$

d) $F_{net,x} + F_{net,y} = 0$

$F_x = 106.6$ , $F_y = 80.93$

# Chapter 5: Friction, Drag, and Elasticity

(1) Suppose you have a 120 kg wooden crate resting on a wood floor. The coefficients of static and $\boxed{\text{kinetic}}$ friction are 0.5 and $\boxed{0.3}$ respectively.

(a) What maximum force can you exert horizontally on the crate w/o moving it?

$f_s$ = max N ≠ mon

$\mu_k = 0.3$ $\quad \vec{N} = mg$

$\mu_s = 0.5$ $\quad = 120\,kg \cdot 9.8\,m/s^2$

$= 1176\,N$

a) $f_s \leq \mu_s F_N \Rightarrow 0.5 \times 1176N = \boxed{588\,N}$

b) If you continue to exert this force once the crate starts to slip, what will the magnitude of its acceleration then be?

$N = \frac{kg\,m}{s^2} \cdot \frac{1}{kg}$

$f_k = 0.3 \times 1176N = 352.8\,N$

$a = \frac{F - f_k}{M}$

$a = \frac{588N - 352.8N}{120kg} = \frac{235.2N}{120\,kg} = \boxed{1.96\,\frac{m}{s^2}}$

(2) Suppose a skier (Fig 2) is sliding down a slope with an incline of 25 degrees. If the coefficient of kinetic friction is 0.1 what is the skier's aceleration?

$a = \frac{F_{net}}{M}$ ; $N = mg$ ; $f_s \leq \mu_s \times N$ ; $f_k = \mu_k \times N$

$f_k = \mu_k mg \sin(25)$

$a = \frac{\mu_k \cancel{m} g \sin(25)}{\cancel{m}}$

$a = \mu_k g \sin(25)$

$(0.1)(9.8\,m/s^2)(\sin 25)$

$= 0.414\,m/s^2$

③ Drag Force: Suppose the skier reaches a top speed of 40 m/s. If his area is 0.75 m², the density of air is 1.225 kg/m³ and C = 0.75, what is the magnitude of the dragforce in Newtons?

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

$F_D = \left(\frac{1}{2}\right)(0.75)\left(1.225 \frac{kg}{m^3}\right)(0.75 m^2)\left(40 \frac{m}{s}\right)^2$

$\frac{kg \cdot m^2 \cdot m^2}{m^3 s^2}$

$\boxed{= 13.78 N}$

$= \frac{kg\, m^4}{m^3 s^2}$

$= \frac{kg\, m}{s^2} = N$

④ a mass of 2300 kg is place on top of a 10.0 m long wooden beam w radius of 4 cm. If the length of the beam decreases by 3 mm, what is the Young's modulus of the wood? *units*

$E = \frac{Stress}{Strain}$

$Stress = \frac{mg}{\pi r^2} = \frac{2300 kg \cdot 9.8 m/s^2}{\pi\, 0.04^2 m^2} = 4484190. \frac{kg}{m s^2}$

$Stress = \frac{F}{A}$

$Strain = \frac{-0.003 \cancel{m}}{10 \cancel{m}} = -0.0003 m$

$Strain = \Delta L / L$

$\frac{Mg \cdot L}{\pi r^2 \cdot \Delta L}$

$\boxed{E = \frac{Stress}{Strain} = -1.4943 \times 10^{10} \ kg/ms^2}$

$\frac{kg \cdot ms^{-2} \cdot \cancel{m}}{\pi m^2 \cdot \cancel{m}}$

$= k$

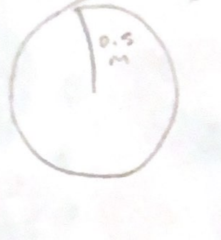
$\frac{kg}{m s^2}$

$m^{1-2}$

$= m^{-1}$

(4) Chapter 6: Uniform Circular Motion and

(1) a pitcher in baseball pitches a ball at 144 km phr, and the ball rotates around his arm at a radius of 0.5m. What is the angular velocity of the ball as he throws it, in radians per second.




$\frac{V}{R} = \frac{rW}{R}$

$\left(144 \frac{\cancel{km}}{\cancel{hr}}\right)\left(\frac{1000 m}{1 \cancel{km}}\right)\left(\frac{\cancel{hr}}{3600 s}\right)$

$= 40 \ m/s$

$W = \frac{V}{R}$

$= \frac{V}{R} = \frac{40 m/s}{0.5 m} = \boxed{80 \ r/s}$

(2) What is the ideal banking angle for a gentle turn of 0.9 km radius on a highway with a 120 km phr speed limit assuming everyone travels at the limit?

$0.9 \cancel{km} \cdot \frac{1000 m}{\cancel{km}}$

$r = 0.9 km = 900 m$ $\quad \tan\theta = \frac{v^2}{rg}$

$V = 120 Kmph = 33.3 m/s$

$\theta = ?$

$\Downarrow$

$\theta = \tan^{-1}\left(\frac{(33.3 m/s)^2}{900m \cdot 9.8 m/s^2}\right)$

$\frac{\cancel{m^2}\ \cancel{s^2}}{\cancel{s^2}\ \cancel{m^2}}$

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

③ Two race cars driviers routinely navigate a turn as shown in Fig 3
(a) Which path may be taken at a higher speed, if both paths correspond to the same force of friction and centripetal force?
(b) Suppose path 1 has a radius of curvature of 400M, and path 2 has a radius of curvature of 800M. The coeffeenent of friction is 1.0 If the force of friction balances the centripetal force, what are the tangential velocities of each race car?

a) path 2

b) path 1


path 2


$\mu_k = 1.0$ $Tv = r \cdot w$

$w$ = angular velocity

path 1 = $v = r \cdot w$

$\Rightarrow v = 400M \cdot w$

path 2

$v = 800m \cdot w$