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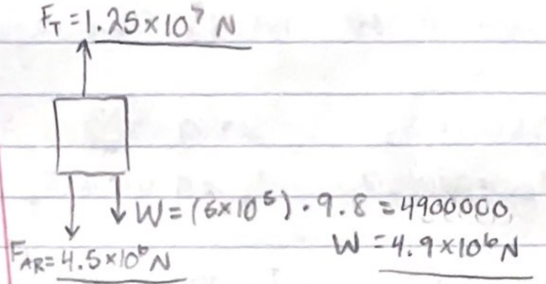
Midterm #2

chapter 4

1) A 5×10^5 kg rocket is accelerating straight up. The Thrusters produce an upwards force of 1.25×10^7 N, and air resistance is 4.5×10^6 N downwards. a) draw a FBD including weight of the rocket, the thrust, and air resistance. b) what is the rockets acceleration?



$F = m \cdot a \rightarrow \frac{F}{m} = a$

$a = \frac{1.25\times10^7 - (4.5\times10^6 + 4.9\times10^6)}{5\times10^5}$

$a = \frac{3.1\times10^6}{5\times10^5}$

$\boxed{a = 6.2 \text{ m/s}^2}$

2) A football player with mass 70 kg pushes on a player with mass 90 kg a) According to Newtons 3rd law, if the first player exerts a force of 700N on the second player, what is the force the second player exerts on the first player?

a) -700N

3) A rocket sled is decelerated at a rate of 200 m/s², and it has a mass of 2000 kg. There is a constant air resistance force of 1000 N. What additional force is required to give the rocket the deceleration

$F = m \cdot a$

$F_1 + F_2 = m \cdot a$

$1000N + F_2 = 2000 \cdot 200$

$F_2 = 400000 - 1000$

$F_2 = 399000$ N

$F_2 = 399000$ N
in the same direction as air resistance

a

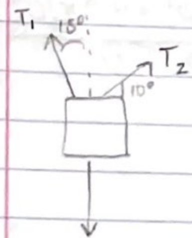
4) a 76 kg person is being pulled away from a burning building

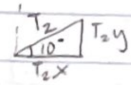
a) draw a FBD including the two tension vectors and the womans weight

b) write down an expression for $F_{net,x}$

c) write down an expression for $F_{net,y}$

d) assuming $\bar{F}_{net} = 0$, calculate the tension in the two ropes



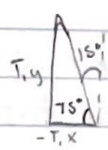


$\cos(10°) = \frac{T_{2x}}{T_2}$ $\quad\quad$ $\sin(10°) = \frac{T_{2y}}{T_2}$

$T_{2x} = \cos(10°) \cdot T_2$ $\quad\quad$ $T_{2y} = \sin(10°) \cdot T_2$

c) $\boxed{F_{net\,y} = T_1 \cdot \sin(75°) + T_2 \cdot \sin(10°) - 744.8}$

$w = 76 \times 9.8 = 744.8\,N$



$\cos(\theta) = \frac{A}{h}$ $\quad\quad$ $\sin(\theta) = \frac{O}{h}$

$\cos(75°) = \frac{T_{1x}}{T_1}$ $\quad\quad$ $\sin(75°) = \frac{T_{1y}}{T_1}$

$T_{1x} = -T_1 \cdot \cos(75°)$ $\quad\quad$ $T_{1y} = T_1 \cdot \sin(75°)$

$T_1 \sin(75°) + T_2 \sin(10°) - 744.8 = 0$

$\frac{T_2 \cos(10°)}{\cos(75°)}(\sin(75°)) + T_2 \sin(10°) - 744.8 = 0$

b) $\boxed{F_{net\,x} = -T_1 \cdot \cos(75°) + T_2 \cdot \cos(10°)} = 0$

$T_2 \cdot 3.675 + T_2 \sin(10°) = 744.8$

$T_2(3.675 + \sin(10°)) = 744.8$

$T_2 \cdot 3.8486 = 744.8$

d) $\boxed{T_2 = 193.5\,N}$

$T_2 \cdot \cos(10°) = T_1 \cos(75°)$

$\frac{T_2 \cos(10°)}{\cos(75°)} = T_1$

$\frac{193.5 \cdot \cos(10°)}{\cos(75°)} = T_1$

d) $\boxed{T_1 = 736.3\,N}$

chapter 5

1) Suppose you have a 120 kg wooden crate resting on a wooden floor. $\mu_s = 0.5$ $\mu_k = 0.3$

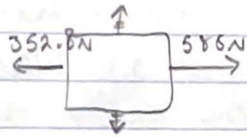
a) what max force can you exert horizontally on the crate without moving it

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

$F_N = 120 \cdot 9.8 = 1176 N$

$f_s \leq \mu_s \cdot N \leq 0.5 \times 1176 = 588 N$

$f_k = \mu_k \cdot N = 352.8 N$



a) the max force you can exert is 588 N

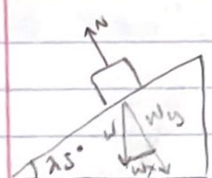
$F = ma$

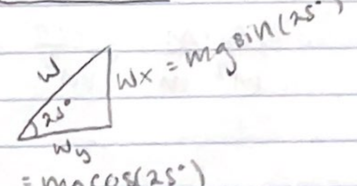
$588 - 352.8 = 120a$

$a = 1.96 m/s^2$

b) Mag. of acceleration = $1.96 m/s^2$

2) Suppose a skier is sliding down a slope w/ incline 25°. If the coefficient of kinetic friction is 0.1, what is the skiers acceleration?





$\cancel{m}g \sin(25°) - \mu \cancel{m}g = \cancel{m}a$

$g\sin(25°) - \mu g = a$

$9.8(0.4) - 9.8(0.1) = a$

$9.8(\sin(25°) - 0.1) = a$

$\boxed{a = 3.16 m/s^2}$

3) Suppose the skier reaches a top speed of 40 m/s. If his area is $0.75 m^2$, density of air is $1.225 kg/m^3$, and $C = 0.75$, what is the magnitude of the drag force in Newtons?

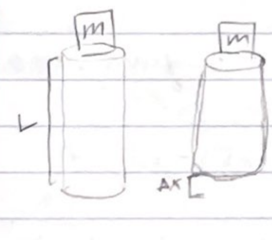
$$F_D = \frac{1}{2} C \rho A v^2$$

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

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

4) A mass of 2300 kg is place on top of a 10m long wooden beam w/radius 4cm. If the length of the beam decreases by 3mm, what is the young's modulus of the wood?

Stress = Y × Strain or $\frac{F}{A} = y\left(\frac{\Delta x}{L}\right)$



$F = 2300 \cdot 9.8 = 22540$ N

$A = \pi r^2 = \pi(0.04)^2 = 0.0016\pi \; m^2$

$\Delta x = 0.003$ m

$L = 10$m

$$y = \frac{FL}{A\Delta x} = \frac{22540(10)}{0.0016\pi \cdot 0.003}$$

$$\frac{N \cdot m}{m^2 \cdot m} = \frac{Nm}{m^3} = \frac{N}{m^2}$$

$$\boxed{y = 14947301738.7 \; N/m^2}$$

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

$= 40\ m/s$

chapter 6

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

$$\omega = \frac{v}{r} = \frac{40\ m/s}{0.5\ m} = \boxed{80\ rad/s}$$

2) what is the ideal banking angle for a gentle turn of 0.9 km radius on a highway w/ a 120 km/hr speed limit?

$$mg\frac{\sin(\theta)}{\cos(\theta)} = \frac{mv^2}{r}$$

$$\cancel{m}g\tan(\theta) = \frac{v^2}{r}$$

$$\tan(\theta) = \frac{v^2}{rg}$$

$$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$

$$v = \frac{120\ km}{hr}\left(\frac{1hr}{3600s}\right)\left(\frac{1000m}{1km}\right)$$

$$v = 33.33\ m/s$$

$$r = 0.9\ km = 900\ m$$

$$\theta = \tan^{-1}\left(\frac{(33.33)^2\ m^2/s^2}{9.8\ m/s^2 \cdot 900\ m}\right)$$

$$\theta = \tan^{-1}(0.125976)$$

$$\boxed{\theta = 7.18°}$$

3) a) which path may be taken at a higher speed, if both paths correspond to the same force of friction and cent. force?
b) Suppose path 1 has a radius of curvature of 400m and path 2 has a radius of curvature of 800m. $\mu = 1$ if $F_f = F_c$ what are the tangential velocities of each race car?

$$\mu N = \frac{mv^2}{r}$$
$$\mu mg = \frac{mv^2}{r}$$
$$\mu g = \frac{v^2}{r}$$
$$g = \frac{v^2}{r}$$
$$v = \sqrt{g \cdot r}$$

$$V_t = r \cdot \omega$$

$$\mu g = \frac{v^2}{r}$$
$$\mu g = \frac{v^2}{\frac{v_t}{r}}$$
$$\mu g = \frac{v^2 \cdot r}{v_t}$$
$$V_t = \frac{v^2 r}{\mu g}$$
$$V_{t_1} = \frac{v^2(400)}{9.8}$$
$$V_{t_2} = \frac{v^2(800)}{9.8}$$

a) path 2 can be taken at a higher speed

b) the tangential velocity of path 2 will be twice that of path 1?