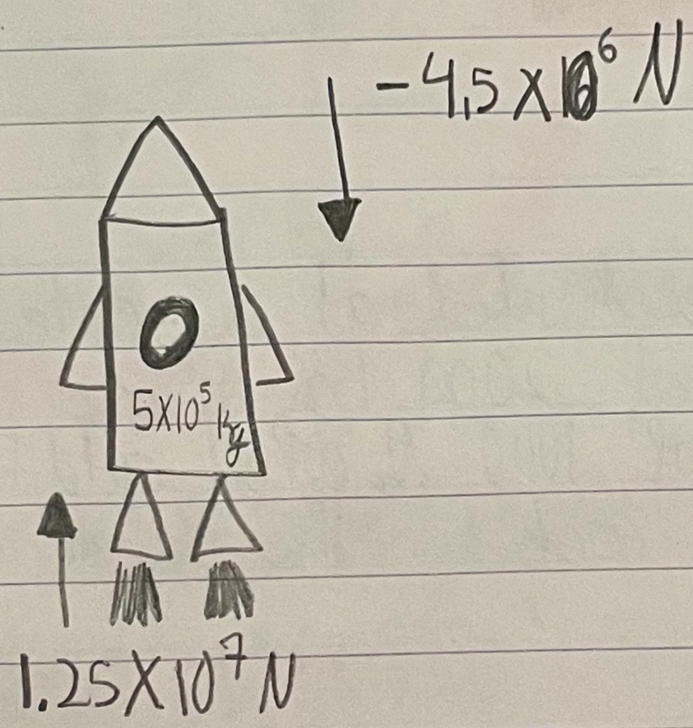
Midterm 2

Chapter 4: Dynamics, Force and Newton's Law of motion

1 A 5×10^5 kg rocket is accelerating straight up. The thrusters produce an upward force of 1.25×10^7 N and the force of air resistance is 4.5×10^6 N downward. a) Draw a free-body diagram including the weight of the rocket. b) what is the rocket's acceleration?



Mass $= 5 \times 10^5$ kg

Force$_{Net}$ $= 8 \times 10^6$ N

Acceleration $= ?$

$$\frac{F}{m} = \frac{ma}{m}$$

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

$$a = \frac{8 \times 10^6}{5 \times 10^5} = 16$$

Accelleration $= 16$ m/s^2

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

$\vec{F}_{AB} = -\vec{F}_{BA}$ $\vec{F}_{AB} = 700\,N$

$F_{BA} = -700\,N$

3 A rocket sled is decelerated at a rate of $200\,m/s^2$, 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?

$F_{Net} = p - ma$

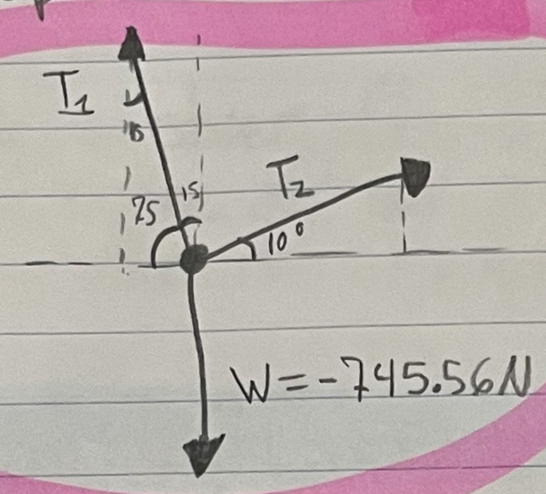
$= 1000 - (2000)(200)$

$= -399000$

To give the rocket deceleration 399000 N of force is needed

4 A 76.0 kg person is being pulled away from a burning building as shown in fig 1. a) draw a free body diagram including the two vectors and the woman's weight. b) Write down an expression for F_{netx} c) write down an expression for $F_{net\,y}$ D) Assuming $F_{net} = 0$, calculate the tension in the two ropes

a)



$\vec{w} = -mg\hat{j}$

$w = -(76)(9.81)\hat{j}$

$w = -745.56$

b) $T_2\cos(10) - T_1\cos(75) = F_{Netx} = 0$

c) $T_2\sin(10) + T_1\sin(75) - 745.56 = F_{Net\,y} = 0$

$T_2\cos(10) - T_1\cos(75) = 0$

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

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

$T_2\sin(10) + \left(\frac{T_2\cos(10)}{\cos(75)}\right)(\sin(75)) - 745.56 = 0$

$T_2(0.173) + T_2(3.675) - 745.56 = 0$

$T_2(3.849) - 745.56 = 0 \quad +745.56$
$+745.56$

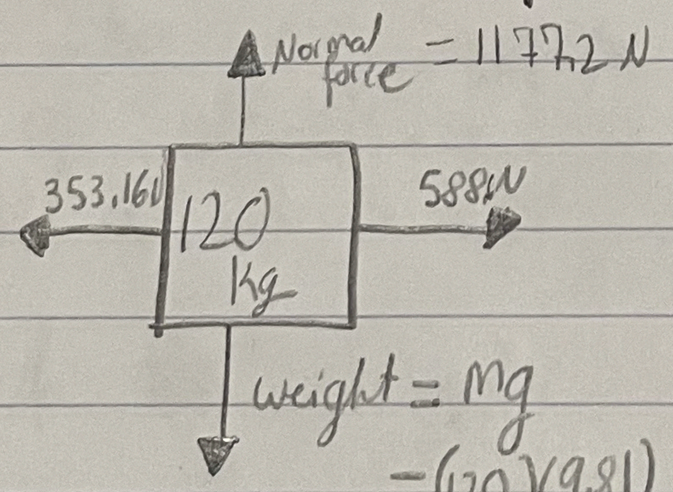
$\frac{T_2(3.849)}{3.849} = \frac{745.56}{3.849}$

d) $T_2 = 193.70\ N$

$T_1 = 737.03\ N$

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 kinetic friction are 0.5 and 0.3 respectively. a) What maximum 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 be then?



$F = \mu F_{Normal}$

$F_{static} = (0.5)(1177.2)$
$= 588.6\ N$

a) Maximum force you can exert horizontally without moving the crate is 588.6 N

$F_{kinetic} = (0.3)(1177.2)$
$= 353.16$

$$\frac{588.6 - 353.16}{120} = \frac{(120)(a)}{120}$$ ← $F = ma$

b) $a = 1.962\ m/s^2$

2 Suppose a skier (fig. 2) is sliding down a slope with an incline of 25 degrees. if the coeficcient of kinetic friction is 0.1, what is the skier's acceleration?

$$\frac{ma}{m} = \frac{mg\sin(\theta) - mg\mu\cos(\theta)}{m}$$

$$a = g\sin(\theta) - g\mu\cos(\theta)$$

$$a = (9.81)(\sin 25) - (9.81)(0.1)(\cos 25)$$

$a = 3.25\ m/s^2$

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

$F_D = C\rho A v^2$
$= (0.75)(1.225)(0.75)(40)$

$F_D = 27.5625\ N$

4 A mass of 2300 kg is place on top of a 10.0 m long wooden beam with radius of 4 cm. if the length of the beam decreases by 3 mm, what is the young's modulus of the wood? pay attention to the units

mass = 2300 kg

Force = (2300)(9.81)
= 22563 N

$\frac{\text{Force}}{\text{Area}} = Y \frac{L_0 - L_1}{L_1}$

Area = π 0.16 m^2

Y = ?

L_1 = 10.0 meters = 1000 cm

L_1 = 10 meters - 0.003 meters
= 100 cm - 0.3 cm
= 999.7

$$\frac{22563}{\pi 0.16} = Y \frac{10 - 9.997 m}{10 m}$$

$$\frac{4487.66}{3 \times 10^{-4}} = \frac{Y(3 \times 10^{-4})}{3 \times 10^{-4}}$$

= 14962554 0.9 N/m^2

Chapter 6: Uniform Circular Motion and Gravitation

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

$$\frac{v}{r} = \frac{r\omega}{r}$$

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

$$\omega = \frac{v}{r}$$

$$\omega = \frac{40}{0.5}$$

$$\omega = 80\ rad/s$$

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

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

$$\frac{120\ km}{h} \cdot \frac{1\ hr}{3600\ s} \cdot \frac{1000\ m}{1\ km} = 33.3\ m/s$$

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

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

$$\theta = 7.15^\circ$$

3 Two race car drivers 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 coefficient 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

25

Two bonus points:

4 The existance of the dwarf planet pluto was proposed based on irregularities in Neptune's orbit. pluto was subsequently discovered near its predicted position. But now it appears that the discovery was fortuitous, because pluto is small and the irregularities in Neptune's orbit were not well known. To illustrate that pluto has a minor effect on the orbit of Neptune compared with the closest planet to Neptune, a) calculate the acceleration due to gravity at Neptune due to pluto when they are 4.5×10^{12} m apart, as they are now. the mass of pluto is 1.4×10^{22} kg
b) Now calculate the acceleration due to gravity at Neptune due to uranus, presently about 2.5×10^{12} m apart and compare it with that due to Pluto. the mass of Uranus is 8.62×10^{25} kg

$$a = \frac{Gm}{r}$$

$$= \frac{6.67 \times 10^{-11}(1.4 \times 10^{22})}{(4.5 \times 10^{12})^2}$$

$$a = 4.61 \times 10^{-14}$$

a) $a = 4.61 \times 10^{-14}$ m/s²

$$a = \frac{Gm}{r^2}$$

$$a = \frac{(6.67 \times 10^{-11})(8.62 \times 10^{25})}{(2.5 \times 10^{12})^2}$$

$$= 9.19 \times 10^{-10} \text{ m/s}^2$$

b) $a = 9.19 \times 10^{-10}$ m/s²

Uranus's acceleration is faster by a ratio of 19934.9 m/s²

$$\frac{9.19 \times 10^{-10}}{4.61 \times 10^{-14}}$$