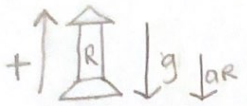
PHYS 150 Midterm 3 for Calculus-based Physics Sparamillo NOV 21, 2021

Chapter 4: Dynamics, force and Newton's Laws 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 downwards. (a) Draw a free-body diagram including the weight of the rocket, the thrust, and air resistance, (b) What is the rocket's acceleration?

Score: 14/20

a)



b) rocket's acceleration

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

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

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

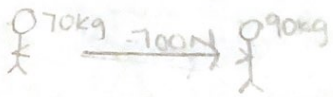
$= 3.1 \times 10^6$ N

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

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 700N on the second player, what is the force the second player exerts on the first player?

Newton's 3rd law:

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



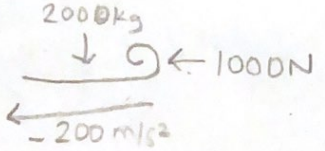
(-1)

70kg 700N → ← 90kg -700N

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

(?) It's just Newton's 3rd Law.

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 1000 N. What additional force is required to give the rocket the deceleration?



$F_{net} = ma$

$= 2000\ kg \cdot -200\ m/s^2$

$= -4 \times 10^5 N + -1000 N$

$= -4 \times 10^5 N$

$F_N = p - ma$

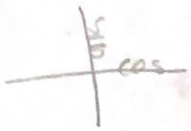
④ A 76.0-kg person is being pulled away from a burning as shown in Fig. 1

(a) Draw a free-body Diagram including the tho tension vectors and the woman's weight

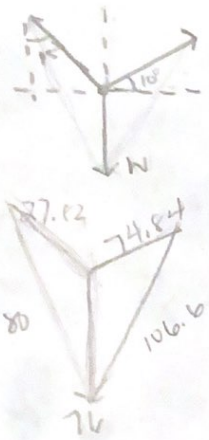
(b) write down an expression for $F_{net,x}$.

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

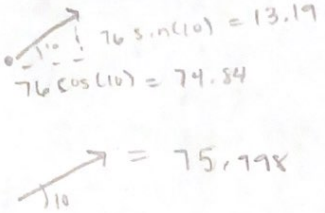
(d) Assuming $\vec{F}_{net} = 0$, calculate the tension in the two ropes



a) free body diagram



b) $F_{net,x}$



$= 75.798$

$F_{net,x}$

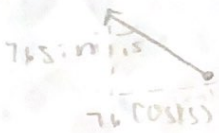
$= \sqrt{(76\sin(10))^2 + (76\cos(10))^2} = 15.998$

$W = mg$

$76kg \cdot 9.8$

$744.8 N$

c) $F_{net,y}$



$F_{net,y} = \sqrt{(76\sin(15))^2 + (76\cos(15))^2}$

$= 27.82$

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

$F_x = 106.6$, $F_y = 80.93$

(-2) The net forces in the x-direction and y-direction are separately zero, and the final results must be hundreds of Newtons to balance the weight

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 w/o moving it?

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

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

$= 1176\,N$

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

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

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

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

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

(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 acceleration?

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

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

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

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

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

$= 0.414\,m/s^2$

(-1) You have to subtract the weight force down the incline, and the force of friction up the incline

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 $1.225 \, kg/m^3$ and $C = 0.75$, what is the magnitude of the drag force in Newtons?

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

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

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

$$= 13.78 \, N$$

(-1) Some math error, because 40 squared is much larger than 14

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

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

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

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

$$Stress = \frac{mg}{\pi r^2} = \frac{2300 kg \cdot 9.8 m/s^2}{\pi \, 0.04^2 m^2} = 448419 0. \frac{kg}{m s^2}$$

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

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

$$Strain = \Delta L / L$$

$$E = \frac{Stress}{Strain} = -1.4943 \times 10^{10} \frac{kg}{m s^2}$$

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

$$\downarrow \frac{kg \cdot m s^{-2} \cdot m}{\pi m^2 \cdot m}$$

$$= k$$

$$M^{1-2} \quad \frac{kg}{m s^2}$$

$$= M^{-1}$$

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.

$V = r\omega$

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

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

$= 40 \ m/s$

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

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?

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

$r = 0.9km = 900m$

$v = 120 kmph = 33.3 m/s$

$\theta = ?$

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

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

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

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

(3) Two race cars drivers routinely navigate a turn as shown in Fig 3 (see)

(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

b) path 1 path 2

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

w = angular velocity

path 1 $= v = r \cdot w$

$\Rightarrow v = 400m \cdot 2w$

path 2

$v = 800m \cdot 2w$

(-1) Equate centripetal force with friction ...