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11/19/22
Hanson

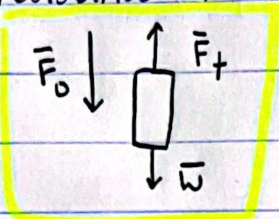
Score: 22/20 Awesome!

Midterm #2 Algebra Based Physics

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

① 5×10^5 kg rocket accel forward, thrusters up force = 1.25×10^7 N
air resistance force = 4.5×10^6 N down

(a)



(b) gravity = $9.8\ m/s^2$

$9.81\ m/s \cdot 5\times10^5\ kg = 4.9\times10^6\ kg\ m/s^2 \ (N) = 4.9\times10^6\ N$

$4.90\times10^6\ N + \underset{\text{(air drag)}}{4.50\times10^6\ N} = 9.4\times10^6\ N$

tot. thrust avail. − total drag ⇒ $1.25\times10^7\ N - 9.4\times10^6\ N$
$= 12.50\times10^6 - 9.4\times10^6$

$N = kg\ m/s^2\ (\div\ kg) \rightarrow m/s^2$ $= 3.10\times10^6\ N$ (effective thrust)
↳ works against mass of 5×10^5 kg

thrust ÷ mass = $3.10\times10^6\ kg\ m/s^2 / 5\times10^5\ kg$
$= 0.62\times10^1\ m/s^2$ ⇒ $\boxed{6.20\ m/s^2}$

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 = ?

$m_1 = 70$ kg $m_2 = 90$ kg $f_1 = 700$ N

every action = equal + opp. reaction
700 N in pos. direction BUT neg. for second player
↳ $\boxed{-700\ N}$

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③ rocket sled decel at rate = $200\ m/s^2$, mass = 2000 kg

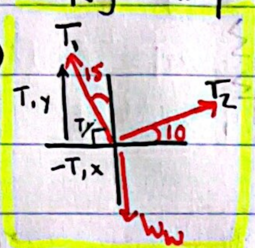
const. air resist force = 1000 N. Find additional force required to give the rocket the decel.?

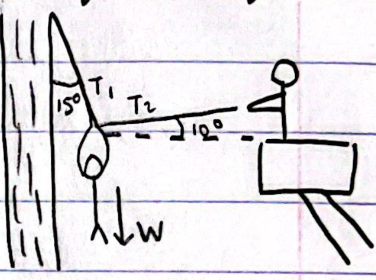
$$f = m \cdot a$$
$$= (2000\ kg) \cdot (200\ m/s^2)$$
$$= 400{,}000$$

additonal force needed = $\boxed{4.00 \times 10^5\ N}$

④ 76.0 kg lady pulled away from burning building

(a)





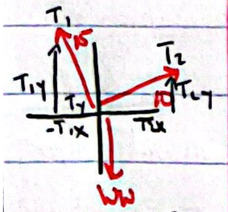
(b) expression for $F_{net,x}$

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

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

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

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



$W_w = 76 \times 9.80$

$\underline{W_w = 745\ N}$

$\sum F_x = m\cancel{a}_x = 0$

$\sum F_y = m\cancel{a}_y = 0$

$\sin\theta = o/h$

$\sin 75 = T_{1y}/T_1$

$\underline{T_{1y} = T_1 \sin 75}$

$\cos\theta = a/h$

$\cos 75° = \dfrac{-T_{1x}}{T_1}$

$\underline{T_{1x} = -T_1 \cos 75}$

$\sin\theta = o/h$

$\sin 10 = T_{2y}/T_2 \rightarrow \underline{T_{2y} = T_2 \sin 10}$

$\cos\theta = a/h$

$\cos 10 = \dfrac{T_{2x}}{T_2}$

$\underline{T_{2x} = T_2 \cos 10}$

	x	y
T_1	$-T_1\cos 75$	$T_1 \sin 75$
T_2	$T_2 \cos 10$	$T_2 \sin 10$
$+W_w$	0	-745
$\vec{R}$	0	0

work on next page →

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

$T_2 \cos 10 = T_1 \cos 75$

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

$\Downarrow$

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

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

$+745 \quad +745$

$3.67\, T_2 + 0.174\, T_2 = 745$

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

Tension #2

$\boxed{T_2 = 194\ N}$

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

$\boxed{T_1 = 738\ N}$

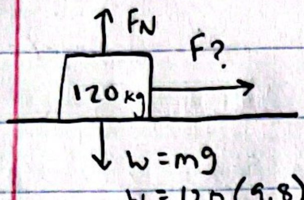
Tension #1

well done!

3 Ch.5 : Friction, Drag, Elasticity

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

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



$w = 120(9.8) = -1{,}180\ N$

$\mu_s = 0.5$

$\Sigma F_y = ma_y$

$\Sigma F_y = 0$

$F_N + W = 0$

$F_N - 1{,}180 = 0$

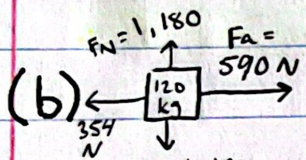
$F_N = 1{,}180$

$f_s \le \mu_s F_N$

$f_s \le 0.5(1{,}180)$

$\boxed{f_s \le 590\ N}$

(b)



$\mu_K = 0.3$

$f_K = \mu_K F_n$

$f_K = 0.3(1{,}180)$

$f_K = 354\ N$

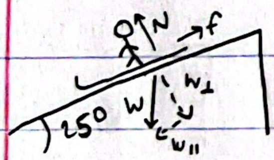
$\Sigma F_x = ma$

$\frac{590 - 354}{120} = \frac{120(a)}{120}$

$\boxed{a = 1.97\ m/s^2}$

② skier down slope with incline 25°

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



$\sin\theta = o/h$

$\sin 25° = \frac{w_x}{w}$

$w_x = w \sin 25$

$f_k = \mu_k F_N$

$f_k = 0.1(w_y)$

$f_k = 0.1(w \cos 25)$

$\cos\theta = a/h$

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

$w_y = -w\cos 25$

$\Sigma F_x = ma_x$

$w_y - F_k = ma_x$

$w \sin 25 - (0.1(w\cos 25)) = ma_x$

$w[\sin 25 - 0.1 \cos 25] = ma_x$

$mg[\sin 25 - 0.1 \cos 25] = ma_x$

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

$0.422 - 0.090$

$9.81[0.332] = a_x$

$\boxed{3.25\ m/s^2 = a_x}$

③ Drag Force: skier reach top speed 40 m/s, area = $0.75\ m^2$, density of air = $1.225\ kg\ m^{-3}$, c = 0.75
find magnit. of drag (N)

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

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

$\boxed{F_D = 551.25\ N}$

④ mass = 2300 kg on top of 10 m wood, radius = 4 cm
length of beam dec. by 3 mm, what is Young's modulus of the wood? (units!)

$\bar{F} = mg$

3 mm → m = 0.003 m

4 mm → m = 0.04 m

$\bar{F} = mg$

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

$= 22563\ N$

m = 2300 kg

r = 0.04 m

$A = \pi r^2 = 5 \times 10^{-3}\ m^2$

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

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

$Y = \frac{22563\ N / 5\times10^{-3}\ m^2}{0.003\ m / 10\ m}$

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

Nice!

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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 veloc of ball as throws (in rad/s)?

ang. veloc = $v = r\omega$ → $\frac{144\ km/hr}{0.5} = \frac{(0.5\ m)(\omega)}{0.5}$

ang. accel = $a = r\alpha$

$\frac{144\ km/hr}{0.5\ m}$

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

$= 40\ m/s$

$\frac{40\ m/s}{0.5\ m} = \omega$

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

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?

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

$\frac{120\ km}{hr} \times \frac{1000\ m}{1\ km} \times \frac{1\ hr}{3600\ s} = 33.\bar{3}\ \frac{m}{s}$

120 km/h → m/s

$\tan\theta = \frac{33.3^2}{900\,(9.8)}$ $\frac{1108.89}{8820}$

0.9 km = 900 m

1.200

0.900

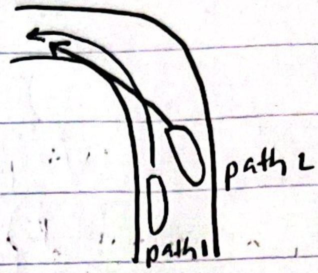
$\tan\theta = 0.1257$

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

$\theta = 7.164 \approx \boxed{\theta = 7.16°}$

(3) Two race car drivers routinely navigate a turn as shown

(a) which path may be taken at a higher speed, if both paths corresp. 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 tangental veloc. of each race car?

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

$$\frac{v^2}{r} = \mu g \qquad v = \sqrt{r \mu g}$$

Path #1 = $V = \sqrt{1 \cdot 9.81\,m/s^2 \cdot 400m} = \boxed{62.6\ m/s}$

Path #2 = $V \sqrt{1 \cdot 9.81\,m/s^2 \cdot 800m} = \boxed{88.6\ m/s}$

④ TWO Bonus Points

planet pluto

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

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

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

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

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

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

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

$= \frac{20,000}{1}$

(+2) Bonus!

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