GE 205: Dynamics | Midterm Exam | 3/2/23 – 3/4/23

Open notes, open book, and calculators allowed. Work neatly and clearly mark your answers. Partial credit may be given.

Name: _____

Question:	1	2	3	4	Total
Points:	10	20	30	40	100
Score:					

1. (10 points) A 3500 lb car decelerates from 60 mph to 45 mph in 8 seconds. Neglecting friction, what is the average force applied by the brakes?

$L_1 + \bar{I}mp_{1\to 2} = L_2$

$mv_1 + Ft = mv_2$

$\bar{F}t = mv_2 - mv_1$

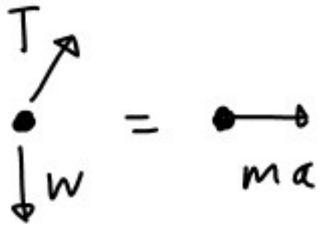
$F = \frac{m(v_2 - v_1)}{t} = \frac{109(66-88)}{8} = \boxed{300\,lb}$

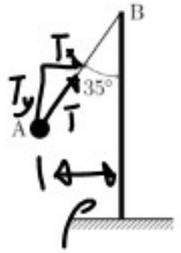
$60\ mph = 88\ ft/s$

$45\ mph = 66\ ft/s$

$3500\ lb = 109\ slug$

2. (20 points) In the game of tetherball, a "tether" connects the ball A to the top of the pole at B. This tether is 2 m long and makes the angle shown with the vertical pole. Assuming a constant velocity, what is the magnitude of the velocity and acceleration of the ball as it travels in a circular path around the pole?





$\tan 35° = \frac{T_x}{T_y} = \frac{ma}{mg} = \frac{a}{g}$

$T_y = W = mg$

$T_x = ma$

$g \tan 35° = a$

$9.8 \tan 35° = \boxed{6.86\ m/s^2}$

$\rho = 2 \sin 35° = 1.15\ m$

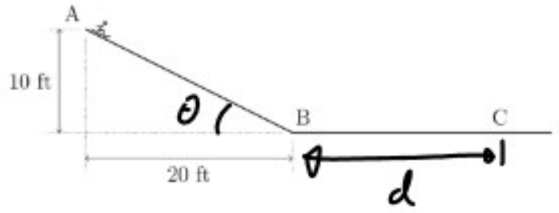
$a = \frac{v^2}{\rho}$

$v = \sqrt{a\rho}$

$= \sqrt{6.86 \cdot 1.15} = \boxed{2.8\ m/s}$

3. (30 points) Dr. Devine is sledding down a hill after a snowstorm. He starts at rest at A in the figure below. He passes through point B and stops some distance later at C.
   (a) What is the distance between points B and C?
   (b) How long does it take for him to stop after he passes point B?

   The coefficient of friction between his sled and the snow is $\mu_k = 0.1$, and the total weight of the sled and rider is 130 lbs.



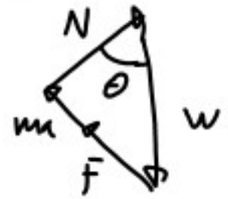
$V_A + \cancel{T_A} + U_{A\to B} = \cancel{V_B} + T_B$

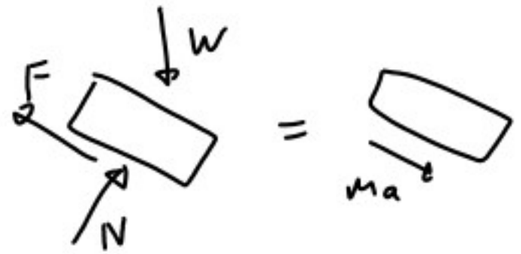
$mgh + Fd = T_B$

$130 \cdot 10 - 11.6\sqrt{10^2+20^2} = T_B$

$= 1040 \text{ lbft}$

$\tan\theta = \frac{10}{20} \Rightarrow \theta = 26.6^\circ$





$N = W\cos\theta$

$F = \mu_K N = 0.1N$

$F = 0.1 \cdot 130 \cos 26.6$

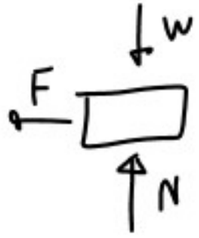
$= 11.6 \text{ lb}$

$\cancel{V_B} + T_B + U_{B\to C} = \cancel{V_C} + \cancel{T_C}$

$1040 - Fd = 0$

$1040 = Fd$

$\frac{1040}{F} = \frac{1040}{13} = \boxed{80 \text{ ft}} = d$



$F = 0.1N$

$= 0.1W$

$= 0.1 \cdot 130$

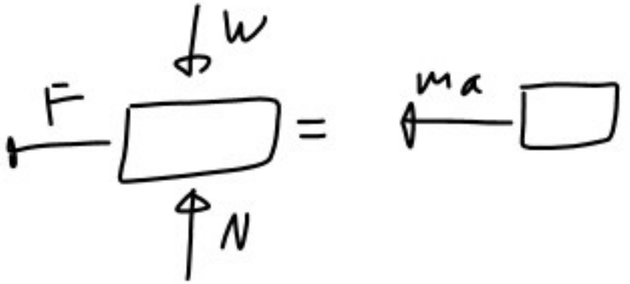
$= 13 \text{ lb}$

$V = V_0 + at$

$0 = 22.7 - 3.22t$

$\boxed{t = 7\ s}$

$T_B = 1040 = \frac{1}{2}mv^2 = \frac{1}{2}\frac{W}{g}v^2 = \frac{1}{2}\frac{130}{32.2}v^2 \Rightarrow v = 22.7\ ft/s$



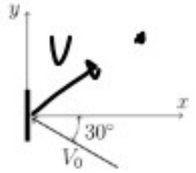
$ma = 13\ lb$

$\frac{W}{g}a = 13$

$\frac{130}{32.2}a = 13$

$a = 3.22\ ft/s^2$

4. (40 points) Wile E. Coyote runs into a painting of a tunnel at 15 mph at a 30° angle as shown below. After bouncing off of the painting with a coefficient of restitution $e = 0.8$ he slides along the ground with a coefficient of friction of $\mu_k = 0.4$. Where does he come to rest?



15 mph = 22 ft/s

$V_n = V_0 \cos 30 = 22 \cos 30 = -19$ ft/s

$V_t = V_0 \sin 30 = 22 \sin 30 = 11$ ft/s

$V_A' - V_B' = e(V_B - V_A)$

$V_A' = e(-V_A) = 0.8(19 \text{ ft/s}) = 15.2$ ft/s

$F = 0.4N = 0.4W$

$\vec{V} = 15.2\,i + 11\,j$ ft/s

$V = \sqrt{15.2^2 + 11^2} = 18.76$ ft/s

$T_A + U_{A \to B} = T_B$

$\frac{1}{2} m v^2 + F d = 0$

$\frac{1}{2} \frac{W}{g} V^2 - 0.4 W d = 0$

$\frac{1}{2} \frac{\cancel{W}}{g} V^2 = 0.4 \cancel{W} d$

$\frac{V^2}{2g0.4} = d$

$\frac{18.76^2}{2 \cdot 32.2 \cdot 0.4} = 13.66$ ft

$$\lambda = \frac{\vec{V}}{V} = \frac{15.2\,i + 11\,j}{13.76} = 0.81\,i + 0.59\,j$$

$$d\lambda = 13.66\,(0.81\,i + 0.59\,j) = \boxed{11\,i + 8\,j \text{ FT}}$$