There are 3 problems on this exam. The exam is closed notes and closed books, only the provided equation sheet can be used. Please show all your work.

1. The sports car has a mass of 1.5 Mg and a center of mass at G. **Determine the shortest time it takes for it to reach a speed of 80 km/h**, starting from rest, if the engine only drives the rear wheels, whereas the front wheels are free rolling. The coefficient of static friction between the wheels and the road is 0.2. Neglect the mass of the wheels for the calculation. **25 points**

\[ \text{Diagram:} \]

2. Four inelastic cables C are attached to a plate P and hold the 1-ft-long spring 0.25 ft in compression when no weight is on the plate. There is also an undeformed spring nested within this compressed spring. If the block, having a weight of 10 lb, is moving downward at \( v = 4 \text{ ft/s} \), when it is 2 ft above the plate, **determine the maximum compression in each spring after it strikes the plate**. Neglect the mass of the plate and springs and any energy lost in the collision. (Note: The outer spring is \( k \) and the inner is \( k' \)) **25 points**

\[ \text{Diagram:} \]
3. Block $A$ is initially sliding at 20 m/s along a smooth surface. Assuming the block does not leave the track, after it crests the top of the hill, it travels down the slope prior to impacting block $B$. If blocks $A$ and $B$ couple together, what is their velocity immediately following the collision? Additionally, for what time along the rough patch will these blocks travel before coming to a stop? The coefficient of friction between the rough surface and the blocks are $\mu_s = 0.35$. Blocks $A$ and $B$ weight 100 N and 150 N, respectively. **25 points**

![Diagram of a block sliding down a hill and impacting another block.]

4. The ping pong ball has a mass of 2g. If it is struck with the velocity shown, determine how high $h$ it rises above the end of the smooth table after the rebound. Take $e = 0.8$. **25 Points**

![Diagram of a person striking a ping pong ball at a 30° angle with a velocity of 18 m/s.]
\[ m = 1.5 \text{ Mg} = 1.5 \times 10^3 \text{ kg} \]

\[ v_i = 0 \]

\[ v_f = 80 \text{ km/h} \]

\[ u_s = 0.2 \]

\[ t = ? \]

\[ a \Delta t = dv \]

\[ a t = v \left| \frac{v_f}{0} \right. \text{ m/s} \text{ and } a_x \]

\[ \Sigma F_x = f = ma_{gx} = \mu N_B \quad \text{(1)} \]

\[ \Sigma F_y = N_A + N_B - W = 0 \]

\[ \Sigma M_A = \Sigma (M_L)_A = N_B (2m) - W (1.25m) = ma_{gx} (0.35) \quad \text{(2)} \]

\[ a_{gx} = \frac{\mu N_B}{m} \text{ into (2)} \]

\[ 2m (N_B) - W (1.25m) = \left[ \frac{\mu N_B}{m} \right] 0.35m \]

\[ 2N_B = 18393.75 = 0.67N_B \]

\[ 1.93N_B = 18393.75 \quad N_B = 9.53 \text{ kN} \]

\[ a_{gx} = 0.2 \left( 9.53 \times 10^3 \text{N} \right) = 1.27 \text{ m/s}^2 \]

\[ v_f = \frac{80 \text{ km}}{\text{h}} \left[ \frac{1 \text{ hr}}{60 \text{ min}} \right] \left[ \frac{1 \text{ min}}{60 \text{ sec}} \right] \left[ \frac{1000 \text{ m}}{1 \text{ km}} \right] = 22.2 \text{ m/s} \]

\[ a_{gx} t = v_f \quad t = \frac{v_f}{a_{gx}} = \frac{22.2 \text{ m/s}}{1.27 \text{ m/s}^2} \quad t = 17.5 \text{ s} \]
1 ft spring compressed 0.25 ft

\( V_1 = 4 \text{ ft/s} \)

\( V_f = 0 \)

\( W = 10 \text{ lb} \)

\( m = 0.31 \text{ slug} \)

\( k = 360 \frac{\text{lb}}{\text{ft}} \)

\( k' = 600 \frac{\text{lb}}{\text{ft}} \)

\( T_1 + V_1^2 = \frac{1}{2} kx^2 + \frac{1}{2} k' (S - 0.25)^2 - W(z + S) \)

\( \frac{1}{2} k(0.25)^2 \) \( \frac{1}{2} m V_1^2 = \frac{1}{2} kx^2 + \frac{1}{2} k' (S^2 - 0.5S + 0.0625) - 2W - Ws \)

\( \frac{1}{2} k(0.25)^2 \) \( \frac{1}{2} k(0.31)(4.1^2) = \frac{1}{2} k(360 \frac{\text{lb}}{\text{ft}}) S^2 + \frac{1}{2} k(600 \frac{\text{lb}}{\text{ft}}) (S^2 - 0.5S + 0.0625) - 2(10 \text{lb}) - 10 \text{lb}(5) \)

11.25 + 2.48 = 18.032 + 300S^2 - 150S + 18.75 - 20 - 10S

480S^2 - 1605 - 14.98 = 0

\[ S = -b \pm \sqrt{b^2 - 4ac} \]

\[ 2a \]

\[ S = \frac{160 \pm \sqrt{(160)^2 - 4(480)(-14.98)}}{2(480)} \]

\[ S = \frac{160 \pm 181}{960} \]

\[ S = 0.36 \text{ ft} \]

large spring compressed a total of 0.61 ft

Small spring compressed 0.11 ft
\[ V_{A_1} = 20 \text{ m/s} \quad V_{B_1} = 0 \]

\[ V_{A_2} = ? \quad V_{A_2} = ? \]

\[ W_A = 100 \text{ N} \]

\[ W_B = 150 \text{ N} \]

\[ m_A = 10.19 \text{ kg} \]

\[ m_B = 15.29 \text{ kg} \]

\[ T_1 + V_1^0 = T_2 + V_2 \]

\[ \frac{1}{2} m_A V_{A_1}^2 = \frac{1}{2} m_{A_2} V_{A_2}^2 - 40 \text{ m}(100 \text{ N}) \]

\[ \frac{1}{2} (10.19) \left( \frac{20 \text{ m}}{6} \right)^2 = \frac{1}{2} (10.19) V_{A_2}^2 - 4000 \]

\[ V_{A_2} = \sqrt{\frac{2038 + 4000}{5.095}} = 1185 \]

\[ V_{A_2} = 34.42 \text{ m/s} \]

\[ \sum mV = \sum mV \]

\[ m_A V_{A_2} = (m_A + m_B) V_{AB} \]

\[ V_{AB} = \frac{m_A V_{A_2}}{(m_A + m_B)} = \frac{10.19 \times 1185}{10.19 + 15.29} \]

\[ V_{AB} = 13.76 \text{ m/s} \]

\[ V_{A_1} = 0 = N - 250 \text{ N} \]

\[ N = 250 \text{ N} \]

\[ mV_1 + \int F \, dt = mV_2^0 \]

\[ 25.48 \times 10 (13.76 \text{ m/s}) - f \cdot t = 0 \]

\[ t = \frac{25.48 \times 10 (13.76)}{0.35 (250 \text{ N})} = 4.015 \]
$m = 2g = 0.002kg$

$x_f = 2.25m$

$x_i = 0$

$y_i = ?$

$y_f = 0$

$\theta = 30^\circ$

$\Delta v = 18m/s$

$x_f = x_i + v_{x_i}t$

$2.25m = 15.6t$

$t = 0.144s$

$\text{vert}$

$v_{y_f} = -v_{y_i} - gt$

$v_{y_f} = -9 = 9.81(0.144s)$

$v_{y_f} = -1.081m/s$

$v_{A_x} = 15.6m/s$

$v_{A_y} = -1.081m/s$

$e = \frac{[0 - v_{By}]}{[-10.41, -0]} = 0.8$

$v_{By} = +8.33m/s$

$v_{Bx} = 15.6m/s$

$x = 0.75m$

$x_f = x_i + v_{Bx}t$

$0.75m = 15.6t$

$t = 0.048s$

$y_f = 0 + v_{y_i}t - \frac{1}{2}gt^2$

$h = 8.33(0.0485) - \frac{1}{2} (9.81m/s^2)(0.048)^2$

$h = 0.389m$