HW #4
Assigned May 1, 2019. Due May 8, 2019 at 6:00 pm CST on Canvas.

Name: ______________________________ Section Number: _____

Please refer to the homework guidelines on the web regarding late HW policy and TA help. This HW requires Matlab programming. Start early.

1. (20 points)
A car weighing 1500 kg collides with a van weighing 2500 kg at right angles in the center of an intersection. A detective arrives at the scene and finds that the car and van stuck together and skidded 15 m at 53 degrees as shown.

After pulling out his EA3 Webtext on his wifi laptop and doing some calculations, he charges the owner of the car with speeding (in a 60 km/hr zone), as well as running through a stop sign. How fast was the car going before going through the collision? Take the coefficient of friction between the tires and the road to be \( \mu = 0.8 \).
2. (20 points)
Two railroad cars are traveling at the initial indicated velocities along a smooth track. The mass of car A is 2 times that of car B.

![Diagram showing two railroad cars with velocities v = 2 m/s and v = 1 m/s](image)

2-1. If the linkage mechanisms are broken and the two cars experience a perfectly elastic collision, what happens? First a few true/false (think about what happens prior to calculating):

[ ] The cars move together as a unit with a single velocity after collision (since the heavier car overtakes the lighter car).

[ ] The lighter car moves faster than the heavier car after collision (due to transfer of momentum).

[ ] Car A bounces backwards and begins moving in the negative x direction.

Now, calculate the final velocity of car A and car B to support your answers.

2-2. If the cars couple when they collide (plastic collision), what is the final velocity of the mini-train?

2-3. After coupling, the cars have problems - the wheels get locked, the track is rough and the linkage fails. Assuming the rough track can be modeled by simple Coulomb friction with a coefficient of friction of 0.5, determine the decelerations of each car and state if they will separate.

2-4. Considering car B, calculate the distance it will travel before coming to rest on the rough track.
3. (50 points)

This problem uses Matlab. Turn in your program and graph(s), as well as discussion of the solution. Be neat!

Consider the spring-damper system shown, where \( k=2000 \) N/m, \( b=1200 \) N·s/m and the spring is initially compressed with \( x_0=-0.02 \) m.

3-1. Derive the equation of motion for system (a) with applied force \( F(t) \). Write the expressions for calculating the power flowing into the spring and the power flowing into the damper.

3-2. Modify your prior Matlab program or write a new one to calculate the displacement and velocity of the spring (for system a) as a function of time for time up to 8 seconds. Use an initial time step of 0.01.

- First, code the given force profile inside the loop over time and plot it outside the loop to be sure you have the right input.
- Then, set your force profile to be zero and see whether your results make sense by comparing to theoretical values.
- Plot the displacement and velocity of the spring over time.
- Plot the energy stored in the spring, the power flowing into the spring and the power flowing into the damper over time (that's 3 plots; review web text and be careful of signs and units!). Note that you can write the expression for power in terms of energy over time or in terms of force and velocity: you can calculate power both ways to check your code.
- Discuss your results.
- Try time steps that are 10x larger and 10x smaller and see how your solution is affected.

3-3. Now a mass of 100Kg is added into the system as shown in figure (b). Re-derive the equations of motion for this system.
3-4. Modify your Matlab code again to calculate the displacement and velocity of the spring as a function of time for time up to 8 seconds (for system (b)). Use 0 for the initial velocity. Use an initial time step of 0.01.

- Plot the displacement and velocity of the spring over time.
- Plot the energy stored in the spring, the power flowing into the spring and the power flowing into the damper over time.
- Discuss your results. Did the displacement of the spring change its slope at the same time as the force profile?
- Try time steps that are 10x larger and 10x smaller and see how your solution is affected.

3-5. Take your code from 3-4 (for the case with a mass): can you use it to calculate the case without a mass (3-2) by setting the mass to be zero or a very small number? What kind of results do you obtain?