Closed book, closed notes. Answer 5 of these 6 questions. This first part of the test is worth 25 points. Turn this part of the test in to receive the second part.

1. Define the following terms related to vehicle dynamics:
   a. SAE coordinate system
   b. equivalent mass
   c. “weight” shift

2. What two functions does a differential accomplish for a rear-wheel drive vehicle?

3. Write and describe an equation that would determine the maximum/top speed of a vehicle in one of the lower gears, i.e., maximum/top speed is “gear bound.”
4. Briefly outline the process for determining the drag coefficient and the rolling resistance for a road vehicle from experimental “coastdown” data that has already been collected.

5. Assume you are an engineer assigned the task of designing the braking system for a new car. Your analysis indicates that the slope of the ideal brake proportioning line is 2.85. List 5 of the most important design factors that you have under your control to create this ideal brake proportioning.

6. Name the two simple ride models discussed in this class. Name or describe the two frequencies that each model predicts.
Data sheets for a test vehicle are attached to this test. Use this vehicle’s data in all subsequent problems.

7. Use the graph to determine the slope of the brake proportioning line that creates simultaneous “lock up” of the front and rear brakes when the coefficient of friction is $\mu = 0.80$.

Use the published curb weight for your calculations.
8. Your test vehicle is traveling at 30 mph (=44 ft/s) in 2\textsuperscript{nd} gear when the driver presses the accelerator pedal fully to accelerate the vehicle as quickly as possible.

Use one time step to estimate the speed of the test vehicle after 0.50 seconds. Fill in the table below to help with your calculation, but also show all of your actual calculations on this test sheet.

The 2\textsuperscript{nd} order engine model for your test vehicle is given at the bottom of the data sheet. Assume the following:

- vehicle weight = curb weight
- transmission and differential efficiency, $\eta_t = \eta_f = 95\%$
- mass factor = 1.15
- rolling resistance coefficient = 0.015
- drag coefficient, $C_D = 0.32$
- air temperature, $T_{air} = 75 \, ^\circ\text{F}$

<table>
<thead>
<tr>
<th>Initial Vehicle Speed</th>
<th>Engine Speed</th>
<th>Engine Power</th>
<th>Engine Torque</th>
<th>Tractive Force</th>
<th>Rolling Resist.</th>
<th>Aerodynamic Drag</th>
<th>Vehicle Acceleration after 0.5 sec</th>
<th>Vehicle Velocity after 0.5 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft/s</td>
<td>RPM</td>
<td>hp</td>
<td>ft-lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>lbf</td>
<td>ft/sec(^2)</td>
<td>ft/sec</td>
</tr>
</tbody>
</table>
9. Your test vehicle is traveling up an incline of $\theta = 4^\circ$ and is accelerating at $a_x = 12.3 \, \text{ft/s}^2$.

- Calculate front and rear axle loads.
- What is the minimum coefficient of friction required at the rear drive axle to generate this acceleration?