Problem 1. The symmetric (left/right) car below is shown viewed from the front.
   a) what is the total weight on the outside wheels at zero speed?
   b) What is the total weight on the outside wheels at velocity V and turning a corner
      of radius R.

   \[ \begin{align*}
   &\text{a)} \text{ by symmetry } \frac{W}{2} \\
   &\text{b)} \text{ moments about } A = W \frac{t}{2} + W \frac{V^2 h}{R} - W t = 0 \\
   &W t = W \frac{V^2 h}{R} + W \frac{t}{2} \\
   &W t = \frac{W}{2} + \frac{W V^2 h}{R} t
   \end{align*} \]

Problem 2. A tire and wheel is shown below with imbalance masses.
   a) is the combination statically balanced \( \forall s \) \n   b) when dynamically balancing the combination, what imbalance weights would you
      place and in what locations?

   \[ M = \frac{m R}{R} \]

   with this choice for \( M \) we have
   \[ m w^2 R = M w^2 r \checkmark \]

   balance weights are attached to the wheel.
Problem 3. For a cornering car
a) compute the yaw rate gain \( \frac{\text{yaw rate}}{\text{steer angle}} = r/\delta \) at low speeds \( K=0 \)
b) compute the yaw rate gain for nonzero \( K \).

\[
r = \text{yaw rate (deg/sec)} = \frac{180}{\pi} \frac{V}{R}
\]

For \( K=0 \), \( S = \frac{180}{\pi} \frac{L}{R} \) (deg)

\[
a) \quad \frac{r}{\delta} = \frac{V}{L}
\]

\[
b) \quad S = \frac{180}{\pi} \frac{L}{R} + K \text{ag}
\text{ where ag} = \frac{V^2}{Rg}
\]

Thus, \( S = \frac{180}{\pi} \frac{L}{R} + K \frac{V^2}{Rg} \) (x)

but \( r = \frac{V}{R} \frac{180}{\pi} \) deg/sec

so \( R = \frac{V}{r} \frac{180}{\pi} \)

\[
\frac{r}{\delta} = \frac{V}{R} \frac{180}{\pi} \frac{180 \frac{L}{R} + K \frac{V^2}{Rg}}{
\pi \frac{L}{R} + \frac{KV^2}{Rg}}
\]

\[
\frac{r}{\delta} = \frac{V}{L + \frac{KV^2}{180 \pi g}}
\]
Problem 4. The road-to-body transfer function is shown below for a ¼-car model with a frictionless leaf spring. Sketch the qualitative change in the transfer function when friction is added to the leaf spring and the vibration amplitude is small.

Problem 5. In the figure below, vehicle instability causes the actual trajectory of the car to differ from the desired trajectory. Describe the action of an electronic stability control (ESC) system?

desired motion

The brake is automatically applied to the front left wheel.
Problem 6.

When driving in sand, is it better to increase or decrease your tire inflation?

When driving in the rain, is it better to increase or decrease your tire inflation?

For maximum braking, the tire rubber on the road should be moving at the same speed as the road (true or false).

Far maximum acceleration, it is better to have rear wheel drive than front wheel drive (true or false). State your assumptions on the CG location. CG is centered.

The tire critical speed is that speed at which centrifugal forces cause the tire to fly apart (true or false).

A torque converter can output more torque than is input from the engine (true or false).

Sketch a pair of U-joints on a single drive shaft that are properly phased.

Brake force proportioning is independent of the amount of braking (true or false).

A sway bar on the front of a car keeps the load on the left and right front wheels about equal (true or false).

The lagging shoe in a drum brake is more likely to stick when wet (true or false).