Problem 1. Reference to Figure 2.9 on page 32. Assume that the dynamometer brake produces 3 ft-lbs of torque per psi of Mean Effective Pressure.

a) At what torque and speed is the engine most fuel efficient?
b) At this peak efficiency point, what is the horsepower output?
c) If the engine is constrained to operate on the "Operating Schedule of Ideal Transmission" shown, what is the peak horsepower output?

From the figure:

Engine Speed = 3600 RPM
Torque = 240 ft-lbs

ans (a)
(b) 

\[ HP = \frac{W \cdot T}{550 \text{ ft-lb/s}} \]

\[ W = 3600 \text{ RPM} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{2\pi \text{ Rad}}{1 \text{ Rev}} = 377 \text{ Rad/s} \]

\[ HP = \frac{(377 \text{ Rad/s}) \times (240 \text{ lb-ft})}{550 \text{ ft-lb/s}} \]

\[ = 164.5 \text{ HP} \]

Ans (b)

(c) The point shown has:

Engine speed = 5700 RPM

\[ T_e = 300 \text{ ft-lb} \]

\[ HP = \frac{(5700 \text{ RPM} \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{2\pi \text{ Rad}}{1 \text{ Rev}}) \times (300 \text{ ft-lb})}{(550 \frac{\text{ ft-lb}}{\text{s}})} \]

\[ HP = 325.6 \text{ HP} \]

Ans (c)
Problem 2. Locking and non-locking differentials (see Fig. 2.10 for suspension geometry)

a) For a non-locking differential, what is the effect of increasing the differential gear ratio on traction limits?

b) If the front and rear suspensions are identical, how much of the drive train reaction torque is transferred to the front wheels?

a) From HW #2:

\[ F_{x,\text{max}} = \mu \frac{W_b}{L} \frac{1}{1 - \frac{b}{L} \mu + \frac{2\mu r}{N_f} \frac{K_F}{K_D}} \]

\[ N_f = \text{Diff. gear ratio} \]

Increasing \( N_f \) will lead to an increase of \( F_{x,\text{max}} \)
b) By inspection:

\[ \angle a = \frac{1}{2} \]

(ans (6))
Problem #3

Problem 3. Consider the drum brake of figure 3.2 and assume that it is a scale drawing of a real system.

a) The inside diameter of the drum is 0.2 meter. Using a scale, find e, m and n.

b) Go to www.gmpfriction.com/Client/Images/GMP_473_dry_Data_Sheet.pdf and get their dynamic coefficient of friction for the GMP 473 material. With this material and \( P_a = 100 \text{lbs} \), what is the braking torque of the brake.

![Diagram of drum brake]

**a) From figure:**

Measurements:

- \( \text{diameter} = \)
- \( e = \)
- \( m = \)
- \( n = \)

Scale factor =

\[
\begin{align*}
& e = 0.134 \text{ m} \\
& m = 0.072 \text{ m} \\
& n = 0.07 \text{ m}
\end{align*}
\]
(b) Dynamic CoF = 0.495

\[
\text{Torque} = R \cdot Pa \cdot \mu e \left( \frac{1}{m \cdot \mu n} + \frac{1}{m \cdot \mu n} \right)
\]

\[
P_a = 100 \text{ lbs}
\]

\[
P_a = 444.8 \text{ N}
\]

\[
\text{Torque} = \left( \frac{0.2}{2} \right) (444.8 \text{ N})(0.495)(0.134) \left( \frac{1}{0.073 - 0.495 \cdot 0.07} + \frac{1}{0.072 + 0.495 \cdot 0.07} \right)
\]

\[
\text{Torque} = 106.7 \text{ N-m}
\]

\[\text{ans (b)} \checkmark\]
Problem 4. In reference to figure 3.8 on page 63 and related calculations, find the coordinates Fxmr and Fxmf corresponding to the Front and Rear Lockup point.

\[ F_x = -\mu_p W \]

and \[ a_x = \frac{-F_x}{M} \]

\[ = \frac{-F_x}{W} \cdot g \]

So:

\[ \frac{W a_x}{g} = -F_x = -\mu_p W \]
Next:

\[ W_f = W_{fs} - \frac{W_a x h}{g}\frac{1}{L} \]  \hspace{1cm} (1-9) \\

\[ W_r = W_{rs} + \frac{W_a x h}{g}\frac{1}{L} \]  \hspace{1cm} (1-9)

Combining:

\[ W_f = W_{fs} + \mu_p W\frac{h}{L} \]

\[ W_r = W_{rs} - \mu_p W\frac{h}{L} \]

\[ W_f \text{ and } W_r \text{ are front and rear weights during braking respectively.} \]

Next:

\[ F_{xmf} = \mu_p W_f \text{ and } F_{xmr} = \mu_p W_r \]

\[ F_{xmf} = \mu_p W_{fs} + (\mu_p)^2 W\frac{h}{L} \]

\[ F_{xmr} = \mu_p W_{rs} - (\mu_p)^2 W\frac{h}{L} \]