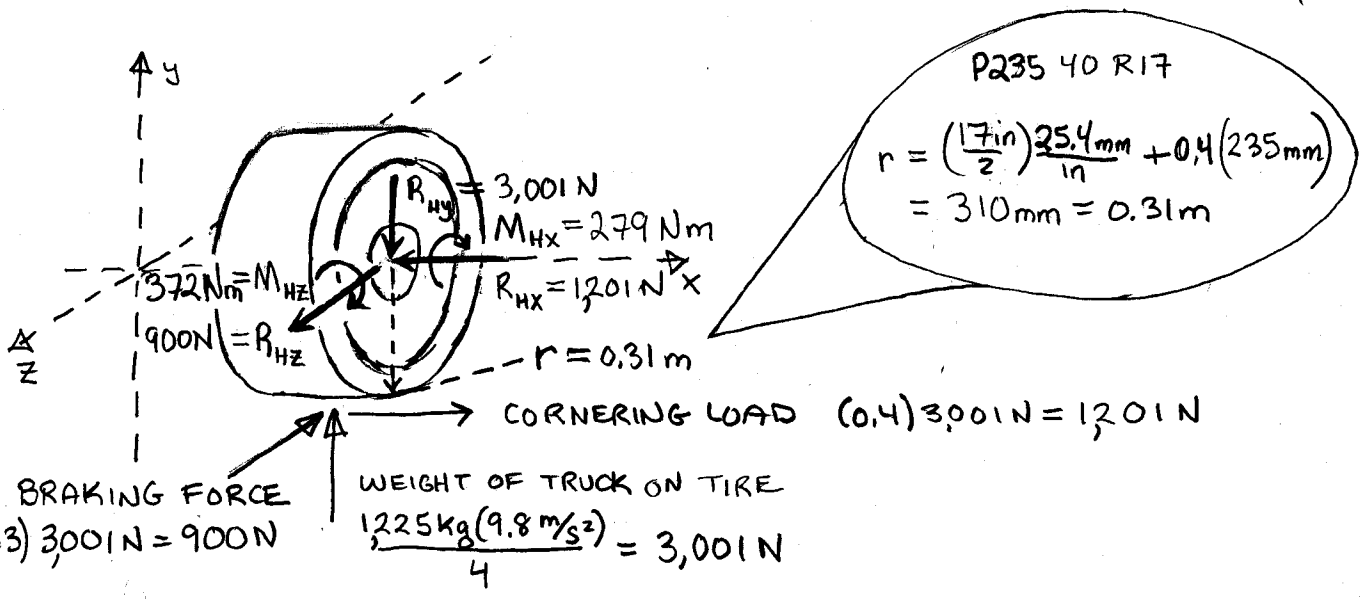
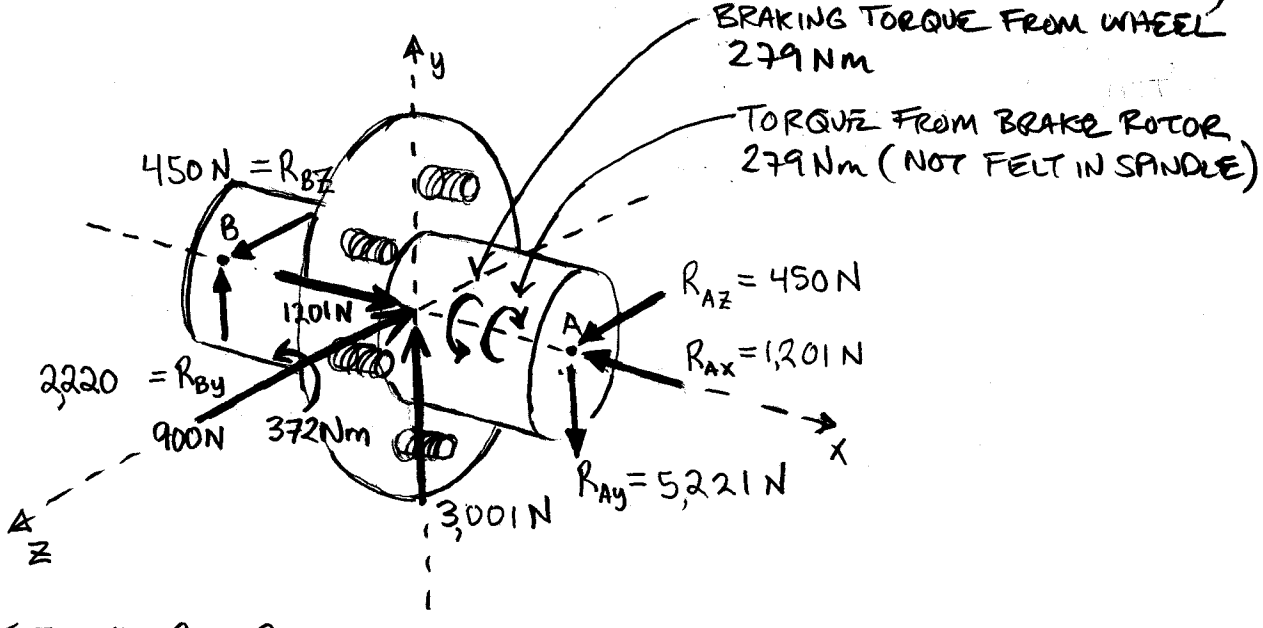
LAB #2 YIELD CRITERIA/FAILURE THEORIES

ME 340
1/14/99

FBD OF TIRE & WHEEL: (FIND HUB REACTIONS)



FBD OF HUB: (ENLARGED TO SHOW DETAIL; FIND BEARING REACTIONS)



$\Sigma F_y = 0$; $R_{Ay} - R_{By} = 3,001$ N

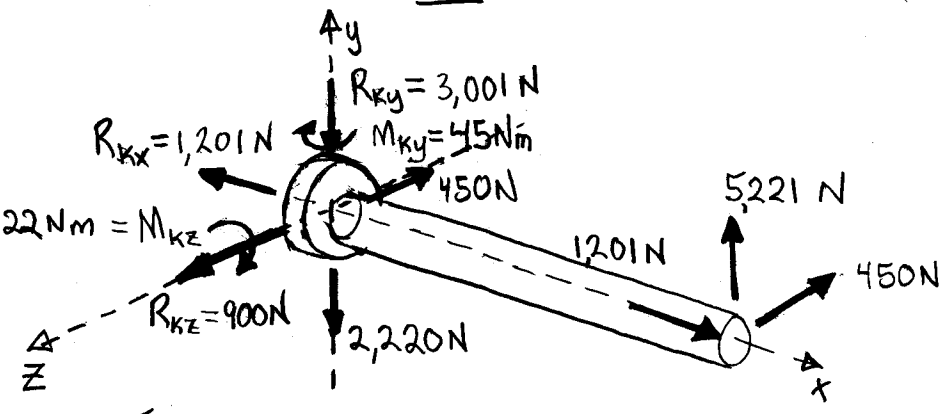
$\Sigma F_z = 0$; $R_{Az} + R_{Bz} = 900$ N

$\Sigma M_y^B = 0$; $900N(.05m) = R_{Az}(0.10m) \rightarrow R_{Az} = 450N$ & $R_{Bz} = 450N$

$\Sigma M_z^B = 0$; $-R_{Ay}(0.10m) + 372Nm + 3,001N(0.05m) = 0$

$R_{Ay} = 5,221N$ & $R_{By} = 2,220N$

FINALLY, THE FBD OF THE SPINDLE: (FIND STEERING KNUCKLE RXNS)



NOTE: THIS STATIC ANALYSIS ASSUMES THE LOADS FROM THE INNER BEARING ARE APPLIED AT THE VERY INNER MOST END OF THE SPINDLE AS POINT LOADS. IE: APPLIED AT SAME POINT AS STEERING KNUCKLE LOADS.

$\Sigma F_x = 0$; $R_{Kx} = 1,201$ N

$\Sigma F_y = 0$; $R_{Ky} = 2,220 - 5,221 = 3,001$ N

$\Sigma F_z = 0$; $R_{Kz} = 450 + 450 = 900$ N

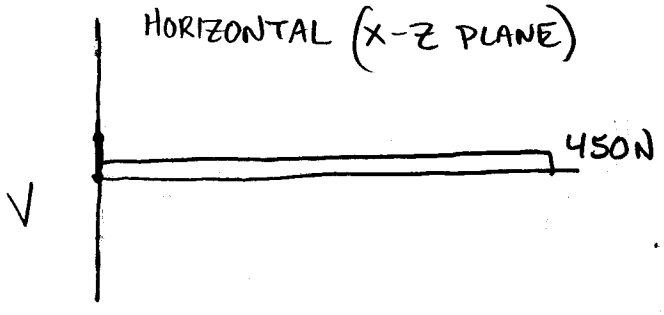
$\Sigma M_x^K = 0$; $0 = 0$

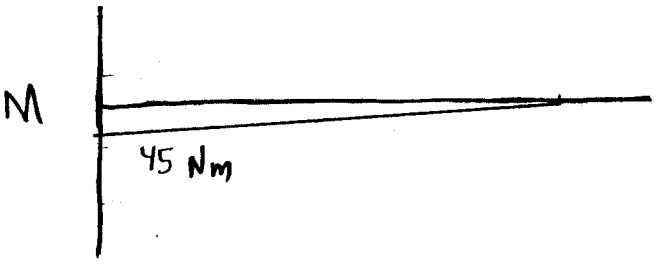
$\Sigma M_y^K = 0$; $M_{Ky} = 450\text{N}(0.10\text{m}) = 45\text{Nm}$

$\Sigma M_z^K = 0$; $M_{Kz} = 5,221\text{ N}(0.10\text{m}) = 522\text{ Nm}$

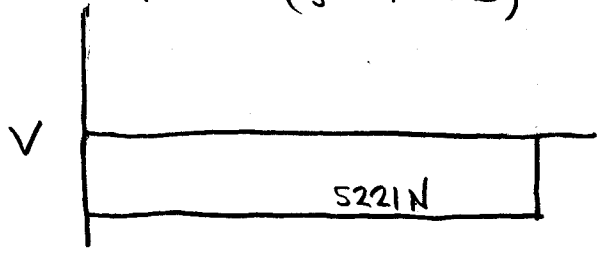
SHEAR AND BENDING MOMENT DIAGRAMS:

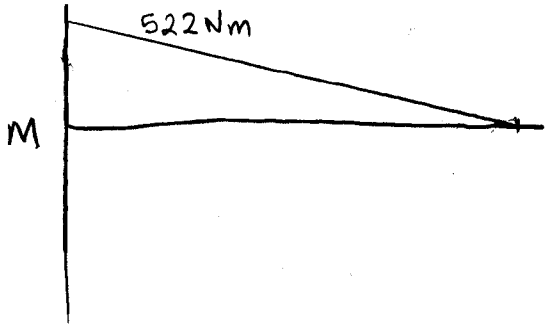
HORIZONTAL (X-Z PLANE)





VERTICAL (Y-X PLANE)





MAXIMUM BENDING MOMENT = $M_{max} = \sqrt{45^2 + 522^2} = 524\ Nm$

MAXIMUM SHEAR = $V_{max} = \sqrt{450^2 + 5221^2} = 5240N$

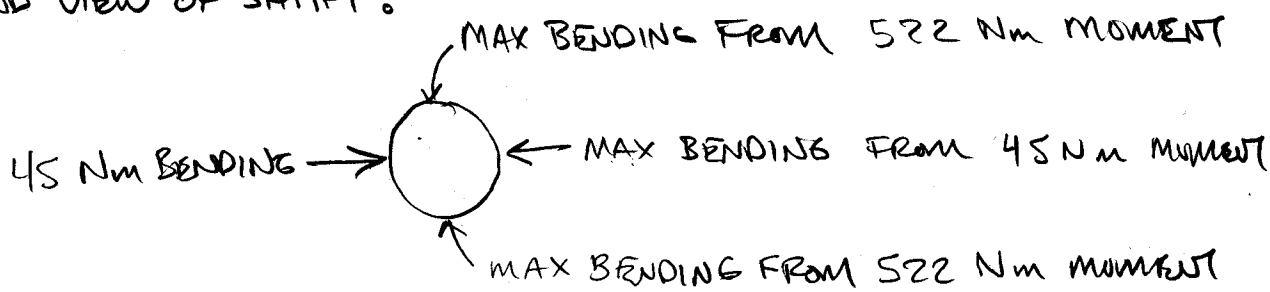
$$\sigma_b = \frac{Mc}{I} = \frac{32M}{\pi D^3} = \frac{32(524\ Nm)}{\pi(0.03m)^3} = 198\ MPa$$ (MAX BENDING STRESS)

$$\tau_b = \frac{4}{3}\frac{V}{A} = \frac{4}{3}\frac{(5240N)}{\frac{\pi}{4}(0.03m)^2} = 9.98\ MPa$$ (MAX TRANSVERSE SHEAR STRESS)

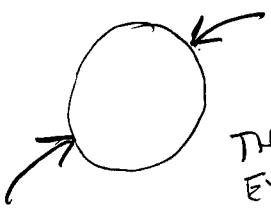
$$\sigma_a = \frac{P}{A} = \frac{1,201\ N}{\frac{\pi}{4}(0.03m)^2} = 1.70\ MPa$$ (MAX AXIAL STRESS)

THE CRITICAL POINT IS THE POINT OF MAXIMUM STRESS; IE THE POINT WHERE THE FRACTURE WOULD START IF THE PART ACTUALLY BROKE. ABOVE, THE MAXIMUM STRESSES HAVE BEEN CALCULATED, BUT THESE EXIST AT DIFFERENT PLACES IN THE SPINDLE! THE BENDING STRESS ABOVE WILL OBVIOUSLY DOMINATE, SO WE LOOK AT THAT POINT. THIS MAX BENDING STRESS EXISTS WHERE THE SPINDLE MEETS THE STEERING KNUCKLE, BUT ONLY ON THE "TOP & BOTTOM" OF THE SHAFT

END VIEW OF SHAFT:



— OR —



AT THE CRITICAL POINT JUST DESCRIBED, BOTH THE AXIAL STRESS & BENDING STRESS ARE PRESENT. THE TRANSVERSE SHEAR STRESS IS ZERO HERE. THUS WE MUST USE VON MISES TO FIND THE EQUIVALENT STRESS AT THIS POINT.

$$\text{VON MISES} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}} \qquad \text{(2-D VON MISES)}$$

$$= \sqrt{(198 + 1.70)^2 + 0 - 0 + 0}$$

$$= 200\,\text{MPa} = \sigma' \text{ OR } \sigma_{eq}$$

$$\text{FACTOR OF SAFETY IN YIELD} = \frac{S_y}{\sigma'} = \frac{1462\,\text{MPa}}{200\,\text{MPa}}$$

$$= 7.3$$