**Question 1: (25 Points)**

Considering the stress concentration for normal and shear stresses at the discontinuity at A, determine the maximum principal stresses at the discontinuity if \( F = 1000 \) N.

\[
M_y = 1000 \times 0.4 = 400 \text{ Nm}
\]

\( F = 1000 \text{ N} \)

\[\begin{align*}
\text{From Figure A-13-7} \\
D/d &= \frac{d}{2d} = 1.6 \\
r_1d &= \frac{3}{2d} = 0.125
\end{align*}\]

Due to Normal Force,
\[K_t = 1.8 > 1.7\]

Due to \( M_y \)

Figure A-13-Q (A-13-Q)

\[K_t = 1.6 > 1.5\]

\[
\sigma' = K_t \sigma_s = 1.8 \frac{1000}{\pi (0.024) \frac{1}{4}} = 3.98 \text{ MPa}
\]

Compression.

\[
\sigma_\max = \sigma_t + \sigma' = 4.72 + 3.98 = 4.76 \text{ MPa}
\]

As no shear stress \( \Rightarrow \) Normal stress are principal.
Question 2: (25 Points)

For a shaft made of grade 60 cast iron \((S_{ut} = 431 \text{ MPa}, \ S_{uc} = 1293 \text{ MPa})\). Determine the factor of safety basing on (a) Brittle Coulomb Mohr’s (b) Modified Mohr’s and (c) Maximum Normal Stress theories, for the following state of stress:
\[\sigma_x = 40 \text{ MPa}, \ \sigma_y = -80 \text{ MPa} \text{ and } \tau_{xy} = 100 \text{ MPa}.\]

\[\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \frac{40 + (-80)}{2} \pm \sqrt{\left(\frac{40 - (-80)}{2}\right)^2 + 100^2} = -20 \pm 116.6 = -136.6 \text{ MPa}, 96.6 \text{ MPa}.

\[\text{BCM}\]
\[\sigma' = 96.6 \text{ MPa} \Rightarrow \sigma' = 96.6 \text{ MPa}, \ \sigma'' = -136.6 \text{ MPa}.

\[n = \frac{1}{\frac{96.6}{431} + \frac{136.6}{1293}} = 3.032. \text{ (Safe)}\]

\[\text{MM}\]
\[|\sigma'^{'}| = 136.6 = 1.41 > 1 \Rightarrow \frac{S_{uc} - \sigma_y}{\sigma_y} = \frac{1}{n} \Rightarrow \frac{1293 - 96.6}{96.6} = 8.921. \text{ (Safe)}\]

\[n = \frac{1293 - 431}{96.6 + 136.6} = \frac{893}{1293} \]

\[\text{MNS}\]
\[\frac{S_{uc}}{S_{ut}} = \frac{1293}{431} = 3 > \frac{|\sigma'|}{\sigma''} \Rightarrow n = \frac{S_{ut}}{\sigma''} = \frac{431}{96.6} = 4.462. \text{ (Safe)}\]