ROBLEM SET 7
DUE FRIDAY NOVEMBER 7th

MOHR’S CIRCLE

1. Given a plane with stresses $\sigma_x$ and $\sigma_y$ and $\tau_{xy}$, draw the Mohr’s circle if the plane rotates 45º clockwise to the current axes. Hint: $\tau_{xy} < 0 \text{ and } \sigma_x > \sigma_y$

2. Given a plane with stresses $\sigma_x$ and $\sigma_y$ and $\tau_{xy}$, draw the Mohr’s circle if the plane rotates counterclockwise to the current axes between 45-90 degrees. Hint: $\tau_{xy} > 0 \text{ and } \sigma_x < \sigma_y$

3. Given a plane with stresses $\sigma_x$ and $\sigma_y$ and $\tau_{xy}$, draw the Mohr’s circle if the principal axes are clockwise to the current axes and between 45-90 degrees away. Hint: $\tau_{xy} < 0 \text{ and } \sigma_x < \sigma_y$

4. Given a plane with stresses $\sigma_x$ and $\sigma_y$ and $\tau_{xy}$, draw the Mohr’s circle if the principle axes are aligned with current axes. Hint: $\tau_{xy} = 0 \text{ and } \sigma_x > \sigma_y$

LENNARD-JONES POTENTIAL

5. Two atoms interact at T=0ºK via a van der Waals Lennard-Jones potential with $A=4.7\times10^{-78} \text{ Jm}^6$. The interaction force versus separation distance plot is given in the following figure.

![Lennard-Jones Potential Plot](image)

(a) Calculate the binding energy ($k_BT$) and the bond stiffness (N/m).
(b) The two atoms are held at a particular separation distance $r$ using an atomic force microscope so that the attractive component of the force is equal to -0.003 nN. At this distance are the atoms attracted to each other or repelled away from each other? Justify your answer with a numerical calculation.
6. Draw the following Common Potential Functions based on the information given. The capital Gammas represent your Potential functions $U(r)$ that was discussed in class. (Note: some may be impossible)

1) **Ideal Gas**
   \[
   \Gamma(r) = 0
   \]

2) **Hard Sphere**
   \[
   \begin{align*}
   \Gamma(r) &= \infty \ (r \leq \sigma) \\ 
   \Gamma(r) &= 0 \ (r > \sigma)
   \end{align*}
   \]

3) **Point Repulsion**
   \[
   \Gamma(r) = dr^{-\delta}
   \]
   $\delta = \text{index of repulsion};$
   \[
   9 < \delta < 15
   \]
   If $\delta = 4 \implies \text{"Maxwellian molecules"}$

4) **Square Well**
   \[
   \begin{align*}
   \Gamma(r) &= \infty \ (r \leq \sigma) \\ 
   \Gamma(r) &= -\varepsilon \ (\sigma < r \leq R\sigma) \\ 
   \Gamma(r) &= 0 \ (r > R\sigma)
   \end{align*}
   \]

5) **Sutherland**
   \[
   \begin{align*}
   \Gamma(r) &= \infty \ (r \leq \sigma) \\ 
   \Gamma(r) &= -cr^{-\gamma} \ (r > \sigma)
   \end{align*}
   \]
   Typically, $\gamma = 6$

6) **Lennard-Jones**
\[ \Gamma(r) = 4\epsilon \left[ \left( \frac{\sigma}{r} \right)^{12} - \left( \frac{\sigma}{r} \right)^6 \right] \]

7) **Buckingham**

\[ \Gamma(r) = b \exp(-ar) - \frac{c}{r^6} - \frac{c'}{r^8} \]

- 4-parameter
- exponential form for repulsive (theoretically better)
- includes induced dipole / induced dipole & induced dipole / induced quadrupole
- numerically difficult