For full credit, you must:

- use free body diagrams where appropriate,
- express your with the proper units and to the appropriate number of significant digits, and
- present a clear and accurate solution procedure.

Students are expected to abide by the University of Alabama Academic Honor Code (reproduced below from the Undergraduate Catalog).

**Academic Honor Code**

All students in attendance at The University of Alabama are expected to be honorable and to observe standards of conduct appropriate to a community of scholars. The University of Alabama expects from its students a higher standard of conduct than the minimum required to avoid discipline. At the beginning of each semester and on tests and projects at the discretion of the professor, each student will be expected to sign an Academic Honor Pledge. The pledge reads as follows:

I promise or affirm that I will not at any time be involved with cheating, plagiarism, fabrication, or misrepresentation while enrolled as a student at The University of Alabama. I have read the Academic Honor Code, which explains disciplinary procedures that will result from the aforementioned. I understand that violation of this code will result in penalties as severe as indefinite suspension from the University.

**NOTE:** Write on the front side of each page. Work on the back of any page will not be graded. Additional paper will be provided upon request.
Problem 1:
The state of stress shown below has been determined for a machine component.

(a) Use Mohr’s circle of stress to find all of the principal stresses, and sketch the stress block in this orientation and indicate the angle of rotation to this direction.

(b) Determine the maximum in-plane shearing stress, and sketch the stress block in this orientation and indicate the angle of rotation to this direction.

(c) Determine the absolute maximum shearing stress.

\[ \sigma_{xy} = \frac{(60+20)}{2} = 50 \text{ MPa} \]
\[ R = \sqrt{(80-50)^2 + 20^2} = 36.1 \text{ MPa} \]
\[ \sigma_{p1} = 50 + 36.1 = 86.1 \text{ MPa} \]
\[ \sigma_{p2} = 50 - 36.1 = 13.9 \text{ MPa} \]
\[ \tau_{max} = 36.1 \text{ MPa} \]
\[ \tan \theta_p = \frac{20}{30} \quad \theta_p = 16.85^\circ \]

\[ \tau_{max} = \tau_{max \text{ in plane}} = 36.1 \text{ MPa} \]
Problem 2:
For the beam shown below:

(a) Write down the boundary conditions for the beam.
(b) This beam is statically determinate [circle one].
(c) Determine the equations of statics (equilibrium equations) for the beam.
(d) Determine the slope and deflection equations of the beam in terms of the reactions and applied load. DO NOT SOLVE FOR THE CONSTANTS OF INTEGRATION.

\[ V(x) = 0, \ v(x) = 0, \ v'(x) = 0 \]
\[ x = L, \ v(x) = 0 \]

\[ E F_x = R_x = 0 \]
\[ E F_y = (W_0 L) - R_y - A_y = 0 \]
\[ E M_y = W_0 L^2 - R_L = 0 \]
\[ 3 E M_R = W_0 L^2 - A_y L \]

\[ M(x) = \frac{W_0 x^2}{2} - A_y x \]
\[ E L V'' = \frac{W_0 x^3}{2} - A_y x \]
\[ E L V' = \frac{1}{6} W_0 x^3 - \frac{1}{2} A_y x^2 + C_1 \]
\[ E L V = \frac{1}{24} W_0 x^4 - \frac{1}{6} A_y x^3 + C_1 x + C_2 \]
Problem 3:
Determine the state of stress at point A. Indicate the components of stress in the proper directions on the block provided.

Is the state of stress indicated on your block a principal stress state?

\[ \sigma_h = \frac{P}{t} = \frac{150}{0.2} = 750 \text{ psi} \]
\[ \sigma_A = \frac{P}{2t} = \frac{150}{0.4} = 375 \text{ psi} \]
\[ \sigma_r = \frac{150 + 3.6}{2} = 19.8 \text{ in} \]
\[ t = 0.2 \text{ in} \]
\[ \sigma_H = \frac{(150 \times 12)}{0.2^2} = 1425 \text{ psi} \]
\[ \sigma_A = \frac{(150 \times 12)}{2(0.2)} = 712.5 \text{ psi} \]
\[ \sigma = A \sigma \]

\[ A = \frac{1}{2} \pi r^2 = \frac{1}{2} \pi (2^2 - 1.8^2) = 1.194 \]
\[ \gamma = \frac{4t}{3r} = \frac{4(2)}{3 	imes 1.2} = 0.849 \]
Moments of Inertia about a horizontal line through the centroid

For the circle, the polar moment of inertia is also given

\[ I = \frac{\pi d^4}{64} \]
\[ I_p = \frac{\pi d^4}{32} \]

\[
\begin{align*}
I &= \frac{bh^3}{12} \\
I &= \frac{bh^3}{36}
\end{align*}
\]

And for a semicircle:

\[
\bar{y} = \frac{4r}{3\pi}
\]

\[ I_{\text{any axis}} = I_{\text{centroid}} + Ad^2 \]