Mid-term Exam 2

1. A circular bar ABCD is subjected to torsions as shown. The allowable shear stress in the shaft is 10 ksi. (i) What is the required diameter \( d \) of the shaft if it has a solid cross section? (ii) What is the required outside diameter \( d \) of the shaft if the shaft is hollow with an inside diameter of 1 in.? (15%)

![Diagram of a circular bar with forces applied](image)

2. A solid circular bar ABCD with fixed supports is acted upon by torques \( T_o \) and \( 2T_o \) at the locations as shown. Find the maximum angle of twist \( \phi_{\text{max}} \) of the bar. (20%)

![Diagram of a bar with torques applied](image)

3. A solid circular bar having diameter \( d \) is to be replaced by a rectangular tube having cross-sectional dimensions \( d \times 2d \) to the median line of the cross section. (i) Determine the required thickness of the tube so that the maximum shear stress in the tube will not exceed the maximum shear stress in the solid bar. (ii) Calculate the torsion constant \( J \) for the rectangular tube. (15%)

![Diagram of a circle and rectangle](image)
4. Use the square element subjected to pure shear $\tau$ to prove that $G = \frac{0.5E}{(1+\nu)}$. (20%)

5. The beam ABCDE has simple supports at A, C, and E and a hinge (or pin) at D. The beam is subjected to two concentrated load as shown. Draw the shear-force and bending-moment diagrams for the beam. (The hinge at D can transmit a shear force but not a bending moment) (20%)

6. The moment diagram of a simply supported beam AB is shown below. (i) Draw the shear force diagram of the beam. (ii) Draw all the loads (including their directions and magnitudes) on the beam. (15%)