Ph.D. Qualifying Examination

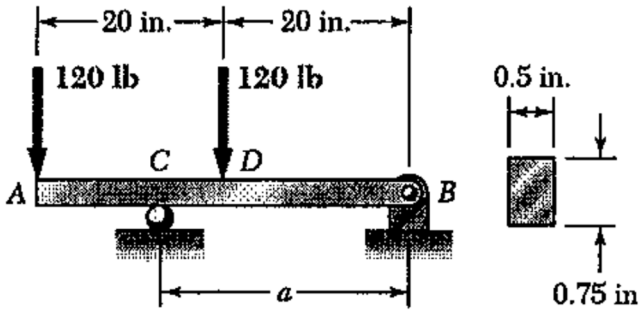
Mechanics of Materials

Spring 2017

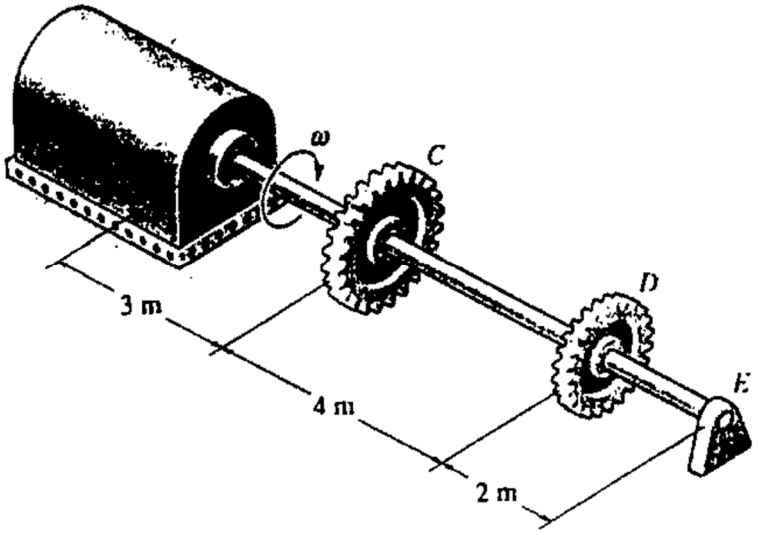
Notes:

- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes (one sheet of formulas is allowed)
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

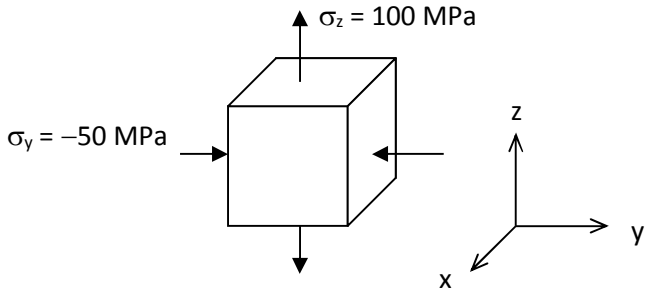
1. Determine (a) the distance '*a*' for which the maximum absolute value of the bending moment in the beam is as small as possible and (b) the corresponding maximum normal stress due to bending.



2. The turbine develops 150 kW of power, which is transmitted to the gears such that C receives 7% and D 30% of the power. If the shaft is 100 mm in diameter and rotates at ω=800 rev/min, determine (a) the absolute maximum shear stress in the shaft and (b) the angle of twist of end E relative to B (point where shaft meets the motor, i.e. 3 m from point C). The journal bearing at E allows the shaft to run freely about its axis.



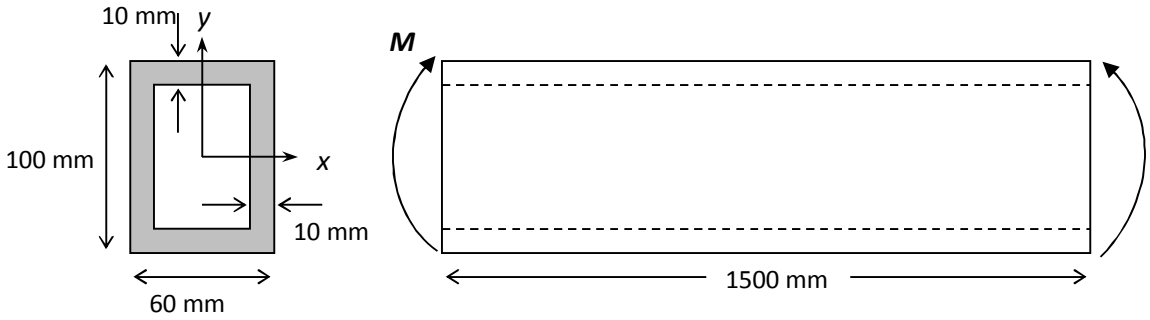
3. Consider the stress state shown:



(a) Use Mohr's circle to determine the maximum shear stress in this system (pay attention to the three-dimensional effect). In what plane/direction does this maximum shear exist? (You may draw a simple sketch to show it.)

(b) Do all the shear components τ_{xy}, τ_{yz} and τ_{xz} vanish? What about the shear strains γ_{xy}, γ_{yz}, and γ_{xz}? If not, obtain the values.

4. The rectangular hollow tube shown is made of an elastic material (Young's modulus 70 GPa and Poisson's ratio 0.3), and is undergoing pure bending.



(a) Determine the moment of inertia I_x, by using $I_x = \int_A y^2 dA$ (<u>not</u> by using any existing formula).

(b) If the maximum allowable stress is 100 MPa, what will be the maximum bending moment allowed?