SAS
F06

BAE 417
Design of Machine Systems

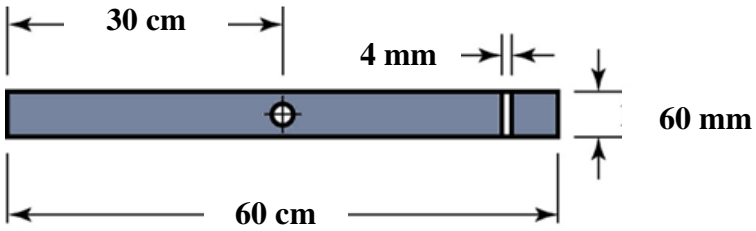
Exam No. 1
(Take Home, Open-Book, Open-Note)

Name: _____

Instructions: Solve six of the following seven problems completely. You must solve problem No. 3. Each problem is worth 14 points, plus two points for entering your correctly in the blank above, for an exam total of 100 points. If you would like receive up to 10 points extra credit, simply solve the remaining problem. List all assumptions used in arriving at you final answer. You are to provide supporting work for each solution. Work neatly as partial credit will be awarded. This is to be an individual effort. Students should not confer with their contemporaries. Any questions regarding the problem statements should be directed to the instructor of the course.

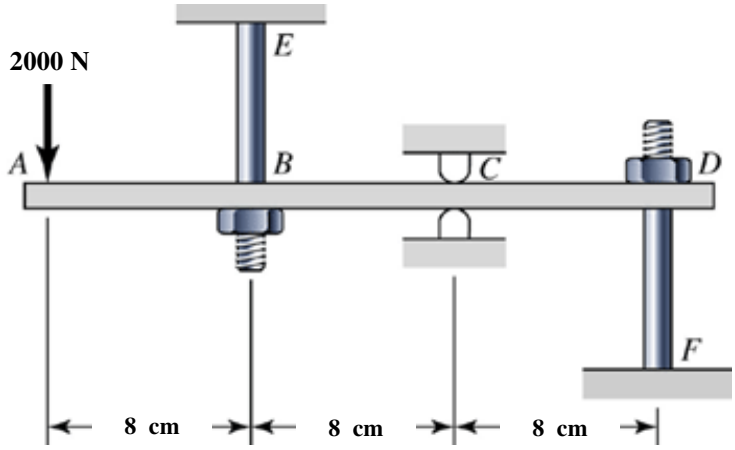
1. A pressure vessel has an outside diameter of 25 cm and a wall thickness of 6 mm. What internal pressure can this vessel handle if the maximum shear stress is not to exceed 100 MPa? Assume a Young's modulus for the material of 200 GPa and a Poisson's ratio of 0.291.

2. A rotary lawn-mower blade rotates at 3600 rev/min. The steel blade has a uniform cross section 4 mm thick by 60 mm wide, and has a 15 mm diameter hole in the center as shown in the figure below. Estimate the maximum tensile stress at the center section due to rotation.

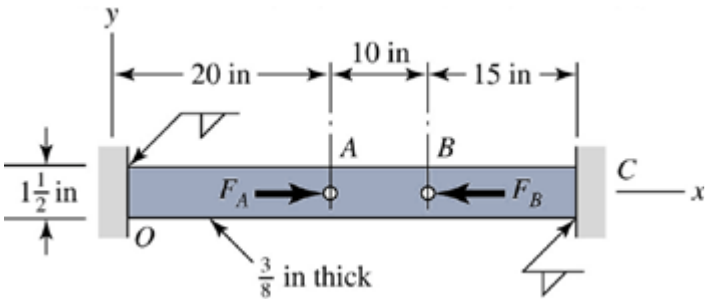


3. Determine the maximum principal stress for the axle tube extensions fabricated for mounting dual rear wheels on the $^1/_4$ Scale Tractor. Assume the tires have a section width of 12.0 in. and they are spaced 2.0 in. apart. Further, assume the wheel offset is zero, that is, the hub face of the wheel center is located at the center of the tire cross-section. Assume a worst-case scenario where the dynamic wheel load (outside dual) is 1,400 lb_f and the maximum tractive effort from the same wheel is 1,200 lb_f. The axle tube extensions are fabricated from 2.5 in. diameter (nominal) schedule 40 black iron pipe. The actual dimensions of the pipe are 2.875 inches in diameter (outside) with a wall thickness of 0.203 inches.

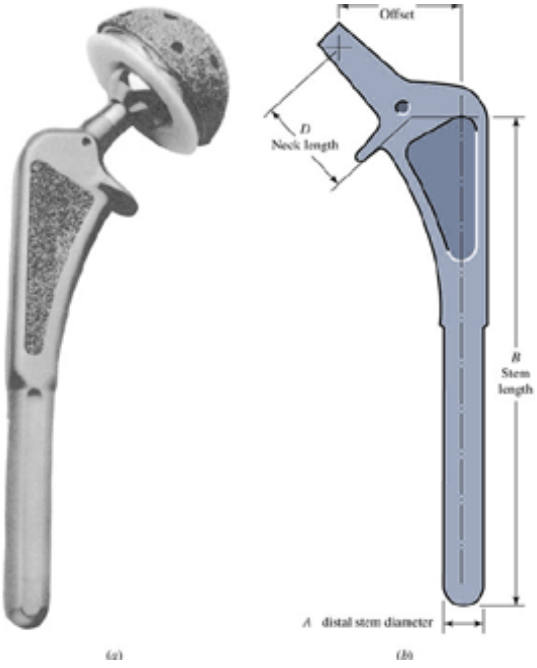
4. The steel beam *ABCD* shown is simply supported at *C* as shown and supported at *B* and *D* by steel bolts each having a diameter of 10 mm. The lengths of *BE* and *DF* are 50 and 75 mm, respectively. The beam has a second area moment of 20,800 mm^4. Prior to loading, the nuts are just in contact with the horizontal beam. A force of 2000 N is then applied at point *A*. Determine the stresses in the bolts and the deflections of points *A, B,* and *D*. For steel, let E = 200 GPa.



5. The figure shows a 0.375 in. by 1.500 in. rectangular steel bar welded to fixed supports at each end. The bar is axially loaded by the forces F_A = 10 kip and F_B = 5 kip acting on pins at A and B. Assuming that the bar will not buckle laterally, find the reactions at the fixed supports.



6. The figure below shows a hip prosthesis containing a stem that is cemented into a reamed cavity in the femur. The cup is cemented and fastened to the hip with bone screws. Shown are porous layers of titanium into which bone tissue will grow to form a longer-lasting bond than that afforded by cement alone. The bearing surfaces are a plastic cup and a titanium femoral head. The lip shown in the figures bears against the cutoff end of the femur to transfer the load to the leg from the hip. Walking will induce several million stress fluctuations per year for an average person, so there is danger that the prosthesis will loosen the cement bonds or that metal cracks may occur because of the many repetitions of stress. Prostheses like this are made in many different sizes. Typical dimensions are ball diameter 50 mm, stem diameter 15 mm, stem length 155 mm, offset 38 mm, and neck length 39 mm. Develop an outline to follow in making a complete stress analysis of this prosthesis. Describe the material properties needed, the equations required, and how the loading is to be defined.



7. For the beam shown below, determine the support reaction at B.