9:00 - 10: 00
35-225

MIT ID# (last four digits) _____

Unified Quiz 2M

March 4, 2005

- Put your MIT ID# (last four digits) on each page of the exam.
- Read all questions carefully.
- Do all work on that question on the page(s) provided. Use back of the page(s) if necessary.
- Show all your work, especially intermediate results. Partial credit cannot be given without intermediate results.
- Show the logical path of your work. Explain clearly your reasoning and what you are doing. *In some cases, the reasoning is worth as much (or more) than the actual answers*.
- Please be neat. It will be easier to identify correct or partially correct responses when the response is neat.
- Be sure to show the appropriate units. Intermediate answers and final answers are not correct without the units.
- Report significant digits only.
- Box your final answers.
- ***Calculators, handwritten "crib sheets", and Unified Handout #M-5 allowed.***

EXAM SCORING

#1M (30%)	
#2M (40%)	
#3M (30%)	
FINAL SCORE	

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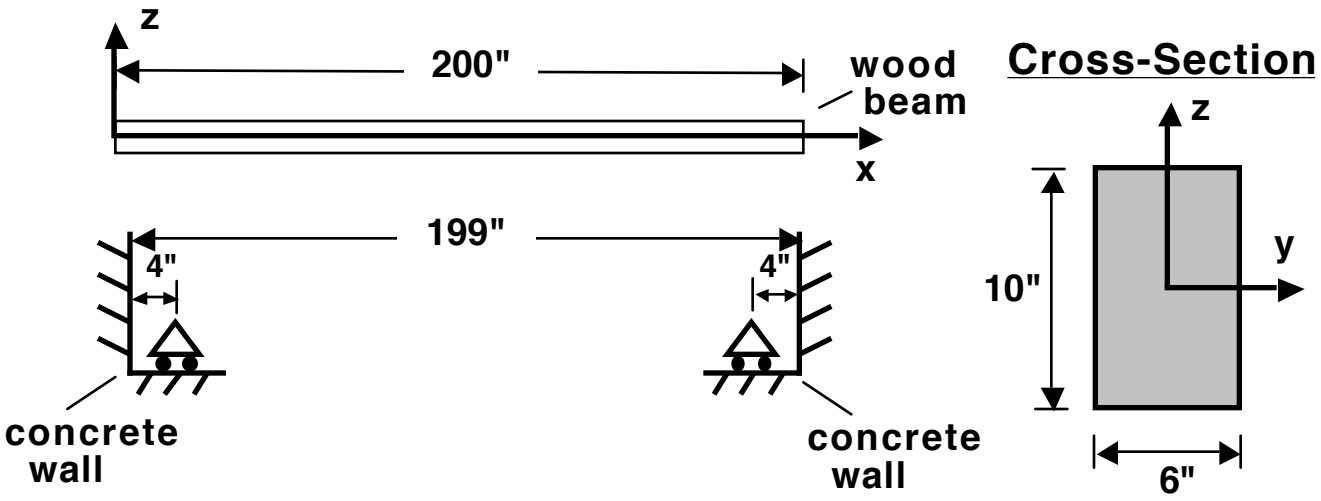
PROBLEM #1M (30%)

A 200-inch long wood (E = 3.5 Msi, ν = 0.3) beam is to be used as the major load-carrying component in the construction of a home. The beam has a rectangular cross-section 6 inches across and 10 inches deep. The beam is to rest on the poured concrete walls of the foundation and the ends are to fit between the extended concrete walls. This can be modeled as two roller joints, 4 inches inboard of the outer wall, as shown, with the end walls providing resistance so that the wood beam cannot expand, but can contract. When the concrete hardens and the forms are removed, it is found that the distance between the end-walls is 199 inches.



(a) Using the roller-model shown above, determine the end load that would need to be applied to the wood beam so that it will fit between the end-walls.

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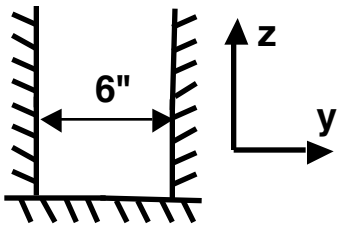
PROBLEM #1M (continued)

(b) The actual poured concrete configuration has a "pouch" in the wall that measures exactly 6 inches in width into which the beam is to fit. Does this present any additional issues/difficulties that must be taken into consideration? Be as clear and as quantitative as possible.

"POUCH"
Cross-Section



PROBLEM #1M (continued)

(c) Recommend what should be done in this situation given your analysis and any further ideas you may have.

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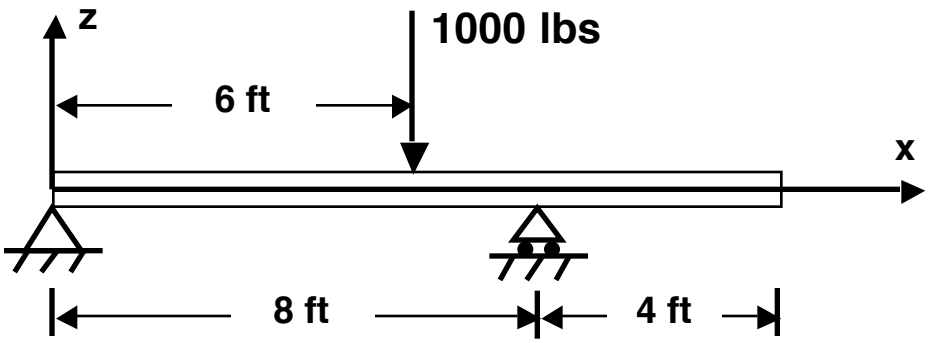
PROBLEM #2M (40%)

An aluminum beam (E = 10 Msi, ν = 0.3) is supported by a pin at one end and by a roller joint at its two-thirds span point. The beam is a total of 12 feet long and has a solid square cross-section with sides of 6 inches. The beam has a downward point load of 1000 pounds at the midspan.



(a) Sketch the shear force and bending moment resultant distributions as a function of position along the beam. Be sure to note the key values of each and their locations.

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PROBLEM #2M (continued)

(b) Determine the location of the maximum axial stress (i.e. σ_{xx}).

PROBLEM #2M (continued)

(c) Determine the location of the maximum shear stress (i.e. τ_{xz}).

(d) How do the answers to parts (a), (b), and (c) change if steel (E = 30 Msi, ν = 0.3) is used rather than aluminum?

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PROBLEM #2M (continued)

(e) How does the maximum deflection of the beam change when the beam is made of steel rather than aluminum?

(f) A third support (a pin) is added at the tip of the beam. Would the procedure for determining the answers to part (a) change? Be sure to explain ***clearly***. Use figures, ratios, etc. as appropriate.

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PROBLEM #2M (continued)

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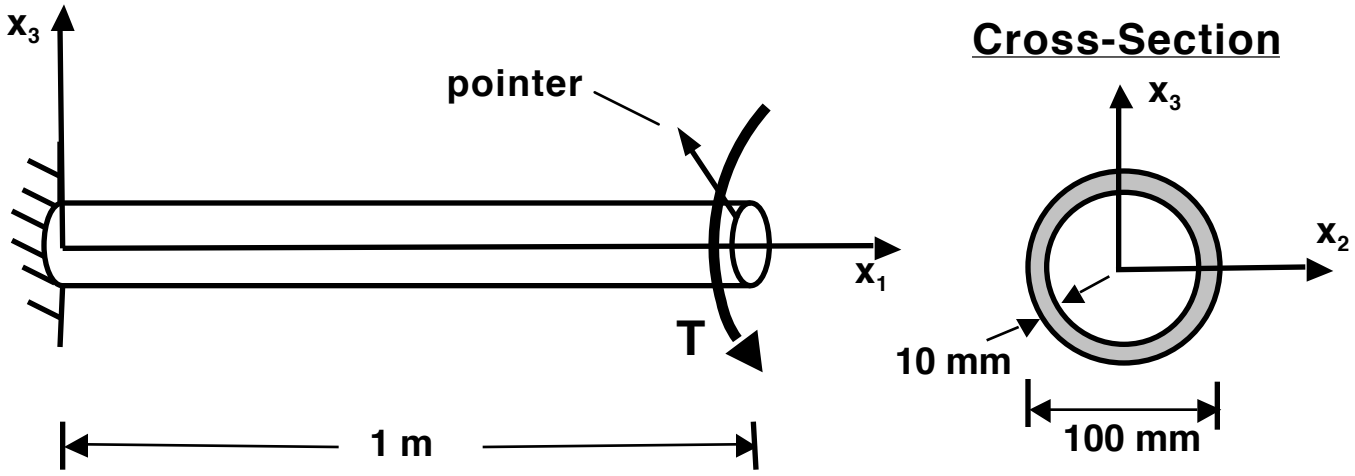
PROBLEM #3M (30%)

A shaft configuration has been chosen to be used as a metering device to determine torque applied in an overall system. The shaft is rigidly attached to a wall and is loaded at its end by the applied torque. Attached to the end of the shaft is an arrow to indicate the rotation of the shaft. The shaft is 1 meter in length and is a tube with an outer diameter of 100 mm and a wall thickness of 10 mm. Two materials are being considered for use. The first is steel which has a Young's modulus of 210 GPa, a Poisson's ratio of 0.3, and a yield stress of 345 MPa. The second is titanium which has a Young's modulus of 105 GPa, a Poisson's ratio of 0.3, and a yield stress of 1400 MPa.



(a) One of the critical cases is indicated by a rotation of 1°. Determine the ratio of the torques required for this case for the two materials under consideration.

PROBLEM #3M (continued)

(b) For the critical cases of the 1° rotation, determine the ratio of the maximum stress for the two materials under consideration.

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PROBLEM #3M (continued)