1:30 - 2: 45
Walker

MIT ID# (last four digits) ____________________

Unified Quiz 7M

May 21, 2007

- Put the last four digits of your MIT ID # 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 and handwritten "crib sheets" are allowed.***
- ***Unified Handout #M-11 entitled "CONCEPT REVIEW SHEET for Unified Q7M" allowed.***

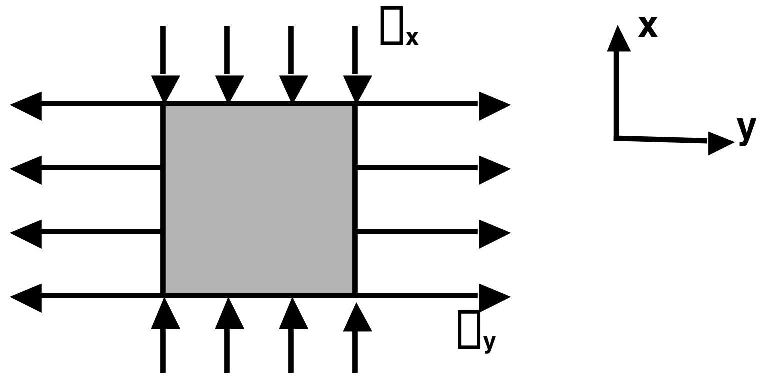
EXAM SCORING

#1M (1/3)	
#2M (1/3)	
#3M (1/3)	
FINAL SCORE	

Unified Quiz 7 - Materials and Structures (Q7M) **MIT ID#**
May 21, 2007 **(last four digits)** ____________________

PROBLEM #1M (1/3)

An aircraft structure is to be designed using either the basic strength approach or the damage tolerance approach. The component is loaded such that analysis shows that the material is subjected to a biaxial stress state with the stress in the x-direction being half in magnitude to that of the stress in the y-direction. The stress in the x-direction is compressive while that in the y-direction is tensile. There is no shear stress. Aluminum is being considered for this piece. The particular aluminum has a modulus of 70 GPa, a Poisson's ratio of 0.31, a value of the tensile ultimate strength of 200 MPa, and a value of fracture toughness of 25.0 MPa(m)$^{1/2}$.



Using the numbers given as the design values, determine the size of the crack that must be tolerated via the damage tolerant approach, in order to design for the same loading ability as via the basic strength approach.

In applying both approaches, consider the ultimate load condition. For the basic strength approach, use the von Mises criterion. For the damage tolerance approach, only consider the stress perpendicular to the crack and assume that the geometric factor associated with the assumed crack configuration is equal to 1.

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PROBLEM #1M (continued)

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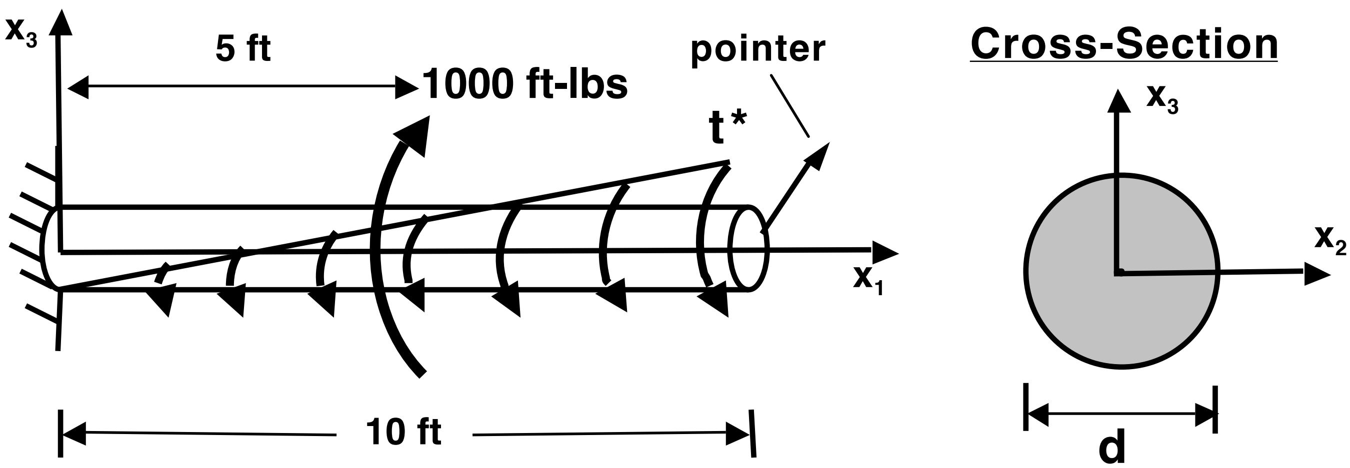
PROBLEM #1M (continued)

PROBLEM #2M (1/3)

A shaft configuration has been chosen to be used as a metering device to determine torque applied in an overall system. The shaft is clamped to a solid wall at one end and is free at the other. Attached to that free end of the shaft is an arrow to indicate the rotation of the shaft. The structural configuration is loaded by a distributed torque of linear increasing magnitude varying from 0 ft-lbs/ft at the wall to a key measurement value, t*, at the free end. In addition, there is a concentrated torque of -1000 ft-lbs at the midpoint of the shaft. The shaft is 10 feet long and has a solid circular cross-section with a diameter of d that is to be determined. Two materials are being considered for use. The first is steel with a Young's modulus of 30 Msi, a Poisson's ratio of 0.3, and a yield stress of 50 ksi. The second is titanium with a Young's modulus of 15 Msi, a Poisson's ratio of 0.3, and a yield stress of 200 ksi.



(a) One of the critical cases is indicated by a rotation of 1.5°. Determine the ratio of the diameters required for this case for the two materials under consideration.

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PROBLEM #2M (continued)

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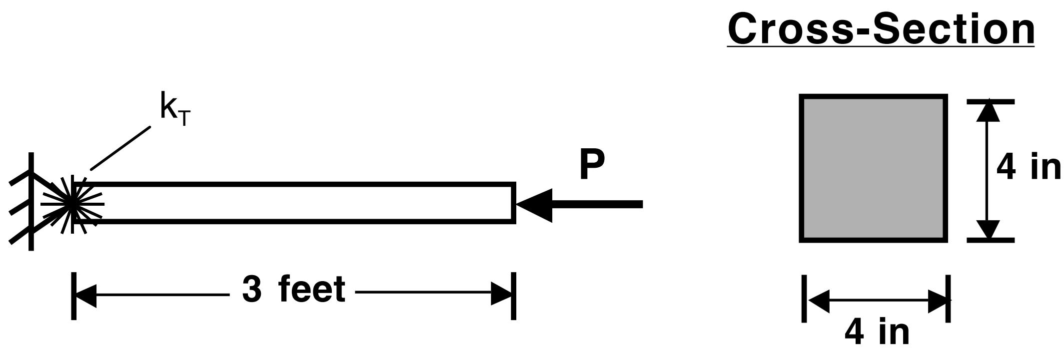
PROBLEM #2M (continued)

(b) For the critical cases of the 1.5° rotation, determine the ratio of the maximum stress for the two materials under consideration for the diameters as determined.

PROBLEM #3M (1/3)

A component of a load transfer device in an industrial machinery system has a square cross-section of 4 inches to a side and is 3 feet long. This piece can be modeled as a component that is attached via a torsional spring of stiffness k_T at one end, and has a compressive load applied at the other unsupported end. This load, of magnitude P, is a "follower load" in that it moves with the end of the structure. The component has been sized so that it will not yield or crush. The component is made of machinery-grade steel with a modulus of 30 Msi.



(a) Set up the equation(s) needed to determine the response of this component assuming that manufacturing, alignment, and loading are "perfect". This includes ***any*** deformation prior to instability. Describe how you would use the resulting equation(s) to determine the response but **DO NOT SOLVE**. As much as possible, describe the *nature* of the solution that results. Use figures if/as appropriate.

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PROBLEM #3M (continued)

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PROBLEM #3M (continued)

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PROBLEM #3M (continued)

(b) **Describe** the differences in the approach to determine the response when imperfections must be considered. Do not use equations unless **absolutely necessary**. As before, as much as possible, describe the *nature* of the solutions that result. Use figures if/as appropriate. In this overall description, do not use numbers, but only describe in a generic sense.