Your Name: ______________________________

Your TA & section day: ____________________

MAE 325 Prelim 1

Thursday November 18, 1999, 7:30 — 9:00 PM

Draft November 17, 1999

3 problems, 100 points, and 90 minutes.

Please follow these directions to ease grading and to maximize your score.

a) No books, notes, or calculators allowed. Ask for extra scrap paper if you need it.

b) Put *scrap* work not to be graded on left hand pages, *neat work to be graded* on right hand pages. If you need the space, clearly mark work to be graded that is on left hand pages.

c) Full credit if
- work is I.) neat,
  II.) clear, and
  III.) well organized;
- reasonable justification, enough to distinguish an informed answer from a guess, is given (unless otherwise stated). That is, all answers and work need some explanation;
- your answers are TIDILY REDUCED; and
- your answers are $\boxed{\text{boxed}}$ in.

d) If you base your answer on an unreasonable intermediate result we will <u>not</u> track your reasoning.

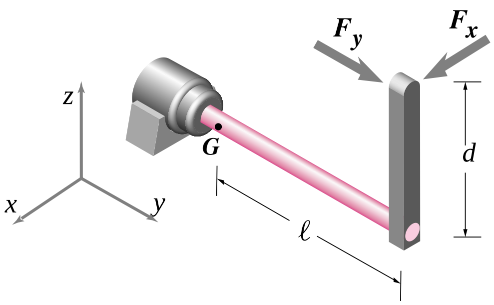
e) If you remember large appropriate formulas you may use them (at your own risk should they not apply or not be efficient).

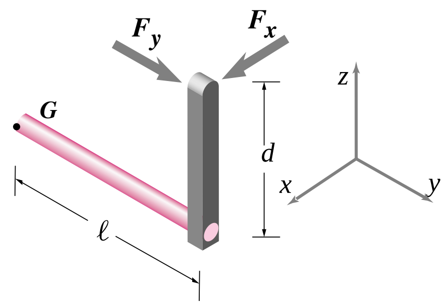
f) Unless otherwise stated, you will get full credit for, instead of doing a calculation, presenting Matlab code that would generate the desired answer. To ease grading and save space, your Matlab code can use shortcut notation like "$\dot{\theta}_7$ `= 18`" instead of, say, "`theta7dot = 18`".

Problem	1:	/35
Problem	2:	/35
Problem	3:	/30
TOTAL:		**/100**

1) (35 pt) A round shaft with length ℓ and radius r has a lever arm (length d) attached to it with two loads applied. The shaft has area moment of inertia $I = \pi r^4/4$, polar moment of inertia $J = \pi r^4/2$, and cross sectional area $A = \pi r^2$. Neglect gravity. Assume linear elastic behaviour and the usual strength-of-solids assumptions about loading of long narrow structures. Neglect the effect of stress concentrations. Point D is at the outer edge of the bar in the front (a distance r in the x direction from the center line).

$\Leftarrow$ *Please put scrap work for problem 1 on the page to the left* $\Leftarrow$.
$\Downarrow$ *Put neat, clear work to be graded for problem 1 below.* $\Downarrow$
(*If you need the space, clearly mark work to be graded on the scrap page.)*



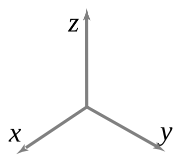


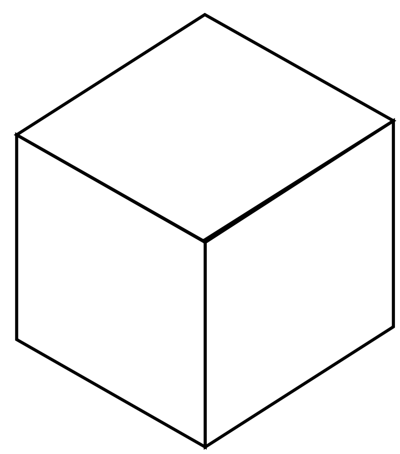
Free Body Diagram

a) (8 points) Complete the free body diagram of the structure with a cut at the section G. Use statics to find the forces and moments at this cut in terms of ℓ, d, F_x and F_y. (Parts (b) and (c) below depend on this being correct and will not be graded if this part is incorrect.)

b) (27 points) Fill in the components of the stress matrix at point G, assign values to all of the tractions shown. Answer in terms of ℓ, d, r, F_x and F_y. The rows and columns have the standard x, y, z interpretations. Signs are important. [hint: you may want to draw a cube and label the stress components on its surface]

$$[\sigma] = \begin{bmatrix} \quad & \quad & \quad \\ \quad & \quad & \quad \\ \quad & \quad & \quad \end{bmatrix}$$





c) (Extra credit, 5 points) Assuming F_x and F_y are positive and that ℓ and d are much bigger than r. What is the magnitude of the maximum tension stress at D? On what surface does it act (make a sketch and write a formula for any angle(s) that you mark). Give your answers in terms of ℓ, d, r, I, J, A, F_x and F_y [You may use Mohr's circle(s) or any other method. The answer depends on care with signs. The answer is not tidy.]

2) (35 pt) For student projects structures are often built of balsa wood instead of with stronger engineering materials like steel. A student team makes a solid square cross section cantilever beam (clamped at one end, loaded transversely at the other) and finds that its failure load is 100 lbf. They then take an equal length and equal mass square cross section steel beam and load it.

a) (15 points) Estimate the failure load of the steel beam? (A numerical answer is desired.) Make the standard strength-of-materials assumptions for both beams.

b) (15 points) How much stiffer is the steel beam than the balsa beam (stiffness = force/deflection)?

c) In words, give a qualitative explanation for the solutions you found above.

Some key assumptions you should use:
- The failure stress of mild steel in tension is about 100 times that of balsa wood.
- The "Young's modulus" (the elastic modulus in tension) of steel is about 100 times that of Balsa.
- The density (mass per unit volume) of steel is about 36 times that of balsa wood.

$\Leftarrow$ *Please put scrap work for problem 2 on the page to the left* $\Leftarrow$.
$\Downarrow$ *Put neat, clear work to be graded for problem 2 below.* $\Downarrow$
(If you need the space, clearly mark work to be graded on the scrap page.)

3) (30 pt) Hmm...

$\Leftarrow$ *Please put scrap work for problem 3 on the page to the left* $\Leftarrow$.
$\Downarrow$ *Put neat, clear work to be graded for problem 3 below.* $\Downarrow$
(<u>If</u> you need the space, clearly mark work to be graded on the scrap page.)

a)

b)