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GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

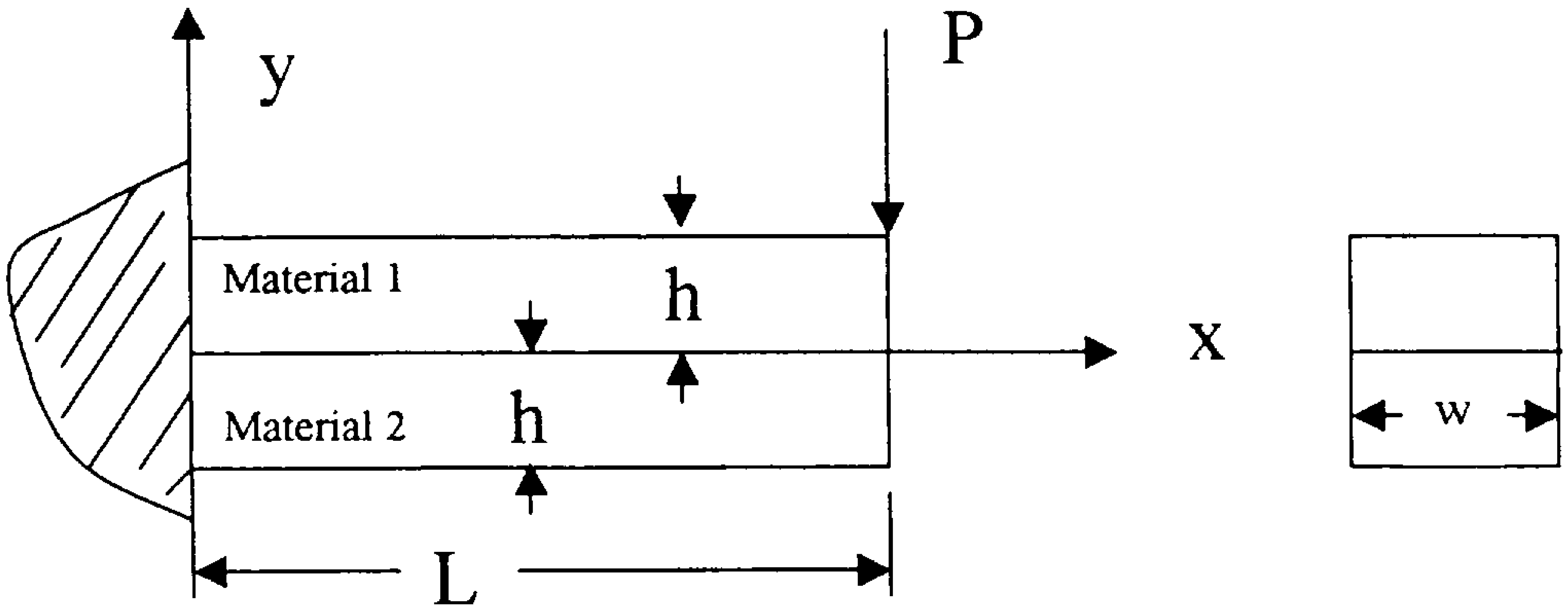
Ph.D. Qualifiers Exam - Spring Semester 2001

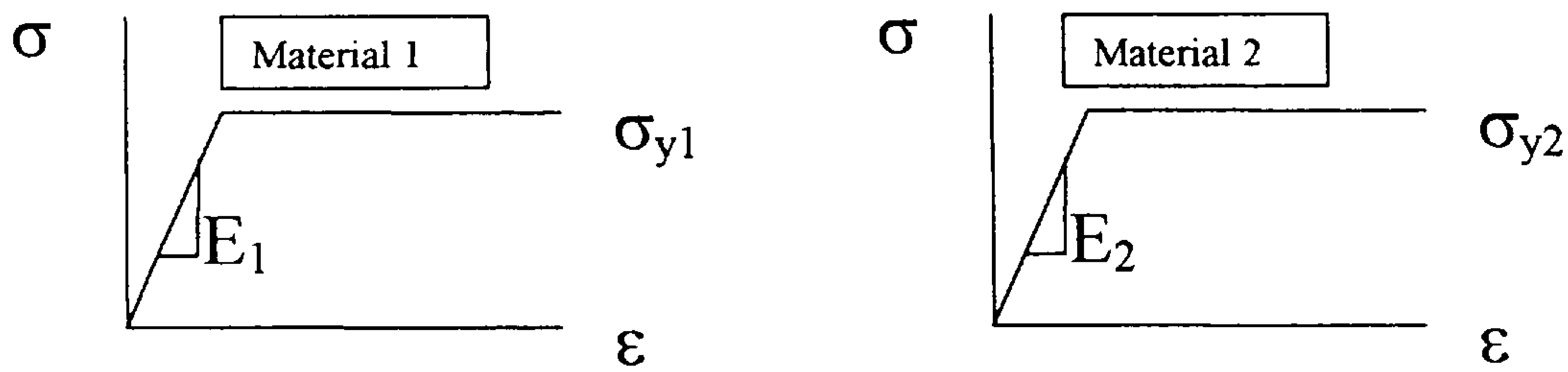
Mechanics of Materials
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

- **Please sign your name on the back of this page—**

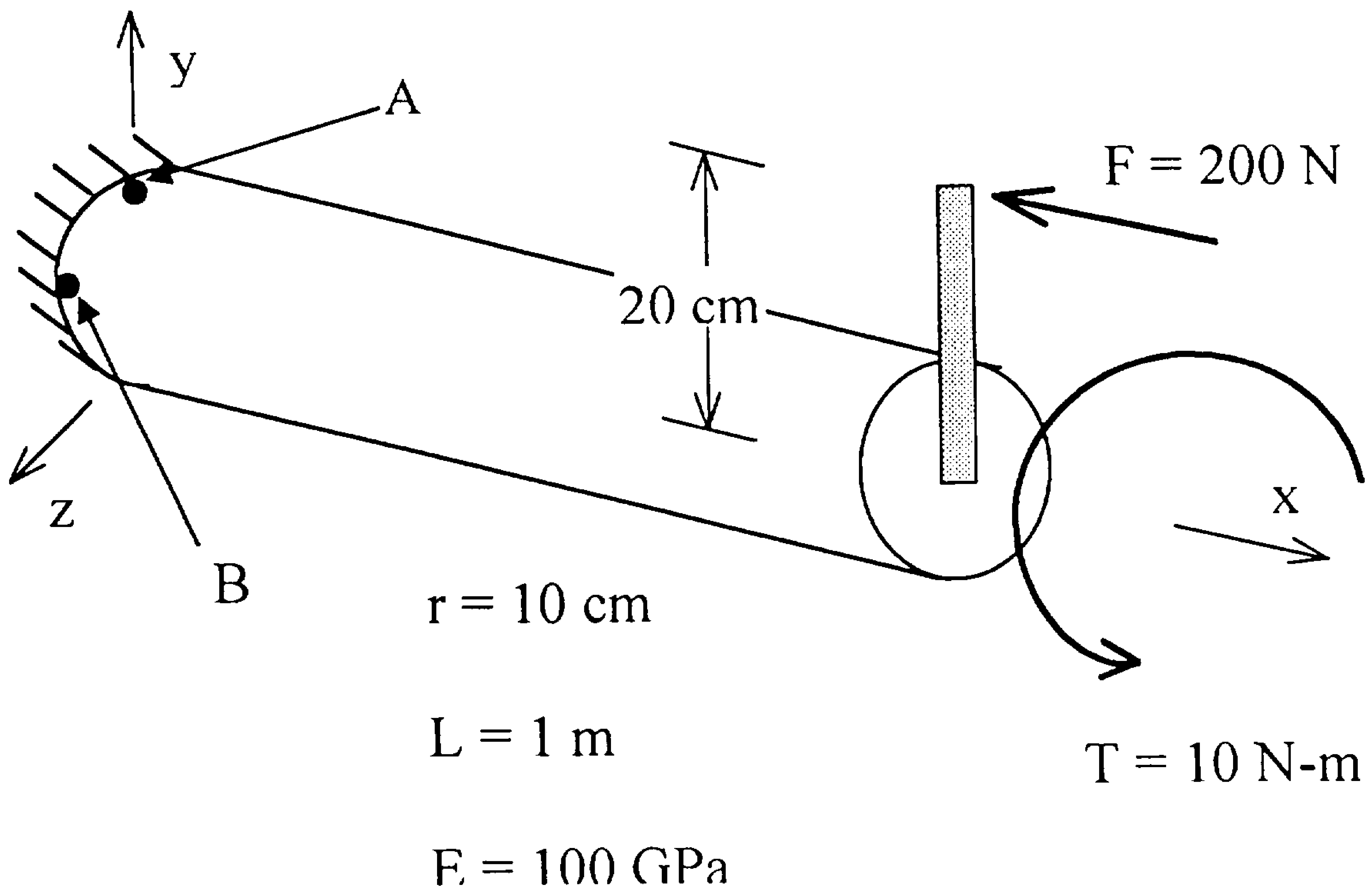
Beam Problem:





The bi-material cantilever beam above is subjected to the loading shown. Neglect transverse shear and use simple beam theory. Also, assume that tension and compression stress-strain behavior is symmetric.

1. Determine the solution for the deflection at the end if $E_1 = E_2$ in the absence of yielding. In this case, where will the beam yield first, and at what value of load P, if $\sigma_{y1} = 2\sigma_{y2}$?
2. Find the load P at which the beam will first yield if $E_1 = 0.5E_2$ and $\sigma_{y1} = \sigma_{y2} = \sigma_y$
3. Determine the limiting load that the <u>fully plastic</u> (yielded) beam can sustain for $\sigma_{y1} = \sigma_{y2} = \sigma_y$.



Consider the rod (1m long, 10cm radius) welded to the wall as shown above. A torque of 10 N-m is applied to the right end and a force of 200 N is applied to a bar attached to the right end.

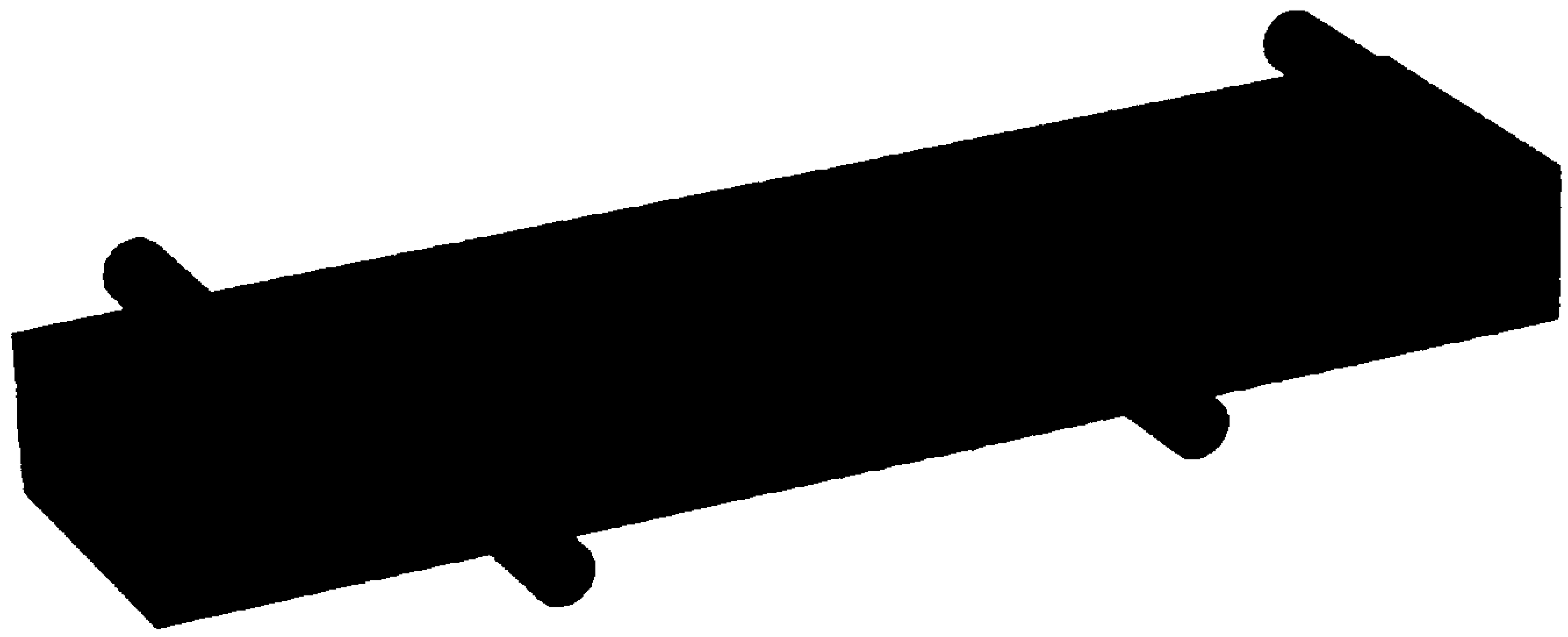
You may leave your answers in symbolic form if you wish, as long as you define any new symbols that you introduce.

<u>State *all* assumptions that you use in your analysis.</u>

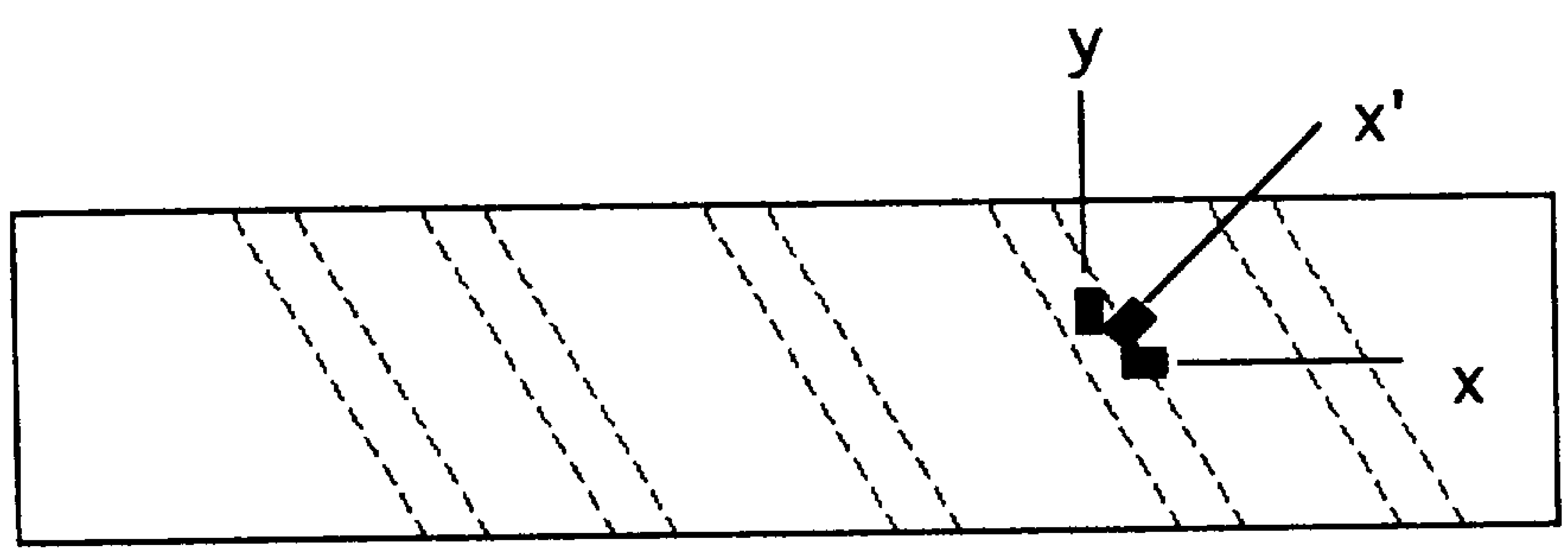
Find the maximum normal stress at point A.

Find the maximum shear stress at point B.

The elastic beam shown in Figure 1a is subjected to four point bending. There is a strain rosette on the top surface. A top view is shown in Figure 1.b. The strain gages are placed directly over the second hole from the right. The holes do not pass straight through. The strains indicated are e_{xx}=0.001, e_{yy}=-0.0005, $e_{x'x'}$=-0.0003. The material is homogeneous with a Young's modulus of 30 GPa and a Poisson's ratio of 0.33.



A.



B.

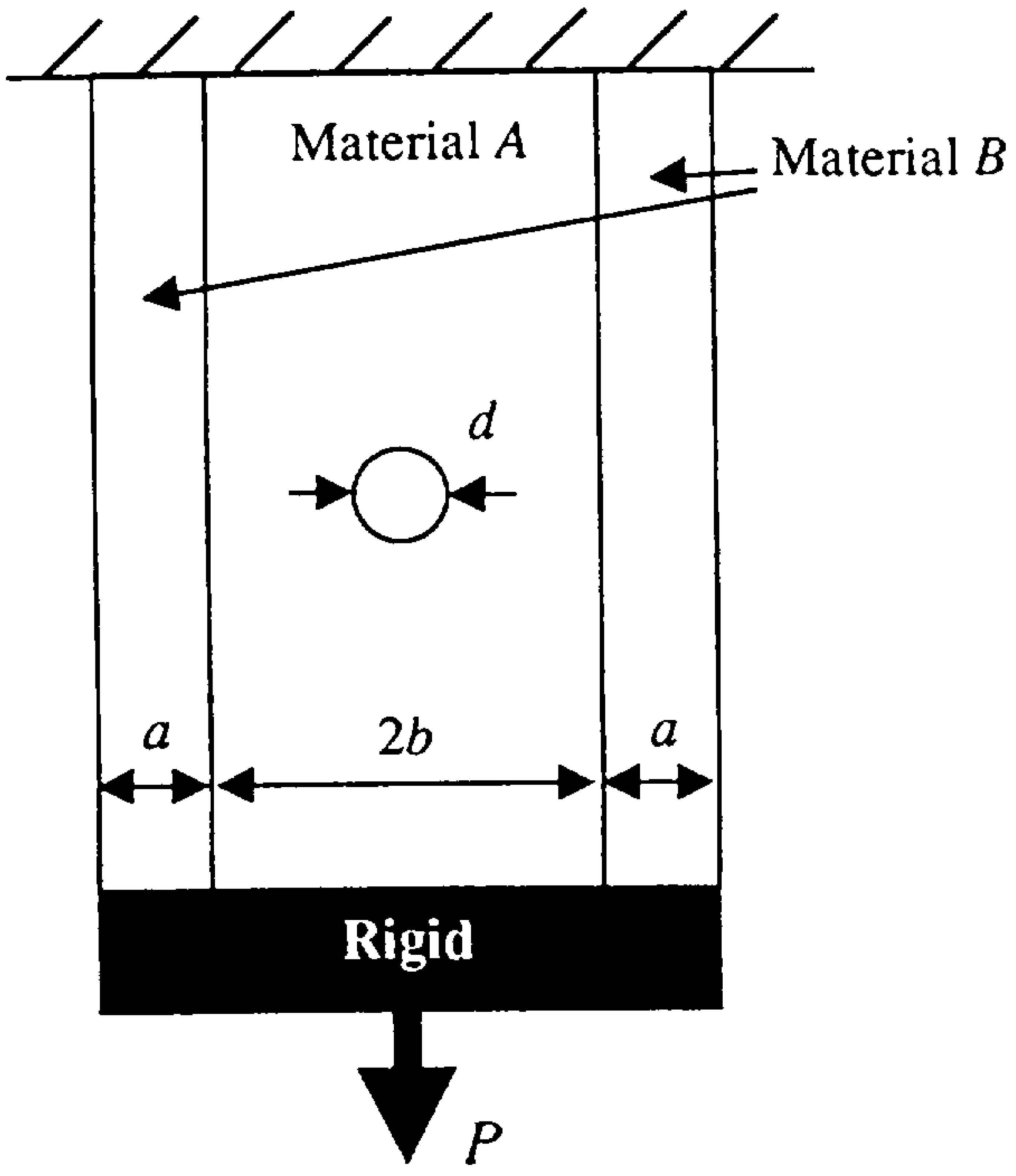
Figure 1.

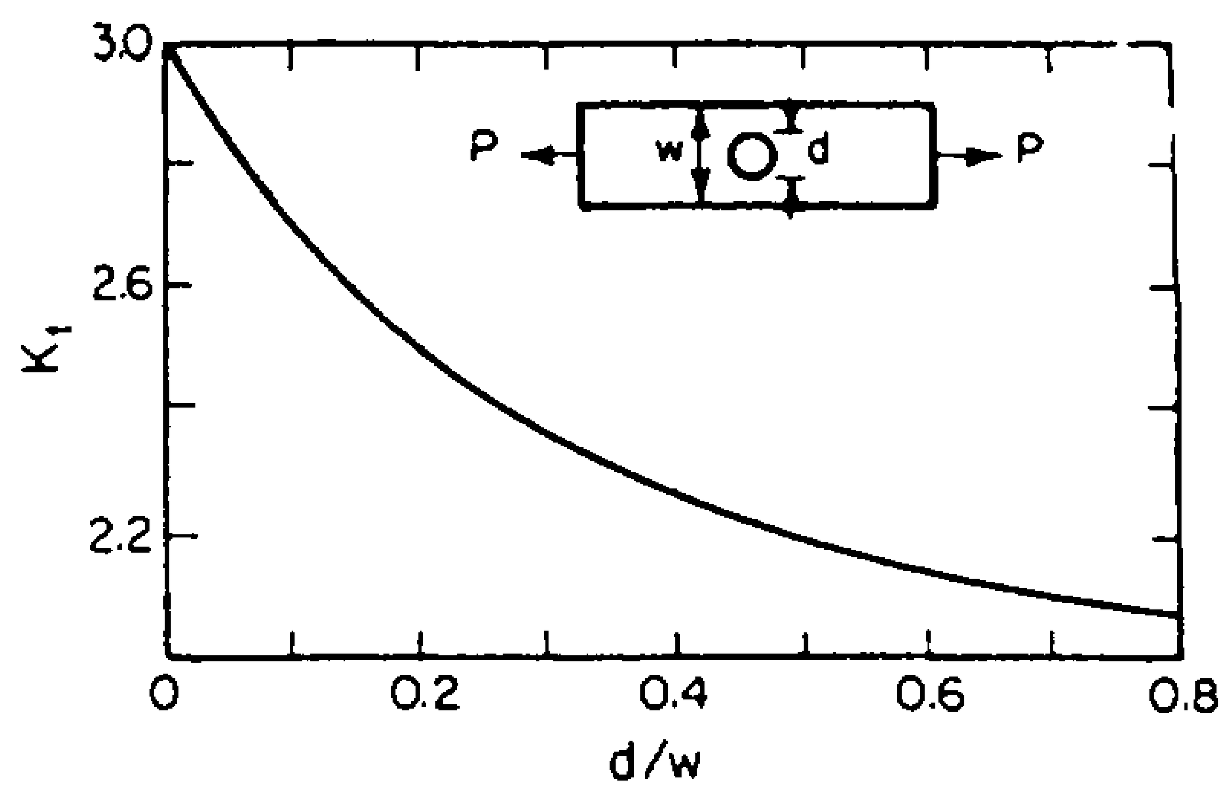
1. What assumptions are made when developing the flexure formula? Are any of them violated by this system?

2. Determine the principle strains (values and direction) in the plane of the strain gages from the strain gage readings. Either use Mohr's circle or find the eigenvalues and eigenvectors of the strain matrix. You must show your work for credit. You can check your results using your calculator.

3. Calculate the principle stress components in the material beneath the strain gages (all six of them). Use the 3 dimensional Hooke's law.

A plate of unit thickness as shown is made from two materials having elastic modulus, E^A and E^B, and yield strength, σ_o^A and σ_o^B. Neglect end effects where load is applied. A hole with diameter d is located at the center of the plate.





$$S_{nom} = \frac{P}{(w-d)t}$$

t = thickness

(a) If $E^A = E^B = E$, $\sigma_o^A = \sigma_o$, $\sigma_o^B = 2\sigma_o$, $a/b = 2/3$, and $d = 0$ (i.e., no hole), at what load P and in which material will yielding first occur?

(b) If $E^A = E$, $E^B = 2E$, $\sigma_o^A = \sigma_o^B = \sigma_o$, $a/b = 2/3$, and $d = 0$ (i.e., no hole), at what load P and in which material will yielding first occur?

(c) Now consider the case where Materials A and B are the same (i.e., $E^A = E^B = E$, $\sigma_o^A = \sigma_o^B = \sigma_o$), $a/b = 2/3$, and $d = (a+b)/5$. At what load P and at what location will yielding first occur?

(d) Now consider two geometrically similar plates with $d_1 = 10d_2$, $W_1 = 10W_2$, and $d_1/W_1 = d_2/W_2 = 0.1$ made from the same material (see figures below). If the stress σ varies cyclically, comment (qualitatively) on the difference, if any, in the endurance limit for these two plates. Explain your reasoning.