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RESERVE DESK

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2000

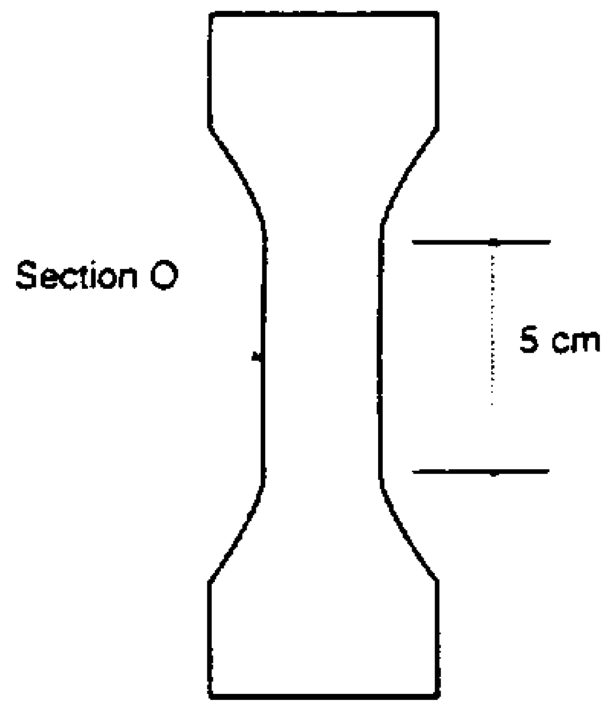
Mechanics & Materials
EXAM AREA

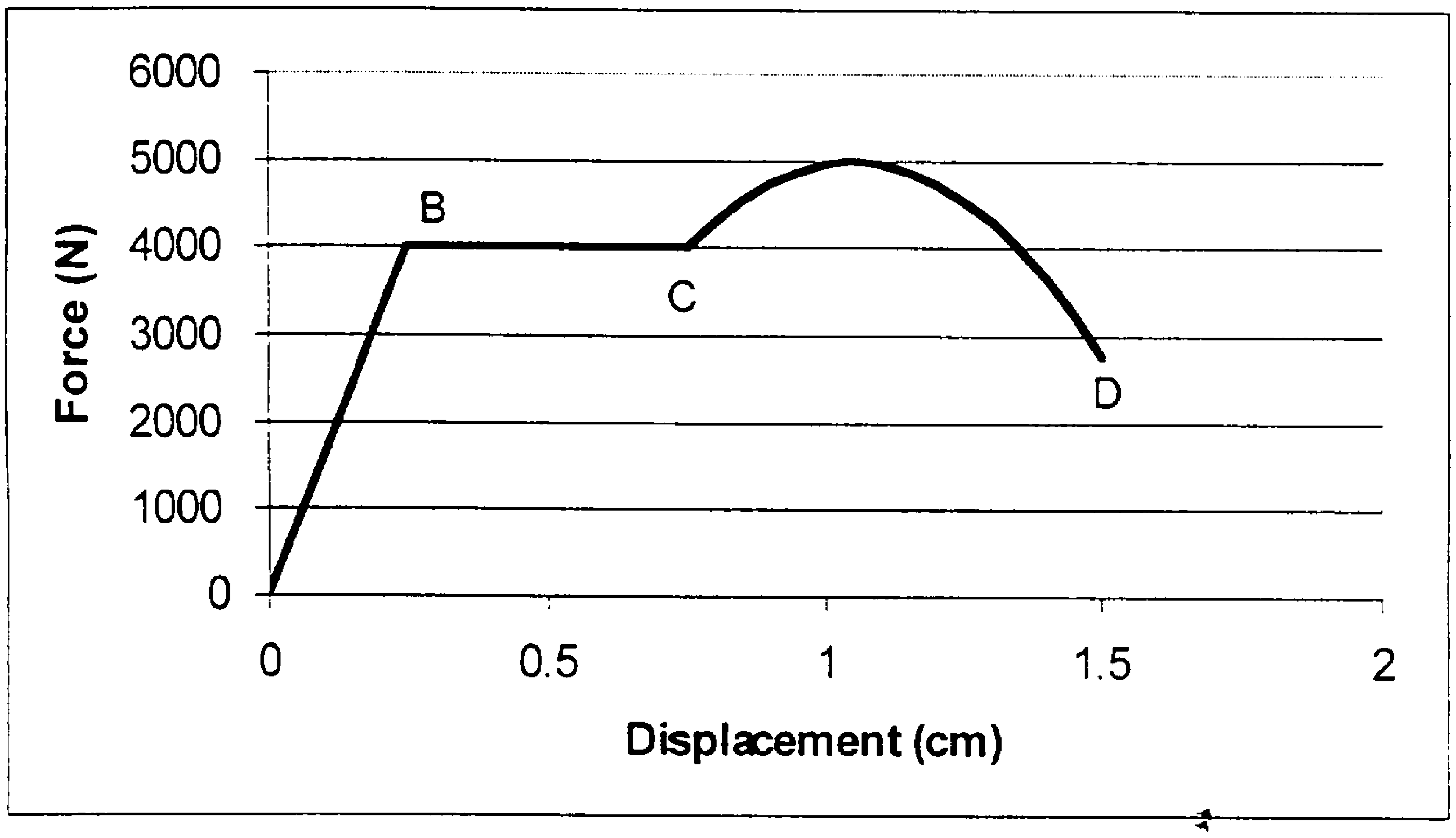
Assigned Number **(DO NOT SIGN YOUR NAME)**

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

1. Determine the required diameter of a steel shaft that must transmit a torque of 4,000 N-m. Design requirements dictate that the yield strength of the shaft can not be exceeded employing a factor of safety of 2 and that the shaft can not twist more than 2° on a length of 2 m. The yield strength of the steel (as determined from a tensile test) is 400 MPa and the shear modulus is 80,000 MPa. The polar moment of inertia for a circular cross section is $\pi d^4 / 32$.

2. The cylindrical test specimen shown below is loaded to failure in tension under displacement control. An extensometer is used to measure the deformation of an initially 5 cm long X 1 cm diameter gage length, producing the Force-deformation curve shown. Failure occurs at section O (the middle of the gage length). Just prior to failure, section O is noted to have a reduced diameter of 5mm. Assume that Poisson's ratio during elastic deformation is 0.3.



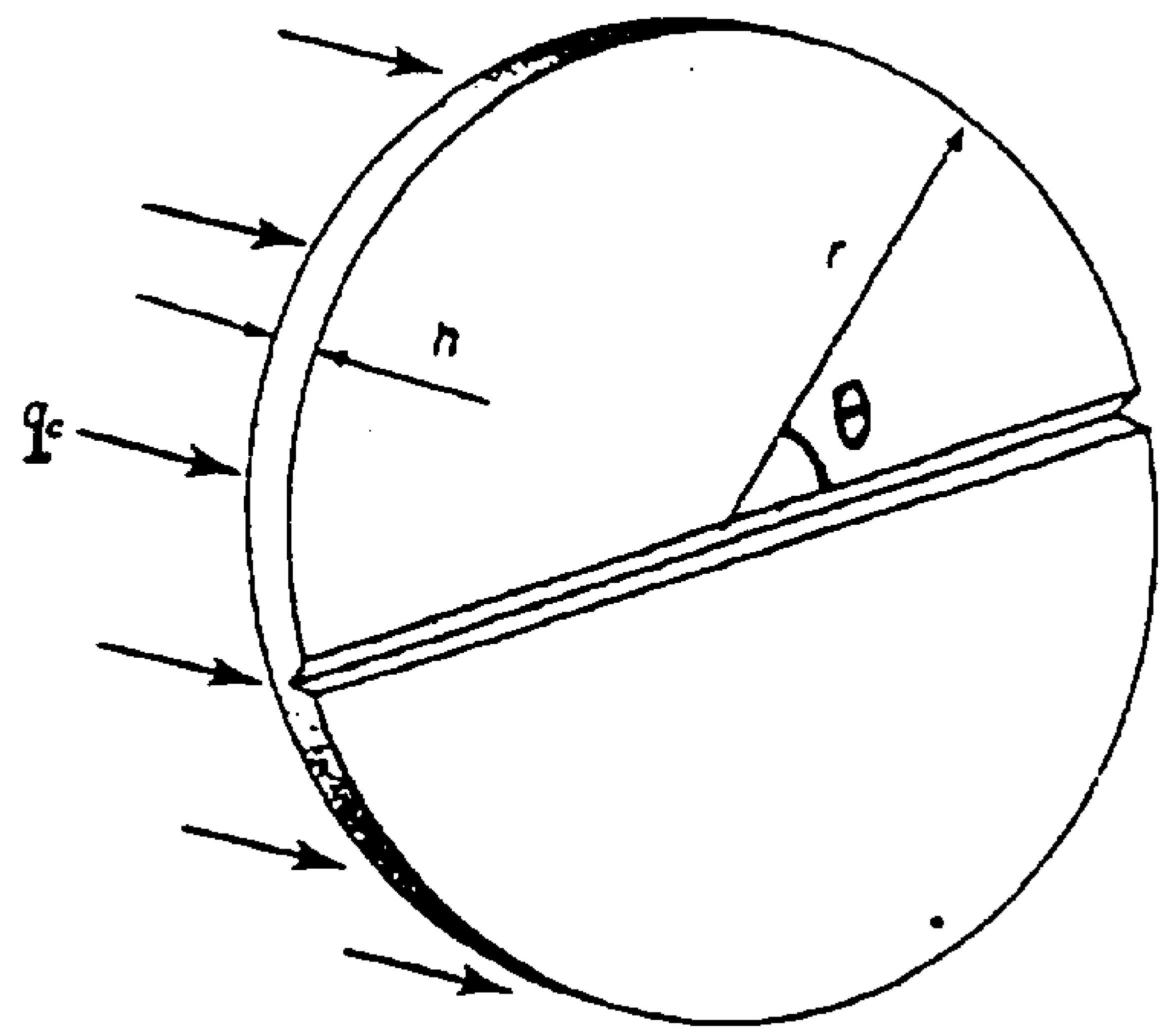


Fill in the missing values (for section O) from the following chart. List and JUSTIFY any additional assumptions that you make.

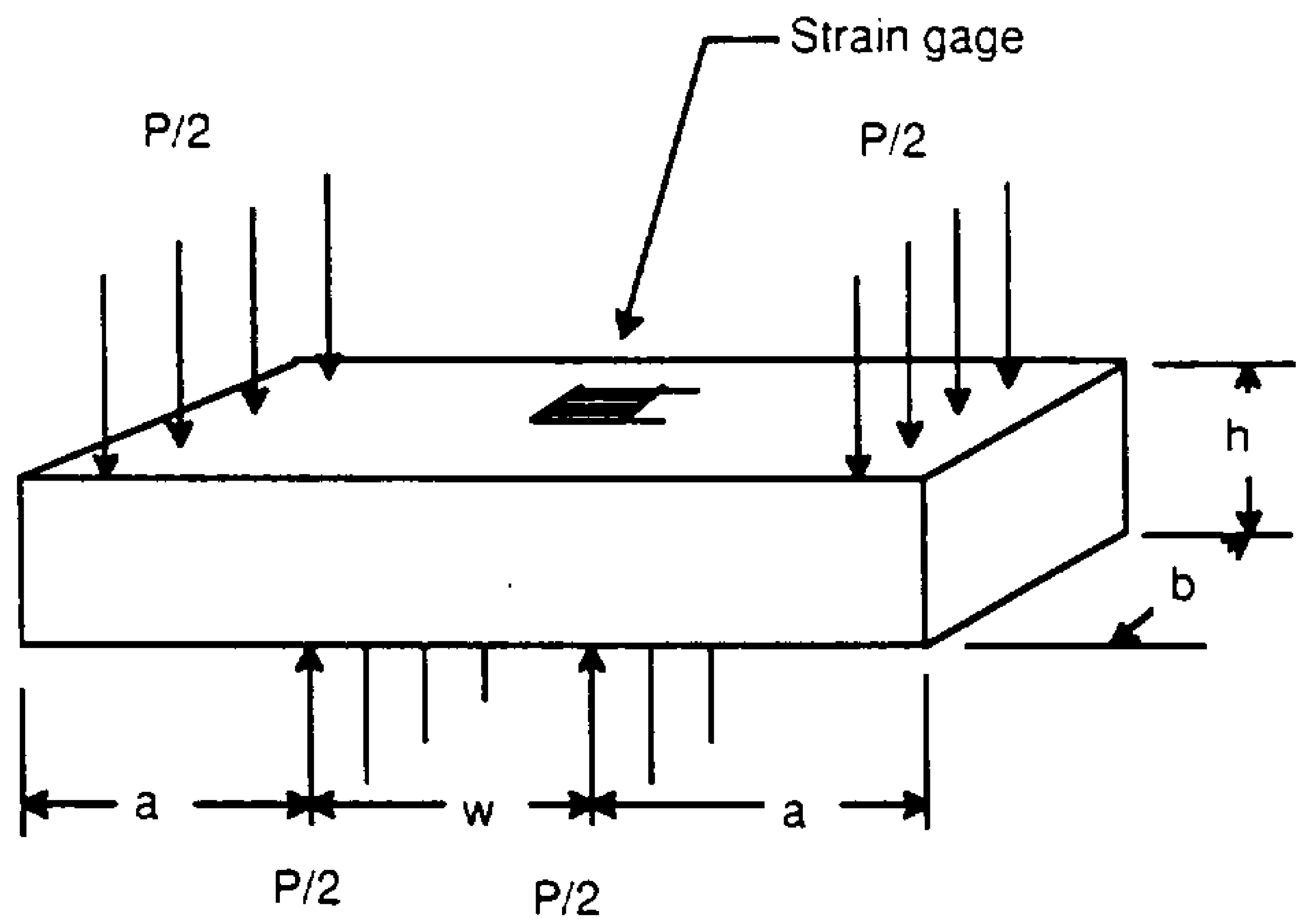
Point	Displacement (mm)	Force (N)	Engineering stress	Engineering strain	True stress	Natural (true) strain
B	0.25	4000				
C	0.75	4000				
D	1.5	2750				

3. A circular burst plate is installed to protect a vessel from excessive pressure. This burst plate is flat and clamped at its edges. A sharp notch is machined across a diameter on the unpressurized side as shown. The plate has a radius of 40 mm and a thickness of h = 4 mm. The material parameters for the plate are $\sigma_y = 1500$ MPa, $\nu = 0.333$, E = 200 GPa, and $K_{IC} = 34.64$ MPa$\sqrt{m}$. It is known that under bending due to the pressure, the maximum stresses occur at the center of the plate and are $\sigma_\theta = \sigma_r = \frac{3q_c r^2(1+\nu)}{8h^2}$, where q_c is the burst pressure. Assume $K = 1.12\sigma\sqrt{\pi a}$.

(1) If the burst pressure is 20 MPa, what is the required notch depth?
(2) State the condition for ensuring burst without yielding. Will this plate burst or yield?



4. The beam shown below is in four point bending. In response to the following questions, please state all of your assumptions and draw sketches that describe the geometry you are using.



a) Draw the shear and moment diagrams.

b) Use geometry to develop the relationship between the strain measured by the strain gage, ε_{xx}, and the radius of curvature, ρ. Develop an expression for the strain, $\varepsilon_{xx}(y)$, as a function of the distance from the neutral axis, y, the height of the specimen, h, and the strain measured from the strain gage.

c) Sketch a free body diagram for the beam sliced through the strain gage with the cut parallel to the smallest face. Write down the equations for force and moment balance for this surface.

d) Given the uniaxial stress/strain relation $\sigma_{xx}=E\varepsilon_{xx}$, integrate the expressions in part c) to show that

$$\frac{Mh}{2I} = E\varepsilon_{xx}^{gage}$$

where $I = \frac{1}{12}bh^3$