GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1999

Mechanics & Materials
EXAM AREA

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

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

Please **p r i n t** your name here.

The Exam Committee will get a copy of this exam and will not be [illegible] whose paper it is until it is graded.

Mechanics of Material, Spring 1999

PLEASE READ BEFORE YOU START:

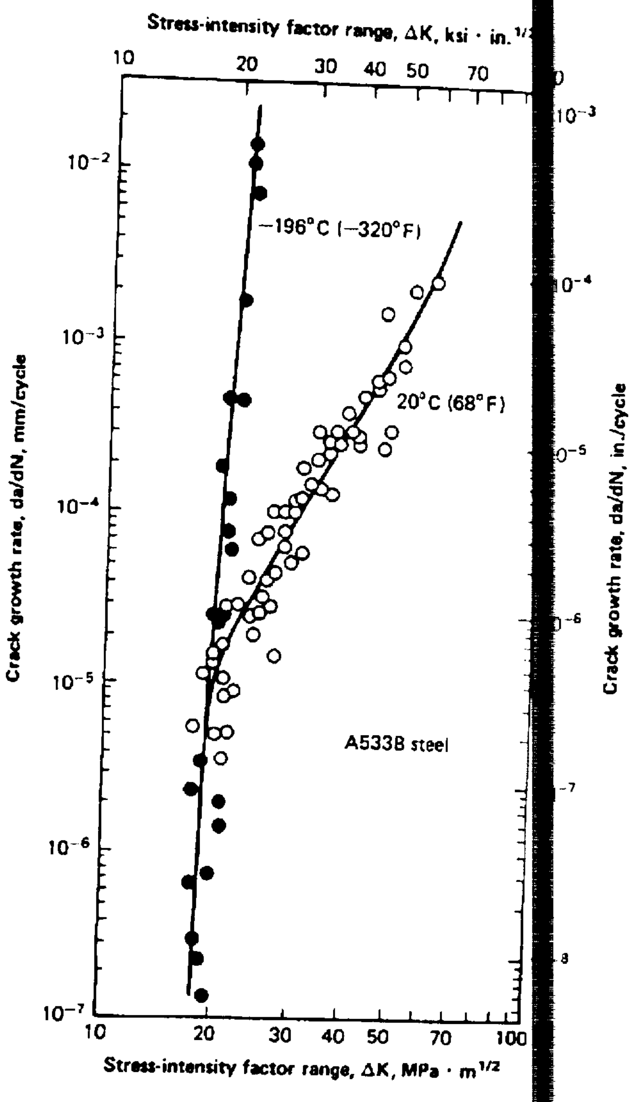
You are required to finish *only* four (4) of the five (5) problems in this exam. Please circle below the four problems you would like to be graded.

Problem I **Problem II** **Problem III** **Problem IV** **Problem V**

If not specified, the four problems with the lowest scores will be considered. (*No extra credit will be given for finishing all five problems*).

Problem I

(a) The plot below shows the fatigue crack growth data from A5 3B steel tested at R 0.1 at two different temperatures. If an edge crack ($F = 1.1$ of length $a = 10$ mm exists in a wide plate made from this material that is experie cing a uniaxial $R = ($ loading, what is the maximum stress *amplitude* that can be s tained so that the cr does not grow at either temperature?



(b) Please briefly give the likely reason why these crack growth nds with temperatu are observed. (It may be helpful to discuss the reason why th e appears to be a significant difference in the fracture toughness between these vo temperatures.)

Problem II

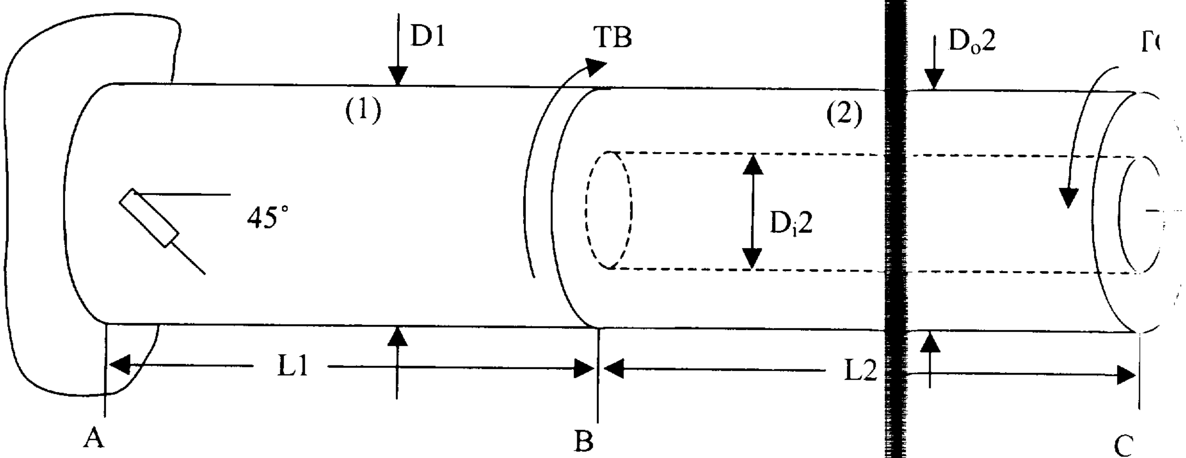
A steel shaft AC has a solid segment of length L1 and a hollow gment of length L2
The shaft is subjected to torsional loads as shown below.

G = 80 GPa
L1 = L2 = 2m
D1 = D_o2 = 100 mm
D_i2 = 50 mm
TB = 22,000 N · m
TC = 10,000 N · m

a) Determine the location (s) and magnitude of the absolut aximum shear st e

b) Determine the angle of rotation at point C, ϕ_C.

c) You suspect that the given shear modulus for the shaft n erial may not be accurate. You therefore attach a strain gage to the outsid of segment (1) at a orientation with respect to the longitudinal axis. Under t same torsional loa conditions shown in the figure, you measure a strain of 0 4%. Estimate the actual shear modulus (G) of the shaft material based on t strain gage data.



Problem III

(a) Show that the Mohr's circle is a valid graphical approach fo tress or strain analy i

(b) Specify the conditions under which the Morh's circle ca be used. Illustrate t approach for a general state that can be analyzed.

Problem IV

List three failure (fracture or plasticity) criteria and briefly describe them.

Problem V

(a). A thin-walled pipe with closed ends has an outer diameter d and a wall thickness t. It is subjected to an internal pressure P and the ductile material has a yield strength. Derive an equation for the required thickness corresponding to specified values of the internal radius and the safety factor n against yielding.

(b). If this pipe is subjected to an internal pressure of 10 MPa and a torque of 1500N · m in the axial direction, and is made of AISI 1030 steel with yield strength 648 MPa, what is the safety factor against yielding? Assume $d = 80$ mm and $t = 4.0$ mm.