ADELAIDE UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

#4109 SOLID MECHANICS

NOVEMBER 2000

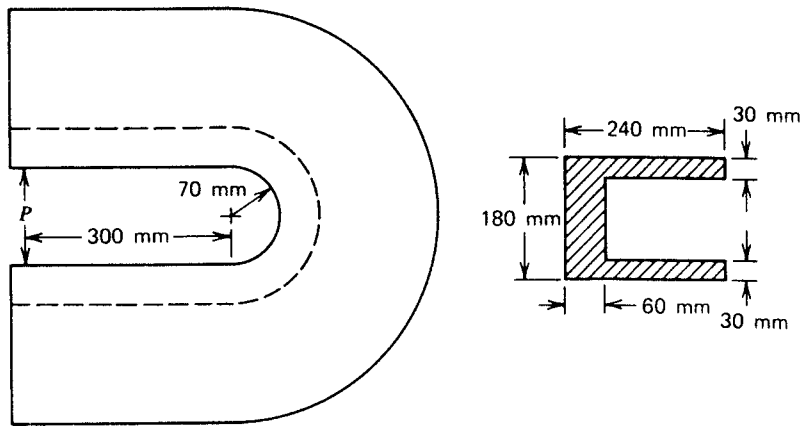
TIME ALLOWED: 3 HOURS

- In addition candidates are allowed ten minutes before the examination begins to read the paper.
- The use of notes, textbooks, and calculating devices is permitted in the examination room.
- Answer any **SIX** questions only.
- All questions carry equal marks.
- Appropriate engineering assumptions may be made for inadequate data.

QUESTION ONE

In figure Q.1. is shown a cast iron frame with a U-shaped cross-section. The ultimate tensile strength of the cast iron is σ_{uit} = 320 MN/m^2. Load P is acting at the open end of the U section shown in the figure (at a distance 300mm from the centroid of the section).

Determine the maximum value of Load P, based on a factor of safety SF = 4.00 which is based on the ultimate strength mentioned above.



Use Curved-Beam theory to calculate your answers.

QUESTION TWO

Consider a stressed model in the field of a plane polariscope and assume that analyser and polarisers are crossed. Use an exponential representation for the light wave. Derive the equation of light passing from the analyser. Derive the equation for the light intensity and determine the criteria for isoclinics and isochromatics.

QUESTION THREE

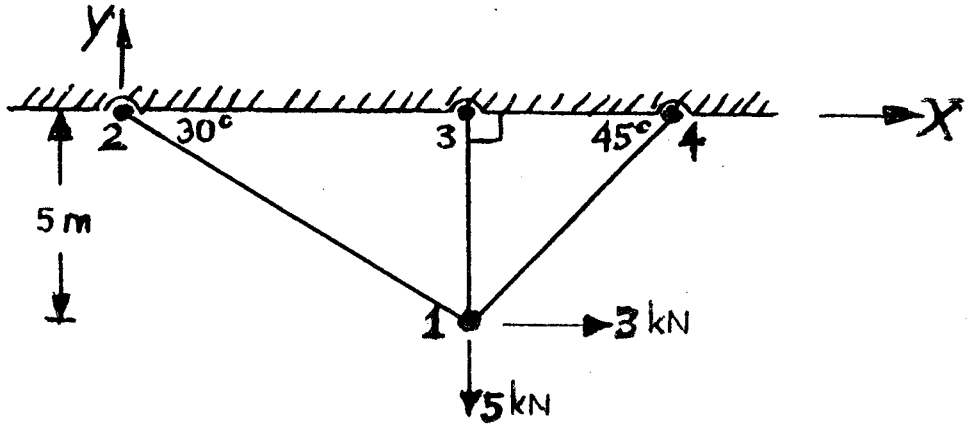
The following observations are made with a rectangular rosette mounted on a steel (E=207 GPa and ν=0.30) specimen. Determine the principle strains, the principle stresses, and the principle angles $\varnothing_1$ and $\varnothing_2$.

Case Number	ε_A, με	ε_B, ε	ε_C, ε
1	1000	-500	0
2	1800	600	-400
3	-1000	400	400
4	1600	-200	-1800
5	-400	0	400

Plot the graphs showing the variations of (σ_1 vs ε_1) and (σ_2 vs ε_2).

QUESTION FOUR

The structure shown in the figure below has been used in a warehouse moving crane mechanism. Find the nodal displacements and the forces in the members of the plane pin-jointed truss system shown. The cross-sectional areas of members 1, 2 and 3 are A_o, A_o and $\sqrt{2}\,A_o$ respectively and all have a constant E. It may be assumed that there is no initial lack-of-fit.



QUESTION FIVE

A welded component is required to have a fatigue life of 100,000 cycles. Determine whether the design is adequate, using the following information, and by calculating the fatigue crack propagation life.

a) The component is made of martensitic steel, with yield stress of 689 MN/m^2 and fracture toughness, K_{IC} of 165 MN $m^{-3/2}$.

b) The maximum initial flaw size detectable by the inspection technique is 7.62mm (for an assumed single edge crack in tension).

c) The component is to be subjected to a stress which varies from 310 to 172 MN m^{-2}.

d) For the geometrical configuration of an edge crack in tension the stress intensity factor, K_I, and crack size, a, relationship is:

$$K_I = 1.12\sigma \sqrt{(\pi a)}$$

where σ = applied stress.

e) The crack growth rate-stress intensity factor relationship is:

$$\frac{da}{dN} = 1.37x10^{-10}(\Delta K_I)^{2.25}$$

where N = number of fatigue cycles.

QUESTION SIX (i)

A base plate made of aluminium alloy having σ_{yield} is 50 MN/m^2, was used to hold down engine assembly in a marine environment. After a year in service a 25 mm edge-crack was found in the plate. The usual service stress was 150 MN/m^2 with a 5% accuracy in it determination.

1 Calculate the size of the plastic zone at the crack tip.

2 Calculate fracture toughness using
   (a) the LEFM approach and
   (b) Irwin's plastic zone correction.

Calculate the percentage error in using the LEFM approach for the calculation of fracture toughness values.

QUESTION SIX (ii)

An accident report on a steel pressure vessel which fractured in a brittle manner when an internal pressure of 25 MN/m^2 has been applied to it shows that the vessel has a longitudinal surface crack of 10.5 mm long and 3.6 mm deep. A subsequent fracture mechanics test on a sample of the steel showed that it had a plane strain fracture toughness value of 77 $MN/m^{-3/2}$. If the vessel diameter was 1.2m and its wall thickness was 12 mm, determine whether the data reported are consistent with the observed failure. Determine the calculated internal pressure.

QUESTION SEVEN

A compound cylinder is formed by shrinking a tube of 300mm internal diameter and 25mm wall thickness onto another tube of 300 mm external diameter and 20 mm wall thickness, both tubes being made of steel with E=200 GPa, σ_y = 420 MN/m^2, ν = 0.3

The stress set up at the junction owing to shrinkage is 15 MN/m^2. The compound tube is then subjected to an internal pressure of 75 MN/m^2. Assume external pressure on the outside cylinder to be zero.

Compare the hoop stress distribution, now obtained, with that of a single cylinder of 350mm external diameter and 45 mm thickness subjected to the same internal pressure.