NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

INDUSTRIAL AND MANUFACTURING ENGINEERING DEPARTMENT

SECOND SEMESTER EXAMINATION - AUGUST/SEPTEMBER 2009

SOLID MECHANICS II **COURSE CODE TIE 2203**

Examination duration 3 hours

INSTRUCTIONS TO CANDIDATE

Answer any FIVE questions out of seven.
Show all working
All Questions carry equal marks (20)

Additional Material

Table 1.1 Table of k_1 and k_2 values for rectangular sections in Torsion [1]

d/b	1.0	1.5	1.75	2.0	2.5	3.0	4.0	6.0	8.0	10.0	Infinity
k_1	0.208	0.231	0.239	0.246	0.258	0.267	0.282	0.99	0.307	0.313	0.333
k_2	0.141	0.196	0.214	0.229	0.249	0.263	0.281	0.299	0.307	0.313	0.333

[1]S. Timoshenko, Strength of Materials, Part I, Elementary Theory and Problems, Van Nostrand, New York.

Question One

At a point in a material the direct stresses are 40 MN/m^2 (tensile) and 60 MN/m^2 (tensile) in mutually perpendicular directions. On the planes carrying the applied direct stresses, there also acts an applied shear stress of value 30 MN/m^2.
(a) From first principles derive the equations for the direct stress and shear stresses on the plane, assuming unit area. **[8]**

(b) Calculate, relative to the direction of the 40 MN/m^2 stress;
(i) the angles of the principal planes **[6]**

(ii) the values of the principal stresses **[6]**

Question Two

In a certain material under load a plane AB carries a tensile direct stress of 30 MN/m^2 and a shear stress of 20 MN/m^2, while another plane BC carries a tensile direct stress of 20 MN/ m^2 and a shear stress. If the planes are inclined to one another at 30^o and plane AC at right angles to plane AB carries a direct stress unknown in magnitude and nature, compute:
(i) the value of the shear stress on BC, **[10]**

(ii) the magnitude and nature of the direct stress on AC, **[5]**
(iii) the principal stresses **[5]**

Question Three

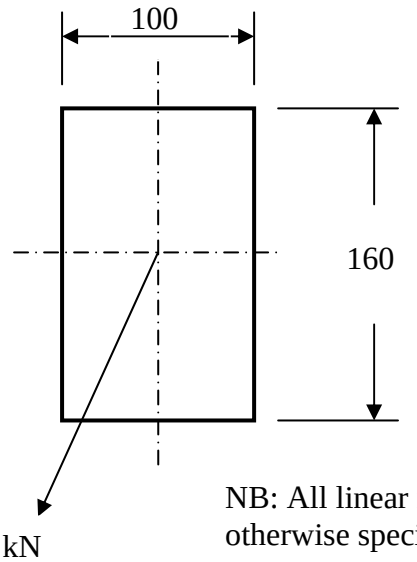
A thick cylinder of external diameter 100 mm and 50 mm internal diameter is wound with steel wire of 1 mm diameter, initially stressed to 20 MN/m^2 until the outside diameter is 120 mm. Determine the maximum hoop stress set up in the cylinder if an internal pressure of 30 MN/m^2 is now applied. **[20]**

Question Four

A thick walled pressure vessel has internal and external radii, respectively, 100 mm and 150 mm. It is subjected to an internal pressure of 60 MN/m^2 and an external pressure of 30 MN/m^2. Determine;
(a) the hoop stress, **[7]**
(b) the radial stresses, at the inside and outside of the vessel; **[7]**
(c) the longitudinal stress if the cylinder is assumed to have closed ends. **[6]**

Question Five

A cantilever beam 2.6 m long, is of rectangular cross-section 160 mm x 100 mm, and is loaded at its free end with a load of 10 kN inclined at an angle of 30^o to the vertical as shown in figure Q5 below. Determine;
(i) the position of the greatest tensile stress in the section. **[8]**
(ii) the magnitude of the greatest tensile stress in the section. **[7]**
(iii) What will be the vertical deflection at the end? **[5]**
Consider E = 210 GN/m^2



NB: All linear measurements in mm unless otherwise specified

Figure Q5

Question Six

A horizontal strut 4 m long is constructed from rectangular section steel, 80 mm wide by 100 mm deep and is mounted with pinned ends. The structure carries an axial load of 240 kN together with a uniformly distributed load of 10 kN/m on its full length.
If E = 200 GN/m^2;
(a) determine the maximum stress set up in the strut, **[10]**

(b) check the result using the approximate Perry method with $M_{\max} = M_0\left[\frac{P_e}{P_e - P}\right]$, **[10]**

(c) Comment on the results. **[5]**

Question Seven

A rectangular steel bar 0.025 m wide and 0.038 m deep is subjected to a torque of 0.45 kNm. Using the experimentally derived formulae estimate;
(a) the maximum shear stress set up in the material of the bar **[6]**
(b) the angle of twist **[6]**
(c) What percentage of error would be involved in each case, (a) and (b), if the approximate equations are used? **[8]**
G = 80 GN/m^2 for steel

End of Examination!!!