THE INSTITUTION OF ENGINEERS, SRI LANKA

PART I EXAMINATION – March 2008

103 PROPERTIES & STRENGTH OF MATERIALS

Time Allowed: 3 hours

Answer **Five (5)** questions selecting at least two (02) from each of the two sections **A and B.**

Use separate answer books for each section.

SECTION A

Q.1

a. Sketch the iron-cementite equilibrium phase diagram. [*10 marks*]

b. Using this diagram describe the microstructures that result from the following procedures. You are expected to include the name, chemical composition and amount of phases present in each case.

(i) 1.0% carbon steel held at 1200^0C for 2 hours

(ii) 0.8% carbon steel slowly cooled from 1000^0C to room temperature

(iii) 0.6% carbon steel slowly cooled from 1200^0C to room temperature

(iv) 0.6% carbon steel rapidly quenched from 1200^0C to room temperature

[10 *marks*]

Q.2

a. Calculate the amount of energy released by 1kg of uranium-235 due to the fission reaction by neutron bombardment. Relative atomic masses of uranium, neutron, lanthanum and bromine are 235.1, 1.009, 148 and 84.9 respectively. Assume that destruction of 1g of mass produces $931 \times 6.023 \times 10^{23}$ MeV of energy.

Take $1eV = 1.6 \times 10^{-19}$ J. [*06 marks*]

b. Draw a schematic diagram to show the salient features of a nuclear reactor.

[*08marks*]

c. Write a short essay on the materials used for the components of a nuclear reactor.

[*06 marks*]

Q.3

a. Derive the Bragg's equation for constructive interference in x-ray diffraction.

[*05 marks*]

b. An X-ray diffractometer recorder chart for an element, which could either have FCC or BCC structure, shows diffraction peaks at the angles of deviation of 40^0, 58^0, 73^0, 86.8^0, 100.4^0 and 114.7^0. The wavelength of the X-ray is 0.154nm.

i. Determine the crystal structure of the element used.

ii. Determine its lattice parameter. [15 *marks*]

Q.4

a. Sketch the tensile stress-strain diagram of pure copper showing its salient features.

[*03 marks*]

b. Explain how the strength, ductility and toughness of the given copper sample could be determined from this diagram? [*06 marks*]

c. Describe the test (other than tensile test) that is widely used to determine the toughness of metals. [*05 marks*]

d. Describe the mechanism of fatigue failure. [*06 marks*]

SECTION B

Q.5

Beam AB is simply supported and has a uniform cross sectional area of 0.06 m^2. The beam is made up of a material having density 24 kN/m^3. It is subjected to two concentrated loads as shown in Figure Q.5.

(i) Calculate the self weight per unit length of the beam. [*04 marks*]

(ii) Find the support reactions due to the applied loading including the self weight. [*04 marks*]

(iii) Draw the bending moment and shear force diagrams. [*12 marks*]

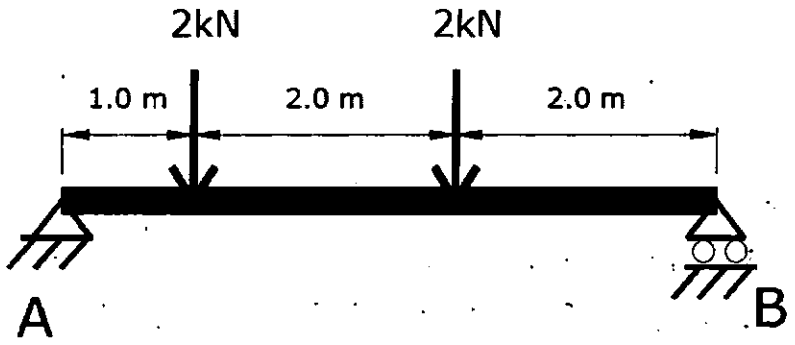

Figure Q.5

Q.6

A uniform cantilever beam AB of length L is fixed at end A and free at end B. The beam has a uniform bending stiffness EI. It carries a point load **P** acting at distance **a** from the fixed end as shown in Figure Q.6.

a. By using Macaulay's method derive an expression for the transverse deflection and rotation at a distance x along the beam. [*14 marks*]

b. Hence show that the deflection at the tip of a tip loaded cantilever is $\frac{PL^3}{3EI}$. [*6 marks*]

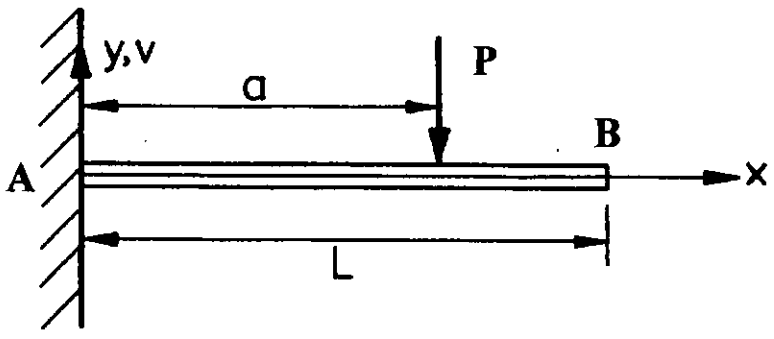

Figure Q.6

Q.7

There is a possibility to use either a box section or an I section for a column. It is necessary to make a comparison by answering following questions.

a. Find the locations of centroid of the box section and I the section shown in Figure Q.7. *[4 marks]*

b. Calculate the second moment areas of both sections about horizontal and vertical axes passing through the centroid. *[12 marks]*

c. Compare their buckling resistance when subjected similar support conditions under equal compressive axial forces. *[4 marks]*

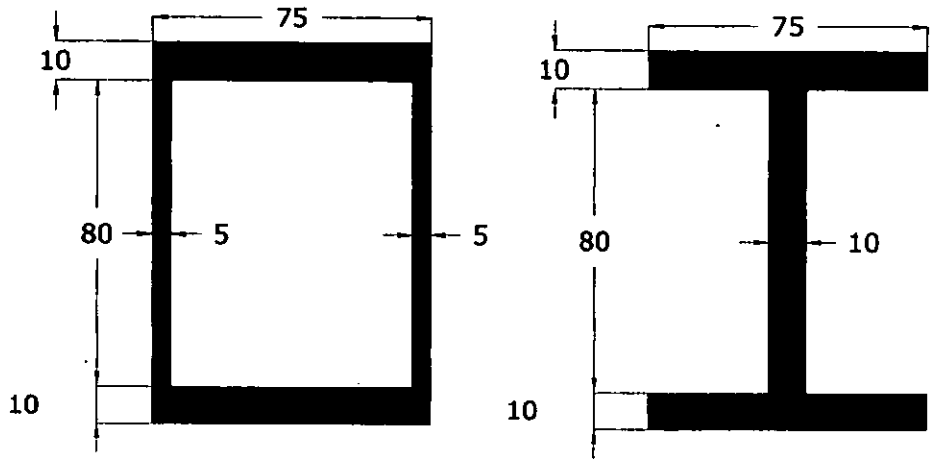

Figure Q.7

(All dimensions are in millimetres)

Q.8

A pressurised cylinder subject to torque has wall stresses as shown in Figure Q.8 (x is the longitudinal direction, and y is the hoop direction). What are the stresses on a face at 30° anti-clockwise to the x-face? You can use either Mohr's circle or equilibrium of the element to derive your answers. [*20 marks*]

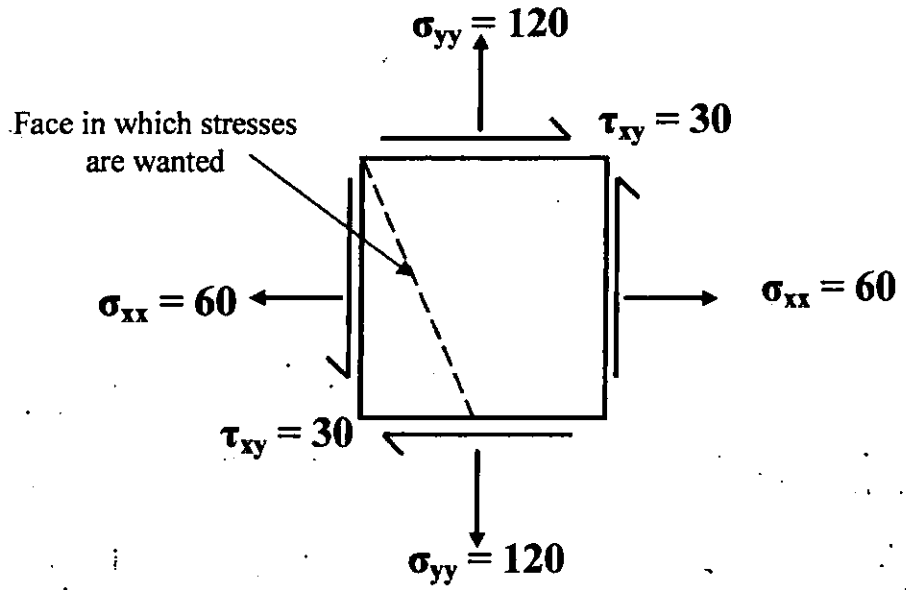

Figure Q.8

(Stresses given are all in N/mm^2)