THE INSTITUTION OF ENGINEERS, SRI LANKA

PART I EXAMINATION – NOVEMBER 2009

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

1) (a) Draw the Mg-Sn phase equilibrium diagram using the information given below using weight percent of tin (Sn%) on the composition axis:

- Mg and Sn form an intermediate compound Mg_2Sn at 71%Sn
- The melting points of Mg, Sn and Mg_2Sn are 650^0C, 230^0C and 800^0C respectively
- There are two eutectic points found in this system
- The eutectic between Mg and Mg_2Sn contains 36%Sn and melts at 560^0C
- The eutectic between Sn and Mg_2Sn contains 98%Sn and melts at 200^0C
- Magnesium rich phase 'α' contains a maximum of 15%Sn at 560^0C and the solubility of Sn in Mg decreases to zero at 200^0C
- Magnesium is insoluble in tin in solid state [15marks]

(b) Sketch the microstructure of the Mg-36%Sn alloy at 200^0C and calculate the relative proportion of the 'α' phase in this alloy. [05marks]

2) Figure Q.2 shows all the locations of the void spaces available in an FCC unit cell. These spaces are named as *octahedral interstices* and located at the center of each edge as well as at the body-center of the unit cell as shown.

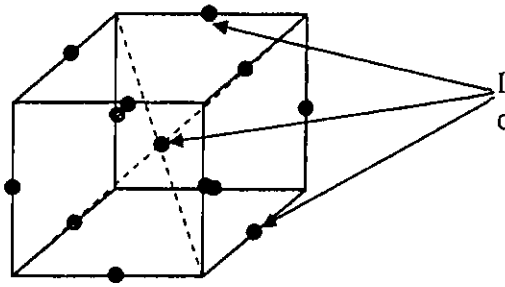


Figure Q.2

a. Find the diameter of the largest foreign atom that can occupy one of these interstices. Take the lattice parameter as 'a'. [8 marks]

b. If all these void spaces are completely occupied by foreign atoms (that just fit in), how many such atoms will be there in a single unit cell? [4 marks]

c. What fraction of the volume will be filled with parent atoms and foreign atoms together in this lattice? [8 marks]

3) a. With the aid of suitable examples describe the process of nuclear fission. [04marks]

b. What is meant by *fission chain reactions*? [03marks]

c. 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 [08marks]

d. One radioactive isotope declines in intensity from 150*Ci* to 20*Ci* in 79.2 hours and another from 500m*Ci* to 60m*Ci* in 108 hours. Will their intensities ever become equal? If so, when? [05marks]

SECTION B

(5) Figure Q.5 shows a Beam ABC, supported at A (hinged) and B (roller) and has a uniform cross sectional area of 0.08 m^2. The beam is made up of a material having density 24 kN/m^3. It is subjected to three concentrated loads as shown in Figure Q.5.

a. Calculate the self weight per unit length of the beam. [2 marks]

b. Find the support reactions due to the applied loading including the self weight. [6 marks]

c. Draw the bending moment and shear force diagrams. [12 marks]

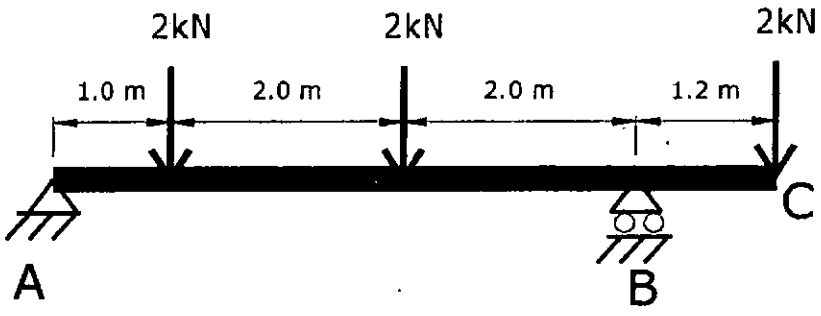


Figure Q.5

(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. By using Macaulay's method, derive an expression for the transverse deflection and rotation at a distance x along the beam. Hence find the rotation at the tip of a tip loaded cantilever. [20 marks]

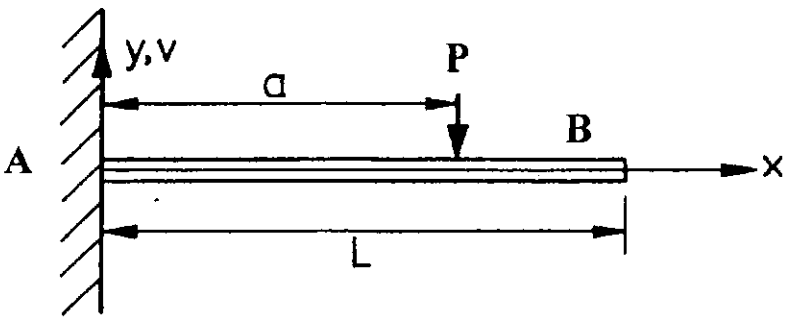
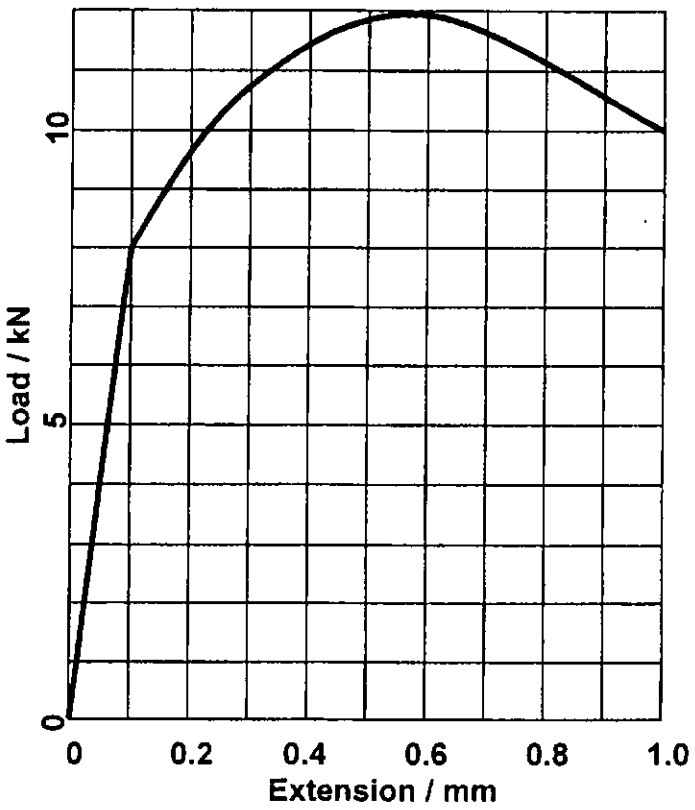


Figure Q.6

4) Use the force-extension diagram given below to determine the following. The spec
used to obtain this force-extension diagram had 25mm gauge length and 5mm diameter.

a. Yield stress of the material
b. Elastic modulus
c. 1% Proof stress
d. Ultimate tensile strength
e. Work done during elastic deformation [20marks]



(20)

(7) A cross section of a beam is shown in Figure Q.7. At the section considered, the shear fo has been calculated as 10 kN. Sketch the shear stress distribution across the beam indicating important values. [20 marks]

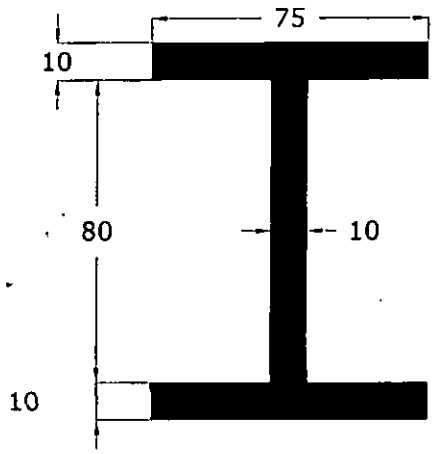


Figure Q.7

(8) An initially straight pin-ended strut is loaded by a force P applied at an eccentricity e, which represents a misalignment between the strut and the load. It is designed to carry the loads as shown in Figure Q.8.

a. Why a small error in the load position is of importance when dealing with struts and columns, and less important when dealing with beams loaded primarily in flexure? [5 marks]

b. By considering a deflection of the strut, v, measured from the undeformed position, derive the governing differential equation for the deflection. [7 marks]

c. Show that the solution of this differential equation takes the form

$$v = A\sin\alpha x + B\cos\alpha x + C$$

What are the coefficients A, B, C and α? [8 marks]

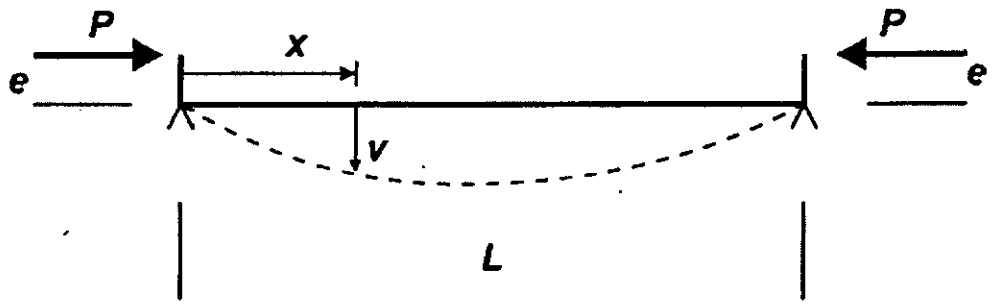


Figure Q.8