THE INSTITUTION OF ENGINEERS, SRI LANK

IESL ENGINEERING COURSE

PART I EXAMINATION – MARCH / APRIL 2006

103 Properties & Strength of Materials

Time allowed : 3 hours

Answer **FIVE (05)** 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. Using the information given below, sketch the aluminium-silicon phase diagram taking percentage by weight of silicon on the composition axis:

- It is a eutectic system
- The melting point of pure aluminium is 650^0 C
- The melting point of silicon is 1400^0 C
- Aluminium is insoluble in silicon
- The eutectic temperature is 580^0 C
- The eutectic composition is 20% by weight of silicon
- The aluminium-rich phase (α) is a solid solution of silicon in aluminium
- Maximum solubility of silicon in 'α' is 5% by weight at 580^0 C
- Solubility of silicon in 'α' falls to zero at 500^0 C [12marks]

b. Sketch the microstructure of the eutectic alloy at 575^0 C and estimate the proportion of pure silicon in this alloy at this temperature. [08marks]

2)

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

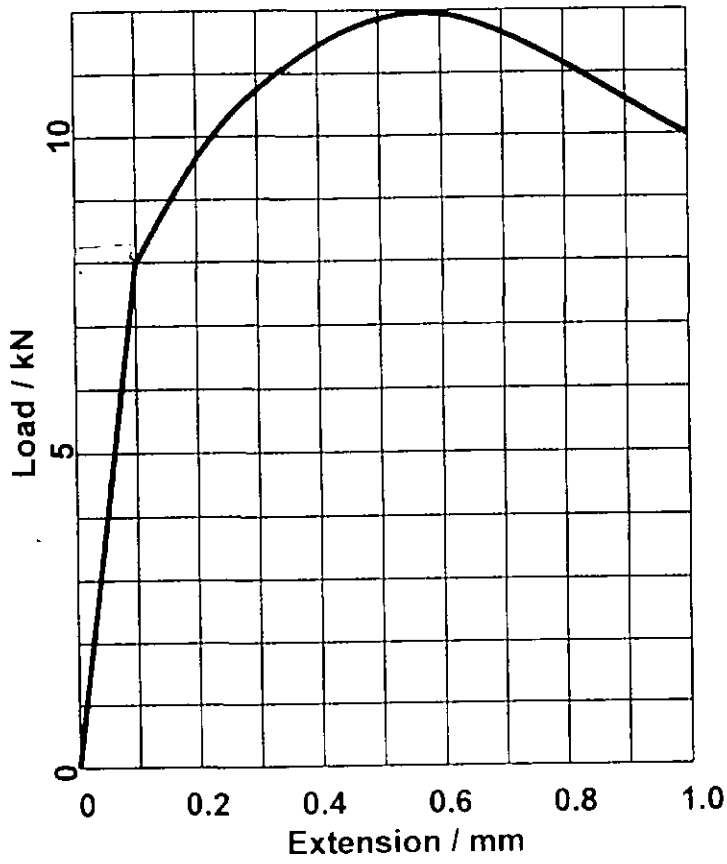
b. What is meant by *fission chain reactions*? [03marks]

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]

3) Use the force-extension diagram below to determine the following. The speci… 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*]



4)

a. Polonium has relative atomic mass of 210 and crystallizes in simple cubic structure. Find the lattice constant of Polonium if it's density is 9.4 g/cm^3. [05marks]

b. What is the planar density of (110) plane of Polonium lattice? [03marks]

c. Describe how silicon intrinsic semiconductor is converted to n-type and p-type extrinsic semiconductors. [12marks]

SECTION – B
STRENGTH OF MATERIALS

Question 5.

A simply supported beam carries concentrated loads at B and C and a uniformly distributed load of 1 kN/m over the length CD as shown in the Figure Q5. below.

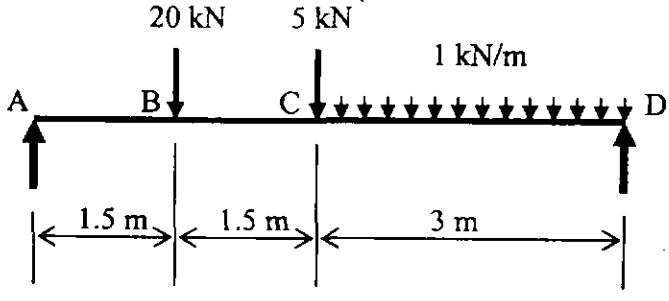


Fig. Q.5.

(a) Using principle of superposition or any other method of your choice, draw the bending moment diagram for the beam.

(b) Draw the shear force diagram and find the position of the maximum shear force.

Question 6.

(a) A simply supported beam of length l is carrying a uniformly distributed load w over its span as shown in Fig. Q6 below. Find the central deflection of the beam under this loading system.

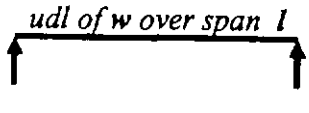


Fig. Q.6.

Question 7.

A solid circular steel shaft of 25 cm diameter is to be replaced by a hollow shaft with ratio of the external to internal diameters, 2 to 1.

a) Find the size of the hollow shaft if the maximum shearing stress is to be the same as for the solid shaft.

b) If the cost of steel is proportional to the mass of steel what is the percentage saving in cost by the change?

c) If G is 80 GN/m^2, with a maximum shearing stress of 80 MN/m^2, what would be the twist in the new shaft at a 10 m length at 110 rpm?

Question 8.

"Strain rosettes such as the one illustrated in Fig. Q8 are commonly used to measure the direct strains and stresses induced on materials under practical loading conditions. Each of the three strain gauges indicated in the figure are lengths of wires glued to the surface of the material on which the strain measurements are to be taken. As the material is stressed, the wires will undergo stretching resulting in a change of their electrical resistance, which can be measured using a Wheatstone bridge. The change in resistance can then be translated to indicate the strain in each of the three directions".

On one such experiment using the strain rosette shown the strains measured in the three directions A, B and C were found to be ε_a, ε_b and ε_c.

Assuming

$$\varepsilon = \frac{1}{2}(\varepsilon_1 + \varepsilon_2) + \frac{1}{2}(\varepsilon_1 + \varepsilon_2)\cos 2\theta,$$

Where; ε_1 & ε_2 are strains in principal directions,

θ is the angle between directions of ε_1 and ε measured anti-clockwise from ε_1,

ε is the strain in any arbitrary direction as described by the angle above.

Show that the principal directions of the given strain system can be indicated with respect to the direction A, by an angle α, where;

$$\tan 2\alpha = \frac{(\varepsilon_a - 2\varepsilon_b + \varepsilon_c)}{(\varepsilon_a - \varepsilon_c)}$$

Also show that the sum of two mutually perpendicular normal (direct) strains is a constant.

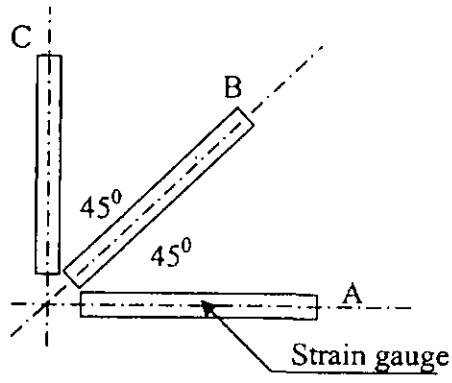


Fig. Q.8.