2022

MECHANICAL ENGINEERING

PAPER-I

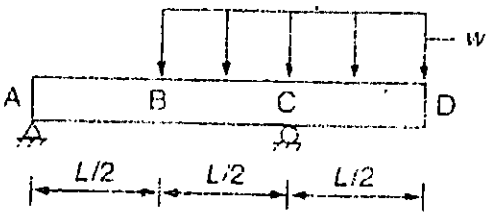
Time Allowed — 3 Hours *Full Marks — 200*

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

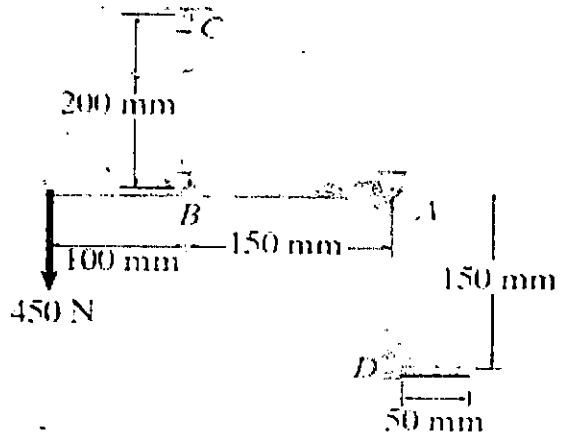
*Answers may be given either in **English** or in **Bengali** but all answers must be in one and same language.*

Answer any five questions

1. (a) Draw the shear force and bending moment diagrams for a simply supported beam with overhang loaded as shown in figure below.



(b) The rigid link is supported by a pin at A, a steel wire BC having an unstretched length of 200 mm and cross-sectional area of 22.5 mm^2 and a short aluminium block having an unloaded length of 50 mm and cross-sectional area of 40 mm^2 as shown in figure. If the link is subjected to the vertical load shown, determine the rotation of the link about the pin A. Modulus of elasticity of steel, E_{st} = 200 GPa and Modulus of elasticity of aluminium, E_{al} = 70 GPa.



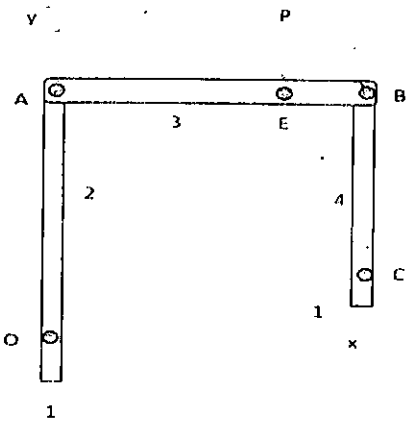
(c) Show that, in a general two-dimensional stress system

(i) Sum of normal stresses in any two mutually perpendicular directions is constant.

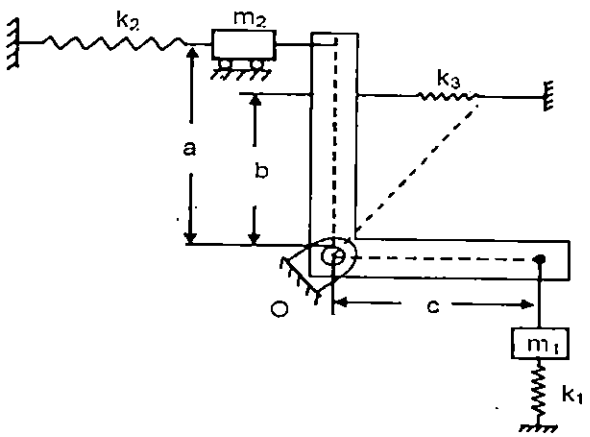
(ii) Principal planes are planes of maximum normal stresses also.

20+10+10=40

2. (a) For the four-bar linkage in the position illustrated in figure below, a vertical load 'P' is acting at point 'E' on the horizontal coupler link '3', (i.e., link is parallel to the 'X'-axis). The coupler link is pinned to the vertical side links '2' and '4' at points 'A' and 'B'. The links are made of a steel alloy with a compressive Yield strength σ_{ys}= 410 MPa and a modulus of elasticity 'E'= 207GPa. The side links have hollow circular cross-sections with 50 mm outside diameters and 6.25 mm wall thicknesses. Assume that the value for the end-condition constant for both side links is 'C'=1. The known link lengths are 'R_{AO}' = 2.4 m, 'R_{BA}' = 1.8 m, 'R_{BC}' = 1.5 m and 'R_{EA}' = 1.2 m. Determine (i) the radii of gyration for links '2' and '4', (ii) the values of the slenderness ratios for links '2' and '4' and at the point of tangency between Euler's column formula and Johnson's parabolic equation, (iii) the critical loads for links '2' and '4', and (iv) the maximum value of load 'P' if the factors of safety guarding against buckling for links '2' and '4' are both specified as N=2.



(b) Figure below shown is an indicator mechanism. The bell crank arm is pivoted at *O* and has mass moment of inertia 'I'. Find natural frequency of the system.



30+10=40

3. (a) A 200 mm wide x 22 mm thick strip of metal is fed through a pair of powered rolls to reduce its thickness to 18 mm in one pass. The rolls are of 500 mm diameter and rotating at 60 rpm. If the coefficient of friction between the rolls and the work material is taken as 0.15, determine whether or not the rolling operation is possible. If it is possible, calculate the roll force. Assume average flow stress, σ as 150 MPa.

(b) A strip of brass 200 mm wide and 20 mm thick is rolled at room temperature to a thickness of 16 mm in a single pass. The roll radius is 300 mm and the rolls rotate at 120 rpm. Taking the true stress of brass in the unstrained condition as 200 MPa and in the strained condition as 300 MPa, Calculate the roll force required. How much will be the torque on the roll? Also determine the power requirement.

20+20=40

Contd...P3

4. (a) Using an open-die forging operation, a solid cylindrical piece of stainless steel having 100 mm dia x 72 mm height is reduced in height to 60 mm at room temperature. Assuming the coefficient of friction as 0.22 and the flow stress for this material at the required true strain as 1000 MPa, calculate the forging force at the end of hammer stroke.

(b) A billet of metal 800 mm long x 150 mm diameter is to be extruded into a cylindrical component. Direct extrusion process is to be used. If the estimated extrusion ratio is 4.0 and average flow stress experienced by the metal during deformation is 100 MPa, calculate the true strain and the force necessary for the extrusion process. State any assumption made.

(c) A company that operates for 50 weeks in a year is concerned about its stocks of copper cable. This costs Rs 240 a meter and there is a demand for 8,000 meters a week. Each replenishment costs Rs 1,050 for administration and Rs 1,650 for delivery, while holding costs are estimated at 25 per cent of value held a year. Assuming no shortages are allowed, what is the optimal inventory policy for the company? How would this analysis differ if the company wanted to maximize its profits rather than minimize cost? What is the gross profit if the company sells the cable for Rs 360 a meter?

10+10+20=40

5. (a) State the effect of electrolyte concentration on metal removal rate in Electrochemical machining process.

(b) For machining a metallic sheet in EDM, the charging capacitance is 15 microfarad and gap voltage is 130 volts. Calculate the surface roughness value of the machined surface is K is considered as 4.

(c) In a RC type pulse generator, the maximum charging voltage is 100 volts and charging capacitance is 100 microfarad. Determine the sparking energy between the electrodes.

(d) During EDM drilling process of a 15 mm diameter hole in 6 mm thickness plate, brass tool electrode is used and kerosene dielectric was utilised. The resistance and capacitance in the relaxation circuit used as 50 Ω and 20 μF. The supply voltage given is 150 V and the discharge gap is so maintained that discharge takes place at the condition of maximum power delivery to the discharging circuit. Considering constant K to be 0.18, determine the volumetric material removal rate and approximate cycle time.

10+6+6+18=40

6. (a) What would be the crystal structure of an alloy if the density of the alloy is 11270 Kg/m^3, the atomic weight is 184.4 g/mole and the radius of an atom is 0.146 nm.

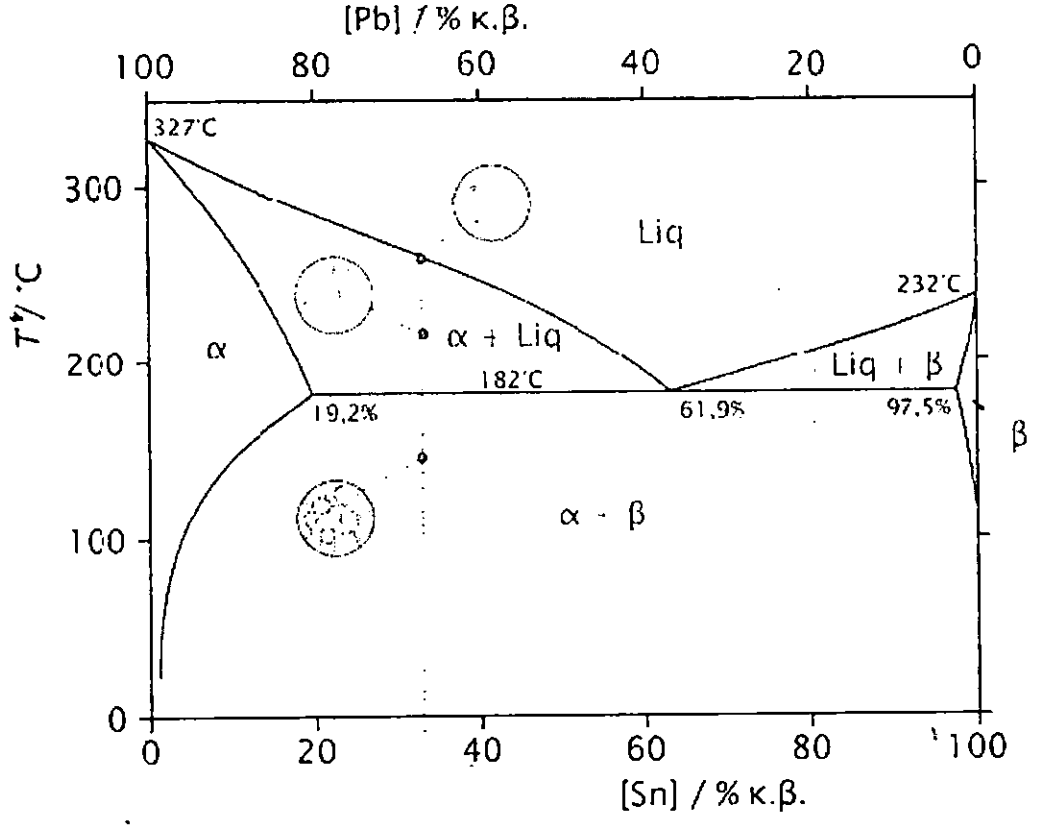
(i) SC (ii) FCC (iii) BCC

Explain the reason behind your choice.

(b) The yield strength of a polycrystalline material increases from 115 MPa to 215 MPa if average grain diameter decreases from 0.04 mm to 0.01 mm. find the yield strength of the material if grain size number is ASTM 9.

20+20=40

7. (a) A crucible contains 1 Kg of an alloy of composition 90% Tin and 10% Lead at a temperature just above the Eutectic Temperature. Calculate the amount of tin to be added to the crucible to completely solidify the alloy without changing the system temperature. Pb-Sn phase diagram is given below:



(b) Plot Fe-Fe_3C phase diagram and determine the amount of different phases in SAE 1050 steel at
(i) Just above A3 Critical Temperature
(ii) Just above A1 Critical Temperature
(iii) Just below A1 Critical Temperature
(iv) Room Temperature considering very slow cooling

(c) What is strain hardening? Give the reasons of strain hardening.

15+15+ 10=40