# MECHANICAL ENGINEERING

## PAPER - II

*Time Allowed: 3 hours* *Maximum Marks: 200*

*Candidates should attempt Question 1 in Section 'A' which is compulsory, TWO questions from Section 'B' and TWO questions from Section 'C'.*

*Question 1 is of short answer type, limiting answer of each part to 30 words. Assume suitable data, if necessary and indicate the same clearly.*

## SECTION A

1. (a) What do you mean by alloy steel ? Write effects of following alloying elements on steel

   (i) Nickel

   (ii) Chromium

   (b) Illustrate the graphical comparison of following theories of failures for two-dimensional stress system

   (i) Maximum normal stress theory

   (ii) Maximum shear stress theory

   (iii) Distortion energy theory

   (c) What do you understand by backlash in gears ? Along which circle is it measured? How can we change backlash during mounting of gears ?

   (d) Why is gear finishing done ? Explain 'gear shaving' and 'gear furnishing' finishing operations.

   (e) Explain the pressure angle of cam. Why is high value of pressure angle not preferred?

   (f) What do you understand by 'Selective Assembly' process? How is the range of clearance reduced?

   (g) Explain good 'gating design' in molding. What are its advantages ?

   (h) The torque developed by an engine is given by the equation given below :

   $T = 14250 + 2200 \sin 2\theta - 1800 \cos 2\theta$

   where 'T' is the torque in N-m and $\theta$ is the crank angle displacement from inner dead centre position. Determine the mean torque.

   (i) What do you mean by 'autogeneous' and 'homogeneous' welding processes?

   Metallurgically name the three distinct zones in a welded part. Enumerate the most important factors governing the fusion welding process.

   (j) Explain 'batch model' and 'mixed model' assembly lines. Enumerate the advantages of 'mixed model' assembly line over 'batch model' assembly line.

   (k) Define 'value'. Differentiate between 'value engineering' and 'value-analysis'. State various phases of value-analysis job plan.

   (l) Illustrate the following probability distributions schematically and specify their applications:

(i) Normal

(ii) Weibull

(iii) Exponential

(m) What do you understand by degree of freedom of planer mechanism ? State the Gruber's Equation to find the d.o.f. of a mechanism.

(n) (i) Explain Lower pairs and Higher pairs.

(ii) What will be the number of inversions in a kinematic chain having 'n' links ?

(iii) State whether the helical gears which are in contact are a 'higher pair' or 'lower pair'.

(o) What is 3 – 2 – 1 principle of location with respect to fixture design? Explain.

(p) A hollow cylinder C.I. column, 3 m long has its internal and external diameters as 80 mm and 100 mm respectively. Calculate the safe load using Rankine Formula; is

(i) both ends are hinged and

(ii) both ends are fixed. Take crushing strength of material as 600 $N/mm^2$, Rankine constant 1/1600 and factor of safety 3.

(q) How do the slacks in PERT and floats in CPM decide on selection of critical path ?

(r) Draw sketch showing various angles of single point cutting tool for turning aluminium alloys.

(s) What is meant by 'interpolation in CNC programming' ? What for are 'G' and 'M' codes used in NC part programming?

(t) Draw a flow chart to compute crippling load for column with different end conditions.

Euler's equation for crippling load is $P_{cr} = \frac{\pi^2 EI}{l^2}$

$l = L$ for both ends hinged

$l = 2L$ for one fixed and the other free

$l = \frac{L}{\sqrt{2}}$ for one end fixed and one end hinged

$l = L/2$ for both ends fixed

## SECTION B

2. (a) A simply supported beam of length 10 m carries a uniformly varying load whose intensity varies from a maximum value of 5 kN/m at both ends to zero at the centre of the beam. It is desired to replace the beam with another simply supported beam which will be subjected to the same maximum 'Betiding Moment' and 'Shear Force' as in the case of the previous one. Determine the length and rate of loading for the second beam, if it is subjected to a uniformly distributed load over its whole length. Draw the variations of 'SF' and 'BM' in both the cases.

(25)

(b) A long strut AS of length $l$ is of uniform section throughout. A thrust P is applied at the ends eccentrically on the same side of the centre line with eccentricity at the end B twice than that at the end A. Show that the maximum bending moment occurs at a distance x from the end A, where

$$\tan kx = \frac{2 - \cos kl}{\sin kl} \text{ and } k = \sqrt{\frac{P}{EI}}$$

3. (a) A full journal bearing operating under a steady load has the following specifications:

(1) Journal diameter : 60 mm

(2) Bearing length : 60 mm

(3) Radial load on bearing : 2·8 kN

(4) Journal speed : 1020 rpm

(5) Radial clearance : 005 mm

(6) Viscosity of oil : $80 \times 10^{-9}$ N-s/mm$^2$

(7) Density of oil : 860 kg/m$^3$

(8) Specific heat of oil : 1·76 kJ/kg-°C

Using Raymonds & Boyd table given at the end of the problem, determine

(i) Summerfield Number

(ii) Power loss in friction

(iii) Temperature rise if heat generated is entirely carried by oil

(iv) Minimum film thickness, and its location

(20)

**Table** – Giving Raymonds & Boyd data for journal bearing for L/D = 1.

| Attitude ε | $h_0/c$ | S | ϕ | $\frac{r}{c}f$ | $\frac{Q}{r\omega_s l}$ | $\frac{Q_s}{Q}$ | $\frac{P}{P_{max}}$ |
|---|---|---|---|---|---|---|---|
| 0 | 1·0 | 00 | 85 | ∞ | π | 0 | – |
| 0·1 | 0·9 | 1·33 | 79·5 | 26·4 | 3·37 | 0·150 | 0·540 |
| 0·2 | 0·8 | 0·630 | 74·02 | 12·8 | 3·59 | 0·280 | 0·529 |
| 0·4 | 0·6 | 0·264 | 63·10 | 5·79 | 3·99 | 0·497 | 0·484 |
| 0·6 | 0·4 | 0·121 | 50·58 | 3·22 | 4·33 | 0·680 | 0·415 |

(b) A car has a three cylinder engine which produces maximum torque of 200 N-m at 2000 rpm. The power is transmitted by a single plate friction clutch of 230 mm outside diameter. Design dimensions of friction surfaces. Further when the car is engaged at a speed of 60 1cm/hi, calculate the clutch slip period (time) during engagement.

Additional data as under:

(i) Engine speed at beginning of clutch engagement : 2000 rpm

(ii) Engine torque at engagement : 100 N-m

(iii) Mass of car (loaded) : 1500 kg

(iv) Wheel diameter: 710 mm

(v) Coefficient of friction : 0·3

(vi) Permissible pressure for friction material : 0·25 N/mm$^2$

(vii) Mass moment of inertia of engine rotating parts, flywheel and driving side of clutch 1·5kg-m$^2$

(viii) Gear reduction at differential : 4·12

(ix) Torque available at the rear wheels : 105 N-m

Uniform wear theory may be used for the clutch plate design.

(20)

4. (a) Define Body Centrode' and 'Space Centrode' for a link in mechanism. Explain how you will find these.

(10)

(b) The crank length of a petrol engine is 50 mm and the connecting rod is 175 mm long and the crank rotates at a uniform speed of 400 rpm. Calculate the velocity and acceleration of the piston at different positions of the piston along its stroke and plot the two curves.

Also find the crank position at which the piston's acceleration becomes zero.

(30)

## SECTION C

5. (a) Enumerate the steps involved in 'Powder Metallurgy' process. Discuss these steps. Name the materials used in 'Powder Metallurgy'. What are the limitations of Powder Metallurgy ?

(10)

(b) What do you understand by forging process ?

Name the typical forging processes. Derive the expression for the maximum force required for forging a flat strip. State the assumptions made. The initial thickness of the work- piece is h and the width is $2l$.

(20)

(c) A strip of lead with initial dimensions 24 mm x 24 mm x 150 mm is forged between two flat dies to a final size of 6mm x 96mm x 150 mm. If the coefficient of friction is 0·25, determine the maximum forging force. The average yield stress of lead in tension is 7 N/mm$^2$.

(10)

6. (a) Mild steel is being machined at a cutting speed of 200 m/min with a tool rake angle of 10°. The width of cut and uncut thickness are 2 mm and 0·2 mm respectively. If the average value of coefficient of friction between the tool and the chip is 0·5 and the shear stress of the work material is 400 N/mm$^2$, determine (i) shear angle and (ii) cutting and thrust components of the machining force.

(10)

(b) Explain the grinding process for the following operations : (i) Roll grinding (ii) Thread grinding, and explain speed, feed and depth of cut as applicable to grinding works.

(10)

(c) Define NC, CNC and DNC. Also explain their developments, and improvements in their applications.

(10)

(d) Prepare a part program for machining a rectangular contour of 200 mm x 100 mm size from a suitable MS blank of 5 mm thickness. Also, a reamed hole of 16 mm has to be made centrally in the rectangular contour. Take speeds and feeds arbitrarily.

(10)

7. (a) A company has factories A, B and C which supply warehouses D, E, F and G. Monthly factory capacities are 180, 170 and 200 units respectively. Monthly warehouses requirements are 90, 100, 120 and 180 units respectively. Unit shipping cost in Rupees are given in the table below, Determine the initial feasible solution using Vogel's Approximation and find the optimum distribution for this company.

(20)

| | | D | E | F | G | Supplies |
|---|---|---|---|---|---|---|
| | A | 44 | 50 | 40 | 39 | 180 |
| Factories | B | 42 | 51 | 54 | 53 | 170 |
| | C | 41 | 40 | 42 | 45 | 200 |
| Requirements | | 90 | 100 | 120 | 180 | |

(b) Draw the PERT network for the activities whose three time estimates are given in the table.

| Activity | Predecessor activity | Optimistic time | Pessimistic time | Most likely time |
|---|---|---|---|---|
| A | - | 1 | 5 | 3 |
| B | - | 2 | 4 | 3 |
| C | - | 3 | 5 | 4 |
| D | A | 2 | 10 | 9 |
| E | C | 4 | 6 | 5 |
| F | B, D, E | 5 | 13 | 6 |
| G | A | 2 | 6 | 4 |
| H | G, F | 0 | 6 | 3 |

From the three time estimates obtain the expected times of all the activities and slacks of all the events. Also find the critical path.

(20)