MECHANICAL ENGINEERING

Paper – I

*Time allowed : **Three** Hours*

*Maximum Marks : **200***

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.*

*Questions no. **1** and **5** are compulsory. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections **A** and **B**.*

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

*Answers must be written in **ENGLISH** only.*

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION A

Q1. (a) Draw the displacement-cam angle and velocity-cam angle diagrams of constant accleration and deceleration of cam-follower profile. What are its limitations ? *8*

(b) Explain the terms : cycle, amplitude, phase angle and natural frequency related to mechanical vibrations. *8*

(c) Describe the Mohr's circle diagram as applied to two-dimensional stress, indicating principal dimensions and angles and what they represent. *8*

(d) What is meant by dislocation ? State different types of dislocations with neat sketches. *8*

(e) Show that the forging load can be estimated using the expression, $P = 1{\cdot}15\ \bar{\sigma}\, A$, where $\bar{\sigma}$ = mean yield stress, A = cross-section area. *8*

Q2. (a) A hoisting drum, carrying a steel wire rope, is mounted at the end of a cantilever beam as shown in Fig. 1. Determine the equivalent spring constant of the system when suspended length of the wire is l. Assume that the net cross-sectional diameter of the wire is d and the Young's modulus of the beam and wire rope is E. *10*

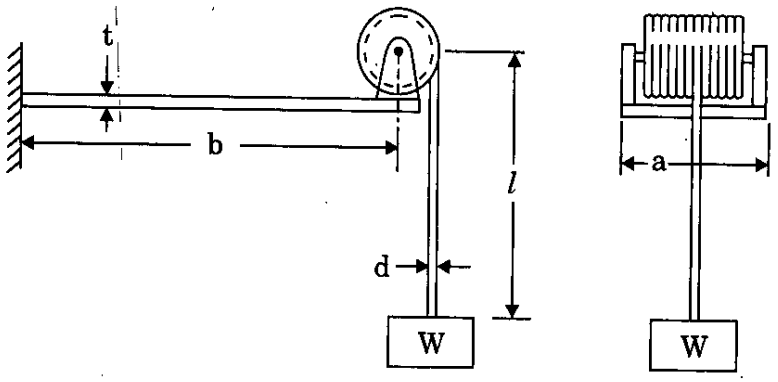

Fig. 1

(b) A simply supported circular beam of diameter D is subjected to a load of W. It is desired to replace this beam by a hollow beam having 80% flexural strength, but with outside diameter D_1 and inside diameter $0{\cdot}5\ D_1$. Compare the weight of both beams for flexural strength, if they are supported over same span. *10*

(c) The total sleeve movement in a spring controlled Hartnell governor is 30 mm. The mass of rotating balls is 1·4 kg each. At the mid-position of the sleeve, the sleeve arm, which is 65 mm long, is horizontal. The ball arm is 75 mm long. The balls rotate at a radius of 100 mm when the sleeve is at mid-position. Due to the wrong adjustment of spring, the top speed of the governor is 422 rpm and that corresponding to the lower position is 435 rpm. Determine

(i) the stiffness of the spring, and

(ii) the required initial compression of the spring to give an equilibrium speed at the topmost position which is 12 rpm more than at the lowest position, if the sleeve mass is neglected. Neglect the effect of obliquity of arms. *20*

Q3. (a) A flat belt drives a pulley having angle of lap of 115° and coefficient of friction of 0·3 between belt and pulley. The belt is made of neoprene rubber of density 900 kg/m^3 and is 86 mm wide and 6 mm thick. The maximum stress which the belt can sustain without deformation is 2 MPa. If the belt is used to drive a 100% efficient generator, what will be the power output of the generator and at what speed of the belt ? *10*

(b) It is proposed to balance 50% of the reciprocating masses in a single cylinder reciprocating engine, which is rotating at 150 rpm. The masses of revolving and reciprocating parts are 30 kg acting at crank radius and 40 kg respectively. If the stroke is 350 mm, find

(i) the balance mass required at a radius of 320 mm, and

(ii) the unbalanced force at the crank position of 45° from the dead centre.

Take acceleration due to gravity, g = 9·80 m/s^2. *10*

(c) A shaft S_1 has two interconnected gears A and B mounted on it. The gear A is in mesh with gear C mounted on shaft S_2. Gear D is mounted on shaft S_3, which is co-axial to shaft S_2. Gears B and D are in mesh. The module of connected gears A and C is 2 mm and that of B and D is 3 mm. The speed of the shaft S_3 is approximately less than 1/12 (one-twelfth) of that of shaft S_2. The number of teeth on pinions B and C are 24 each. Find the

(i) suitable number of teeth on gears, pinions,

(ii) actual velocity ratio, and

(iii) distance between shafts S_1 and S_2. *20*

Q4. (a) Write briefly on grey cast iron and white cast iron. *10*

(b) What is annealing ? Explain the following terms :

(i) Full annealing

(ii) Process annealing

(iii) Stress-Relief annealing *10*

(c) Explain the following structures :

(i) BCC

(ii) FCC

With the help of examples, bring out the essential differences in properties and applications of two materials which have BCC and FCC structures. What is the name assigned to the materials which change their structure from BCC to FCC ? *20*

SECTION B

Q5. (a) (i) What are the important constituents of linear programming ?

(ii) State the assumptions to be made in formulation of a problem in linear programming. *8*

(b) (i) Differentiate value-analysis and value engineering.

(ii) State different phases of value-analysis job-plan and explain any one of them. *8*

(c) What are the effects of lowering the friction at the tool-chip interface (with lubricant) on the mechanics of cutting operations ? *8*

(d) In an orthogonal cutting operation, the following data have been observed :

Uncut chip thickness = 0·128 mm

Width of the cut = 6·36 mm

Cutting speed = 2·0 m/s

Rake angle = 10°

Cutting force = 568 N

Thrust force = 228 N

Chip thickness = 0·228 mm

Find shear angle, friction angle and cutting power. *8*

(e) Using Taylor equation for tool life, and assuming n = 0·5 and C = 400, calculate the percentage increase in tool life when the cutting speed is reduced by 50%. *8*

Q6. (a) Name and discuss the factors that contribute to the formation of

(i) discontinuous chip

(ii) chips with built-up edge *10*

(b) (i) Draw the velocity diagram in cutting zone and prove that

$$\frac{V_s}{V} = \frac{\cos \alpha}{\cos(\phi - \alpha)}$$

where, V : cutting velocity

V_s : shear velocity

α : rake angle

ϕ : shear angle

(ii) Why is it not always advisable to increase the cutting speed in order to increase the production rate ? *10*

(c) With the help of sketches, explain the following terms related to rolling of sheet metal :

(i) Angle of bite

(ii) Neutral plane

(iii) Draught

(iv) Camber *20*

Q7. (a) For a particular product, the following information is given :

Selling price per unit : ₹ 100

Variable cost per unit : ₹ 60

Fixed costs : ₹ 10,00,000

Due to inflation, the variable costs have increased by 10% while fixed costs have increased by 5%. If the break-even quantity is to remain constant, by what percentage should the sales price be increased ? *10*

(b) A manufacturing company purchases 9,000 parts of a machine for its annual requirement, ordering one month's requirement at a time. Each part costs ₹ 20. The ordering costs are ₹ 15 per order and the carrying costs are 15% of the average inventory per year. Suggest a more economic purchasing policy for the company. What will be your advice and how much would it save the company per year ? *10*

(c) Arrivals at a telephone booth are considered to be Poisson distributed with an average time of 8 minutes between one arrival and the next. The length of phone call is assumed to be distributed exponentially with mean 3 minutes.

(i) What is the probability that a person arriving at the booth will have to wait ?

(ii) What is the average length of the queue that forms from time to time ?

(iii) What is the probability that it will take him more than 12 minutes altogether to wait for the phone and complete his call ? *20*

Q8. (a) Explain laser beam machining process with the help of a figure. Mention hole depth-to-diameter ratio, energy density and application. *10*

(b) (i) Explain the springback effect in sheet metal forming.

(ii) What are the advantages and limitations of high energy rate forming (HERF) process ? *10*

(c) Explain Merchant's force diagram for orthogonal cutting.

A steel work piece is machined with orthogonal cutting using a tool of 10 degree rake angle. The chip thickness ratio is 0·31. The vertical and horizontal cutting forces are 1200 N and 650 N respectively. Using Merchant's theory,

(i) Calculate the work done in cutting of metal to overcome friction and shear stress.

(ii) Give assumptions made, if the depth of cut is 2 mm and feed is 0·20 mm/revolution, the cutting speed is 200 m/minute.

(iii) Calculate the total work done. *20*