

MECHANICAL ENGINEERING (Paper I)

Time Allowed : Three Hours	Maximum Marks : 300
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QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:

- (a) (i) Define pressure angle for a cam follower mechanism. Explain its importance in the design of cam profile. (ii) A plate cam drives a radial translating follower with cycloidal motion at 1000 rpm. Rise and return strokes are each 120° with two equal dwells. Follower is retained against the cam by a compression spring with a scale of 15 N/mm. Spring is compressed by 2.5 mm in assembly to provide an initial load. For a rise of 10 mm and a follower mass of 1.8 kg, compute the radial component of the cam force and the cam shaft torque at a point located at 100° in the ascending stroke. **20**
- (b) A machine, of mass 17 kg, is mounted on a spring having stiffness 1 N/mm. A piston within the machine of mass 2 kg has a reciprocating motion with a stroke of 75 mm and a speed of 5000 rpm. Assuming the motion to be SHM, determine: (i) amplitude of motion of the machine. (ii) force transmitted to the ground. Damping ratio may be taken as 0.20. **20**
- (c) (i) Under which condition of the state of stress at a point in the two dimensions, the Mohr's circle will be reduced to a point? (ii) How much change in volume would a 100 mm side cube of steel will have when it is kept at a depth of 2 km in sea water? Assume specific gravity of sea water equal to 1.02, modulus of elasticity equal to 2.08 GPa and Poisson's ratio equal to 0.29. **20**
- (d) (i) With the help of a neat sketch, explain the following terms: Crystallographic axes, Primitives and Interfacial angles. (ii) Compare BCC and FCC structures. (iii) What is solid solution? Explain with the help of neat sketches the different types of solid solutions. **20**

2. (a) (i) Explain the concept of controlling force in connection with a centrifugal governor and state its importance in determining the stability of a centrifugal type governor. (ii) In a spring loaded governor of Hartnell type, the mass of each ball is 1 kg. The length of the vertical arm of the bell crank lever is 100 mm and that of horizontal arm is 50 mm. The distance of the fulcrum of each bell crank lever is 80 mm from the axis of rotation of the governor. The extreme radii of rotation of the balls are 75 mm and 112.5 mm. The maximum equilibrium speed is 5 per cent greater than the minimum which is 360 rpm. Find initial compression of the spring and mass of the sleeve neglecting obliquity of the arms. Also find the equilibrium speed corresponding to the radius of rotation equal to 100 mm. **30**
- (b) (i) What is creep of belt in a belt drive? Explain it with the help of a neat sketch. (ii) A leather belt 100 mm wide and 10 mm thick is transmitting power at 1000 m/min. The net driving tension is 1.8

times the tension on the slack side. If the safe permissible stress on the belt section is 1.6 N/mm^2 , calculate the maximum power that can be transmitted at this speed. Assume the density of leather equal to 1000 kg/m^3 . **30**

3. (a) A steel bolt of diameter 1.8 cm passes coaxially through a copper tube of inner diameter 2 cm and outer diameter 3 cm. The length of the tube is 50 cm. Washers are placed at both ends of the tube. The bolt has threads at one end having pitch equal to 0.24 cm. The nut is turned on the bolt through 45° against the washer to tighten the assembly. Determine the stress developed in the bolt and the tube. Assume the modulus of elasticity of steel to be $2 \times 10^5 \text{ N/mm}^2$ and modulus of elasticity of copper is half that of steel. **20**
- (b) The section of a beam is square of 10 cm side with one diagonal vertical. It is subjected to a transverse shear force of magnitude F. Determine the problem of the layer at which the transverse shear stress is maximum. **20**
- (c) A solid circular steel shaft is encased in a hollow copper shaft so as to make a compound shaft. The diameter of the steel shaft is 8 cm and the outside diameter of the copper shaft is 11 cm. The compound shaft of length 2 m is subjected to an axial torque of 8 kNm. Determine the maximum shear stress in steel and copper. Given $G_{\text{steel}} = 2 G_{\text{copper}} = 80 \text{ kN/mm}^2$. **20**
4. (a) Explain the method of controlling the grain size in a polycrystalline material. **15**
- (b) What do you mean by 'stellite'? What are the important properties possessed by this material? Write down the uses of stellite in the engineering applications. **15**
- (c) How are plastics broadly classified? What are the advantages and disadvantages of plastic materials? **10**
- (d) What is tempering of steel? How is it carried out? Differentiate between Cyaniding and Nitriding. **2**

SECTION 'B'

5. Answer any three of the following:
 - (a) What is 3-2-1 principle of location? What are the various degrees of freedom for a body in space? Distinguish between a Jig and a Fixture. **20**
 - (b) What is ultrasonic machining? Draw a neat sketch showing the important parts of an ultrasonic machine, label the parts. Which materials are normally machined using ultrasonic machining? **20**
 - (c) The store of an oil engine repair shop has ten items whose details are shown in Table below. Apply ABC analysis to items of store. Does it satisfy principle of ABC analysis? **20**

Part Code	Description	Price Per Unit Rs.	Units/year
P01	Packing stud	100	100
P02	Tower bolt	200	300
P03	Hexagonal nut	50	700
P04	Bush	300	400
P05	Couplings	500	1000
P06	Big Bearings	3000	30
P07	Small Bearings	1000	100
P08	Fuel Pump	7000	500
P09	Fixture	5000	105
P10	Drill bit	60	1000

- (d) (i) With a neat sketch briefly explain organization of digital computer. (ii) Write down the general structure of a logical IF statement in modern FORTRAN language. (iii) Differentiate between a function sub programme and sub-routine. **20**

6. (a) What is the difference between laser welding and plasma welding? Draw a neat sketch of a plasma torch, label the various parts. **30**

- (b) Derive an equation for the average die pressure in open die forging of a circular disc. Explain the assumptions made in deriving the equation. The solution may be found only for the sliding condition of friction. **30**

7. (a) Four different castings are to be machined on four machines, one casting on each machine, because set-up cost and time are too high to permit a casting being worked on more than one machine. Table below shows time of machining each casting on each machine. Assign the jobs on machines and show that the problem is multi-optimal solutions. Obtain sequential solution. **30**

Casting	M_1	M_2	M_3	M_4
C_1	10	14	22	12
C_2	16	10	18	12
C_3	8	14	20	14
C_4	20	8	16	6

- (b) Following data refers to gas pipe project: **30**

Activity	Predecessor	Optimistic time, a (weeks)	Most likely time, m (weeks)	Pessimistic time, b (weeks)
A	—	3	5	8
B	—	6	7	9
C	A	4	5	9
D	B	3	5	8
E	A	4	6	9
F	C, D	5	8	11
G	C, D, E	3	6	9
H	F	1	2	9

(i) Construct Project network. (ii) Find the expected duration and variance of each activity. (iii) Find the critical path and expected project completion time. (iv) What is the probability of completing the project on or before 30 weeks?

8. (a) What do you understand by the abbreviation HSS. Twist drills are used for making holes in machine parts, label the various features of a twist drill used for making holes in mild steel. What are the tools used for finishing the holes? Make neat sketches to illustrate your answers. **30**

- (b) (i) Describe steps to be followed during “Time Study”. (ii) In a turning shop, a direct time study was on a step turning. The study was conducted by an experienced industrial engineer and one inexperienced engineer. They agreed precisely on cycle, time shown in Table below, but their opinion on rating of workers was differed. The experienced engineer rated the worker 100% and the other engineer rated the worker 120%. They used 0.10 allowance fraction. **30**

Cycle Time (minutes)	Number of Times observed
21	2
25	1
30	1
33	1

Determine the standard time using rating of each engineer.

[Attached: Cumulative distribution function for the standard normal distribution (SND) table, two pages, printed after Paper I]
