

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: (Each answer should not exceed 200 words): **20×3=60**
- (a) Two mating gear wheels of module 6 mm have 19 and 47 teeth of 20° obliquity and with addenda of 6 mm. Find the number of pairs of teeth in contact and the angle turned through by the larger wheel while one pair of teeth is in contact. Explain carefully the advantages obtained by increasing the addendum height for the smaller wheel while maintaining the same working depth. **15+5**
- (b) Write down the expressions for the friction torque in case of flat pivots based on (i) uniform pressure theory and (ii) uniform wear theory. Explain their relevance in design. A single-plate clutch transmits 25 kW at 900 r.p.m. The maximum pressure intensity between the plates is 85 k N/m^2 . The outer diameter of the plate is 360 mm. Both the sides of the plate are effective and the coefficient of friction is 0.25. Determine – (1) the inner diameter of the plate; (2) The axial force to engage the clutch. **5+15**
- (c) (i) What is fatigue? Define fatigue limit and fatigue strength. (ii) Explain how various factors of design affect the fatigue strength. (iii) What is cumulative fatigue damage? Explain Miner's hypothesis and bring out the drawbacks of this hypothesis. **5+5+10**
- (d) (i) What alloys are commonly die-cast? Write the composition, properties and uses of carbide cutting tools. (ii) Define unit cell. Calculate the linear density of the [100] direction for bcc. (iii) Draw T-T-T diagram for eutectoid steel. What is a graphite? **20**
2. (a) The rotor of a d.c. motor is fixed on the midspan of a 10 mm diameter, 300 mm long steel shaft rotating at 600 r.p.m. and supported on spherical bearings. The mass of the rotor is 10 kg. (i) Determine the maximum dynamic stress on the shaft for a speed of 0.8 times the critical speed. (ii) What will happen when the shaft is rotated at 0.95 times the critical speed? Assume for steel: $E = 2.2 \times 10^5 \text{ N/mm}^2$; Yield strength = 220 MPa; Ultimate strength = 420 MPa. **40**
- (b) Briefly explain the following with examples and nail sketches: (i) Whirling of shafts (ii) Free, forced and damped vibrations of a single degree of freedom system. **20**
3. (a) Compare the weights of equal lengths of hollow and solid shaft to transmit a given torque for the same maximum shear stress if the inside diameter is 2/3 of the outside. **20**
- (b) A thin cylinder 150 mm internal diameter and 2.5 mm thick has its ends closed by rigid plates and is then filled with water. When an external axial pull of 37 kN is applied to the ends, the water pressure

is observed to fall by 0.1 N/mm^2 . Determine the value of Poisson's ratio. Assume $E = 140000 \text{ N/mm}^2$; $K = 2200 \text{ N/mm}^2$. **20**

- (c) What is the drawback of maximum principal stress theory? A body is under action of two principal stresses of 40 N/mm^2 and -70 N/mm^2 , and the third principle stress being zero. If the elastic limit in simple tension as well as compression is 200 N/mm^2 , find the factor of safety based on the elastic limit according to – (i) maximum shear stress theory; (ii) maximum strain energy theory; (iii) maximum shear strain energy theory. Take $\mu = 0.3$. **20**

4. (a) Define the term proeutectoid cementite. What is the mechanism involved in gas carburizing? What problems exist in nitriding with respect to dimensional stability? What is martempering? What is the function of an energizer in solid carburizing? **30**
- (b) What factors influence M_s and M_f temperatures? What is temper brittleness and how might it be avoided? What is the process of spheroidizing of steel and what is its purpose? **15**
- (c) Name four types of thermoplastics and write the characteristics and applications of one type. Write in short about fillers and plasticizers. Define metal-matrix composites, their applications and advantages. **15**

SECTION 'B'

5. Answer any three of the following:

- (a) What is the fundamental mechanism of chip formation? Some major tool materials are mentioned below: 1. High-speed steel 2. Carbon steel 3. Ceramics 4. Tungsten carbides 5. Cast alloys 6. CBN 7. Single-crystal diamond. Arrange these in terms of wear resistance and toughness, Define the terms adhesion wear and diffusion wear of cutting tool. Write four material properties that affect machinability. **20**
- (b) Write six advantages of programmable machine tools. Define incremental and absolute system used in NC systems. Discuss the terms roughness, waviness, cutoff and flaws in surface texture measurement. What is the function of machine control unit in NC machines? **20**
- (c) ABC Ltd. has an order for 500000 parts. These parts can be manufactured either by machining process or by forging process. The costs involved in two methods of manufacturing are as follows: **20**

Costs ↓ / Process →	Machining	Forging
Fixed costs (Rs)	15,000	95,000
Variable costs per part (Rs)	6	5

(i) Which of the two methods will be more profit-making for ABC Ltd.? (ii) Find the minimum order quantity for the forging process to be economical.

- (d) (i) In statistical quality control, which would be the more sensitive control limits, $\pm 3\sigma$ or $\pm 2\sigma$? (ii) A manufacturer likes to prepare a statistical quality control chart for the number of mounting bracket hole discrepancies in the power supply chassis of a TV set. Twenty samples of size 200 have been taken and discrepancies are as follows: **5+15**

Sample number	Number of discrepancies	Sample number	Number of discrepancies
1	11	11	5
2	7	12	7
3	4	13	9
4	1	14	5
5	5	15	17
6	13	16	18
7	6	17	9
8	5	18	5

9	3	19	7
10	0	20	0

Determine the preliminary control limits. Construct the control chart. Plot the twenty samples. Is the process under control?

6. (a) What are the advantages and disadvantages of d.c. welding machine? What happens during the hold time of a spot weld? Why is the slop control so important in spot welding aluminum? When would you choose gas welding over arc welding? What do explosive welding and diffusion bonding have in common? **30**
- (b) Sketch four methods for the manufacture of a pipe. A double-action press for deep drawing a cup is good. Why? Name some advantages of ECM and explain why the gap between electrode and the workpiece is so important in ECM. Name applications and advantages of water-jet cutting. **30**
7. (a) (i) What are the sources of error in forecasting? (ii) With the help of regression analysis, compute the demand for computers when the populations are 36, 45, 50 and 55 millions from the collected data as give below: **5+25**

Population (in millions)	Number of computers demanded (in thousand)
5	28
7	40
15	65
22	80
27	96

Draw the demand curve using computed value.

- (b) The project network for manufacturing a product is given below with seven events (A-G) and eight activities. The estimates of optimistic, most likely and pessimistic times in days are shown as t_0 - t_m - t_p , in that order, for each activity: **30**
- [Figure: Project network (events as circles). Activities with t_0 - t_m - t_p : A → C: 6-8-10; A → D: 3-5-7; A → B: 8-11-14; C → E: 3-4-5; D → E: 2-5-8; E → F: 0-0-0 (dummy); B → F: 0-0-0 (dummy); F → G: 4-6-8. A is the start event and G the end event.]
- (i) Determine the slack time for each activity. (ii) Find the critical path. (iii) Find the earliest possible project completion time.
8. (a) Explain the terms climb milling, gun drills, Morse taper. Sketch a plain milling cutter and indicate the rake angle, clearance angle and tooth face. What are the advantages and limitations of broaching process? Show a standard system of marking grinding wheels with a chart. **30**
- (b) What is the benefit to the large company of following a JIT policy? **5**
- (c) The daily demand for a product is normally distributed with a mean of 60 and a standard deviation of 7. The source of supply is reliable and maintains a constant lead time of six days. If the cost of placing the order is Rs 10 and annual holding costs are Rs 0.50 per unit, compute the order quantity and reorder point to satisfy 95% of the customers. Given that 95% corresponds to 1.645 standard deviations. **25**
