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 sequential 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.

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

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

Neat sketch may be drawn, wherever required.

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

SECTION A

Q1. (a) A chain drive is used for reduction of speed from 260 rpm to 120 rpm. The number of teeth in the driving sprocket is 30. Find the number of teeth on the driven sprocket. If the pitch circle diameter of the driven sprocket is 500 mm and centre distance is 1 m, determine the pitch and length of the chain. *8*

(b) A mechanical vibrating system has the following measurements :

Mass = 6 kg

Equivalent spring of stiffness for combined springs = 4·5 N/mm. If the vibrating system has a dashpot attached which exerts a force of 30 N when the mass has a velocity of 2 m/sec, find *8*

(i) Critical damping co-efficient

(ii) Damping factor

(iii) Logarithmic decrement

(iv) Ratio of two consecutive amplitudes

(c) Define hardness. Why are hardness tests performed more frequently than any other mechanical tests ? What are the common hardness tests ? Write the correlation formula between Brinell hardness number and tensile strength for most steels. *8*

(d) What is hydrodynamic lubrication in bearings ? State the assumptions made in deriving Reynolds' equation for hydrodynamic bearings. *8*

(e) A 30 mm diameter bar is subjected to an axial tensile load of 110 kN. If now, to reduce weight while keeping the external diameter constant, the bar is bored axially to generate a cylinder of uniform thickness, what is the maximum diameter of bore possible ? It is given that the maximum allowable stress is 225 MPa. The axial tensile load is to remain constant at 110 kN. *8*

Q2. (a) A single cylinder reciprocating engine has a reciprocating mass of 60 kg. The crank rotates at 60 rpm and the stroke is 320 mm. The mass of the revolving parts at 160 mm radius is 40 kg. If two-thirds of the reciprocating parts and whole of the revolving parts are to be balanced, determine the

(i) balance mass required at a radius of 350 mm, and

(ii) unbalanced force when the crank has turned 50° from the top dead centre. *15*

(b) Two shafts are of the same material, length and weight. One is solid and is of 100 mm diameter, the other is hollow. If the hollow shaft is to store 30% more energy than the solid shaft when transmitting torque, what must be the internal and external diameters ? Assume the same maximum shear stress applies to both shafts. *15*

(c) (i) Explain the strain vs. time plot of a viscoelastic material when a linear spring and a linear dashpot are arranged in series. Also, explain the strain vs. time plot when the same linear spring and linear dashpot are arranged in parallel. *5*

(ii) The yield strength of a polycrystalline material increases from 130 MPa to 230 MPa on decreasing the grain size diameter from 0·05 mm to 0·01 mm. Find the yield stress for a grain size of 0·016 mm using Hall-Petch equation. *5*

Q3. (a) The follower of a tangent cam is operated through a roller of 40 mm diameter and its line of stroke passes through the axis of cam. The minimum radius of the cam is 30 mm and the nose radius is 10 mm. The lift is 25 mm. If the speed of the crank shaft is 500 rpm, calculate the velocity and acceleration of the follower at the instant when the cam is

(i) in full lift position, and

(ii) 20° from the full lift position. *15*

(b) A safety valve of 50 mm diameter is held in position by a spring of 100 mm mean diameter. The working pressure of the valve is 1·6 MPa. Determine the minimum diameter of the wire and the number of coils required, if the initial deformation of the spring should not exceed 20 mm. Assume shear modulus as 80 GPa and an allowable shear stress of 70 MPa. Use Wahl's correction factor in the equation of shear stress. *15*

(c) A Porter governor has equal arms of 200 mm each and pivoted on the axis of rotation. Each ball is of 40 N weight and weight of the central load is 200 N. The radius of rotation of the ball is 100 mm when the governor begins to rise 150 mm and governor is at maximum speed. Find the range of speed, lift, governor effort and power of the governor when the friction in the sleeve is neglected. *10*

Q4. **(a)** **(i)** In an epicyclic gear train as shown in the figure, the arm carries two gears A and B having 30 and 40 teeth respectively. If the arm rotates at 120 rpm in the anticlockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 200 rpm in the clockwise direction, what will be the speed of gear B ?   **5**
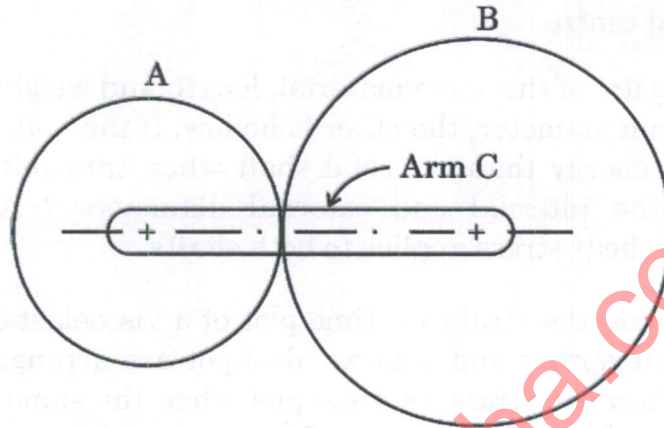
(ii) A machine shaft running at 300 rpm requires a torque which varies uniformly from 1000 N to 3200 N during the first half revolution, remains constant for the next one revolution and then remains constant for the next two revolutions, thus completing the cycle of operation. The motor has a constant torque and has a rotor of mass 40 kg with radius of gyration 0·25 m. If, in addition, a flywheel of mass 1800 kg and radius of gyration of 0·5 m is fitted to the shaft, determine :   **10**

    (1)   Power of the motor, and

    (2)   Percentage fluctuation of speed.

(b) A thin steel disc of uniform thickness and of 260 mm diameter with a central hole of 60 mm diameter rotates at 9000 rpm. Calculate the maximum shear stress developed in the disc. For the disc material, density = 7000 kg/m^3 and Poisson's ratio = 0·3.   **15**

(c) **(i)** Determine the composition, in atom percent, of an alloy that consists of 95 wt% aluminium and 5 wt% copper. Atomic weight of aluminium is 26·98 g/mol and that of copper is 63·55 g/mol.   **5**

    (ii) Draw a typical creep curve and explain the salient steps of creep.   **5**

SECTION B

Q5. (a) Describe the working principle of Plasma Arc Machining (PAM) process with a sketch. What are the gases used in PAM ? What is 'Stand off' distance and its effect on the machining process ? *8*

(b) (i) What is the principle of working of Electro-Chemical Machining (ECM) ?

(ii) Compare ECM with EDM.

(iii) Describe an ECM machine in brief. *8*

(c) Two types of food supplements A and B are available in the market having different compositions of three types of vitamins V_1, V_2 and V_3. Suppose one piece of food supplement A contains 1 mg of vitamin V_1, 100 mg of vitamin V_2 and 10 mg of vitamin V_3. One piece of B contains 1 mg of vitamin V_1, 10 mg of vitamin V_2 and 100 mg of vitamin V_3. For a person the minimum daily requirement of these vitamins is 1 mg of V_1, 50 mg of V_2 and 10 mg of V_3, whereas cost of these food supplements A and B is ₹ 1 and ₹ 1·50 respectively.

Find out how many pieces of A and B should be consumed daily so that the daily requirement of the vitamins can be fulfilled with least price. *8*

(d) In a certain manufacturing unit there is an annual requirement of 800 pieces of product, which may be ordered with different lot sizes as mentioned in the following table (maintaining 50% average inventory level), while cost of the product is ₹ 1,000.

No. of orders per year	Lot Size	Average Inventory
1	800	400
2	400	200
4	200	100
8	100	50
12	66·7	33·3
16	50	25
32	25	12·5

If ordering cost is ₹ 1,250 per order and inventory carrying cost is 20% per year of the average inventory, then find out the ordering quantity (out of the given orders), which minimizes the total cost. Also, find out this least total cost. *8*

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(e) Draw a flowchart and write a C-program to find all numbers between 1 to 100 divisible by 4. Write the algorithm, showing the steps involved. 8

Q6. (a) Compare the tool life of two cutting tools (HSS and carbide) at a speed of 30 m/min. The tool life is 130 minutes. The tool life equation for the HSS tool is given by $VT^{1/7} = C_1$ and for carbide $VT^{1/5} = C_2$ at a cutting speed of 24 m/min.

(i) What are the two important geometric parameters of a tool that affect tool life ?

(ii) Draw the typical characteristics of the variation of tool life with these two parameters. 15

(b) The demand for a particular product is given for the last 8 periods. Find out the forecast (by exponential smoothing method) taking value of $\alpha = 0.1$ and $\alpha = 0.3$, and conclude for which value of α the forecast is better. As the forecast for the initial period is not given, so it may be assumed to be equal to the demand for the first period. 15

Period	1	2	3	4	5	6	7	8
Demand	10	18	29	15	30	12	16	8

(c) Discuss the organisation of a computer system under two main categories :

(i) Hardware

(ii) Software

Draw a neat sketch of the computer system hardware, showing schematically the main components. 10

Q7. (a) (i) During an orthogonal machining (turning) operation of C-40 steel, the following data were obtained :

Chip thickness = 0·45 mm

Width of cut = 2·5 mm

Feed = 0·25 mm/rev

Tangential cut force = 1130 N

Feed thrust force = 295 N

Cutting speed = 2·5 m/s

Rake angle = + 10°

Determine :

(I) Shear force at the shear plane

(II) Kinetic coefficient of friction at the chip tool interface

(ii) What is the difference between orthogonal cutting and oblique cutting ? *15*

(b) A transport company ships truckloads of raw materials of textiles from three warehouses W_1, W_2 and W_3 to four textile manufacturing units M_1, M_2, M_3 and M_4. The supply (in truckloads) and the demand (also in truckloads), along with the respective unit transport costs per truckload on the different routes have been shown in the table below. The unit transportation costs have been given in the respective cells in hundreds of rupees. Find out the shipping schedule using VAM method in order to incur least shipping cost in transportation, fulfilling the demands of the manufacturing units, as per the availability of the raw materials. Also, calculate the least transportation cost incurred. *15*

Textile Manufacturing Units

	M_1	M_2	M_3	M_4	Supply
W_1	10	2	20	11	15
W_2	12	7	9	20	25
W_3	4	14	16	18	10
Demand →	5	15	15	15	

(c) (i) In a maintenance unit in a factory which is attended by a single worker, the arrival rate of cases of repair is 25 per hour. Time needed in getting the service is exponentially distributed with mean time of 90 seconds. What will be the average waiting time of a service while waiting in the queue for its turn. 5

(ii) A manufacturing unit of fasteners has been started, which has incurred ₹ 4,00,000 as fixed cost. However, the variable cost per piece of fastener is coming out to be ₹ 250. If the sale price is being proposed to be ₹ 500 per piece of fastener, then, after how much of total expenditure will the manufacturer start earning profit ? Also, what will be the margin of safety at this time ? 5

Q8. (a) What are the causes of errors in the design and operation of jigs and fixtures ? What measures should be taken to minimise the effects of the causes of error ? 15

(b) Consider the project of starting a new branch office of a company with which the company wants to sell a new product. Various activities are listed below. Draw the network and decide the critical path. 15

Activity	Description	Predecessor activity	Time (week)
A	Decide site and organise office	–	5
B	Hire personnel	A	4
C	Train personnel	B	7
D	Explore the advertising agents	A	2
E	Plan advertisers meeting and decide product features	D	4
F	Conduct advertising campaign	E	10
G	Finalize product and packaging	–	2
H	Set up plant and packaging unit	G	10
I	Produce initial product (Test)	H, J	6
J	Order stock from vendor	–	13
K	Finalize deals	D	9
L	Finalize sale to dealers	C, K	3
M	Transport stock to dealers	I, L	5

(c) What is the basic purpose of production, planning and control ? Also, mention its various functions in brief. 10