MECHANICAL ENGINEERING PAPER I

Time allowed: 3 hours **Maximum marks: 300**

INSTRUCTIONS

Each question is printed both in Hindi and in English.
Answers must be written in the, medium specified in the Admission.
Certificate issued to you, which must be stated clearly on the cover of the answer-book in the space provided for the purpose.
No credit will be given for the answers written in a medium other than that specified in the Admission Certificate.
Candidates should attempt Questions **1** *and* **5** *which are compulsory and any* ***THREE*** *of the remaining questions selecting at least* ***ONE*** *question from each Section.*
All questions carry equal marks.
If any data considered insufficient, assume suitable value.
Newton may be converted into kg using the equality 1 kilonewton (1 kN) = 100 kg, if found necessary.

Section A

1. Answer any three of the following: (Each answer should not exceed 200 words):

20 x 3 = 60

(a) Explain the common sources of damping in a real-life's system undergoing vibrations. Given examples in brief. Plot frequency response curves for different values of damping in a viscously damped vibration system with harmonic excitation.

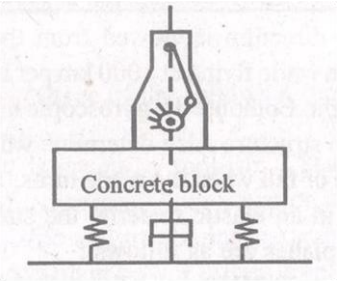
(b) In a mechanism, a slider is guided along a slot of a rotating slotted lever. Explain the various acceleration terms involved. Derive an expression for Coriolis component of acceleration.

(c) Show that the involute profile satisfies the law of gearing. Elaborate the advantages of involute profile for gears.

(d) Discuss the requirements for satisfactory performance of a centrifugal governor. Define controlling force, stability, sensitiveness and hunting with reference to governors.

2.(a) A vehicle with a rider has a total mass of 450 kg and travels along a rough road at 96 km per hour. The road is assumed to be represented by a harmonic curve with an amplitude of 2.5 cm and a curve length of 6.1 m. Determine: (i) the spring stiffness so that the resonance occurs under the conditions specified (ii) the required spring stiffness so that a steady-state amplitude of 0.6 cm is obtained at the given sped and also if the rider would leave his seat under this condition. Neglect the effect of damping. 20

(b) An engine is mounted on a concrete block which is isolated from the floor as shown in Fig. 1.



The unbalanced force of the engine in Newton's at n r.p.m. is given by

$$F = 100\left(\frac{n}{1000}\right)^2 \cos\left(\frac{2\pi nt}{60}\right)$$

At 1000 r.p.m. it is found that the force transmitted to the floor has amplitude of 100 Newton's. Determine the amplitude of the transmitted force at 1500 r.p.m. when the damper is disconnected. 20

(c) The mass of a machine is 100 kg. Its vibrations are damped by a viscous dashpot which diminishes amplitude of vibrations from 4 cm to 1 cm in three complete oscillations. If the machine is mounted on four springs each to stiffness 250 Newton per cm, find (i) the resistance of the dashpot at unit velocity and (ii) the periodic time of the damped vibrations. 20

3.(a) Investigate the states of primary and secondary balancing of a four-stroke cycle four-cylinder engine with a firing order of I-II-III-IV. What will be the change in this state when the firing is altered to I-II-IV-III. 20

(b) In the epicylic gear train shown in Fig. 2 the arm A, carrying the compound wheels D and E, turns freely on the output shaft. The input speed is 100 r.p.m. in counter clockwise direction when seen from the right. Input power is 7.5 kW. Calculate the holding torque to keep the wheel C fixed. The number of teeth for different gears are as shown in Fig. 2. 20

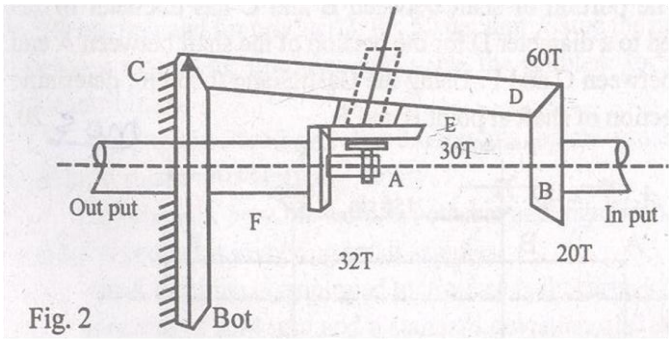


Fig. 2

(c) The rotor of a turbojet engine has mass of 200 kg and a radius of gyration 25 cm. The engine rotates at a speed of 10000 r.p.m. in the clockwise direction if viewed from the front of the aero-plane. The aero-plane while flying at 1000 km per hour turns with a radius of 2 km to the right. Compute the gyroscopic moment exerted by the rotor on the plane structure. Also determine whether the nose of the plane tends to rise or fall when the plane turns. 20

4.(a) At a point in an elastic material the stresses on three mutually perpendicular planes are as follows:

First plane: 50 MN/m^2 tensile and 40 MN/m^2 shear.

Second plane: 30 MN/m^2 compressive and 40 MN/m^2 complimentary shear.

Third plane: No stress.

Find - (i) the position of principal planes and the magnitude of principal stresses,

(ii) the position of planes on which maximum shear stress act calculate the normal and shear stress on them. 20

(b) Find the ratio of thickness to internal diameter of a thick tube subjected to internal pressure when the pressure is 5/8 of the value of the maximum permissible circumferential stress. Find the increase in internal diameter of such a tube of 100 mm internal diameter when the internal pressure is 100 MN/m^2. E = 200 x 10^9 N/m^2; Poisson's ratio = 0.286. 20

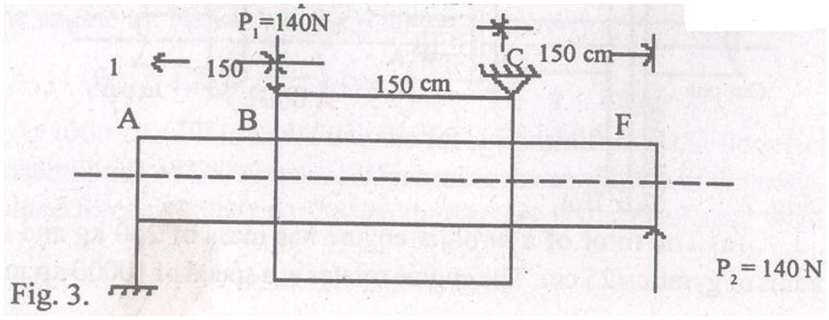


Fig. 3.

(c) A shaft is supported by two anti-friction bearings with loads of 140 Newton's each acting at points B and F as shown in Fig.3. The portion of shaft between B and C has diameter of 2D compared to a diameter D for the portion of the shaft between A and B; and between C and F. Using the Castigliano's theorem, determine the deflection of shaft at point B and F. 20

Section B

5. Answer any three of the following (each answer should not exceed 200 words): **20 x 3 = 60**

(a) What is meant by tool-life? State various criteria for specifying tool-life, discuss Taylor's equation to explain the relationship between tool-life and machining parameters.

(b) Describe the ECM process and explain how it differs from an EDM process.

(c) What is meant by ABC Analysis? Describe its applications for an automotive engine industry.

(d) Describe the salient features of queuing theory applicable to single and multichannel path systems.

6.(a) What are the various Linear programming techniques? 10

(b) Define the terms objective function and constrains giving suitable example. 10

(c) A manufacturer has two products, both of which are made in two steps by machines A and B. The process times for the two products on the machines are as follows:

Product	Machine A	Machine B
1	4	5
2	5	2

For the coming period, machine A has 100 hours available and machine B has 80 hours available. The contribution for product 1 is Rs. 100 per unit and for product 2, Rs. 50 per unit. Using the method of simplex algorithm, formulae and solve the problem for maximum contribution. 40

7.(a) Explain Student's distribution and the chi-square distribution in relation to sampling theory. 30

(b) Explain how the tests hypothesis and significance are extended to problems involving small samples. 30

8.(a) A machine is employed to produce ball bearings having a mean diameter of 5.74 mm and a standard deviation of 0.08 mm. To determine whether the machine is in proper working order, a sample of 6 ball bearings is taken and the mean diameter is completed from this sample. Design a suitable decision rule whereby one can be fairly certain that the quality of products are conforming to required standards. 40

(b) With the help of a diagram describe differential indexing method. 20

MECHANICAL ENGINEERING PAPER II

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Section A

1. Answer any three of the following (Answers to each of the parts (a), (b) and (c) should be in about 200 words only): **20 X 3 = 60**

(a) State the steady flow energy equation and simplify the same for the following devices:
  (i) Boiler and Condenser,
  (ii) Nozzle and Diffuser.
  (iii) Turbine and Compressor.

(b) Explain what you understand by Boundary layer separation and how it is controlled.

(c) Specify non-dimensional parameters and their uses in model experiments. Name a few parameters as used in fluid mechanics and give their mathematical expression and physical concept.

(d) Explain why gas turbines are widely used in aero applications but have failed to replace I.C. Engine in road transport.

2.(a) An ideal gas internal combustion engine operates on a cycle which when represented on a P-*v* diagram is a rectangle, P_1 and P_2 are the lower and higher pressures respectively, v_1 and v_2 are the lower and higher volumes respectively. Show that the thermal efficiency of the engine is 40

$$\eta = \frac{\gamma - 1}{\frac{\gamma P_2}{P_2 - P_1} + \frac{v_1}{v_2 - v_1}}$$

(b) With the aid of *p-v* and T-*s* diagrams compare the thermal efficiencies of Otto, duel and diesel cycles on the following conditions: 20

(i) On the basis of the same compression ratio and the same heat input.
(ii) On the basis of the same maximum temperature and the same maximum pressure.

3.(a) A spherical vessel is filled completely with water of weight W. Show that the resultant fluid pressure on each of the halves into which it is divided by a vertical diametrical plane is W √l3/4. 30

(b) What do you understand by stagnation property? Air at a temperature 30°C and atmospheric pressure is flowing with a velocity of 300 m/s. What will be the total temperature? Assuming the flow to be isentropic, find the stagnation pressure. 30

4.(a) Derive from first principles an expression for the heat flow by conduction from the inner to the outer surface of a long thick walled cylindrical shell. 30

(b) A steam pipe 10 cm outer diameter, is covered with two layers of insulating material each 25 mm thick, the thermal conductivity of one material being three times that of the other. Show that the effective conductivity of the two layers is 15% less when the better insulating material is on the inside than when it is on the outside. 30

Section B

5. Answer any three of the following parts. (Answer to each part should not exceed 200 words): **20 x 3 = 60**

(a) Explain the phenomena of Diesel knock. Suggest three different methods to control it.

(b) Explain the phenomena of cavitation in centrifugal pumps and how it is prevented.

(c) Explain what are solar cells and how they are used for solar energy application. Discuss their special advantages and limitations.

(d) Show that the work done in a compressor can be reduced by using inter-cooling between the stages. Obtain an expression for the intermediate pressure for the work done to be minimum.

6.(a) Discuss the mixture requirements of petrol engines under different conditions of engine operation such as crushing, acceleration idling, maximum power, etc., and explain how these requirements are met with. 20

(b) An axial compressor provides a total-head pressure ratio of 4:1 with an overall total head isentropic efficiency of 85%, when the inlet total head temperature is 290 K. Find the polytropic efficiency. 20

(c) Explain 'surging' in compressors. How is it controlled? 20

7. At design speed, the following data apply to a gas turbine set employing a separate power turbine, heat exchanger, and inter-cooler between two-stage compressions:

Isentropic efficiency of compression in each stage	84%
Isentropic efficiency of compressor turbine	90%
Isentropic efficiency of power turbine	85%
Pressure ratio in each stage of compression	2 : 1
Temperature after intercooler	295°K
Air mass flow	13.6 kg/sec
Heat exchanger thermal ratio	0.75
Maximum turbine temperature	900°K
Ambient temperature	288 K
Ambient pressure	1.013 bar
L.C.V. of fuel	43000 kJ/kg

Find the net power output, specific fuel consumption and overall thermal efficiency. 60

8.(a) (i) Explain in detail how you would determine whether a refrigerator is sufficiently charged with the refrigerant. 10

(ii) Discuss the relative merits of freon-12 and Ammonia as refrigerants. 10

(b) An air-water vapour mixture at 20°C and 1 atmosphere has a relative humidity of 50%. Calculate:

(i) the partial pressure of water vapour.

(ii) the dew-point.

(iii) the specific humidity.

Also calculate the amount of water vapour condensed per kg of dry are if the mixture is cooled to 5°C in a constant pressure process. 30