## 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) Prove that the minimum number of binary link in a constrained mechanism with simple hinges is four.

(b) For a V-engine consisting of two cylinders spaced apart by an angle β, show that the engine may be passively for first-order forces, but the second-order horizontal forces remain unbalanced.

(c) Discuss interference and undercutting of involute teeth. To avoid interference without undercutting, derive an expression for minimum number of teeth on the opinion when the interference just starts.

(d) Explain the phenomenon of hunting in centrifugal governors. Calculate the natural period of oscillation of the governor balls considering Hartnell governor.

2.(a) For a damped vibration system with base excitation (dynamic movement of supports) as shown in Fig. 1, find expressions for amplitude and phase angle using rotating vector diagram.   20


Fig. 1.   Fig. 2.
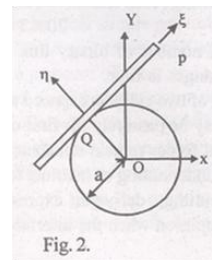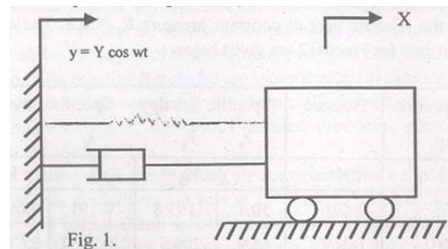
(b) A rigid rod (Fig. 2) slides over a fixed circle of radius a. The distance of rod's tip P, measured from the contact point Q is denoted by s, and the rod makes an angle φ with the fixed x-axis. Find the acceleration components (a_x, a_y) of point P with respect to the fixed frame (X. Y), also find the components (a_ξ, a_η) of the absolute acceleration in the direction of moving axes (ξ, η).   20

(c) The hinge point of a simple pendulum oscillates horizontally with an amplitude X and frequency ω as shown in Fig. 3. Assuming the amplitude of oscillation to be small, derive the equation of motion and find out the steady state amplitude of angular oscillation of the pendulum when   20

$$\omega = \frac{1}{2}\left(\frac{g}{l}\right)^{1/2}$$

Fig. 3.
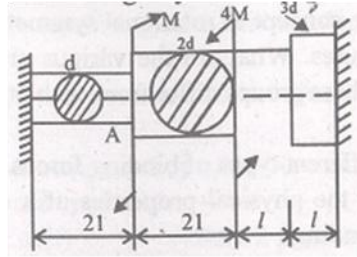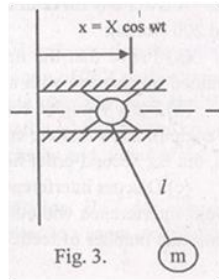
3.(a) For the shaft loaded as shown in Fig. 4, calculate the maximum shear stress induced and the angle of twist for cross-section A. Value of modulus of rigidity is G.   20

(b) A shaft circular in section and of length l is subjected to a variable torque given by $(kx^2)/l$ where x is the distance measured from one end of the shaft and k is a constant. Find the angle of twist for the shaft by using Castiglione's theorem. Torsional rigidity of the shaft G see in Fig. 5. 20

Fig. 5   Fig. 6
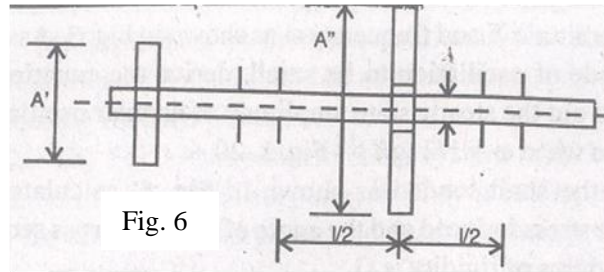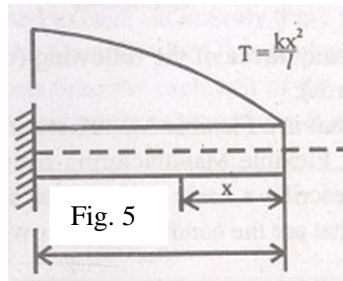
(c) In Fig. 6. diameter of pulleys D' = 20 cm, D"= 60cm; mass of pulley P'_0 = 200kg. P_0"= 400kg, the tensions of the belts P'_1 = 8000 N, P'_2 = 4000 N, P''_1 = -10000 N, P''_2 = 6000 N; shaft length l = 2 m, angle of inclination of the belt on second pulley to the z axis $\alpha = 45°$ and the permissible stress of the shaft material = 10,000 N/m^2. Determine the diameter of the shaft.   20

4.(a) Discuss the concept of rotational symmetry for classification of crystal structures. What are the various crystallographic point groups? How do these groups differ from each other in terms of unit cells?   20

(b) Discuss different types of binding forces in holding the crystals together. How the physical properties of a crystal are effected by the type of bonding?   20

(c) Describe different methods of surface hardening of metals. Discuss different methods of heat-treatment for the manufacture of metal gears.   20

Section-B

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

  (a)   What is a Flexible Manufacturing System? Discuss the applications of Flexible Manufacturing Systems.

  (b)   Describe a basic exponential smoothening model for forecasting. What are the conditions under which this method works best?

  (c)   What are the advantages and disadvantages of Laser Beam Machining? What are the areas of its application?

  (d)   What are the basic rules for locating and clamping in the design of jigs and fixtures? What is the impact of CNC machining on the designing of jigs and fixtures?

6.(a) In a machining process, explain the factors which affect the accuracy of machined surfaces. Suggest various ways of reducing chatter.   20

(b) What are the advantages of numerically controlled machines? Explain how through numerically controlled processes, automation is having an important impact on process technology for both high-volume standardized as well as low volume products.   20

(c) Draw a neat iron-carbon diagram showing the variation in iron structure as carbon percentage is increased. How do heat treatment processes like annealing and case-hardening affect the physical properties?   20

7.(a) Define Economic Order Quantity (EOQ), How is EOQ determined? 10

(b) A company buys 80.000 containers per year. The following costs arc applicable:

P (Cost per unit)   =   Rs. 12 per container
O (Cost per order)   =   Rs. 2400/
H (Holding cost)   =   Rs. 3 per container per year
i (Interest rate)   =   15% per annum including charges for insurance and taxes

One warehouse is used to hold exclusively these products. Calculate the Economic Order Quantity (EOQ) and annual stocking cost.

(c) The process time for each unit of the two products on the mixing machine A and packaging machine D are as follow:

Product	Machine A (hr/unit)	Machine B (hr/unit)
Chemical X	2	3
Chemical Y	4	2

The contribution to profit by chemical X is Rs. 60/- and that by chemical Y is Rs 50/-. For the upcoming two-week period, machine A has 80 hours of processing time available and machine B has 60 hour available. Write the statement of the linear optimization model in the standard linear programming formal and use the simplex method lo find optimal solution.   30

8.(a) Define the terms: use value, esteem value, cost value and exchange value as related to value engineering. What are the value tests for developing better value alternatives? Discuss that different phases of job plan due to mudge for value engineering.   20

(b) Describe the principle of Electro-Chemical Machining (ECM) and discuss its advantages and disadvantages. How does ECM differ from Electro-Discharge Machining?   20

(c) Write a subroutine MULT to multiply two matrices $[A]_{LXM}$ and $[B]_{MXN}$. Write a main program to generate a unit matrix $[T]_{10X10}$ and use the subroutine MULT to obtain $[T]^2$ and $[T]^3$.   20

MECHANICAL ENGINEERING PAPER II

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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.*

The numbers of marks carried by each question is indicated at the end of the question.

If any data is considered insufficient, assume suitable value.

Use of Psychometric chart is permitted.

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) What do you understand by the terra "dope" in connection with fuel additives? Name two organic and two metallic dopes and explain why metallic dopes are most effective and commonly used with gasoline.

   (b) What is meant by the term 'Signature Analysis"? What ate the various techniques of signature analysis used in preventive maintenance of power plant equipment?

   (c) Compare the C.I. and S.I engines for the following factors: (i) fuel economy (ii) Smoothness of operation (iii) Specific power output (iv) exhaust emissions (v) initial and maintenance costs

   (d) What is meant by a lumped capacity? What are the physical assumptions necessary for a lumped capacity unsteady state analysis to apply?

2.(a) A gas is confined to a cylinder by a spring loaded frictionless piston, so that the pressure in the fluid is a linear function $P = a + bV$. The internal energy of the gas is given by U $= 34 + PV(3.15)$ where U is in kJ, P in kPa and V in m^3. If the gas changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3 with no work other than that done on piston, find the direction and magnitude of work and heat transfer. **40**

  (b) Distinguish between "Road" octane number, "Motor" octane number and "Research" octane number of a fuel. How does the molecular structure of hydrocarbons influence their octane rating? Illustrate with suitable examples.   **20**

3.(a) An experimental four stroke petrol engine of 1710 cm^3 capacity is to develop maximum power at 5400 rpm. The volumetric efficiency at this speed is assumed to be 70 percent and the air-fuel ratio is 13 :1. Two carburetors are to be fitted and it is expected that at peak power, the air speed at choke will be 107 m/sec. The coefficient of discharge for the venturi is assumed to be 0.85 and that of the main petrol jet 0.66. An allowance should be made for the emulsion tube, the diameter of which can be taken as 1/2.5 of the choke diameter. The petrol surface is 6 mm below the choke at this engine condition. Calculate the sizes of suitable choke and main jet. The specific gravity of petrol is 0.75 Atmospheric pressure and temperature are 1.013 bar and 27° C respectively.   **40**

(b) Discuss the advantages and disadvantages of fuel injection system for spark ignition engines as compared to carburetion.

Why is fuel injection preferred in racing car and aero SI engines? 20

4.(a) Air flows at the rate of 10 kg/hr through a tube 12 mm diameter which is maintained at a temperature 50O"C. Estimate length of tube required if the air temperature is to rise from15° C to 300 °C, the air pressure at the entry being 1.013 bar. The expression Nu =0.02 $(Re)^{0.8}$ may be used together with the following data:

Thermal conductivity at the mean air temperature 0.0575 W/m°C,

Absolute viscosity 1.02 X 10^{-5}kg/ms,

For air C_P = 1.005 kJ/kg°K, R=0.287 kJ/kg°K. 45

(b) Distinguish, with the help of suitable graph/diagram, between "film boiling", "Pool boiling" and "Nucleate boiling" and explain the significance of each of these stage of boiling. 15

Section-B

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

(a) What are the requirements of a good refrigerant? Why carbon dioxide is not used as a refrigerant in tropical climates? Why Freon-12 is being replaced and which are the eco-friendly replacement refrigerants being tried?

(b) Explain the phenomena of "shock" formation in flow of a fluid through a convergent divergent nozzle. How does it effect the mass flow rate and exit temperature?

(c) How can smoke intensity be measured? Describe with sketches the two important types of smoke meters.

(d) What do you understand by (i) "Once through boiler", (ii) "Super critical boiler" and (iii) "Fluidized bed combustion boiler". What are the advantages and drawbacks of each of these types of boilers, and their most suitable files of application?

6.(a) An axial flow 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. This compressor is designed for 50% reaction with inlet and outlet air angles from the rotor blades of 45° and 10° respectively. The mean blade speed and axial velocity are constant throughout the compressor. Assuming a value of 201.16 m/sec for the blade speed and a work done factor of 0.86, find the number of stages required. What is the inlet Mach number relative to the motor at the mean blade height of the first stage? 45

(b) Sketch and explain the performance characteristics of centrifugal compressors. Compare them with axial flow compressor. 15

7.(a) A constant pressure gas turbine works between pressures P_1 and P_2 and there is no exhaust heat regeneration. If the ratio between the maximum and minimum temperatures of the cycle is t and if the isentropic efficiencies of the turbine and the compressor are η_t and η_c respectively, show that the efficiency of the cycle is given by the expression. 45

$$\eta = \left(1 - \frac{1}{\alpha}\right)\frac{(\beta - \alpha)}{(W - \alpha + 1)}$$

where,

$$W = \eta_c(t - 1), \qquad \alpha = (P_2/P_1)^{\frac{\gamma-1}{\gamma}}, \qquad \beta = \eta_c\eta_t t$$

(b) Distinguish between "Open cycle" and "Closed cycle" gas turbines. Give advantages, disadvantages and field of application of each. Why are gas tribunes not used commercially as prime movers for automobiles while they have replaced IC engines in aircraft applications? 15

8.(a) A boiler bums coal of the following composition: C = 80%, H = 3.8%, O_2 = 2.2% and the remainder ash. On a particular occasion, the percentage of CO_2 passing up the chimney was 10%.The temperature of the exhaust gases was then 250° C. If the sample of the gas is analyzed, by the ORSAT apparatus at room temperature, what percentage of CO_2 would you expect assuming complete combustion of fuel? 40

(b) Explain the principle and operation of an Electrostatic Precipitator. What is "Corona" discharge? What parameters influence the performance of an electrostatic precipitator and how can its efficiency be increased? 20