MECHANICAL ENGINEERING PAPER I

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

INSTRUCTIONS

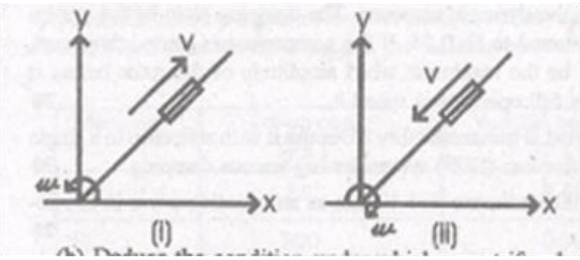
Each question is printed both in Hindi and in English.
Answers must be written in the, medium specified in the Admission.
Certificate issued to you, which must be stated clearly on the cover of the answer-book in the space provided for the purpose.
No credit will be given for the answers written in a 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 3 = 60

(a) What is the coriolis acceleration? Find the magnitude and direction of this acceleration in the following cases.



(b) Deduce the condition under which a centrifugal governor becomes unstable.

(c) What is a failure theory? Discuss the importance. Enumerate various failure theories and mention their fields of application.

(d) Draw Mohr's circle for a 2-D case stress field subjected to
(i) Pure shear (ii) Pure bi-axial tension
(iii) Pure uni-axial compression (iv) Pure uni-axial tension.

2.(a) What is the effect of centrifugal force of the transmission of power in a belt drive? A prime movers running at 300 rpm, drives a d.c. generator at 500 rpm, by a belt drive. Diameter of the pulley on the output shaft of the prime mover is 600 mm. Assuming a slip of 39%, determine the diameter of the generator pulley if the belt running over it is 6 mm thick. 30

(b) A spure gear pinion is driven by an electric motor of power 15 kW running at 740 rpm, pitch diameter of the pinion is 108 mm and speed reduction is 3:1. Module is 6 mm, and the pressure angle is 20^o. The pinion a mounted on a shaft located in symmetrical bearings over a span of 300 mm. The gear is overhanging by 50 mm on the left of two bearings 200 mm apart. Calculate the bearing reactions for the gear when the pinion rotates clockwise. 30

3.(a) A compressor rotor having a mass of 55 kg is mounted on a shaft of stiffness 1.4×10^7 N/m. Determine the critical speed of the rotor assuming the bearings to be rigid. If the

rotor has an eccentricity of 1000 micron and its operating speed is 6000 rpm, determine the dynamic started from rest, what will be the maximum whirl amplitude of the rotor before it reaches its full operational speed? 30

(b) What a transmissibility? Discuss it with reference to a single degree of freedom (SDF) system having viscous damping. 30

Take M l5 concrete and 40 mm as an effective cover in the design.

4.(a) The reciprocating mass per cylinder in a 60º V-twin engine is 12 kg. The stroke and the connecting rod length are 10 cm and 25 cm respectively. If the engine runs 2000 rpm, determine the minimum and minimum value of the primary and secondary forces. Also, find out the crank positions correspondence to these values. 30

(b) Develop an equation for the relationship between the angular velocities of the input and output cranks of a four-bar linkage. 30

SECTION B

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

(a) (i) Mention the crystal structures for the following element:

Iron; Chromium; Tungsten; Nickel and Zinc.

(ii) Sketch the following for an FCC structure:

(iii) and < 110 >

(b) Write a FORTRAN programme for the amount payable (A) after *n* yean on a principle amount (P) at a rate of interest (*i* %) compounded annually. The formula for calculating the amount is given below:

$$A = P\left(1 + \frac{i}{100}\right)^n$$

(c) How do you define tool life. Describe the mechanisms of tool failure.

(d) A machine shop manager has two machines that can do the same operations. The setup costs and the variable coats are given below:

Machine	Set-up cost (Rs.)	Variable coat/unit (Rs)
A	80	2.40
B	800	0.90

A decision has to be taken to select the machine A or B to minimize the total cost of production when an order comes.

(i) Determine the total cost equation for the two machines,

(ii) At what volume of production do machines A or B break-even?

(iii) What is the decision rule?

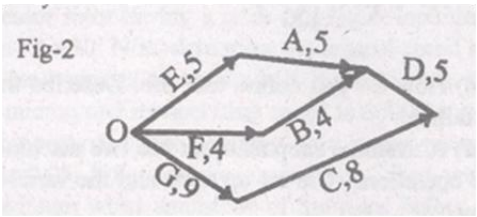
6.(a) Two products x_1 or x_2 are to be produced which require machining on machines M_1 and M_2 as per the following table:

Machine	Machine hours required For x_1	Machine hours required For x_2	Total machine hours available
M_1	1	2	40
M_2	3	2	60

Profit contribution rates for x_1 and x_2 are Rs. 60 and Rs 50 respectively. Obtain a solution for the manufacture of products x_1 and x_2 so as to maximize the profit. 30

(b) A network is shown below (Fig.2) in which A, B, C, D, E, F and G are the activities having the durations 5, 4, 8, 5, 5, 4 and 9 respectively.

Fig-2



(i) Calculate the earliest start time, earliest finish time, latest start time, latest finish time and total slack for each activity using a deadline of 20 days for project completion.

(ii) Indicate the critical path and its completion time. 30

7.(a) (i) Show with a neat sketch the forces acting on a chip in orthogonal machining. Derive an expression to calculate the coefficient of friction between tool chip interface.

(ii) During an orthogonal machining operation on mild steel, the results obtained are:

Uncut chip thickness = 0.25 mm

Chip thickness = 0.75 mm

Width of the cut = 2.5 mm

Rake angle = 0^o

Horizontal cutting force = 900 N

Thrust force = 400 N

Compute the coefficient of friction between the tool and chip interface. Determine also the ultimate shear stress of the work material. 40

(b) Differentiate between roughness and waviness. How do you measure the roughness of a ground surface using talysurf instrument? 20

8.(a) Describe with a neat sketch the principal of explosive forming of sheet metal. Give examples of two components that are manufactured by high energy rate forming. 30

(b) State basic principal of operation of CNC machine tools. Describe the essentials of control system used in position (point to point) and path control of the toot with respect to the work pieces. 30

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) (i) What is the perpetual motion machine of the second kind?
(ii) Why is a reversible adiabatic process one of constant entropy?
(iii) Show that the irreversibility for an adiabatic steady state process is given by

$$I = mT_0(S_2 - S_1)$$

(b) Air at 100 KPa and 300° C is contained in a piston cylinder arrangement as shown in fig.(l):

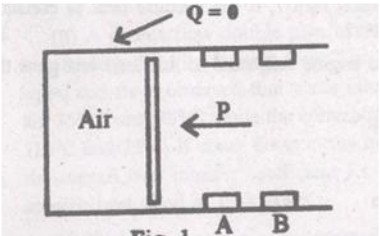

Fig. 1.

(c) The cylinder is perfectly insulated and piston is held in position by stops at A. The outside pressure is atm. The stops A are suddenly removed and the air allowed to expand till the piston stops at stops B. The volume increases to 1.5 times the initial value. Assume that the friction between piston and cylinder is zero; calculate the final pressure and temperature of air. State your assumptions clearly.

(d) Explain the process of heat exchange by radiation between two bodies. Define the various laws and terms used in estimation.

(e) Describe the method of determining calorific value of a solid fuel using a Bomb calorimeter, the following results were recorded during evaluation of a coal sample:
Mass of coal 1 gm
Mass of water in calorimeter 2500 gm
Water equivalent of apparatus 744 gm
Initial temperature of water 17.48° C
Maximum observed temperature of water 20.07° C
Specific heat of water 4.187 J/g °C
What are the calorific values of this fuel?

2.(a) Discuss with suitable graphs, how the efficiency of the Otto cycle various with

(i) Compression ratio and

(ii) Ratio of specific heats of the working medium. 25

(b) What is the percentage change in the efficiency of Otto cycle having a compression ratio 7, if the specific heat at constant volume increases by 1%? 35

3. A two stroke engine subjected to full load test gave the following results:

Cylinder dia	22 cm
Stroke	27 cm
Brake dia	1.5 m
Speed	450 rev/min
brake load	4.6 kg
imep	2.9 kgf/cm^2
fuel consumption	5.4 kg/hr
rise in temperature of jacket water	36º C
jacket water flow	440 kg/hr
air/fuel ratio by mass	31
temperature of exhaust gas	355ºC
room temperature	20º C
atmospheric pressure	76 cm Hg
calorific value of fuel	10500 kcal/kg
proportion of hydrogen by mass in fuel	15

Take R = 29.27 for air C_P = 0.24 for exhaust gas C_P = 0.49 kcal/kg K for dry steam.

Determine:

(i) the indicated thermal efficiency

(ii) the specific fuel consumption in gm/BHP hr

(iii) the volumetric efficiency

(iv) Draw up the heat balance on percentage basis. 60

4.(a) Define the terms:

(i) overall heal transfer coefficient

(ii) log mean temperature difference

(iii) effectiveness of heat exchangers 15

(b) A counterflow double pipe heat exchanger is used to heat water using oil as the heating fluid. The heat exchanger area is 16 sq.m and its is observed that water inlet and outlet temperatures are 35ºC and 75ºC while the corresponding oil temperatures are 110ºC and 75ºC. If water flows at the rate of 68 kg/min, calculate the overall heat transfer coefficient for the heat exchanger. Take specific heat of oil as 1.9 kJ/kg °C. 20

(c) Estimate the exit water temperature for the above heat exchanger if the water flow rate is reduced to 40 kg/min with oil continuing to flow at the earlier rate. Assume the effectiveness of the heat exchanger under these conditions to be 0.74. 25

Section B

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

(a) Discuss the desirable thermodynamic properties of a working fluid for a power plant operating on Rankine cycle. 20

(b) Discuss the influence of modification used in Rankine cycle on the operational performance of power plants. 20

(c) What do you understand by the term “binary vapour cycle”? Discuss its advantages and limitations. 20

(d) State the factors considered in selection of a refrigerant and compare the two commonly used refrigerants viz. ammonia and Freon. 20

6. An ammonia ice plant operates between a condenser temperature of 35°C and evaporator temperature of -15°C. It produces 10 tons of ice per day from water at 30°C to ice at -5°C. Assuming simple saturation cycle, determine:

(i) the capacity of the refrigerating plant;
(ii) the mass flow rate of refrigerant;
(iii) the discharge temperature;
(iv) the compressor cylinder diameter and stroke;
(v) the power of compressor motor; and
(vi) the theoretical and actual C.O.P.

Take:
Volumetric efficiency of compressor = 0.65;
Speed of compressor = 1200 rpm;
Stroke bore ratio of compressor = 1.2;
Adiabatic efficiency of compressor = 0.85;
Mechanical efficiency of compressor = 0.95;
Use the properties of Ammonia as given below:

Saturation Temp.	Saturation Pressure	Saturated liquid & Vapour						Vapour 50°C		Superheated 100°C	
t	P	v_f	v_g	h_f	h_g	s_f	s_g	h	s	h	s
C	bar	m^3/kg		kJ/kg		kJ/kg-K		kJ/kg	kJ/kg-K	kJ/kg	kJ/kg-K
-15	2.36	1.52	0.509	112.3	1426	0.457	5.549	1543	5.963	1656	6.3
35	13.5	1.7	0.096	3417.5	1476	1.282	4.93	1616	5.368	1744	5.7

7.(a) Define "strength of shock wave" and explain its significance. 20

(b) Air available at saturated atmospheric conditions flows through a heated constant area pipe. If the flow is decelerated from Mach number 1.5 to Mach number 1.0. determine:

(i) the change in temperature;
(ii) the heat addition to air 40

8. A simple gas turbine with heat exchanger has a compressor and a turbine having respective isentropic efficiencies η_c and η_t. Show that the combined effect of small pressure drop ΔP_{hg} in gas side heat exchanger and ΔP in combustion chamber and air side of heat exchanger is to reduce the specific work output by an amount given by

$$\left(\frac{\gamma-1}{\gamma}\right)\left[\frac{\frac{C_p T_3 \eta_t}{\gamma-1}}{\frac{\gamma}{r_p - P_1}}\right]\left[\Delta P_{hg} + \frac{\Delta P}{r_p}\right]$$

where
T_3 = turbine inlet temperature;
P_1 = compressor inlet pressure;
r_p = pressure ratio in compressor; 60