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.

Section A

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

20 x 3 = 60

(a) Prove that Poisson's ratio cannot be greater than 0.5.

(b) State the restrictions or assumptions made in deriving the formula for Theory of Bending'

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

(c) Describe the three kinds of lower pairs, giving a sketch of each kind, and state the types of relative motion of which the pairs permit.

(d) Describe a 'Pantograph', with a neat sketch, and state its uses.

2. (a) A simply supported beam carries a uniformly varying load with zero intensity at left support and an intensity of *w* at the right support.
Calculate the maximum deflection and maximum slope and mention the positions on the beam where these occurs.

(b) A compound cylinder is made by shrinking a jacket with outer diameter of 20 cm on a hollow cylinder with diameters 10 cm and 15 cm. When the compound cylinder is subjected to an internal pressure of 350 kgf/cm^2, the maximum circumferential stress in both the cylinders is same. Calculate the maximum stress developed and the internal diameter of the jacket. Take the value of E = 2 x 10^6 kg/cm^2.

3. (a) In a four-cylinder petrol engine equally spaced, the cranks, numbered from the front end, are 1,2,3 and 4. Cranks 1 and 4 are in phase and 180° ahead of cranks 2 and 3. The reciprocating masses of each cylinder weigh 1 kgf. The cranks are 5 cm radius and the connecting rods 20 cm long.
What are the resultant unbalanced forces and couples, primary and secondary, when cranks 1 and 4 are on top dead centre position? The engine is rotating at 1500 r.p.m. in a clockwise direction when viewed from the front. Take the reference plane midway between cylinder 2 and 3.

(b) The moment of inertia of each wheel of a motor cycle is 20kg-m^2. The rotating parts of the engine of the cycle have a moment of inertia of 0.3kg-m^2. The speed of the engine is 6 times the speed of the wheels and in the same sense. The weight of the motor cycle together with rider is 260 kgf and its c.g. is 60 cm above the ground level when the cycle is standing upright and rider is sitting on it.

Find the average angle of inclination with vertical for equilibrium if the cycle is travelling at 60 km per hour and taking a turn of 30 m radius. Wheel diameter is 60 cm.

4. (a) In figure 1 a wedge and block is shown. Calculate the force P that will cause the wedge and block to slide. Take the coefficient of friction as 0.2 for all surfaces.

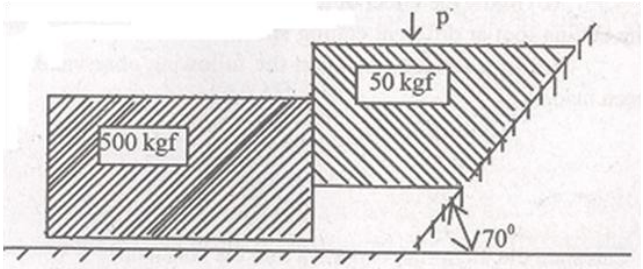

Fig. 1

(b) A refrigerator unit weighing 30 kgf is to be supported by three springs of stiffness K kgf/cm each. If the unit operates at 580r.p.m., what should be the value of spring constant K if only 10% of the shaking force of the unit is to be transmitted to the supporting structure?

Section B

5. Answer briefly and precisely and three of the following (Each answer should not exceed 200 words): **20 X 3 = 60**

(a) The shape of a cutting tool in orthogonal rake system is given by 5°, 10°, 6°, 7°, 15°, 60°, 0 mm.
Show with the help of a sketch the angle of the cutting tool with respect to the tool reference system.

(b) With the help of Merchant's circle diagram of cutting forces, show that

$$\begin{bmatrix} P_S \\ P_n \end{bmatrix} = \begin{bmatrix} \cos\beta & -\sin\beta \\ \sin\beta & -\cos\beta \end{bmatrix} \begin{bmatrix} P_z \\ P_{xy} \end{bmatrix}$$

(c) What should be the properties of an ideal cutting tool material? What are the ingredients of a carbide cutting tool? What kind of coating are provided on coated carbide tools?

(d) How ECM differs with EDM with respect to the mechanics of material removal and energy sources.

6. (a) List of factors which affect tool life of a cutting tool.

(b) Show the effect of machining time on the flank wear of the cutting tool at different cutting speed.

(c) In a turning operation the following observation have been made:

Cutting speed	Tool life
m/min	minutes
30	126
25	310

Calculate the Taylorian exponent and the constant.

(d) In bar drawing through frictionless die, derive an expression for the drawing stress. Strain hardening and strain rate effects may be neglected.
Also determine the maximum possible reduction in area of cross-section of the bar.

7. (a) Explain the effectiveness of the Stock-Time diagram of controlling of stock.

(b) Draw the operating characteristic curve for a single sampling plan. Show on it the consumer risk and producer risk.

(c) A company consumer 75000 pcs of electrodes yearly. Following costs are involved.
Cost per electrode = Rs. 5.50
Procurement cost per lot = Rs. 120
Interest of Inventory carrying cost = 16%
Calculate the Economic Ordering Quantity and also find the number of Orders in a year. Derive the expressions used.
Find the interval of time between the orders if the number of working days in a year to be 280 days.

8. (a) State the objectives of Work-Study.

(b) How would you proceed for making a Work-Simplification Programming for Work-place Tools and Equipment.

(c) Explain terms—Workers Rating and Relaxation Allowance as applied in Time-Study/Work Measurement.

(d) Manufacturing of a Component requires three operations to be performed in three different machines A, B, C. Observed time and the Speed Rating of the Workers are given below:

	Observed Time	Operators Rating
A	0.76 min	110%
B	1.28 min	94%
C	0.12 min	112%

If the factory operates for 2 shifts a day of 8 hrs and for 6 days a week, find the number of machines required to produce 10000 components per week. Assume Relaxation Allowance Time as 20%.

MECHANICAL ENGINEERING PAPER II

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.

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) Show that with the concept of reversible engines, a temperature scale can be defined which is independent of the nature of the thermometric substance.

(b) A missile is travelling with a Mach number of 7. The temperature of atmospheric air is 45°C. Find the stagnation temperature at the nose of the missile. Prove the formula used.

(c) Explain the concept of critical insulation thickness. What is its practical importance? Derive an expression for critical radius for a tube.

(d) What is 'Reynolds' Analogy? Derive the simple Reynolds' analogy. Outline the Prandtl and Taylor modification to the simple theory.

2. (a) A pressure vessel is connected, via a valve, to a gas main in which a gas is maintained at constant pressure and temperature of 15 kgf/cm^2 and 80°C respectively. The pressure vessel is initially evacuated. The valve is opened and a mass of 3 kg of gas passes into the pressure vessel. The valve is closed and the pressure and temperature of the gas in the pressure vessel is then 7 kgf/cm^2 and 60°C, respectively. Determine-

(i) the heat transfer to or from the gas in the vessel;
(ii) the volume of the pressure vessel;
(iii) the volume of the gas before transfer.

For the gas take C_p = 0.22kcal/kgK and C**v**=0.16 kcal/kgK. **30**

(b) The expansion in a turbine is adiabatic and irreversible. The steam enters at 20 kgf/cm^2, 450°C and the exhaust pressure is 0.07 kgf/cm^2. The dryness fraction of the exhaust is 0.91. Calculate, *using steam tables only*.

(i) the lost work due to irreversibility per kg of steam flowing through the turbine;
(ii) the isentropic efficiency of the turbine.

Take environmental temperature as 39°C. **30**

3. (a) The temperature of steam flowing in a pipe is measured by means of a mercury-in-glass thermometer immersed in an oil filled well. The mercury thermometer reads 200°C. Find the true temperature of the stream is the pipe wall temperature is 100°C and heat transfer coefficient between the steam and well is 150 kcal/m^2 hr °C. The length of the well is 5 cm and well wall thickness is 3 mm.

K (for well wall metal) = 40 kcal/m hr °C

Prove the formula used. **30**

(b) Two large parallel planes are situated 3 mm apart in air; one has an emissivity of 0.06 and is at a temperature of 300 K, and the other has an emissivity of 0.15 and is at a temperature of 400 K. Calculate the percentage change in the total heat transfer rate by coating the second surface so as to reduce its emissivity to 0.03Assume thermal conductivity of air 0.0062 cal/cm K. **30**

4. (a) Show by dimensional analysis that in forced convection

$$Nu = \varphi\left(Re, Pr, U^2/c_pT\right)$$

when frictional heating in the fluid cannot be neglected. **20**

(b) In an oil cooler, ethylene glycol flows through a thin copper tube of diameter 25 mm at the rate of 220 kg/hr; 650kg/hr of cooling water flows through the annular space formed by this tube and another tube. The oil enters at 150°C and is required to leave at 50°C, while the water enters at 20°C. Calculate the length of the tube required when

(i) the oil and water move in opposite direction;

(ii) the oil and water move in the same direction.

In both the cases assume specific heat of the oil 0.654 kcal/kg°C, film coefficient of heat transfer on the oil side to be 1400 kcal/m^2 hr °C, and on the water side 3200 kcal/m^2 hr °C.

Section B

5. Answer any three of the following four parts (answer to each part should be in about 200 words): **20 X 3 = 60**

(a) Discuss and justify the statement that factors tending to increase detonation in SI engines tend to reduce knock in CI engines.

(b) Discuss, with graphs, the effect of following parameters on the performance of liquid flat plate solar collectors:

(i) Number of glass cover plates

(ii) Fluid inlet temperature, and

(iii) Selective surfaces.

(c) What are the essential differences between Pressurised Water Reactor (PWR) and Boiling Water Reactor (BWR) used in nuclear power plants? Discuss their relative merits and demerits.

(d) Explain 'thermal comfort' and 'effective' temperature'. How comfort chart is constructed and used?

6. (a) Explain what is meant by the term 'polytropic efficiency' of an axial flow compressor. What is the use of expressing efficiency in this form? Derive an expression for plytropic efficiency in terms of γ (ration of specific heats) and index *n*. **15**

(b) A reaction turbine used 10,000 kg of steam per hour. A one point in turbine the blades are 25 mm high (at exit) and the discharge angle of both fixed and moving blades is 20°. The steam leaves the fixed blades at a pressure of 3 kgf/cm^2 with a dryness fraction of 0.95 and a velocity of 120 m/s. Assuming that the ratio of axial velocity of flow to blade velocity is 0.70 at entry to and 0.76 at exit from the moving blades, find the speed of the turbine in rev/min and the horse power developed in this particular blade ring. Neglect the effect of blade thickness but assume a tip leakage of 6% of the total steam. **45**

7. (a) Show that for a simple ideal gas turbine (Joule) cycle the condition for maximum specific output is

$$T_2 = T_4$$

where T_2 = temperature of air after isentropic compression in compressor; and T_4 = temperature of exhaust gases after isentropic expansion in turbine. **15**

(b) In a Pelton wheel installation the head available to the nozzle is 300 m and the coefficient of velocity for the nozzle is 0.98.The wheel diameter is 1.8 m and the nozzle diameter 125 mm. The buckets deflect the jet through 165°. Assuming the relative velocity of the jet over the buckets is reduced by 16%, calculate the theoretical speed in rev/min for maximum hydraulic efficiency. What is the hydraulic efficiency when running at this speed, and what is the power developed in kW? **45**

8. (a) Differentiate between a flash chamber and accumulator in vapour compression refrigeration systems. When are these used? Show that the use of a flash chamber has no effect on the thermodynamics of the operating cycle. **15**

(b) A summer air conditioning system is to be designed for a hall using the following data:

Outside design conditions = 35° C DBT and 27.2°C WBT
Inside design conditions = 25°C DBT and 50% RH
Solar heat gain through walls, roof and floor = 6000 kcal/hr
Solar heat gain through glass = 5500 kcal/hr
Number of occupants = 38
Latent heat gain per person = 90 kcal/hr
Sensible heat gain per person = 75 kcal/hr
Internal lighting load = 20 lamps of 100 W each and 15
flourescent tubes of 80 W each
Sensible heat gain from other sources = 15,000 kcal/hr
Infiltration air = 21 m^3/min
40% fresh air and 60% re-circulated air are mixed and passed through the conditioner coil which has a dew point temperature of 7°C.

Sketch the block diagram of the system and show the processes on skeleton psychrometric chart, giving enthalpy values at each salient point and calculate-

(i) the amount of total air in kg/hr;
(ii) DBT and RH of supply air in the hall;
(iii) the capacity of conditioner in tons of refrigeration;
(iv) by pass factor of the coil. **45**