MECHANICAL ENGINEERING Paper I

Time Allowed: Three Hours **Maximum Marks: 200**

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions.

Candidates should attempt **FIVE** *questions in all. Question No,* **1** *is compulsory.*
Out of the remaining **SIX** *questions attempt any* **FOUR** *questions.*
The number of marks carried by a part of a question are indicated against it.
Answers must be written in **ENGLISH** *only.*
Assume suitable data, if necessary, and indicate the same clearly.
For air R = 0.287 *kJ/kg-K,* C_p = 1.005 *kJ/kg-K,* γ = 1.4, M = 28.97 *kg/kg-mole, Universal gas constant* R = 8.314 *kJ/kg mole-K.*
Unless otherwise mentioned, symbols and notations have their usual standard meanings.
Neat sketches may be drawn, wherever required.
Attempts of questions shall be counted in chronological 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 answer book must be clearly struck off.
A psychrometric chart is attached to this question paper for necessary use by the candidate.

1. (a) A reversible engine receives equal quantity of heat from two reservoirs A and B maintained at temperatures T_1 and T_2 respectively. The engine rejects heat to a reservoir C at temperature T_3. In case the thermal efficiency of the above engine is K times, the efficiency of reversible engine receiving heat only from reservoir A and rejecting heat to reservoir C and also if the heat supplied by the reservoir C and also if the heat supplied by the reservoir A is the same as it supplies in the combined case show that:

$$K = \frac{1}{2}\left\{\frac{T_2 - T_3}{T_1 - T_3} + \frac{T_2}{T_1}\right\} \times \frac{T_1}{T_2}$$ 20

(b) A heat source at 627° C transfers heat at the rate of 3000 KJ/min to a system maintained at 287° C. A heat sink is available at 27° C. Assuming these temperatures to remain constant, find:
(i) change in entropy of source
(ii) Entropy production accompanying heat transfer
(iii) The original available energy
(iv) The available energy after heat transfer. 20

2. (a) Calculate the percentage loss in the ideal efficiency of a diesel engine with compression ratio 14 if the fuel cut-off is delayed from 5% to 8%. 10

(b) Explain the phenomenon of knocking in SI engine. What are the different factors which influence the knocking? Describe the methods to suppress it. 15

(c) A two stage air compressor takes in air at 1.013 bar and 15° C and delivers at 43.4 bar. The intercooler pressure is 7.56 bar. The intercooling is perfect and the index of compression is 1.3. Calculate the work done in compressing 1 kg of air. If both cylinders have the same stroke and the piston diameters are 9 cm and 3 cm and the volumetric efficiency of the compressor is 90%, will the intercooler pressure be steady or will rise or fall as the compressor continues working? 15

3. (a) A steel pipe having 10 cm bore and 12 cm outside diameter carries hot water at 80° C when the surrounding temperature is 15° C. The thermal conductivity of pipe material is 54 W/mK and inner and outer heat transfer coefficients are 1 KW/m^{2}K and 9 W/m^{2}K, respectively. Calculate the heat loss per meter length of the pipe and the surface temperatures. Also calculate the heat loss and the surface temperatures when the pipe is covered with a 4 cm thick insulation having thermal conductivity of 0.048 W/mK with outer surface heat transfer coefficient reduced to 7 W/m^{2}K. 20

(b) Steel balls 12 mm diameter are annealed by heating to 800°C and then slowly cooling to 127°C in air at 50°C. The heat transfer coefficient for air is 20 W/m^2K. Calculate the time required for cooling process. The properties of steel are taken as k = 45 W/mK, ρ = 7830 Kg/m^3 and C_p = 600 J/KgK. 20

4. (a) A four cylinder single acting ammonia compressor with cylinder dimensions as 7.5 × 10 cm operates at 600 r.p.m. Condenser and evaporator pressures are 12 and 2 bar respectively. The vapour from the evaporator to suction of compressor is dry and saturated and there is no undercooling in the condenser. Compression takes place according to law $PV^{1.2}$ = constant. If clearance is 2% of the stroke, calculate:
(i) Refrigerating capacity in tons of refrigeration
(ii) Power required to drive the compressor in KW.
(iii) Heat rejected to cylinder jacket water in kJ/min.
(iv) Heat rejected to the condenser in KJ/min.
Take value of γ for NH_3 as 1.31. 20

(b) 100 m^3 per minute outdoor air at 43.3° C d.b.t. and 37% relative humidity is mixed with 200 m^3 per minute of air at 38.2°C d.b.t. and 24.5°C wet bulb temperature. The mixed air is dehumidified first by a cooling coil having by-pass factor of 0.32 and apparatus dew point of 15° C and then by a chemical dehumidifier. Air leaves the chemical dehumidifier at 30°C dry bulb temperature. Air is then passed over a cooling coil whose surface temperature is 15° C and by-pass factor 0.26. Calculate:
(i) Capacity of two cooling coils in tons of refrigeration
(ii) Capacity of coil dehumidifier in Kg/min.
(iii) Capacity of chemical dehumidifier in Kg/min.
(iv) Total humidifying capacity of the system in Kg/min. 20

5. (a) A solid cone of radius r_0, and vertex angle 2θ is to rotate at an angular velocity ω. An oil of viscosity μ and thickness h fills the gap between the cone and the housing. Determine the torque T required to rotate the cone. 20

(b) A rectangular container having base area of 1.5 m^2 and length 0.9 m is floating in water with the open end downwards. If the difference in water levels inside and outside the container is 10 cm.
(i) Determine the mass of the container.
(ii) What force will be required to depress the bottom of the container to a depth of 10 m in water if the trapped air has constant temperature?
Atmospheric pressure = 100 KPa. 20

6. (a) A nozzle of diameter 20 mm is fitted to a pipe of diameter 40 mm. Find the force exerted by the nozzle on the water which is flowing through the pipe at the rate of 1.2 m^3/min. 20

(b) A 2.0 m long conical diffuser 20 cm in diameter at the upstream end has 80 cm diameter at the downstream end. At a certain instant the discharge through the diffuser is observed to be 200 liters/sec of water and is found to increase uniformly at a rate of 50 liters/sec. Estimate the local, convective and total acceleration at a section 1.5 m from the upstream end. 20

7. (a) A centrifugal pump has an impeller of 80 cm in diameter and it delivers 1 m^3/sec against a head of 80 m. The impeller runs at 1000 rpm and the width at outlet is 8 cm. If the leakage loss is 3 percent of the discharge, external mechanical loss is 10 KW and the hydraulic efficiency is 80 percent, calculate the blade angle at outlet, the power required and overall efficiency of the pump. 20

(b) A single acting, two stage air compressor running at 300 rpm delivers air at 20 bar, while the intake conditions are 0.98 bar and 305 K. The intermediate pressure is 5 bar and the clearance volume for low pressure compressor is 4

percent of its stroke volume. The compressor delivers 3 m3/min at 1 bar and 15° C. Estimate

(i) Power required to drive the compressor in KW.
(ii) Low pressure cylinder dimensions if L = D
(iii) Isothermal efficiency when the intercooling is perfect and the index n = 1.3 for compression and expansion. 20

8. (a) What are the advantages of using high pressure boilers? With the help of a neat sketch describe a Loeffler Boiler. What is usually the working pressure of such boiler? 20

(b) In a multi-stage Parson's reaction turbine at one of the stages the rotor diameter is 125 cm and speed ratio 0.72. The speed of the rotor is 3000 rpm. Determine:

(i) The blade inlet angle if the blade outlet angle is 22°.
(ii) Diagram efficiency.
(iii) Percentage increase in diagram efficiency and rotor speed if the turbine is designed to run at the best theoretical speed. 20

MECHANICAL ENGINEERING Paper II

Time Allowed: Three Hours **Maximum Marks: 200**

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions:

Candidate should attempt **FIVE** *questions in all. Question No.* **1** *in Section* **A** *is compulsory.*

Out of the remaining, attempt **TWO** *from Section-***B** *and* **TWO** *from Section—***C**.

All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.

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

Unless other-wise mentioned, symbols and notations have their usual standard meanings.

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Attempts of questions shall be counted in chronological 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 answer book must be clearly struck off.

SECTION—A

1. Answer all 20 parts of the question each part carries 2 marks.

(a) Name two situations where worm-worm gear drive is preferred.

(b) Write the expression for secondary unbalanced force in case of a single cylinder Internal combustion engine. How many times this secondary unbalanced force reaches the maximum in One revolution of the crank?

(c) Distinguish between the machine and the structure.

(d) List two reasons for the center of gravity of the loaded shaft is being displaced from the axis of rotation.

(e) What is the amount of clearance and the need for the clearance between nominal diameter of the rivet and rivet hole?

(f) Why is taper provided in a cotter? What is the normal value of taper in cotter joint?

(g) At a point in a two dimensional stress system the normal stresses on two mutually perpendicular planes are σ_x and σ_y and the shear stress is τ_{xy}. At what value of shear stress, one of the principal stress will become zero?

(h) The ratio of inside to outside diameter of a hollow shaft is 0.6. If there is a solid shaft with same torsional strength, what is the ratio of the outside diameter of hollow shaft to the diameter of the equivalent solid shaft?

(i) Distinguish between a beam and a short column. List two differences.

(j) Name the strongest and weakest type of atomic bonds.

(k) Calculate the number of atoms, from first principles, per unit cell of FCC. and B.C.C. structure.

(l) List two effects of Manganese in plain carbon steels.

(m) Briefly explain the characteristic feature of stretch forming.

(n) List four parameters to be considered in the gating design for moulds.

(o) Name two criteria for cutting tool life.

(p) Classify the following cost elements under two types for inventory control:-
   (i) Cost of material handling
   (ii) Cost of inspection upon receiving
   (iii) Cost of advertising to select vendor
   (iv) Pilferage

(q) Certain spare parts can be purchased at two different rates R1 and R2, with a boundary volume V3. If the parts are to be manufactured, the total cost data linearly varying with volume is available.
With a break-even chart, show how the decision to buy/make can be made. Assume V1 < V3 < V2 and R1 > R2 where V1 and V2 are the break-even volumes for R1 and R2 respectively.

(r) What is the approach while allocating quantities in cells, using Vogel

Approximation method for solving Transportation problems?

(s) What is the standard deviation of the project completion time along the critical path, if the standard deviations of the corresponding activities are S1, S2 and S3?

(t) Name four parts of feeding devices in automation.

SECTION—B

2. (a) A rope pulley is designed to transmit 30 kW. Diameter of pulley = 360 mm. Speed = 120 rpm. Angle of groove = 45°. Angle of lap on smaller pulley = 170°. Coefficient of friction = 0.27. Number of ropes = 10. Mass of the rope = $55C^2$ kg/m. Length and working tension of rope is limited to $1255C^2$ kN, where C is the circumference of rope in meter. Find (i) initial tension and (ii) diameter of each rope. 20

(b) In an epicyclic gear of the sun and planet type show in fig. 1, the pitch circle diameter of the internally toothed ring is 252 mm and the module is 3.5 mm. The ring D is stationary. The spider A, which carries three planet wheel P of equal size, is to make one revolution in the same sense as the sun wheel S for every five revolution on the driving spindle carrying the sun wheel S. Determine appropriate number of teeth for all the wheels. 20

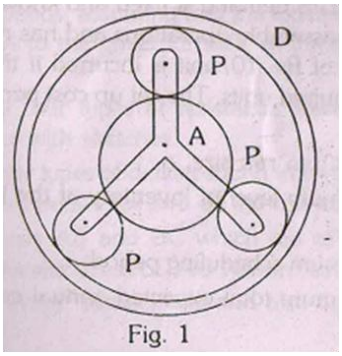

Fig. 1

3. (a) A hollow shaft with diameter ratio 0.7 is required to transmit 500 kW at 300 rpm with a uniform twisting moment. Allowable shear stress in the material is 65 N/mm^2 and the twist in a length of 2.4 m is not to exceed one degree. Calculate the minimum external diameter of the shaft satisfying these conditions. Modulus of rigidity = 8.2×10^4 N/mm^2. 20

(b) For a symmetrical tangent cam with a roller follower, the least radius of the cam is 25 mm and the roller radius is 18 mm. The angle for outward movement is 90° and total life is 20 mm. The cam shaft runs at 900 rpm. Determine

(i) Principal dimensions of the cam

(ii) The acceleration of the follower at the beginning of the lift, where the straight flank merge into the circular nose.

(iii) Acceleration of the follower at the apex of the circular nose i.e. when the angle turned by cam measured from the position when the roller is at the top of the nose, is zero. Assume there is no dwell between outward and inward travel of the follower. 20

4. (a) Explain the functions of the four components of Flexible Manufacturing System. Indicate the situation where FMS is preferred as compared to Transfer lines. 10

(b) ABC Company has to supply 30,000 switches per year to its customer. This demand is fixed and known. The customer uses its items in assembly operations and has no storage space. A shortage cost of Rs. 10/unit is incurred if the company fails to deliver the required units. The set up cost per run is Rs. 3,500. Determine

(i) The optimum run size, q

(ii) The optimum level of inventory at the beginning of any period

(iii) The optimum scheduling period

(iv) The minimum total expected annual cost. 0

(c) Calculate the fundamental deviation and tolerance and hence the limits of size for the shaft and hole for the following fit 64 mm H8-f 7. The diameter steps are 50 mm and 80 mm. For shaft designation f, upper deviation is assumed as $-5.5 D^{0.41}$:- 10

	For	tolerance
Data:	H8	25i
	f7	16i

SECTION—C

5. (a) The following data from the orthogonal cutting test is available:
Rake angle = 10°, chip thickness ratio = 0.35, uncut chip thickness = 0.51, width of cut = 3 mm, yield shear stress of work material = 285 N/mm^2, Mean friction coefficient on tool face = 0.65. Determine the (i) Cutting force (ii) Radial force (iii) Normal force on tool and (iv) Shear force on the tool. 20

(b) A governor of Proell type has each arm 250 mm. The upper and lower ends of the arms are pivoted on the axis of the governor sleeve. Each ball has a mass of 15 kg and attached to the extension of the lower arms which are 100 mm long. The minimum and maximum radii of the governor are 125 and 175 mm. The central sleeve is of mass 75 kg. Determine the range of equilibrium speeds, assuming that the extensions of the lower arms are parallel to the governor axis, at the minimum radius. 20

6. (a) List four types of resistance welding and explain any two of them with sketches. 10

(b) Name four types of defects found in forging and mention the causes and remedies for two of the defects. 10

(c) Two Planes AB and BC which are at right angles are acted upon by tensile stress of 140 N/mm^2 and a compressive stress of 70 N/mm^2 respectively and also by shear stress 35 N/mm^2. Determine the principal stresses and principal planes. Find also the maximum shear stress and planes on which they act.
Sketch the Mohr circle and mark the relevant data. 20

7. (a) A company has three plants at A, B and C which supply to warehouses located at D, E, F, G and H. Weekly plant capacities are 200, 125 and 225 tons respectively. Weekly warehouse requirements are 75, 105, 130, 155 and 85 tons respectively.
Unit transportation cost matrix is given below:

TO/FR	D	E	F	G	H
A	50	82	65	60	35
B	45	70	70	65	50
C	80	45	75	60	40

Determine the optimum cost distribution pattern and also the minimum total cost. 20

(b) A set of data obtained from inspection of castings, with a sample size of 20 castings are shown in the table:

Group No.	No. of defects	Group No.	No. of defects
1	76	6	69
2	68	7	83
3	76	8	93
4	89	9	70
5	47	10	79

Compute
(i) the process average and control limits.
(ii) the process average for future production and
(iii) revised control limits. 10

(c) Construct a flow chart to find the velocity and acceleration of the piston in a single slider mechanism. 10