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) 0.5 kg of air (ideal gas) executes a Carnot power cycle having a thermal efficiency of 50 percent. The heat transfer to the air during the isothermal expansion is 40 kJ. At the beginning of the isothermal expansion the pressure is 7 bar and the volume is 0.12m^3. Determine the maximum and minimum temperatures for the cycle, in K, the volume at the end of isothermal expansion, in m^3, and the work and heat transfer for each of the four processes, in kJ. For air C_V = 0.721 and C_P = 1.008 kJ/kg. K. 20

(b) Steam flows through an adiabatic steady flow turbine. The enthalpy at entrance is 4142 kJ/kg and at exit 2585 kJ/kg. The values of flow availability of steam at entrance and exit are 1787 kJ/kg and 140 kJ/kg, respectively. If the dead state temperature T_0 is 300 K, determine, per kg of steam, the actual work, the maximum possible work for the given change of state of steam, and the change in entropy of steam. Neglect changes in kinetic and potential energy. 20

2. (a) A compressed air bottle of 0.05 m^3 volume contains air at 3.5 atm pressure. This air is used to drive a turbo-generator supplying power to a device which consumes 5 W. Calculate the time for which the device can be operated if the actual output of the turbo-generator is 60 percent of the, maximum theoretical output. The ambient pressure is 1 atm. For air, (C_p/C_V) = 1.4. 20

(b) An insulated vessel is divided into two compartments connected by a valve. Initially, one compartment contains steam at 10 bar, 500°C, and the other is evacuated. The valve is opened and the steam is allowed to fill the entire volume, achieving a final pressure of 1 bar. Determine the final temperature, in °C, the percentage of the vessel volume initially occupied by steam and the amount of entropy produced, in kJ/kg. K. 20

3. (a) In an I.C. engine operating on the dual cycle (limited pressure cycle), the temperature of the working fluid (air) at the beginning of compression is 27°C. The ratio of the maximum and minimum pressures of the cycle is 70 and the compression ratio is 15. The amounts of heat added at constant volume and at constant pressure are equal. Compute the air standard thermal efficiency of the cycle. State three main reasons why the actual thermal efficiency is different from the theoretical value. 20

(b) The following data refer to a steam turbine power plant employing one stage of regenerative feed heating:
State of steam entering H.P. stage: 10 MPa, 600°C
State of steam entering LP. stage: 2 MPa, 400°C

State of steam entering condenser: 0.01 MPa, 0.9 dryness fraction.
The correct amount of steam is bled for feed heating at exit from the H.P. stage. Calculate the mass of steam bled per kg of steam passing through the H.P. stage and the amount of heat supplied in the boiler per second for an output of 10 MW. Neglect pump work. 20

4. (a) For steady adiabatic flow of an ideal gas with constant specific heats through a nozzle or diffuser, show that:

$$\frac{T_0}{T} = 1 + \left(\frac{k-1}{2}\right)M^2$$

where T_0 and T are the stagnation and static temperatures, respectively, k is the ratio of specific heats and M the Mach number. 20

(b) In a turbo jet engine, air enters the diffuser at 0.8 bar, 240 K, with a velocity of 1000 km/hr. The pressure ratio across the compressor is 8. The turbine inlet temperature is 1200 K and the pressure at nozzle exit is 0.8 bar. The turbine work just equals the compressor work input. The diffuser, compressor, turbine and nozzle processes are isentropic an there is no pressure drop for flow through the combustor. Determine the pressure at exit from the diffuser, the compressor and the turbine, and also the velocity at the nozzle exit. Show the various processes on a temperature-entropy diagram. For air C_p = 1.001 kJ/kg. K and C_P/C_V = 1.4. 20

5. (a) A vapour compression refrigeration system using refrigerant12 is employed to produce 8640 kg of ice per day. The condensing and evaporating temperatures of the refrigerant are 48° C and –20°C, respectively. Saturated liquid leaves the condenser and saturated vapour leaves the evaporator. Compression is isentropic. Water at 35°C is used to from ice. The temperature of ice should be -8° C. Heat flows into the brine tank from the surroundings may be taken to be 10 percent of the total heat removed from water to form ice at the specified temperature. Determine the power required to drive film compressor, in kW. Take specific heat of ice = 2.26 kJ/kg. K, latent heat of ice = 334.72 kJ/kg and specific heat of water = 4.187 kJ/kg K.
The following data for refrigerant 12 may be used:

Temperature	Pressure	Enthalpy, kJ/kg		Entropy, kJ/kg. K	
°C	bar	liquid	vapour	liquid	vapour
48	11.64	82.83	205.83	0.2973	0.6802
–20	1.51	17.82	178.74	0.0731	0.7087

Specific heat of vapour = 0.82 kJ/kg. K. 20

(b) Outside air at 35°C, 60% RH is passed over a cooling coil having an apparatus dew point of 10°C and 0.06 bypass factor. The cooled air is then supplied to a room which is to be maintained at 22°C dbt and 60% RH. The supply air rate 4500 kg/hr. Estimate the sensible and latent heat loads of the room and the heat removed in the cooling coil, in kW. 20

6. (a) Air flows over a heated flat plate at a velocity of 50 m/s. The local skin friction coefficient at a point on the plate is 0.004. Estimate the local heat transfer coefficient at this point. The following property data for air are given:
Density = 0.88 kg/m^3; viscosity = 2.286×10^{-5} kg/ms; specific heat C_p = 1.001 kJ/kg. K; thermal conductivity = 0.035 W/m.K Use

$$St.\mathrm{Pr}^{2/3} = \frac{C_f}{2}$$ 20

(b) Two long rods of the same diameter, one made of brass (k = 85 W/m. K.) and the other made of copper (k = 375 W/m. K.), have one of their ends inserted into a furnace. Both rods are exposed to the same environment At a section 10.5 cm away from the furnace end, the temperature of the brass rod is 120°C. At what distance from the furnace end, the same temperature would be reached in the

copper rod? Derive the formula used. 20

7. (a) Show that in a Pelton wheel, where the buckets deflects the water through an angle (180° – α), the hydraulic efficiency of the wheel is given by:

$$\eta_h = \frac{2u(V-u)(1+\cos\alpha)}{V^2}$$

where V is the velocity of the jet, and u the velocity of the wheel at the pitch radius. 20

(b) A 1/5 scale model of a centrifugal pump absorbs 20 kW when pumping against a test head of 8 m at its best speed of 400 rpm. If the actual pump works against 32 m head, find the speed and power required for the actual pump. Determine also the quantities of water discharged by the two pumps. 10

(c) A single acting reciprocating pump operating at 120 rpm has a piston diameter of 200 mm and stroke of 300 mm. The suction and delivery heads are 4 m and 20 m, respectively. If the efficiency of both suction and delivery strokes is 75 percent, determine the power required by the pump. 10

8. (a) Determine the adiabatic flame temperature for the combustion of carbon monoxide (CO) with 150 percent theoretical amount of oxygen to form CO_2. The reactants enter the steady flow reactor at 25°C, 1 atm and the products (CO_2 and excess O_2) leave at 1 atm. At 1 atm, 25°C, the enthalpies of formation of O_2, CO and CO_2 are, respectively, 0 kJ/kg mole, –110,418 kJ/kg mole and –393137 kJ/kg mole. The constant pressure specific heats of CO_2 and O_2 at 1 atm may be assumed to be 56.43 and 36.5 kJ/kg mole. K, respectively, 20

(b) The following data were obtained from a single glass cover flat plate solar heat collector: Mean plate temperature = 70° C;
Ambient and sky temperature = 10°C;
Back insulation thickness = 5 cm;
Insulation thermal conductivity = 0.05 W/m°C;
Coefficient of heat transfer by convection from plate to cover = 3 W/m²°C;
Equivalent coefficient of heat transfer by radiation from plate to cover = 6 W/m²°C; Coefficient of convective heat transfer from cover to ambient air = 25 W/m².°C and Equivalent coefficient for radiant heat transfer from cover to sky = 5 W/m².°C.
Compute the total heat loss per m² collector area. Assume that resistance to heat flow by convection at the back surface of the insulation is negligible. 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) What is coriolis acceleration? Give its formula.

(b) Name mechanisms for generating accurate and approximate straight line motion.

(c) How can the quality of a governor be ascertained?

(d) State the conditions for complete balancing of reciprocating parts of an engine.

(e) Explain the meaning of the following:
Hexagonal screw M 12 × 1.5 × 70; T-Bolt 22 × 100

(f) Why more than one full length leaves are provided in a leaf spring? State the ratio of stress between full length and graduated leaves.

(g) State the units of dynamic and kinematic viscosities in the S.I. units.

(h) What do you understand by basic static load rating of a bearing?

(i) State the standard value of pulley groove angle and the minimum recommended angle of arc of contact for a V-belt.

(j) Define diametral quotient and thermal capacity of a worm gear set.

(k) A timber beam is to be reinforced with two steel flitches of same size. They can be attached cither at the top and bottom or symmetrically on the sides. In which case will the moment of resistance be larger?

(l) What type of riveted joints are used for the longitudinal and circumferential joints of a cylindrical pressure vessel and why?

(m) What is standardisation? Give its four advantages.

(n) Name four types of steel castings.

(o) What are preferred numbers? Give their main advantages.

(p) Name four locating devices for jigs and fixtures.

(q) List four advantages of numerical control.

(r) Write four objectives of plant layout.

(s) What is production planning? State its levels.

(t) Explain standard rating and standard performance.

SECTION—B

2. (a) A disc of mass 5 kg is mounted in the middle of a simple supported horizontal shaft of span 0.5 m and of diameter 10 mm. The centre of gravity of the disc is displaced 2.5 mm from the geometric centre. The equivalent viscous damping for the system may be taken as 50 $N.s.m^{-1}$. The shaft rotates at 740 rpm. Calculate:
(i) dynamic stress in the shaft
(ii) static stress in the shaft, and
(iii) power required to drive the shaft. Take $E = 2 \times 10^5$ N. $(mm)^2$. 20

(b) The roller follower of a cam moves with SHM during ascent and with uniformly accelerated and decelerated motion during descent. The cam rotates at 370 rpm. Draw the cam profile for the following data:
Least radius of cam = 60 mm
Angle of ascent = 540
Angle of dwell between ascent and descent = 48°
Angle of descent = 66°
Lift of follower = 50 mm
Roller dia = 30 mm
Offset = 20 mm
Determine the maximum velocity and acceleration of following during descent. 20

3. (a) A spur pinion is driven by an electric motor of power 15 kW running at 740 rpm. Pitch diameter of pinion is 108 mm and speed reduction is 3 : 1. Module is 6 mm and pressure angle 20°.The pinion is 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. 20

(b) An 8 × 19 (9/9/1) steel wire rope is used to lift a load of 20 kN from a depth of 1 km. The maximum speed of rope is 2.5 ms and the acceleration is 1.5 ms^2 when starting under no slack conditions. Determine the size of the rope required for a desired factor of safety of 4.5 Modified modulus of elasticity for rope is 68600 MPa.

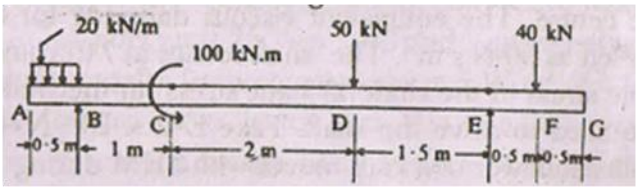
Table 1. Data for 8 × 19 (9 / 9 / 1) steel wire rope construction.

Nominal dia mm	Approximate mass	Breaking load(min)	Recommended sheave dia	Area of rope
d	kg/ 100m	kN		mm^2
8	22. 3	29	17d	0.4252 d^2
9	28. 2	37		
10	34. 2	45		
11	42. 2	55		
12	50. 2	65		
13	58. 9	76		
14	68. 3	88		
16	89. 2	115		
18	113	146		
19	126	163		
20	139	180		

20

4. (a) A thick spherical pressure vessel of inner radius 150mm is subjected to an internal pressure of 80 MPa. Calculate its wall thickness based upon the (i) maximum principal stress theory, and (ii) total strain energy theory. Poisson's ratio = 0.30, yield strength = 300 MPa. 20

(b) Construct the bending moment and shearing force diagrams for the beam shown in Fig.1.



20

SECTION—C

5. (a) What are the major alloying elements to aluminium? Discuss their effects. 10

(b) What are the different type of defects which generally develop due to heat treatment of steels? What are their causes and the measures which can be taken for their prevention? 20

(c) Discuss the underlying principles for the design of jigs and fixtures. 10

6. (a) 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. 15

(b) A seamless tube 32 mm outside diameter is turned on a lathe. Cutting velocity of the tool relative to the workpiece is10 m/min. Rake angle = 35°, depth of cut = 0.125 mm, length o fchip = 60 mm, horizontal cutting force of the tool on the workpiece= 200 N, vertical cutting force required to hold the tool against the work = 80 N. Calculate
(i) coefficient of friction
(ii) chip thickness ratio
(iii) shear plane angle
(iv) velocity of chip relative to the tool, and
(v) velocity of chip relative to the workpiece. 20

(c) Differentiate between the decimal and binary code systems. Find the decimal and binary codes for the number 140. 5

7. (a) The annual fixed costs of a product are known to be Rs.2×10^5 and the annual net profit is Rs. 4×10^4; the average monthly sales being 820 units. A new design is contemplated involving an expenditure of preparations amounting to Rs. 8×10^4 to be returned in two years. It is expected that with new production methods the product to volume ratio may be increased by 5 percent. What would be the new annual sales figure for the new product so that
(i) same net profit is realized
(ii) in addition to this profit a yield of 10 percent on the capital involved will be obtained. 20

(b) A building project consists of 10 activities. Their estimated duration is given below:

Activity	Duration
1 - 2	5
2 - 3	2
2-4	6
3 - 5	4
3 - 6	4
4 - 5	2
4 - 7	3
5 - 8	7
6 - 8	8
7-8	2

Draw the network and compute:
(i) event times
(ii) activity time
(iii) total float, and determine the
(iv) critical path. 20