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 heat engine operates between 600°C and 40°C and derives a reversible refrigeration operating between 40°C and –18°C. Still there is a net output of work equal to 370 kJ, while the heat received by the engine is 2100 kJ. Determine the cooling effect. 20

(b) A compressor takes in 500 kg/min of air at 0.98 bar and 18°C and delivers it at 5.5 bar and 68°C. The diameters of inlet and delivery pipes are respectively 450 mm and 200mm. The power input is 1000 kW. Determine the rate and direction heat flow. (C_v = 1.005 kJ/kg C). 20

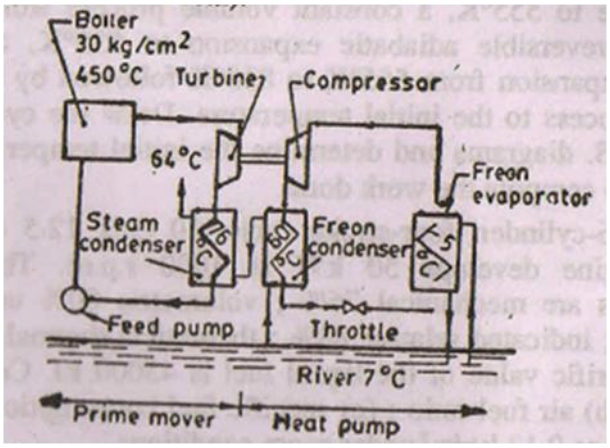
2. A reversible cycle using an ideal gas as the working substance consists of a isentropic compression from and initial temperature to 555°K, a constant volume process from 555° to 835°K, a reversible adiabatic expansion to 555°K, a constant pressure expansion from 555°K to 835°K followed by a constant volume process to the initial temperature. Draw the cycle on p-v and the T-S diagrams and determine the initial temperature, (γ = 1.40). Also compute the work done. 40

3. A 6-cylinder, four-stroke cycle, 10 cm × 12.5 cm stroke, diesel engine develops 50 kW at 1000 r.p.m. The various efficiencies are mechanical 76%; volumetric 80% under room conditions; indicated relative 88%; theoretical thermal 52%. The lower calorific value of the liquid fuel is 45000 kJ. Compute (a) b.m.e.p.; (b) air fuel ratio; (c) specific fuel consumption.
Assume air density as 0 12 kg/m^2 under room conditions. 40

4. The nozzles of de Laval turbine deliver steam at the rate of 900 gm/sec with a velocity of 730 m/sec to a set of blades revolving at the rate of 30000 r.p.m. The diameter of the wheels 11.5 cm. The nozzles are inclined at an angle of 20° to the plane of wheel rotation.
Calculate the (a) diagram efficiency; (b) power developed by (he blades; (c) energy lost in the blades per sec. Assume the blade velocity coefficient as 0.72 and outlet blade angle 25°. (d) Also determine the condition for the maximum efficiency of the turbine. Discuss the physical significance of diagram efficiency. 40

5. Water is drawn from a river at 7°C and has to be heated to 64°C. Calculate the advantage of using the heat pump plant described below over direct heating of the water. The water drawn from the river passes first through the Freon condenser and then through the steam condenser. Assume that a heat source above 450°C is available.
Freon-12 Heat Pump compressor is driven by stream turbine. Its condenser

temperature 60°C and evaporator temperature –5°C. Freon-12 enters compressor as saturated vapour and enters throttle value as saturated liquid. Steam pressure and temperature leaving boiler 30 kg/cm² and 450°C respectively. Steam condenser temperature 76°C.



Enthalpy values of Freon-12: At entry to compressor 187 KJ/ kg, at discharge of compressor 221.5 kJ/kg and at exit condenser 90kJ/kg. (4.18kJ = 1 kcal). 40

6. (a) Show that

$$\omega = \frac{0.622 \times P_w}{P - P_w}$$

where ω = absolute humidity of air P_w = partial pressure of water vapour P = barometric pressure. 20

(b) A drying room is to be maintained at 32°C and 30% R.H. The sensible heat gain to the room is 150000 kJ/hr. The moisture to be evaporated from the objects during drying is 18 kg/hr. If there is no direct heat source to provide for evaporation in the room, calculate the state and rate of supply air at 15°C d b.t. 20

7. A gate which is 2 m wide and 1.2 m high lies in a vertical plane and is hinged at the bottom. There is a liquid on the upstream side of the gate which extends 15 m above the top of the gate and has specific gravity of 1.45. On the downstream side of the gate there is water up to the top of the gate. Find (a) the resultant force acting on the gate, (b) the position on the centre of pressure, and (c) the least force acting horizontally at the top of the gate which is capable of opening it. 40

8. (a) Explain briefly the significance of dimensional analysis in model testing. 20

(b) Using a Buckingham-π theorem show that the discharge Q through a centrifugal pump can be expressed as

$$Q = ND^3 f\left(\frac{g}{N^2 D}, \frac{H}{D}, \frac{\mu}{\rho N D^2}\right)$$

where ρ = mass density of the fluid; N = pump rotational speed; D = diameter of the impeller; H = manometric head; μ = fluid viscosity; g = acceleration due to gravity. 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) State the fundamental law of gearing.

(b) What conditions must be specified for a pair of helical gears to mesh properly?

(c) State Kennedy's three-centre-in-line theorem.

(d) Mention the factors necessary for the design of spur gears.

(e) State D'Alembert's principle and write down its importance.

(f) Specify the important features of a reverted gear train and give connected equations.

(g) What is the effect of inertia of reciprocating parts on the engine frame?

(h) Differentiate between the main function of the fly-wheel and governor.

(i) State the relation between Young's Modulus, Rigidity Modulus and Poisson's Ratio.

(j) Explain what is meant by Hammer blow in a locomotive.

(k) What is principle of Thermit welding? Give chemical reaction involved.

(l) What is the principle involved in Laser Beam Welding?

(m) What is the composition of mild steel? How do properties change with increase in carbon content in steel?

(n) What is the difference between a blind riser and an open riser? How do they function?

(o) What is the difference between a bolt and a screw? Mention their applications in practice.

(p) Differentiate between bending and drawing operation; and piercing and blanking operations.

(q) Mention briefly various cutting tool materials and their applications.

(r) How is time study related to wage incentives? Explain.

(s) What is mean by 'methods study'? Explain.

(t) What is meant by 'value engineering'? Explain.

SECTION—B

2. (a) A vertical shaft of 0.5 cm diameter is 20 cm long and is supported in long bearings at its ends. A disc weighing 50 kgf is attached at the centre of the shaft. Neglecting any increase in stiffness due to the attachment of the disc to the shaft, find the critical speed of rotation and the maximum bending stress when the shaft is rotating at 75% of the critical speed. The centre of the disc is 0.25 mm from the geometric axis of the shaft. $E = 20 \times 10^5$ kgf/cm^2. 25

(b) Deduce an expression for the minimum number of teeth on the pinion of a mating spur gear to avoid interference between the flanks of the pinion teeth and the tips of the gear teeth. 15

3. (a) A shaft of 20 cm diameter has a speed of 2500 RPM and runs in a bearing which has a length of 1.2 times the diameter. The bearing pressure is 7 kgf/cm^2 and the coefficient of friction at the bearing surface is 0.006. Calculate the horse power lost in friction. The oil flow through the bearing controls the temperature of the bearing. If the difference between the outlet temperature and that at inlet is 20°C, obtain the quantity of oil required if the specific heat is 0.45 and specific gravity is 0.88. Determine the pipe size for (i) oil inlet if the maximum velocity of flow is 1.25 m/sec and (ii) oil drain, the drain to run half full with a maximum oil velocity of 15 m/sec. 25

(b) Determine the width of a 9.75 mm thick leather belt required to transmit 20 HP from a motor running at 900 RPM. Diameter of the driving pulley of the motor is 30 cm. The driven pulley runs at 300 RPM and the distance between the centres of the two pulleys is 3 meters. The weight of the leather is 1×10^{-3} kgf/cm^2. Maximum allowable stress in the leather is 25 kgf/cm^2. Coefficient of friction between leather and pulley is 0.3. Assume open belt drive and neglect the sag and slip of the belt. 15

4. (a) An overhanging pulley of 1 meter diameter and weighting 100 kgf transmits 45 HP at 140 RPM, the sides of the belt being vertical. The ratio of tensions is 2 : 1 and if the maximum tensile and shear stresses are limited to 200 and 600 kgf/cm^2 respectively. Find the diameter of the shaft. The centre of the pulley is 35 cm from the nearest bearing. 25

(b) A truck weighing 2500 kgf and moving at 2.5 m/sec has to be brought to rest by a buffer. Find how many springs each of 25 coils will be required to store energy of motion during compression of 20 cm. The spring is made of 25 mm diameter steel rod coiled to a mean diameter of 20 cm. ($N = 1 \times 10^6$ kgf/cm^2). 15

SECTION—C

5. (a) For each of the following mention briefly (i) principle of operation, (ii) field of application:
1. Electro-slag welding process, 2. Submerged arc welding,
3. Plasma arc welding, 4. Ultrasonic welding. 16

(b) Explain various high velocity forming methods and mention the principle involved in each process with their application in practice. 12

(c) What is the main function of risering in castings? Using fundamental principles of metal solidification, explain any two methods of arriving at riser calculation for obtaining a sound casting. 12

6. (a) Explain the impact of hot machining, Rotary machining and High speed machining in metal cutting field and mention their applications. 16

(b) Distinguish between:
(i) Counter sinking and counter boring
(ii) Mandrel and arbor
(iii) Tap and die
(iv) Gear shaping and gear nobbing. 12

(c) Discuss the following methods of surface finish evaluation stating their merits and demerits:
(i) CLA Value (ii) RMS Value (iii) Rz Value.
Sketch an instrument capable of indicating the surface finish. 12

7. (a) Consider two different types of foodstuffs say F_1 and F_2. Assume that these foodstuffs contain vitamins V_1, V_2 vitamins are1 mg of V_1, 50 mg of V_2 and 10 mg of V_3 respectively. Suppose that the foodstuff F_1 contains 1 mg of V_1, 1 mg of V_1, 100 mg of V_2 and 10 mg of V_2 and 100 mg of V_3. Cost of one unit of foodstuff F_1 is Rs. 20 and that of F_2 is Rs. 2.5. Find the minimum cost diet that would supply the body at least the minimum requirement of each vitamin. 15

(b) At a Railway Station, only one train is handled at a time. The railway yard is

sufficient only for two trains to wait while the other is given signal to leave the station. Trains arrive at the station at an average rate of 6 per hour per hour. Assuming Poisson arrivals and Exponential service distribution, find the steady state probabilities for the various number of trains in the system. Also find the waiting time of a new train coming into the yard. 15

(c) Explain with algorithm to solve LP problem using simplex method. 10