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) Using Maxwell's relations, show that for a pure substance

$$T.ds = Cp.dT - Tv\beta.dp$$

$$T.ds = C_v.dT + T\frac{\beta}{K}.dv$$

$$T.ds = C_v\frac{K}{\beta}dp + \frac{C_p}{v\beta}.dv$$

where β is coefficient of cubical expansion, K is coefficient of compressibility and C_p and C_v are specific heats at constant pressure and at constant volume respectively. 15

(b) State the Clausius inequality in words.
An inventor claims that he has developed a heat engine which absorbs 1200 kJ and 800 kJ from reservoirs at 800 K and 600 Kelvin respectively and rejects 600 kJ and 200 kJ as heat to reservoirs at 400 K and 300 K respectively. It delivers 1200 kJ work. Determine whether the heat engine is theoretically possible. 15

(c) A mass m of fluid at temperature T_1 is mixed with an equal mass of the same fluid at temperature T_2. Prove that the resultant change entropy of the universe is 10

$$2mc\frac{(T_1+T_2)/2}{\sqrt{T_1T_2}}$$

2. (a) Explain clearly the terms pre-ignition, detonation and diesel knock. 10

(b) What is supercharging? Explain the thermodynamic cycle for a supercharged I.C. engine. Which engine is more suitable for supercharging - spark ignition engine or compression ignition engine? Why? 10

(c) A 16-cylinder diesel engine has a power output of 800 kW at 900 revolutions per minute. The engine works on the four stroke cycle and has a fuel consumption of 0.238 kg/kW hr. The pressure in the cylinder at the beginning of injection is 32.4 bar and the maximum cylinder pressure is 55 bar. The injector is set at 214 bar and maximum pressure at the injector is around 600 bar. The coefficient of discharge for the injector is 0.6. The specific gravity of the fuel is 0.86. Calculate the orifice area required per injector if the injection takes place over 10 degree crank angle. 10

3. (a) A layer of 5 cm thick insulating brick having conductivity of 1.5 W/mK is placed between two 0.5 cm thick steel plates. The conductivity of mild steel is 50 W/mK. The faces of brick adjacent to the plates are rough having solid-to-solid

contact of 30% of the total area. The average height of the asperities is 0.1 cm. If the outer plate surface temperatures are 100°C and 500°C respectively, calculate the rate of heat transfer per unit area. The conductivity of air is 0.02 W/m K. 25

(b) Air at 25 °C flows over a thin plate with a velocity of 2.5 m/sec. The plate is 2 m long and 1 m wide. Estimate the thermal boundary layer thickness at the trailing edge of the plate and total drag force experienced by the plate. At 25 °C, the density of air is 1.2 Kg/m^3 and kinematic viscosity is 15×10^{-6} m^2/s. Prandtl number for air is 0.69. 15

4. (a) Air enters a chamber at 5°C dry bulb temperature (DBT) and 2.5°C wet bulb temperature at the rate of 100 m^3/min and at the pressure of 1 bar. While passing through the chamber, the air absorbs 50 kW heat and picks up 35 kg/hr of saturated steam at 110°C. Show the process on a psychrometric chart and find the dry and wet bulb temperatures of the leaving air. At 110°C, enthalpy of saturated steam is 2691.3 kJ/kg. 20

(b) Develop an expression to calculate ideal COP of a vapour absorption refrigeration system. Describe its components. A vapour absorption system has a source temperature of 110°C and refrigeration temperature of –5°C and ambient temperature of 35°C.
Calculate its COP. 20

5. (a) What is meant by boundary layer thickness, displacement thickness, momentum thickness and energy thickness? 10

(b) What is the physical significance of Reynolds number and Mach number? Give examples of their area of applications. 10

(c) Oil of viscosity 0.97 poise and 0.9 specific gravity flows through a horizontal circular pipe of 100 mm diameter and 10 m length. Calculate the pressure difference between the ends of the pipe. What is the type of flow? 20

6. (a) Distinguish different types of flows prevailing in fluid problems. 10

(b) What assumptions are made in deriving Bernoulli's equation? 10

(c) Find the discharge of water flowing through an inclined venturimeter of 30 cm main size and 15 cm throat size. The difference between the main and the throat pressure measured by an Inverted liquid manometer with the liquid of specific gravity of 0.6 gives a reading of 30 cm. The loss of head between the main and the throat is 0.2 times the K.E. of the main. 20

7. (a) Explain fluid coupling and torque converter and their area of application. 10

(b) What is the importance of governing? Explain with sketch a simple governing mechanism for a turbine. 10

(c) A pipe of 300 mm diameter and 1000 m length connects two reservoirs kept at 15 m level difference. Find the flow through the pipe. If an additional length of 500 of 300 mm diameter pipe is connected at the later half of the existing pipe, find the increase in discharge. Neglect minor losses. Take $f = 0.02$. 20

8. (a) Discuss the relative merits and demerits of axial flow compressor over centrifugal compressor. Air at a temperature of 300 K enters a ten stage axial flow compressor at the rate of 3.5 kg/sec. The pressure ratio is 6.0 and the isentropic efficiency is 90%. The process is adiabatic and the compressor has symmetrical stages. The axial velocity of 120 m/sec is uniform across the stage and the mean blade speed of each stage is 200 m/sec. Assume that the temperature change is same in each stage. Determine the direction of the air at entry to and exit from the rotor and the stator blades. Also find the power given to the air. Take $C_p = 1.005$ kJ/kg and $\gamma = 1.4$. 20

(b) A De lavel turbine has a mean blade speed of 180 mps. The nozzles are inclined at 17° to the tangent. The steam flow velocity through the nozzle is 550 m/sec.

For a mass flow of 3300 Kg/hour and for axial exit conditions, find
(i) The inlet and outlet angles of the blade system.
(ii) The power output.
(iii) Diagram efficiency 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) Distinguish between Computer education and computerised education.

(b) Study of a machining operation yields the cycle time of 9.0, 8.0, 9.0 and 10.0 minutes. The observed worker was rated at 90%. Providing an allowance factor of 15%, compute the standard time for the operation.

(c) Differentiate between forecasting and prediction.

(d) What is JIT? What is the primary benefit derived from its adoption?

(e) What is concurrent engineering?

(f) Why a large sphere solidifies and cools to ambient temperature at a much slower rate than does a smaller sphere?

(g) Comment on the machined surface characteristics obtained after the EDM process.

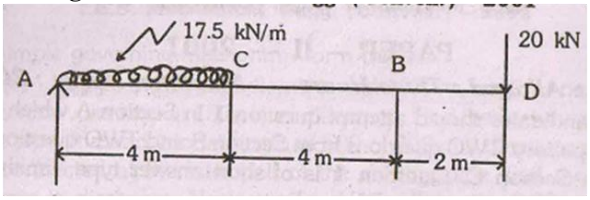
(h) What is diffusion welding?

(i) What is temper embrittlement in alloy steels and what are its effects?

(j) Differentiate between cold, warm and hot working of metals.

(k) Group the following into thermo sets and thermoplastics:
Acrylic, Alkyds, Polyimide, Nylon, Epoxy, Phenolic, Silicone and PVC.

(l) What is meant by point of contraflexure or point of inflexion in a beam? Show the same for the beam given below



(m) A tension member with a cross-sectional area of 30 mm^2 resists a load of 80 kN. Calculate the normal and shear stresses on the plane of maximum shear stress.

(n) Differentiate between strut and column. What is the general expression used for determination of their critical load?

(o) Distinguish between stress concentration factor and stress intensity factor.

(p) Why two universal joints with an intermediate shaft is generally used in practice for transmitting motion from one shaft to other, having angular misalignment? Sketch the arrangement.

(q) What is meant by 6 × 7 Lang Lay-Right Lay wire rope?

(r) Two gears having an angular velocity ratio of 3 : 1 are mounted on shafts whose centers are 136 mm apart. If the module of the gears is 4 mm, how many teeth are there on each gear?

(s) Whether the size of the flywheel for an inline multicylinder engine of

particular h.p. can be reduced by increasing the number of cylinders? If so, why?

(t) What is the difference between whirling and critical speed of a shaft? Mention two physical parameters of the shaft-bearing system, which can increase the critical speed of the shaft.

SECTION—B

2. (a) A single cylinder two stroke vertical engine has a bore of 30 cm and a stroke of 40 cm with a connecting rod of 80 cm long. The mass of the reciprocating parts is 120 kg. When the piston is at quarter stroke and moving down, the pressure on it is 70 N/cm^2. If the speed of the engine crank shaft is 250 rpm clockwise, find the turning moment on the crank shaft. Neglect the mass and inertia effects on connecting rods and crank. 15

(b) The turning moment exerted on the crank shaft of the above engine is given by:

$$T = 10{,}000 + 2000 \sin 2\theta - 1800 \cos 2\theta.$$

where θ is the crank angle measured from T.D.C. Assuming that the load torque to be constant, determine

(i) the power of the engine when turning at 250 rpm.

(ii) the moment of inertia of the flywheel if the speed variation from the mean speed is not to exceed ± 0.25%.

(iii) the angular acceleration of the flywheel for $\theta = 45°$. 15

(c) Can the above engine be completely balanced? If yes, explain the method of balancing. If not, what is the technique adopted for minimisation of unbalance. Find out the mass required at a radius of 30 cm from crankshaft for such balancing.

Also find the resultant unbalance force at the crank position, as given in part (a). 10

3. (a) A steel tube of inner diameter 100 mm and wall thickness 5 mm is subjected to a torsional moment of 1000 Nm. Calculate the principal stresses and orientations of the principal planes on the outer surface of the tube. 10

(b) A helical spring B is placed inside the coils of a second helical spring A, having the same number of coils and free axial length and of same material. The two springs are compressed by an axial load of 210 N which is shared between them. The mean coil diameters of A and B are 90 mm and 60 mm and the wire diameters are 12 mm and 7 mm respectively. Calculate the load shared by individual springs and the maximum stress in each spring. 15

(c) A cantilever tube of length 120 mm is subjected to an axial tension P = 9.0 kN, a torsional moment T = 72.0 Nm, and a bending load F = 1.75 kN at the free end. The material is aluminum alloy with an yield strength of 276 MPa. Find the thickness of the tube limiting the outside diameter to 50 mm so as to ensure a factor of safety of 4. 15

4. (a) Design a set of stepped pulleys to drive a machine from a counter-shaft that runs at 220 rpm. The centre distance between the two sets of pulleys is 2 m. The diameter of the smallest step on the countershaft is 160 mm. The machine is to run at 80, 100 and 130 rpm and should be able to rotate in either directions. Find the length of the belt required for both cases. 15

(b) When two cylindrical parts are assembled by shrinking or by press fitting, a contact pressure is created between the two parts. If the radii of the inner cylinder are a and c and that of the outer cylinder are (c – δ) and b, δ being the radial interference, the contact pressure is given by:

$$P = \frac{E\delta}{c}\left[\frac{\left(b^2 - c^2\right)\left(c^2 - a^2\right)}{2c^2\left(b^2 - a^2\right)}\right]$$

where E is the Young's modulus of the material. Can you outline the steps involved in developing this important design equation? 15

(c) A hollow shaft of diameter ratio 3/8 is required to transmit 600 kW at 110 rpm, the maximum torque being 20% greater than the mean. The shear stress is not to exceed 63 MN/m^2 and the twist in a length off 3 m not to exceed 1.4 degrees. Determine the diameter of the shaft. Assume modulus of rigidity for the shaft material as 84 GN/m^2. 10

SECTION—C

5. (a) Describe the major imperfections that may be present in the crystal structure of metals. How do they influence the mechanical properties of materials? 10

(b) What are super alloys? Discuss in brief the compositions, properties and applications of these alloys. 10

(c) Give a step-by-step procedure for the cold chamber die-casting process. Also discuss the advantages and limitations of hot and cold chamber processes. 20

6. (a) Discuss in brief the flank and crater tool wear mechanisms.
In a certain machining operation with a cutting speed of 50 m/min, tool life of 45 minutes was observed. When the cutting speed was increased to 100 m/min, the tool life decreased to 10 minutes. Estimate the cutting speed for maximum productivity, if tool change time is 2 minutes. 10

(b) (i) Explain the difference between hard and soft automation. Why are they so called? 5

(ii) What are the feature of an intelligent robot? 5

(c) Describe any four common types of discontinuities that may develop in a welded joint. What remedies you suggest to avoid them? 10

(d) Discuss the technical and economics leading to the development of Non Traditional Machining (NTM) processes. 10

7. (a) Demand for a certain item has been as shown below: The forecast for April was 100 units with a smoothing constant of 0.20 and using first order exponential smoothing, what is the July forecast? What do you think about a 0.20 smoothing constant?

Time	Actual Demand
April	200
May	50
June	150

10

(b) Consider the following jobs and their processing times at corresponding machines:-

	Duration (Hours)		
	Machine 1	Machine 2	Machine 3
Job	t_{i1}	t_{i2}	t_{i3}
A	13	5	9
B	5	3	7
C	6	4	5
D	7	2	6

Using Johnson's rule, find the optimal sequence. 10

(c) Assume that the following specify a generalized linear programming problem:-
Maximize: $f(x) = 2\,x_1 + 2\,x_2$ subject to

$$x_1 + x_2 \le 6$$
$$x_1 \le 3$$
$$2x_1 + x_2 \ge 6$$
$$x_1,\ x_2 \ge 0$$

Graph this problem, identifying the three constraint equation lines and the feasible zone common to all of them. Plot dotted lines for values of 3, 6, 9 and 12 for the objective function $f(x)$.
What appears to be the highest feasible value of $f(x)$, and for what values of x_1 and x_2 does it occur? 20