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 cylinder closed at both ends is thermally insulated from the surroundings. It contains a movable, thermally insulated, frictionless and leak proof piston. Initially the pressure, volume and temperature on each side of the piston are P_0, V_0 and T_0. The number of moles of gas on each side is n. Heat is now slowly supplied to the gas on the left side of the piston by an electric heating coil. As a result the gas on the left-hand side expands and displaces the piston, compressing the gas on the right-hand side until its pressure reaches (27/8) P_0. If the ratio of specific beats (c_p/c_v) is 1.5 and the molecular weight of the gas is M, determine, in terms of n, c_v, M and T_0 (i) the work done on the gas on the right-hand side, (ii) the final temperature of the gas on the right-hand side, (iii) the final temperature of the gas on the left hand side and (iv) the heat supplied to the gas on the left hand side.
All assumptions made must be clearly stated.

(b) Two reversible heat engines E_1 and E_2 are kept in series between a hot reservoir at a temperature T_1 of 600 K and a cold reservoir at a temperature T_3 of 300 K. Engine E_1 receives 500 kJ of heat from the reservoir at T_1. The thermal efficiency of both the engines is the same. Determine (i) the temperature at which heat is rejected by engine E_1, and received by engine E_2, (ii) work done by engine E_1, (iii) work done by engine E_2, (iv) heat rejected by engine E_2 to the cold reservoir and (v) the efficiency of the engines.

2. (a) Derive an expression for the air-standard efficiency of a Diesel cycle in terms of the compression ratio (the ratio of the volumes at the beginning and end of the compression process), the cut-off ratio (ratio of volumes at the end and beginning of the constant pressure beat addition process) and the ratio of specific heats at constant pressure and constant volume. Draw a neat sketch of the cycle on the p-V diagram.

(b) An ideal Diesel engine operates with air as the winking substance. The temperature and pressure of the air at the beginning of the compression process are 25°C and 1.005 bar. The compression ratio is 18 and the cut-off occurs at 6.5% of the expansion stroke.

(i) Draw the p-V and the T-s diagrams for the cycle indicating clearly each of the processes;
(ii) Determine the pressure and temperature at the end of each process;
(iii) Determine the air-standard efficiency of the cycle assuming γ = 1.4 for air;
(iv) The work done per cycle (assume C_P =1.0 kJ/kgK);
(v) The mean effective pressure.

3. (a) In a surface condenser air is removed from a screened-off section of the cooling tubes at a temperature of 32°C. The absolute pressure of the steam entering the condenser is 0.075 kgf/cm^2. The mean temperature in the condenser is 36°C and the hot-well temperature is 30°C. Cooling water flowing at the rate of 100000 kg/h enters the condenser at 20°C and leaves it at 32°C. The condensate formed is 2300 kg/h. Determine the vacuum efficiency, the condenser efficiency, the state of steam entering the condenser, the mass of air present in the condenser per m^3 of its volume and the mass of air present per kg of uncondensed steam. Assume the gas constant for air to be 29.3 (kg/-m)/(kg K).

(b) A power plant operates on the regenerative cycle. Steam is supplied to the turbine at 80 kgf/cm^2 and 400°C. It is exhausted to the condenser at 0.05 kgf/cm^2. The plant has two feed-water heaters where steam extracted from the turbine is directly mixed with the feed-water. Steam is extracted from the turbine at pressures of 10 kgf/cm^2 and l.5kgf/cm^2. Determine the mass of steam extracted at each of these pressures per kg mass flow at the turbine inlet, the heat rejected in the condenser per kg mass flow at the turbine inlet, the cycle efficiency and the gain in the cycle efficiency over a Rankine cycle operated under the same initial and final conditions.
Assume expansion of steam to be isentropic.

4. (a) Draw neat schematic diagrams of closed cycle and open cycle gas turbine engines. Label all components and show the flow directions. Show the various thermodynamic processes of the open and the closed cycle on the p-V and the T-s diagrams.

(b) Derive an expression for the optimum pressure ratio that will give the maximum power output per unit mass flow in a Brayton cycle where the compressor and the turbine efficiencies are η_c and η_t respectively, in terms of the maximum and minimum temperatures in the cycle and the ratio of specific heats at constant pressure and constant volume.

(c) The maximum and the minimum temperatures occurring in a closed cycle gas turbine plant are 927°C and 37°C. The pressures at the outlet and the inlet of the compressor are 5 kgf/cm^2 and 1 kgf/cm^2. The compressor and turbine efficiencies are 80% and 88% respectively. Per kg of air flow in the cycle determine the compressor work, the turbine work, the heat supplied to the cycle and the net work done in the cycle. Also determine the thermal efficiency of the cycle and the optimum pressure ratio for maximum power output for the given temperatures. Assume γ for air to be 1.4 and the specific heat at constant pressure to be 0.25 kcal/kgK.

5. (a) Describe with the help of a neat diagram the working of a vapor-compression refrigeration plant. Sketch the corresponding temperature-entropy and pressure-enthalpy diagrams indicating the directions of the various processes. Establish the expressions for the coefficients of performance when the plant is operated as a refrigerator and as a heat pump. How do superheating of the vapor at the entrance" to the compressor and subcooling of the liquid at the entrance of the throttle valve as also the frictional losses in the compressor affect the performance of the machine ? Indicate these effects on the T-s and the p-h diagrams.

(b) An ammonia refrigerator operates on the simple vapour compression cycle. The pressure of liquid ammonia before throttling is 12.3 kgf/cm^2 and its temperature is 27.2°C. The evaporator pressure is 2.53 kgf/cm^2. Ammonia gas leaves the evaporator at –9.5°C. The power input to the compressor is 2.12 kW and the mass flow rate of ammonia is 27 kg/h. Determine the dryness fraction of the gas after throttling, the heat absorbed per hour in the evaporator and the coefficient of performance of the refrigerator. Sketch the cycle on the T-s and the p-h diagrams.
Properties of ammonia are given below:

Temperature	Pressure	Saturation	enthalpy, kcal/kg
°C	kg/cm^2	liquid	gas
–13.8	2.53	27.5	341
+31.1	12.30	77.5	351

Specific heat of liquid at 12.3kgf/cm^2 may be taken to be 1.14 kcal/kg°C and the specific heat of superheated vapor at 2.53 kgf/cm^2 may be taken to be 0.6 kcal/kg°C.

6. (a) Develop an expression for the heat flux passing radially through a long composite cylinder of length L made up of three concentric layers of different materials and thicknesses in terms of r_1 the inside radius of the inner cylinder; r_2, r_3 and r_4, the outside radii of the inner, middle and the outer cylinders respectively; their corresponding thermal conductivities k_1, k_2 and k_3; the temperature T_1 at the inner surface of the inner cylinder and the temperature T_4 at the outer surface of the outer, cylinder, T_1 being greater than T_4.
If the inside heat transfer coefficient of a fluid at temperature T_1 flowing through this cylinder is h_i and the outside heat transfer coefficient of another fluid at temperature T_2 flowing on the outside is h_0, determine the overall heat transfer coefficient referred to the inside surface.

(b) A thick-walled steel pipe of 168 mm outer diameter and 18 mm wall thickness is to be provided with an asbestos layer insulation. The pipe carries saturated steam at a pressure of 100 kgf/cm^2. The velocity of steam in the pipe is 25 m/s. The temperature of the surroundings is 30°C.The outside heat transfer coefficient may be taken to be 15 kcal/m^{2}h°C while the inside heat transfer coefficients of the condensing steam may be taken to be 5000 kcal/m^{2}h°C. If the loss of steam by condensation is to be restricted to 0.5% of the mass flow per 100 meter length of the pipeline, determine the insulation thickness. Assume thermal conductivity of steel to be 40 kcal/mh°C and the thermal conductivity of asbestos to be 0.5 kcal/mh°C. Neglect effect of fouling.

7. (a) What is the .basis for classifying hydraulic turbines? Illustrate your answer by giving names of turbines falling under each category.

(b) An inward flow reaction turbine has a degree of reaction of 0.6. The peripheral velocity of the vanes at entry is 15 m/s. The radial velocity of flow is constant at 3.2 m/s. The diameter of the rotor at entry is twice that at the exit. Determine the blade angles at entry and exit assuming that the absolute velocity of the water leaving the runner is in the radical direction.

(c) Discuss the phenomenon of cavitations in hydraulic turbines.

8. Write short notes on any four of the following:—

(a) Steam accumulator.
(b) Hydraulic ram.
(c) Orifice meter for flow measurement.
(d) Orsat apparatus for analysing the product of combustion.
(e) Governing of steam turbines.
(f) Carburettor.

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. $20 \times 2 = 40$

(i) Why are the shafts generally finished by grinding while beams are used in as rolled condition?

(ii) A helical spring is compressed axially. How does the spring wire get shear strain?

(iii) A piece of sheet metal strip can be easily bent, while the same strip when formed into a channel shape become stiffer. Explain.

(iv) Distinguish between 'fail safe' and 'safe fail' concepts in machine design.

(v) What is the role of hunting tooth or hunting in gear transmission?

(vi) for an increasing the stiffness of a helical spring; one should-
(a) increase/decrease diameter of spring,
(b) increase/decrease diameter of spring wire,
(c) increase/decrease length of spring or length of spring has no effect.
Write the correct answer for each of parts (a), (b)and (c).

(vii) Arrange the following sections in order of increasing torsional rigidity, see Fig. 1.

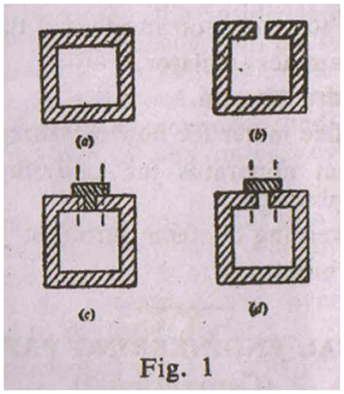

Fig. 1

(viii) Give an approximate composition for each of the following alloys;
(a) High speed steel
(b) Stainless steel

(ix) State the von Mises hypothesis of yielding of metals.

(x) Which of the following coolants are used in machining of (a)alluminium and (b)cast iron —
(a) Soap solution
(b) Kerosene
(c) Soluble oil solution
(d) EP cutting oil

(e) No coolant is used

(xi) A rubber band is elongated to double its initial length. Calculate its true strain.

(xii) List the followings in order of increasing machinability:
(a) Grey cast iron
(b) Mild steel
(c) Brass
(d) Stainless steel

(xiii) What is the relative consumption by volume of oxygen and acetylene in oxy-acetylene welding of mild steel?

(xiv) It is desired to measure the pouring temperature while casting grey cast iron. State a suitable method.

(xv) Write four sentences distinguishing an. NC milling machine from a CNC milling machine.

(xvi) For which of the following cases NC machines can be used economically?
(a) Mass production
(b) Batch production
(c) Job-shop production

(xvii) State the name of frequency distribution used for estimating activity times for PERT. Give a sketch of its distribution.

(xviii) In which of the following processes there is no wear of tool?—
(a) Ultrasonic machining
(b) Electrochemical machining
(c) Electro-discharge machining
(d) Grinding

(xix) With which of the following, value analysis is concerned?—
(a) Inventory control
(b) Quality control
(c) Fixing selling price of a product
(d) Attaching a cost value to every function fulfilled by a part in a product

(xx) What do AQL and AOQ stand for in quality control?

SECTION—B

2. (a) A quick return mechanism of a shaper is shown in Fig. 2. The crank O_1A rotates at 40 r.p.m. in the counter-clockwise direction. Determine the linear velocity of the cutting tool when the crank O_1A is at 45° with the horizontal. All dimensions are given in the figure. 25

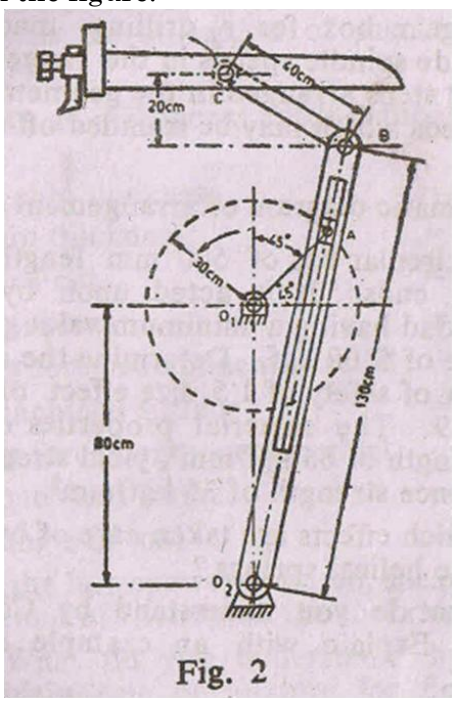

Fig. 2

(b) A hollow shaft of 40 mm outer diameter and 25 mm inner diameter is subjected to a twisting moment of 1200 kgf-cm, simultaneously; it is subjected to an axial thrust of 1000 kgf and a bending moment of 800 kgf-cm. Calculate the maximum compressive and shear stresses. 15

3. (a) A single plate clutch, effective on both sides, is required to transmit 335 HP at 3000 r.p.m. Determine the outer and inner diameters of frictional surface if the coefficient of friction is 0.255, ratio of diameters is 1.25 and the maximum pressure is not to exceed 0.01 kgf/mm^2. Also, determine the axial thrust to be provided by springs. Assume the theory of uniform wear. 15

(b) Two rotors of mass moment of inertia J_2 are connected to the ends of a shaft of length l, diameter d and modulus of rigidity G. The shaft is appropriately supported to permit the rotation of the shaft about its axis. Find the natural frequency of the free torsional vibration of the system. 10

(c) A gear box for a drilling machine is to be designed to provide spindle speeds in the range of 100 r.p.m. to 640 r.p.m in 9 steps arranged in the geometric progression. Calculate the speeds which may be rounded off to the nearest 5 r.p.m.
Sketch a schematic diagram of arrangement of gears. 10

4. (a) A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 2000 kgf and a maximum value of 5000 kgf. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar are given by: ultimate strength of 65 kgf/mm^2, yield strength of 50 kgf/mm^2, and endurance strength of 35 kgf/mm^2. 15

(b) Which effects are taken care of by Wahl correction factor for the helical springs? 10

(c) What do you understand by Computer Aided Design (CAD)? Explain with an example of design of a spring. 10

SECTIONC

5. (a) In a turning operation tool life T is given by VT^n = constant. Determine the value of n if 50% increase in cutting speed V reduces T by 20%. 8

(b) Draw a neat sketch of an enlarged surface profile and show clearly on it (i) mean surface (ii) roughness height (iii) roughness width (iv) waviness height (v) waviness width.
Comment how mean surface can be shown. 10

(c) A stockist finds that monthly demand for a particular ball pen is 2000. The price of each pen is 80 paisa and cost of placing the order is Rs. 20. The cost of stocking the pens per month is 10% of the price of pens. What is the economic ordering quantity? 8

(d) Work sampling studies are conducted to find the utilization of a machine. Out of 200 observations made, only 40 observations indicated the machine to be idle. Find the number of observations to be made in order to satisfy 95%confidence to state the utilization of machine with expected accuracy of ±5%. 9

6. (a) In an orthogonal cutting the following data is observed:
Uncut chip thickness = 0.35 mm
Cut chip thickness = 0.76 mm
Width of cut = 4 mm
Cutting speed = 30 m/min
Cutting force component parallel to machined surface =150 kgf
Cutting force component normal to machined surface = 30 kgf
Rake angle of tool =15°
Determine the horsepower required, shear plane angle, and average coefficient

of friction on the tool rake face. 12

(b) What do you understand by fibre-reinforced plastics? Explain rule of mixture for finding the material properties of the composite. Also give two applications of these materials. 11

(c) In rolling of metals with flat rolls, explain the effect of following parameters on total rolling load and on the pressure distribution contacting roll surface:
(i) Reduction in height of billet
(ii) Diameter of rolls
(iii) Coefficient of friction between rolls and billet. 12

7. (a) Maximize $3x_1 + 10x_2$
subject to $6x_1 + 5x_2 \leq 30$
$3x_1 + 6x_2 \leq 24$
$2.5x_1 + 1.25x_2 \leq 10$
$x_1, x_2 \geq 0$ 12

(b) The network diagram of a project is given in Fig, 3 below. The activity times in days are shown on the arcs. Determine
(i) critical path and critical path time ;
(ii) total float and free float of activity 1-4.
(iii) If due to unavoidable reasons activity (1-3) takes 6 days instead of 4, find the change in the critical path.

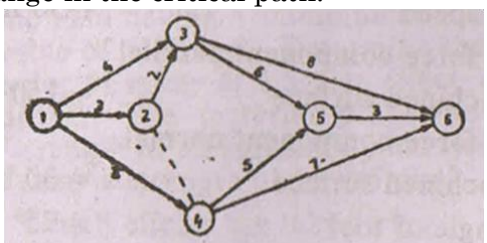

Fig. 3

(c) Six jobs are to be processed on two milling machines. All of them follow the same machine sequence. Determine the optimal job sequence and minimum total expected time from the data given below: 12

Job	Processing time (minutes)	
Number	Machine 1	Machine 2
1	5	7
2	4	3
3	2	8
4	5	3
5	6	1
6	3	5