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, $\gamma = 1.4$, $M = 28.97$ 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) During some integral number of complete cycles a reversible heat engine absorbs 2800 kJ from a heat, reservoir at 1000 K and performs 800 kJ of mechanical work. The engine exchanges heat with two other heat reservoirs one of which is 5400 K and the other at 600 K. Determine the heat exchanged (whether absorbed or rejected) with these two reservoirs, the change in entropy of each of the three reservoirs and the change in the entropy of the universe. Draw a NEAT sketch of the system.

(b) An engine in outer space operates on the Carnot cycle. The only way in which heat is rejected by the engine to the surroundings is by radiation which is proportional to the product of the fourth power of the absolute temperature of the radiating surface and its area. For a given power output of the engine, hot reservoir temperature T_1 and radiator temperature T_2 determine the ratio (T_1/ T_2) for which the area of the radiating surface as a minimum.

(c) A system maintained at constant volume is initially at temperature T_1. If a heat reservoir at temperature T_0 which is less than T_1 is available, determine the maximum work obtainable as the system is cooled to T_0 in terms of T_0. T_1 and C_v.

2. (a) Describe with the help of a neat sketch the construction and working of an Orsat apparatus for volumetric analysis of dry flue gases.

(b) The composition of coal burnt during a boiler trial was it follows:
$C = 62\%$; $H_2 = 3.6\%$; $O_2 = 7.4\%$ and ash 27%. The volumetric analysis, of the flue gas showed the following $CO_2 = 10.25\%$; $CO = 0.80\%$; $O_2 = 8.54\%$ and $N_2 = 80.43\%$. Determine

(i) the air-fuel ratio,
(ii) the percentage of excess air,
(iii) the mass of CO_2, CO, O_2 and N_2 in the flue gates per kg of coal burnt.

3. (a) Derive the condition for maximum efficiency of a two-stage air compressor fitted with a perfect intercooler. What is the expression for minimum work if the air discharged from the l.p. cylinder is cooled to a temperature higher than the initial temperature?

(b) A single acting two-stage reciprocating air compressor is to compress air from 1 kg/cm^2 and 30°C to 12.25 kg/cm^2. The bore of the low pressure cylinder is 30 cm. The stroke length of both the low and the high pressure cylinders is the same and is equal to 40 cm. The compressor runs at 180 r.p.m. The clearance volume in both the cylinders is 3% of the stroke volume. Index of adiabatic compression and expansion is 1.3 in both the cylinders. Determine the shaft horse power required to drive the compressor when (i) the air is cooled to its initial temperature before entering the h.p. cylinder, (ii) when the air is cooled to 45°C in the intercooler. Assume mechanical efficiency to be 85% in both cases. Also assume R = 29.27 kg/-m/kg K.

4. (a) Show that the temperature at the end of the compression process in an ideal Otto cycle is the geometric mean of the maximum and minimum temperatures attained in the cycle if the work done is to be a maximum.

(b) Discuss the performance of a C.I. engine with reference to effect of speed on the B.H.P., the B.M.E.P. and the fuel consumption.

(c) An engine working on the ideal Otto cycle takes in air at 1 kg/cm^2 and 30°C which is compressed to 15 kg/cm^2 at the end of the compression stroke. The temperature attained at the end of constant volume heat addition is 900°C. Assuming adiabatic index to be 1.4 determine (i) the compression ratio, (ii) the thermal efficiency, (iii) the temperature at the end of compression, (iv) the pressure at the end of constant volume heating and (v) the mean effective pressure.

5. (a) Show that for steady isentropic flow of compressible fluid through a convergent-divergent nozzle the throat pressure for maximum mass flow is given by

$$P_t = P_1\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}\left(1+\frac{\gamma-1}{2}M^2\right)^{\frac{\gamma}{\gamma-1}}$$

where M, is the Mach number at the inlet of the nozzle, P_1 is the pressure at the nozzle inlet and P_t is the pressure at the throat. $\gamma = (C_p/C_v)$ and $R = (C_p - C_v)$.

(b) Air is isentropically expanded in a convergent-divergent nozzle from an initial pressure of 5 kg/cm^2 and 25°C to a back pressure of 1.5 kg/cm^2. The velocity of the air entering the nozzle is 100 m/s. The mass flow rate of the air is 2 kg/s. Determine (i) Mach number at inlet to the nozzle, (ii) pressure at the throat, (iii) area of flow at the throat and (iv) the area of flow at the exit of the nozzle. Assume γ for air to be 1.4 and R to be 29.27 kg/-m/kg K.

6. (a) In a single row impulse stage of a steam turbine the nozzle angle is $\alpha_1$while the inlet and outlet angles of the moving blades are identical. Derive the expression for the maximum efficiency of the stage in terms of the nozzle angle, the nozzle efficiency and the blade velocity coefficient. Assume nozzle efficiency to be η_n and blade velocity coefficient to be ψ.

(b) An impulse stage of a steam turbine has a mean diameter of 12 m. The speed of the rotor is 3000 r.p.m. The mass flow rate of steam is 20 kg/s. Steam is supplied to the stage at 15 kg/cm^2 and 300°C where it expands to 10 kg/cm^2. Determine the efficiency and the power output of the stage if the nozzle efficiency is 0.9 and the blade velocity coefficient is 0.92. Assume acceleration from rest for the steam expanding in the nozzle. Assume nozzle angle to be 25°.

7. (a) A furnace is insulated with a firebrick lining of 300 mm thickness. The thermal conductivity of the firebricks is given by $k = k_0(1 + \alpha t)$ where k_0 is equal to 0.7 kcal/mhdegC and α is equal to 7×10^{-4} per degC. The temperature of hot gases in the furnace is 1500°C and the temperature of the surroundings of the furnace is 32°C. The heat transfer coefficient on the hot and cold sides of the brickwork is 35 kcal/m^{2}h degC and 8 kcal/m^{2}h degC respectively. Determine the heat lost from a square meter of the brickwork and the temperatures at the inner and outer surfaces of the brickwork.

(b) In a fire tube boiler the temperature of the flue gases is 1000°C. The temperature of steam and water is 200°C. The thermal conductivity of the steel through which heat is transferred is 40 kcal/mhdegC and the wall thickness is 15 mm. The heat transfer coefficient on the steam and water side is 4800 kcal/m^{2}h deg C. In course of time the steel plate is fouled on the gas side by soot of 1 mm thickness and on the water side by a scale of 0.5 mm thickness. The thermal conductivities of soot and scale are 0.06 kcal/mhdeg C and 0.3 kcal/mhdeg C. Determine the percentage reduction in the heat flux in the boiler due to fouling of the steel plate compared to when it free of fouling. Also determine the change in the temperature drop across the steel plate due to fouling.

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

(i) Supercharging of I.C. engines;
(ii) Morse test on multi-cylinder I.C. engines;
(iii) Reheat factor in multi-stage steam turbines;
(iv) Absorption refrigeration system;
(v) Pelton wheel;
(vi) Simple carburettor;
(vii) Barometric condenser;
(viii) Hydraulic coupling.

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) Which of the following are clearance fits and interference fits?
(i) H_8m_6 (ii) H_8d_6 (iii)H_7f_7 (iv) H_8g_6

(b) Which of the following structures give best forgeability?
(i) Body centered cubic with large grains
(ii) Hexagonal close packed with large grains
(iii) Face centered cubic with small grains
(iv) Body centered cubic with small grains

(c) What is the purpose of cambering of rolls in rolling of metal sheets?

(d) Which of the following process can make the smallest diameter hole?
(i) Drilling (ii) Laser cutting (iii) EDM (iv) Ultrasonic cutting

(e) What lubricants are used for hot extrusion of steel?

(f) What is endurance limit?

(g) Draw Goodman diagram for fatigue loading.

(h) Define reliability as applied to engineering components.

(i) Draw activity time distribution diagram for PERT. What is its name?

(j) In conirolclians of variables, why do we plot x values in preference to x values. (x is the variable dimension)?

(k) What for is Gantt chart used?

(l) Which properties of steel are affected by addition of Ni?

(m) In three-dimensional stress space, draw von Mises' criteria of yielding of metals.

(n) Why is a spring washer used in some bolted joints?

(o) Give the composition of steel used for making spanners.

(p) List the processes used for manufacture of stainless steel tumblers.

(q) What is the difference between a robot and an NC machine?

(r) What is the difference between a bit and a byte as referred to a computer?

(s) Draw a flow chart for finding the average of 100 even numbers starting from 2.

(t) Lost the different computer languages.

SECTION—B

2. (a) A punching press is required to punch 400 mm diameter holes in a plate of 15 mm thickness at a rate of 30 holes per minute. It requires0.60 kgf-m of energy per mm^2 of sheared area. Determine the moment of inertia of the flywheel if the punching takes one-tenth of a second and the r.p.m. of the flywheel varies from 160 to 140.

(b) Draw a neat sketch of toggle press mechanism and explain its working.

(c) Explain the terms 'static balancing' and 'dynamic balancing'. State the necessary conditions to achieve them.

3. (a) A single-plate clutch has an inner diameter d and outer diameter D. The pressure distribution between the contact surfaces is given by

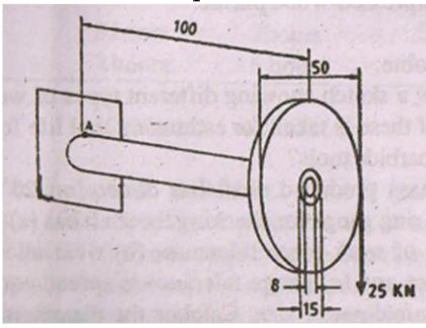
$$P = A + \frac{B}{r}$$

where r is the distance from the centre of the disc and A and B are constants. Determine the torque that can be transmitted by a single-plate clutch and the axial thrust. Suggest how A and B may be determined.

(b) A shaft 12 mm in diameter and 600 mm long between long bearings carries a central load of 4 kgf. If the centre of gravity of the load is 0.2 mm from the axis of the shaft, compute the maximum flexural stress in the shaft when it is running at 90% of its critical speed. The value of E (Young's modulus) of the material of the shaft is 2×10^4 kgf/mm^2.

(c) Explain briefly the variation in coefficient of friction with fluid film thickness in journal bearing.

4. (a) Figure 1 shows a hollow shaft of 15 cm external diameter and 8 cm internal diameter. At its free end a pulley of 50 cm diameter is rigidly fixed. A force of 25 kN is applied tangential to the pulley as shown in the figure. Determine the principal stresses and the absolute maximum shear stress at point A, located 100 cm from the free end and at the top of shaft surface.



(b) Describe in brief the different theories of failure.

(c) What do you understand by 'human aspects' in machine design? Give at least two examples.

SECTION—C

5. (a)
(i) What function does the coating on an arc welding electrode fulfill?
(ii) What is indicated by the welding-electrode designation E 6015?
(iii) What is the advantage of adding iron powder to the coating of arc-welding electrodes?
(iv) Why is ultrasonic welding not practicable for welding thick metals?

(b) Draw a TTT diagram for 0.8% carbon steel and indicate there on the different structures and temperatures.
How would you determine the minimum cooling rate for obtaining martensite structure?

(c) Write two specific applications for each of the following materials:
(i) Polyamide resins (nylon and capron)
(ii) Fibre reinforced plastic (Fibreglass)
(iii) Compressed-wood plastic
(iv) PVC
(v) Textolite.

(d) Draw a sketch showing different types of wear on a turning tool. Which of these is taken for estimating tool life for (i) HSS tools,(ii) Tungsten carbide tools?

6. (a) A mass produced shaft has dimension 20±0.01 mm as its diameter. The ring gauge for checking the shaft has (a) gauge tolerance equal to 10% of work-piece tolerance, (b) wear allowance equal to gauge tolerance and (c) gauge tolerance is spread equally above and below the nominal gauge size. Calculate the diameters of GO and No GO ends of workshop ring gauge. Also sketch the tolerance diagram.

(b) With the help of sketches indicate the directions of first and second slip lines in following cases of plastic deformation:
   (i) At the stress free work surface
   (ii) At the frictionless interface between tool and work
   (iii) At the interface between tool and work with Coulomb Friction.
   (iv) At the interface between tool and work with sticking friction.

(c) Distinguish between the following types of machine tool controls:
NC, CNC, DNC and Adaptive NC

(d) Define the term 'Grinding Ratio'. Explain why it should increase with the increase of grinding wheel surface speed.

7. (a) A company is manufacturing two products A and B. Both of them require machining on lathe and milling machine. The machining time for the respective products, profits and time available on machines are given below. Determine the numbers of A and B that should be manufactured to maximize the profit, and determine the value of this profit:

Product	Machining Time		Profit per Piece
	on Lathe	on Mining M/C	
A	3 hours	2hours	3 units
B	2 hours	6 hours	8 units
Available time	1200 hours	1800 hours	

(b) Two chemical plants located at A and B (see Fig. 2) have stocks of 2000 and 1900 tonnes of a chemical. At D and E there are demands of 1500 and 1700 tonnes respectively. The distances between the points are shown in the figure. Assume transport cost per tonne to be proportional to the distance. It is optimal (in minimizing total transport cost) to send 1500tonnes from A to D, 500 tonnes from A to E and 1200 tonnes from B to E?

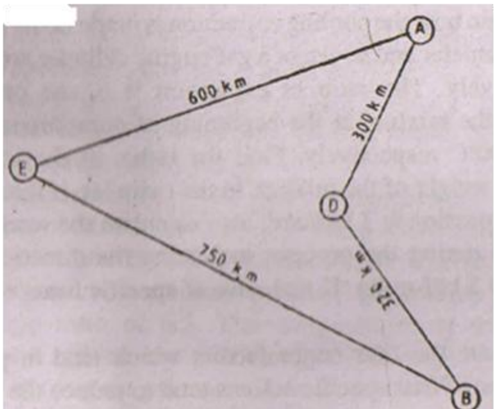


Fig. 2.

(c) A company has the following three options for obtaining a component:
   (i) It can be brought from outside at the rate of Rs. 1.50 per piece.
   (ii) It can be manufactured by the company by a process A in which case variable cost in Rs. 0.80 per piece and fixed cost of Rs.7,000.
   (iii) It can be manufactured by the company by a process B in which variable cost is Rs. 0.50 per piece and fixed cost of Rs. 12,000.

Determine the limiting quantities for the respective options for minimum cost per piece.