MECHANICAL ENGINEERING

Time Allowed: 3 hours ***Maximum Marks: 200***

Candidates should attempt any five questions
All questions carry equal marks
Answers must be written in English.

PAPER-I

1. (a) A mass m of water at T_1 is isobarically and adiabatically mixed with an equal mass of water T_2. Show that

$$\Delta S_{total} = 2mC_p \ln \frac{(T_1 + T_2)/2}{\sqrt{T_1 T_2}}$$

and prove that this is non-negative.

(b) The mass analysis of a hydrocarbon fuel is as follows:

C = 84%, H_2 = 15% and the balance is incombustible material. Find (i) mass of air required per kg of fuel for complete combustion, (ii) analysis of wet exhaust gases, by mass and volume, if 20 kg fuel are supplied, (iii) partial pressure of the steam formed in the exhaust gases if the total pressure of the exhaust gases is 1.03 kg/cm^2, (iv) heat carried away by dry exhaust gases formed per kg of fuel if the temperature of exhaust gas is 375°C and the ambient temperature is 24°C. Take C_p for dry gases = 0.24 kcal/kg°K.

2. (a) What are advantages of closed cycle gas turbine over the open cycle?

(b) Explain the principle of working of a battery ignition system used for a 4-cylinder petrol engine, giving a heat circuit diagram.

(c) A four stroke limited pressure cycle (diesel) engine draws 1.2 kg/sec of au at 1.03 kg/cm^2 and 27°C. Compression ratio of the cycle is 16. Pressure ratio during constant volume heat addition is 2.0. Total heat added is equal to 550 kcl/kg of air in the cylinder. Determine (i) pressure, volume and temperature at all salient points, (ii) % of heat added during constant pressure process, (iii) cut-off ratio (iv), thermal efficiency, (v) mean effective pressure.

Represent the cycle on p—V and T—s planes. Assume C_p = 0.24 kcal/kg°K and C = 0.17 kcal/kg°K.

3. (a) Why is 'bleeding' used in steam turbine plant? Obtain expressions for weight of steam bled, in each of the three heaters, and efficiency of the plant. What is the effect of bleeding on efficiency of the plant? Assume that the bled steam does not mix with feed water.

(b) What are the sources of air leakages into a condenser? Explain the affects of air leakage on the performance of a condenser.

(c) Steam enters, in a stage of impulse-reaction turbine, with a speed of 280 m/sec at an angle of 22° in the direction of blade motion. The mean diameter of the rotor, which rotates at 3200 rpm, is 1.0 m. The blade height is 10 cm. The specific volume of steam at nozzle outlet and blade outlet are 3.6 m^3/kg and 4.1 m^3/kg respectively. The turbine develops 620 h.p. find (i) the weight of steam used per sec, (ii) blade angles, (iii) enthalpy drop in each stage, (iv) degree of reaction and (v) stage efficiency. Assume combined efficiency of nozzles and blades as 90% and carry over coefficient as 0.8.

4. (a) Obtain an expression for the intercooler pressure in terms of initial and final pressures for work done to be minimum in a two stage reciprocating air compressor stating clearly all the assumptions made.

(b) Discuss the merits and demerits of centrifugal compressors over axial flow compressors.

(c) A gas turbine power plant works between pressures of 1 kg/cm^2 and 3 kg/m^2 and temperatures of 285°K and 1100°K. The intercooler cools the air at 2.3 kg/cm^2 to 285°K before the air is sent to the second stage compressor. The compressed air from the second-stage compressor passes through a regenerator, whose effectiveness is 0.72 and then through the combustion chamber. The heated air is then expanded in a high-pressure turbine to 2.3 kg/cm^2 and is then reheated to 11000K. The air is finally expanded in the low-pressure turbine to kg/cm^2. Assuming the compressor and turbine efficiencies to be 85%, determine: (i) the ratio of compression work to the turbine work, (ii) power developed for an air flow of 3.0 kg/see, (iii) the thermal efficiency of the cycle, (iv) heat rejected per sec to the cooling water in the intercooler and (v) heat rejected per sec to the atmosphere. Assume that all the components are mounted on the same shaft. Sketch the flow diagram of the turbine and represent process on T-S plane. Also assume $C_p = 0.24$ and ratio of specific heats to be 1.4.

5. (a) Obtain an expression for radiative heat transfer between two gray surfaces connected by a single refractory surface using electrical network method.

(b) 5000 kg/hr of oil is to be cooled from 70°C to 50°C in counterflow double pipe heat exchanger by using water at 20°C flowing at a velocity of 8.0 m/sec. The size of the inner copper pipe is 1.8 cm ID and 2.1 cm OD, oil flows through the annulus between this pipe and a 3 cm ID steel pipe. Thermal conductivity of copper is 330 kcal/hr-m°C. Find (i) LMTD, (ii) heat transfer coefficients on water and oil sides, (iii) overall heat transfer coefficient and (iv) length of pipe required.

Assume the following data for oil and water at their mean temperatures:

Property (Units)	Oil	Water
ζ (kg/m^3)	864	998.2
C_p (kcal/kg°C)	0.489	1.0
χ (kcal/hr-m°C)	0.126	0.515
μ (kgf-sec/m^2)	152 x 10^{-6}	102.4 x 10^{-6}
γ (m^2/sec)	1.726 x 10^{-4}	1.006 x1 0^{-6}

6. (a) Explain the principle of working of a thermostatic expansion value, giving a neat sketch.

(b) What are the desirable properties of refrigerants used in vapour compression refrigeration systems.

(c) It is desired to maintain a hail at 23°C DBT and 60% R.H. The atmospheric conditions of air are 42°C DBT and 22% R.H. Suggest an air-conditioning system and explain the working of it. Represent the process on psychrometric chart and express equations for capacity of the equipment used.

7. (a) A tank has the form of a frustum of a cone with its larger diameter 'D' at the top. The height of water in the frustum is H. Obtain an expression for emptying all the water through an orifice of area 'a', located at the bottom of the frustum in terms of H, a, D etc.

(b) The following information pertains to an inward flow reaction turbine:

Output = 500 h.p.; Speed = 750 r.p.m.; Head = 70m. Axial length of blade at inlet = 0.1 x wheel diameter at inlet; ratio of outer and inner diameters = 0.5: flow ratio = 0.17; hydraulic efficiency = 92%; overall efficiency = 84%.

Assume radial discharge, constant velocity of flow throughout and area blocked by blade thickness as 5% of area of flow.

Determine (i) diameters at inlet and outlet, (ii) widths of wheel at inlet and outlet, (iii) Guide blade angle, (iv) rare angles at inlet and outlet.

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

(a) Lift and drag and their coefficients

(b) Geometric, kinematic and dynamic similarity

(c) Flooded evaporator

(d) Modem high pressure boilers
(e) Types of combustion chambers used in C.I. engines
(f) Advantages of gas turbines over I.C. engines

MECHANICAL ENGINEERING

Time Allowed: 3 hours ***Maximum Marks: 200***

Candidates should attempt Question 1 in Section A, any TWO in Section B and any TWO in Section C.
The number of marks carried by each question is indicated at the end of the question.
Answers must be written in English

PAPER - II

SECTION A

1. (a) What information regarding slider-crank mechanism is obtained from Klein's construction?
   (b) What is Carioles acceleration? Express this in terms of relevant quantities
   (c) Describe an epicyclic gear frame and list its merits.
   (d) Why is involutes curve universally used as gear tooth profile?
   (e) Why V-threads are not preferred on power screws?
   (f) Why does torque transmitted by a belt drive decrease at high speeds?
   (g) What is the function of a flywheel in a punching press?
   (h) In a three dimensional stress field, state the relationships between the principal stresses according to the criteria:
      (1) maximum shear stress theory
      (2) maximum distortion energy theory and represent graphically the safe working zone for two dimensional cases.
   (i) A cantilever having a square cross-section supports a vertical load at its free end. Compare its free end deflection under the following two conditions:
      (1) When the sides of the square are vertical and horizontal
      (2) When diagonals of the square are vertical and horizontal
   (j) Why in an I-section preferred over a solid rectangular section for use as a beam section?
   (k) With reference to sheet metal working, distinguish between a compound die and a combination die.
   (l) What is submerged are welding and what are its merits?
   (m) Describe investment casting and state its special merits.
   (n) List the desirable properties, with reasons, of a moulding sand.
   (o) What are the functions of cutting fluid in metal cutting operation?
   (p) Describe the methods of exponential determination of temperature on metal cutting tool face.
   (q) What is meant by machinability of a work material, and how is it measured?
   (r) Why is it necessary to perform electron beaimmachining in high vacuum environment?
   (s) Explain hole-standard and shaft-standard systems of tolerance and unilateral and bilateral methods of specifying limits.
   (t) What is meant by selective assembly and when is it used?

$2 \times 20 = 40$

SECTION – B

2. (a) A loaded porter governor has 4 link each 25 cm long, 2 revolving masses each weighing, to N and a central dead weight weighing 200 N. All the links are attached to respective sleeves at

radial distances of 4 cm from the axis of rotation. The masses revolve at a radius of 15 cm at minimum speed and at a radius of 20 cm at maximum speed. Determine the range of speed. 24

(b) What is meant by kinetically equivalent system and what is its application?

The connecting rod of a gasoline engine is 30 cm long between its centres. It has a mass of 1.5 kg and mass-moment of inertia of 70 kg-cm^2. Its centre of gravity is at 20 cm from its small-end centre. Determine the kinetically equivalent 2-mass system of the connecting rod if one of the masses is located at small-end centre.

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3. (a) A 100 mm long steel bush, having 80 mm inside diameter and 40 mm wall thickness, is shrunk fit on a steel shaft with diametral interference of 0.04 mm, Young's modulus of elasricity and Poisson's ratio of the steel are 200 GPa and 0.3 respectively. Coefficient of friction between the bush and the shaft is 0.25. Determine the axial force that is to be applied to remove the bush from the shaft.

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(b) A torque transmitting solid steel shaft of 100 mm diameter is replaced by a hollow one of the same material having its outside diameter twice its inside diameter. Maximum stress in the hollow shaft remained same as that in the solid one. Compare torsional rigidity of the two shafts.

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4. (a) A rectangular steel plate is welded as a cantilever to a vertical column and supports a single concentrated load P and shown in Fig. 1. Determine the weld size if shear stress in the same is not to exceed 140 MPa. 25

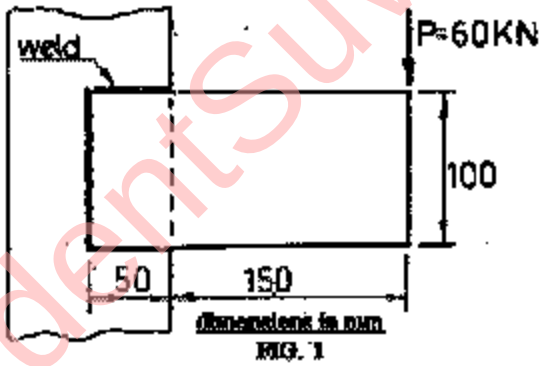

FIG. 1

(b) An electronic motor driven power screw moves a nut in a horizontal plane against a force of 75 KN at a speed of 30 cm/mm. The screw has a single square thread of 6 mm pitch on a major diameter of 40 mm. Coefficient of friction at screw threads is 0.10. Estimate power of the motor.

15

SECTION – C

5. (a) What is shear in punching and blanking dies? Why is it provided? Which component of the die-punch combination is this shear provided to?

10

(b) Discuss the function of blank holder in a drawing die. What is meant by redrawing and why is it needed? Sketch the shape of blank holder for a redrawing die.

10

(c) A cylindrical cup without flange is to be drawn from a 2 mm thick duralumin sheet. The cup shall have diameter of 15 mm and height of 40 mm. reduction ratio in first draw and in subsequent draws may not exceed 40% and 15% respectively. Determine the blank size and the number of draws necessary.

20

6. (a) In a turning operation, life of the cutting tool has been observed to vary with change in spindle speed and feed as follows:

Spindle speed (r.p.m.)	80	106	125
Feed (mm/rev)	0.35	0.30	0.25
Tool life (mm)	110	60	54

Determine tool life when the operation is performed at spindle speed of 130 r.p.m. with a feed of 0.22 mm/rev. 20

(b) Define the terms: tolerance and allowance.

Nominal diameter of a cylinder bore and the fitting piston is 65 mm. Tolerance on both piston and bore is specified as 0.05 mm and the required allowance is 0.09 mm. Determine limit sizes of the piston and the bore and also the largest clearance between the two based on base hole standard.

10

(c) What is a built-up edge and how is it formed during metal cutting operation? What factors influence its formation and what is its effect on performance?

10

7. (a) A garment manufacturing concern produces two types of garments and each type is processed in three sections of the factory. Mao-minutes required by ea type for its processing in different sections, profit yielded by each type and man-minutes available in the sections are given in the table below:

	Processing man-minute in Different sections			**Profit Rs. per piece**
	Sec 1	**Sec 2**	**Sec 3**	
Garment type I	15	30	2	10
Garment type II	60	10	2	20
Availabe man-minute /day	1080	630	48	

Determine (i) number of daily production of each type so that profit becomes maximum, (ii) amount of this maximum profit and (iii) the sections, resources of which are fully utilized

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(b) A component can be manufactured in either of two machines. Operating details of the two machines are given below:

	1st machine	**2nd machine**
Number of pieces produced/hour	15	60
Cost of tooling	Rs. 200	Rs. 420
Setting time	70 min.	230 min.
Machining labour/hour	Rs. 4	Rs. 4
Setting labour/hour	Rs. 15	Rs. 20
Overhead charges	3 times total labour cost	10 times total labour cost

Determine the break-even quantity for production of the component and also compare economy of the two processes after the break-even point.

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(c) A medicine manufacturing company, for packing their product, uses glass phials which they collect from a nearby factory in batches at equal interval of time throughout the year. Determine economic batch size for each collection on the basis of the following data:

Estimated annual requirement	250,000 pieces
Purchase price	Re. 1 per piece
Cost of transportation	Rs. 100 per trip
Cost of storage	Rs. 10 per thousand per year
Interest of investment	15% per year
Minimum inventory to be maintained at any tune	1000 pieces

and calculate cost of inventory per piece including all charges.

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