I.E.S. (Conv.) - 1992

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) 3 kg of air at 1.50 bar pressure and 87°C temperature at condition 1 is compressed polytropically to condition 2 at pressure 7.50 bar index of compression being 1.2. It is then cooled at constant pressure to condition 3 and then finally heated at constant temperature to its original condition 1. Find the net work done and heat transferred.

   (b) 500 kJ of heat is removed from a constant temperature heat reservoir maintained at 835K. The heat is received by a system at constant temperature of 720 K. The temperature of the surroundings the lowest available temperature is 280K. Illustrate the problem by T—S diagram and calculate the net toss of available energy as a result of this irreversible heat transfer.

2. (a) Discuss the importance of nuclear fuels and their properties required in the development of various nuclear power plains.

   (b) A simple jet carburetor has to supply 5 kg of air per minute. The air is at a pressure of 1.013 bar and at a temperature of 27°C. Calculate the throat diameter of the choke for air flow velocity of 90 m/s. Take velocity coefficient to be 0.8. Assume isentropic flow. Assume the flow to be compressible.

3. (a) What are the advantages of using large capacity boilers? With neat sketches describe the operation of a Benson Boiler.

   (b) In a steam power plant operating on Rankine cycle the steam enters the turbine at 70 bar and 550°C with a velocity of 30 m/s. It discharges to the condenser at 0.20 bar with a velocity 90 m/s. lithe steam flow rate is 35 kg/s find the thermal efficiency and the net power produced.

4. (a) Air is expanded reversibly and adiabatically in a nozzle from 13 bar and 150°C to a pressure of 6 bar. The inlet velocity of the nozzle is yen small and the process occurs under steady state flow conditions. Calculate the exit velocity of the nozzle.

   (b) A gas turbine unit receives air at 1 bar and 300K and compresses it adiabatically to 6.20 bar. The compressor efficiency is 88%. The fuel has a heating value of 44186 kJ/kg and the fuel air ratio is 0.017 kg fuel/kg of air. The turbine internal efficiency is 90%. Calculate the work of turbine and Compressor per kg of air compressed and thermal efficiency. For products of combustion C_p = 1.147 kJ/kg K. γ = 1.333.

5. (a) An air compressor has eight stages of equal pressure ratio 1.35. The flow rate through the compressor and its overall efficiency are 50 kg/s and 82% respectively. If the air enters the compressor at a pressure of 1.0 bar and temperature of 313K determine

   (i) State of air at the exit of the compressor

   (ii) Polytropic or small stage efficiency

   (iii) Efficiency of each stage

   (iv) Power required to drive the compressor assuming the overall efficiency as 90%.

(b) One stage of an impulse turbine consists of a converging nozzle ring and one ring of moving blades. The nozzles are inclined at 22° to the blades whose tip angles are both 35°. If the velocity of steam at exit from the nozzle is 660 m/s. find the blade speed so that the steam shall pass on without shock. Find the diagram efficiency neglecting losses if the blades are run at this speed.

6. (a) Show that temperature distribution in a sphere of radius R having a surface temperature of T_w, in which heat is generated at a uniform rate of qg W/m^3 is given by:

$$\left[T(r) - T_w\right] = \frac{qgR^2}{6k}\left(1 - r^2 / R^2\right)$$

where k is the thermal conductivity of the sphere material

(b) A chemical having specific heat of 3.3 kJ/kg K flowing at the rate of 20,000 kg/h enters a parallel flow heat exchanger at 120°C. The flow rate of cooling water is 50.000 kg/h with an inlet temperature of 20°C. The heat transfer area is 10m^2 and the overall heat transfer coefficient is 1050 W/m^2 K. Find the outlet temperatures of water and chemical and effectiveness of the heat exchanger. Take for water specific heat = 4.186 kJ/kg K.

7. (a) A refrigeration machine is required to produce ice at 0°C from water at 20°C. The machine has a condenser temperature of 28 K while the evaporator temperature is 268K. The relative efficiency of the machine is 50° and 6 kg of Freon -12 refrigerants is circulated through the system per minute. The refrigerant enters the compressor with a dryness fraction of 0.6. Specific heat of water is 4. 187 kJ/kg K and the latend heat of ice is 335 KJ/Kg. Calculate the amount of ice produced in 24 hours. The table of properties of Freon-12 is given below

Temperature K	Liquid heat kJ/kg	Latent heat kJ/kg	Entropy of liquid kJ/kg K
298	59.7	138.0	0.2232
268	31.4	154.0	0.1251

(b) A small auditorium is required to be maintained at 22°C dry bulb temperature and 70% relative humidity. The ambient conditions are at 30°C dry bulb temperature and 75% relative humidity. The amount of free air circulated is 200 m^3/min. The required conditions are achieved by first cooling and dehumidifying through a cooling coil having apparatus dew point of 14°C and then by heating. With the help of psychrometric chart find.

(i) The cooling capacity of cooling coil in tons of refrigeration and its bypass factor.

(ii) The amount of water vapour removed by the cooling coil in kg/h.

(iii) Assuming tile b pass factor as 0.2 determine the capacity of the heating coil in kW and its surface temperature.

8. (a) The velocity profile for laminar flow in the boundary layer of a flat plate is given by

$$\frac{u}{U} = \sin\left(\frac{\pi}{2}\ \frac{y}{\delta}\right)$$

where u is the velocity of fluid in the boundary layer at a vertical distance y from tile plate surface and U is the free stream velocity. Prove that the boundary layer thickness δ may be given by the expression

$$\delta = \frac{4.795x}{\left(\mathrm{Re}_x\right)^{1/2}}$$

where Re_x is the Reynolds number of the fluid at a distance x from the leading edge of the plate.

(b) A swimming pool 12 m long and 7m wide holds water to a depth of 2m. If the water is discharged through an opening of area 0.2m at the bottom of the pool, find the time required to empty the tank. Take coefficient of discharge for the opening as 0.6.

(c) Give the range of specific speed values of the Kaplan. Francis turbines and Pelton wheels. What factors decide whether Kaplan. Francis or a Pelton wheel type turbine would be used in a hydro-electric project?

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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) State the conditions for a four—bar linkage to be called a Grashof's linkage and also when this linkage would become a double— crank mechanism.

(b) Define the coefficient of fluctuation of energy in case of a flywheel. How is it related to the coefficient of fluctuation of speed?

(c) What is hunting in a centrifugal governor? When does it occur?

(d) When can on say that a vibrator s stem is critically damped? How is critical damping coefficient related to mass (m) and spring constant (k) of the s stem?

(e) What is a Gyro? How is g gyroscopic torque (T) related to spin velocity (ω_s) and precession velocity (ω_p)?

(f) State the fundamental law of gearing. State when the meshing surfaces can be called conjugate.

(g) Sketch international metric V—thread with flat root and express various dimensions in terms of pitch p.

(h) Distinguish between unilateral and bilateral tolerances.

(i) Define true stress and true strain in a simple tensile test. Express their relations with the corresponding nominal quantities.

(j) How is toughness different from resilience of a material? Give an example where the former is more important.

(k) State Distortion Energy Theory for failure.

(l) From the aspect of corrosion explain how a tin plated iron sheet is different from a galvanized iron sheet.

(m) Distinguish between the microstructures of pearlite and plate marten site formation.

(n) What effects are brought about b the following in plastics?

(i) Reinforcements

(ii) Plasticizers

(o) What is the difference between austempering and ordinary tempering.

(p) What do you understand from mechinability of a material? List any two properties which have a bearing on machinability.

(q) Distinguish between electrochemical machining and electro— chemical grinding.

(r) List an four factors, which determine a plant layout.

(s) What is ABC inventory system?

(t) Define the assignment problem and illustrate ii by an example.

SECTION – B

2. (a) A steel shaft of 7.5 cm diameter has an aluminium disc of 30 cm outside diameter shrunk on it The shrink allowance is 1 part per 1000. Find the tangential and radial stresses at the

interface dime to shrink—fit. Calculate also the r.p.m. of rotation, at which the shrink—fit lossens up. Neglect the expansion of the shaft caused b rotation Take

Poisson's ratio for both metals = 0.

E for steel = 210×10^3 MPa

F for aluminium = 71×10^3 MPa

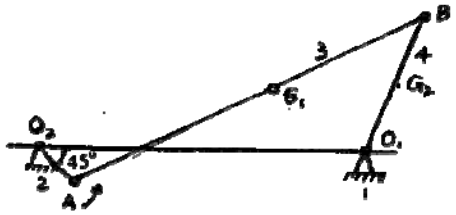
Density of aluminium = 2.76 g/cm^3

20

(b) A uniform beam of span L and flexural rigidit EI is simply supported at its ends, It is earning a load W at a distance b from the left hand support and subjected to an axial force P (compressive). Derive the expression for the deflection of the beam. What would be the deflection under the latral load when b = L/2? What is the critical value of P for which the deflection becomes very large?

20

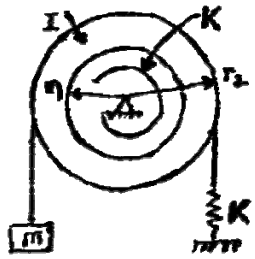
3. (a)



The crank of a four-bar mechanism shown in the above figure is balanced and rotating in anti-clockwise direction at a constant angular speed of 200 rad/sec. The particulars of the mechanism are O_2A = 5 cm: AB = 45 cm: AG_3 = 22.5 cm: O_4B =20 cm: O_4G_2 =10 cm: O_2O_4 = 35 cm: W_3 = 1.2 kg: W_1 = 3 kg: I_3 = 68.6 kg cm^2: I_4 = 550 kg cm^2. G_3 and G_4 are mass-centres of links 3 and 4. W_3. W_4 their respective masses and I_3, I_4 their respective mass moment of Inertia about their mass—centres. For the given angular position of the crank 2. draw velocity and aceleration diagrams and find the angular accelerations of links 3 and 4. Determine also the forces acting at the pin—joints A, B and the external torque which must be applied to link 2. Ignore the gravitation effects.

32

(b)



An integral pulley shown in the above figure is restrained in its movement about its own axis b a torsional spring of stiffness K and a linear spring of stiffness k. A load of mass m is hung from the smaller pulley by means of an inextensible string. Using D' Alembert's principle derive the equation of motion for small oscillations and determine the natural frequency. Take J as mass moment of inertia of the pulley about its axis.

8

4. (a) A single start square thread screw clamp is to be designed for a compressive load of 20 kN. The pad offers a friction torque of 30 Nm Calculate

(i) the pitch and diameter of the screw:

(ii) height of the nut and

(iii) dimensions of the tommy bar operating the screw Assume

Maximum force at the end of the tommy bar = 250 N
Safe compressive stress for the screw = 100 MPa
Safe bearing pressure for the screw and nut = 8 MPa
Safe bending stress in the handle = 95 MPa
Coefficient of screw thread friction = 0.15

20

(b) A shaft running at 500 r.p.m. carries a pulley 100 cm diameter which drives another pulley in the same direction with a sped reduction of 2 : 1 by means of ropes. The drive transmits 250 H.P. Angle of grooves is 40°. The distance between pulley centres is 200 cm. The coefficient of friction between the rope and pulley is 0.2. The rop weighs 1.2 kg/m and has a safe allowable stress of 175 N/cm^2. It is recommended that the initial tension in the rope should not exceed 800 N. Find the number of ropes required and rope diameter. Calculate also the length of each rope

20

SECTION – C

5. (a) Draw continuous-cooling-Transformation (C—C—T) diagram for an eutectoid steel and explain how the cooling rate affects the microstructure of the transformation products.

15

(b) What properties are expected of the alloys used in bearings? Describe the rote of hard particles and soft matrix in the functioning of a bearing alloy.

10

(C) Machine components are received from two vendors. Vendor A supplies 75% of the components known to include 50 defective and Vendor B's supply of 25% components includes 10° defectives. When a sample of site 5 is inspected, only one defective component is found. By this information determine the posterior probability that the components are delivered from Vendor A, from Vendor B.

15

6. (a) Explain the difference between orthogonal and oblique cutting. In an orthogonal cutting process the following observations were made:

Depth of cut = 0.25 mm
Chip thickness ratio = 0.45
Width of cut = 4 mm
Cutting velocity = 40 m/min
Cutting force component parallel to cutting velocity vector = 1150 N
Cutting force component normal to cutting velocity vector = 140 N
Rake angle of the tool = 18°

Determine resultant cutting force, power of cutting, shear plane angle friction angle and force component parallel to shear plane.

16

(b) List the various gear cutting processes. How are they classified? Describe with simple sketches the principle and working of a gear shaper

12

(c) How is the suitability of a sheet metal for deep drawing operation assessed? Discuss the effect of punch and die profile radii on the thickness changes which occur during drawing an also their effect on maximum punch load.

12

7. (a) Two products are manufactured by passing sequentially through three machines. Times per machine allocated to the two products are limited to 10 hours per day. The production time and profit per unit of each product are

Production Time (Minutes)

Product	Machine 1	Machine 2	Machine 3	Profit (Rs)
1	12	10	5	20
2	4	8	10	30

(i) Find the optimal mix of the two products using Simplex Method.

(ii) Identify the machine (s) with abundant capacity at the optimum solution.

(iii) For each machine with full utilization determine the worth per unit increase in its capacity

(iv) Which of the three machines should be given highest priority for capacity increase?

20

(b) What arc essential components of Production Planning? Explain then with simple examples.

12

(c) Write briefly on

(i) Surface integrity of machined parts.

(ii) Value engineering.