I.E.S-(Conv.)-1999

MECHANICAL ENGINEERING

PAPER - I

Time Allowed: Three Hours *Maximum Marks: 200*

Candidates should attempt any FIVE questions. All questions carry equal marks.

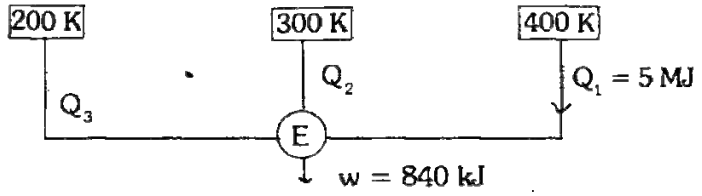
For air R = 0.287 kJ/kg K; c_p = 1.005kJ/kg K; γ = 1.4

Assume 1 bar = 1 kg f/cm^2, if necessary.

1. (a) Show that the cyclic integral of dQ / T for a reversible cycle is equal to zero.

(10)

(b)



A reversible engine as shown in the above figure during a cycle of operation draws 5 MJ from the 400 K reservoir and does 840 kJ of work. Find the amount and direction of heat interaction with other reservoirs.

(15)

(c) Exhaust gases leave an internal combustion engine at 800^o C and 1 atmosphere, after having done 1050 kJ of work per kg of gas in the engine (c_p of gas = 1.1 kJ/kg K). The temperature of the surroundings is 30°C.

(i) How much available energy per kg of gas is lost by throwing away the exhaust gases?

(ii) What is the ratio of the lost available exhaust gas energy to the engine work ?

(15)

2. (a) Describe the method of determining the calorific value of a liquid fuel by means of Bomb Calorimeter. How correction for cooling is obtained in this method?

(12)

(b) What is meant by Evaporative Cooling used in I.C. Engine practice? Explain how the exhaust valves of heavy duty I.C. Engines are cooled.

(13)

(c) Describe four methods for controlling diesel knock, giving advantages and limitations of each method.

(15)

3. (a) For the analysis of heat exchanger problems, in which cases NTU method is applied?

(15)

(b) 8,000 kg/hr of air at 105 C is cooled by passing it through a counter flow exchanger. Find the exit temperature of air if water enters at 15°C and flows at a rate of 7500 kg/hr. U = 145 W/m^2K, A = 20 m^2. Solve the problem by the NTU method.

(20)

(c) Air at 200 k Pa and 200°C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature, all along the length of the tube. How much would the bulk temperature increase over a 3 m length of the tube?

(15)

4. (a) An air conditioning system is designed under the following conditions:

Outdoor conditions – 30°C dbt, 75% R.H.

Required indoor conditions – 22°C dbt, 70% R.H.

Amount of free air circulated – 3.33 m^3/s

Coil dew point temperature – 14° C

The required condition is achieved first by cooling and dehumidification, and then by heating. Estimate (i) the capacity of the cooling coil in tonnes, (ii) the capacity of the heating coil in KW, and (iii) the amount of water vapour removed in kg/s.

(20)

(b) What are the differences between heat pump and refrigeration cycle?

What is the relation between (C.O.P) Heat pump and (C.O.P) Refrigerator? What are the differences between Kelvin Planck and Clausius Statements of 2nd Law?

(20)

5. (a) Show that the loss of head due to friction in pipes can be expressed as $h_f = \frac{4 f L V^2}{d \times 2g}$

Where f = coefficient of friction

L = Length of pipe

V = velocity of flow through pipe

h_f = loss of heat due to friction

(20)

(b) Determine the rate of flow of water through a pipe of diameter 20 cm and length 50 m when one end of the pipe is connected to a tank and other end of the pipe is open to the atmosphere. The pipe is horizontal and the height of water in the tank is 4 m above the centre of pipe. Consider all minor losses and take f = 0.009. The loss of head (h_i) at the entrance of a pipe may be taken as 0.5 $\frac{V^2}{2g}$.

(20)

6. (a) With the help of a diagram explain the differences between (i) Laminar Boundary Layer, (ii) Turbulent Boundary Layer and (iii) Laminar Sub-Layer.

(20)

(b) Find the displacement thickness and the momentum thickness for the velocity distribution in the boundary layer given by $u/U = y/\delta$ where u is the velocity at a distance y from the place and u = U at y = δ, where δ = boundary layer thickness.

(20)

7. (a) What is throttle governing of steam turbine ?

(10)

(b) Steam at 29.4 N/cm^2 absolute and dry saturated comes out of rotor of a reaction turbine having identical bladings. The velocity of steam entering into the turbine is 100 m/s. The mean blade height is 4 cm and the exit angle of the moving blade is 20. The blade velocity is 4/3 times of axial flow velocity at the mean radius. If the steam flow rate is 2.5 kg/s. find (i) the rotor speed, (ii) h.p. developed, (iii) the diagram efficiency, (iv) the percentage increase in relative velocity in the moving blades, and (v) the enthalpy drop of steam in blade passage.

(30)

8. (a) Show that the discharge through a reciprocating pump can be expressed as Q = ALN/60

where Q = discharge through pump per second

A = cross-sectional area of the piston

L = length of the stroke

N = rpm of the crank.

(20)

(b) A double acting reciprocating pump, running at 40 r.p.m. is discharging 1.0 m^3 of water per minute. The pump has a stroke of 40 cm. The diameter of the piston is 20 cm. The delivery and suction heads are 20 m and 5 m respectively. Find the slip of the pump and horse power required to drive the pump.

(20)

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MECHANICAL ENGINEERING

PAPER - II

Candidates should attempt question 1 in Section A which is compulsory, TWO questions from Section B and TWO questions from Section C, Question 1 is of short answers type, limiting answer of each part to 30 words.

SECTION A

1. (a) Distinguish between fatigue strength and fatigue limit.

(b) Give two examples of parts where the design criteria is rigidity and not the strength.

(c) A right hand helical gear is being cut on a milling machine. What changes in machine settings have to be made to cut a left hand helical gear of same pitch and number of teeth ?

(d) What is resonance? Why is it generally avoided?

(e) Explain the effects of alloying Chromium and Nickel in stainless steel.

(f) List at least two factors that promote transition from ductile to brittle fracture.

(g) Distinguish between creep and fatigue.

(h) Describe two distinguishing features of Robots, which make them different from conventional material handling equipments.

(i) Explain the difference between Roughness and Waviness.

(j) Mention two types of dislocations.

(k) Give the reasons for plotting averages of samples instead of individual values in X control chart.

(1) What is the direction of movement of the carriage while cutting left hand thread on a lathe?

(m) What are the principal constituents of brass ?

(n) In R.C.C., why is steel reinforcement provided at the top of the neutral axis for a cantilever beam?

(o) When do you prefer a belt drive to a gear drive?

(p) State the Kennedy's theorem with reference to instantaneous centres.

(q) State the law of gearing.

(r) Distinguish between jig and a fixture.

(s) Why are hydrodynamic bearings used for grinding machines in preference to ball or roller bearings?

(t) Mention the name of the process by which the following are manufactured ?

(i) Tungsten carbide tools (ii) Engine cylindrical block

(iii) Connecting rod (iv) Plastic buckets

(20 x 2 = 40)

SECTION B

2. (a) Construct the profile of a disc cam with translating roller follower using the following data:

Base circle dia = 150 mm, roller dia = 15 mm

lift = 50 mm in 180° and return in 135° and dwell.

Both lift and return motion are simple harmonic.

Cam rotates clockwise.

(20)

(b) In a brick making machine, a wide roller 250 mm in dia mounted on shaft E is driven by a motor carrying a pulley A, which is 150 mm in dia. The pulley in turn drives another pulley of 1200 mm dia mounted on a shaft B by an open belt. On the same shaft B a spur gear of 20 T is mounted, which meshes with a spur gear of 160 T mounted on shaft C. The shaft C also carries a spur wheel of 20 T which drives a 30 T gear on shaft E through an idler gear of 112 T mounted on shaft D. Sketch the arrangement and determines the speed reduction. If motor rotates clockwise (viewing from right) at 1440 rpm, determine the sense of rotation of the roller. What is the surface speed of the roller?

(20)

3. (a) A spur steel pinion (S_0 = 200 MN/m^2) is to drive a spur steel gear (S_0 = 140 MN/m^2). The diameter of the pinion is to be 100 mm and the center distance is 200 mm. The pinion is to transmit 5 kW at 900 rpm. The teeth are to be 20° full depth. Determine the necessary module and width of face to give greatest number of teeth. Design for strength only using Lewis equation.

S_0 is the endurance strength corrected for average stress concentration ?

The allowable stress S is given by $S = S_0\left(\frac{3}{3+v}\right)$

where V is the pitch line velocity in m/sec.

The following table gives the form factor y for use in Lewis strength equation.

(30)

TABLE I—Form Factors y— for use in Lewis strength equation

Number of Teeth	14½° Full-Depth Involute or Composite	Full-Depth Involute	20° 20° Stub Involute
12	0.067	0.078	0.099
13	0.071	0.083	0.103
14	0.075	0.088	0.108
15	0.078	0.092	0.111
16	0.081	0.094	0.115
17	0.084	0.096	0.117

18	0.086	0.098	0.120
19	0.088	0.100	0.123
20	0.090	0.102	0.125
21	0.092	0.104	0.127
23	0.094	0.106	0.130
25	0.097	0.108	0.133
27	0.099	0.111	0.136
30	0.101	0.114	0.139
34	0.104	0.118	0.142
38	0.106	0.122	0.145
43	0.108	0.126	0.147
50	0.110	0.130	0.151
60	0.113	0.134	0.154
75	0.115	0.138	0.158
100	0.117	0.142	0.161
150	0.119	0.146	0.165
300	0.122	0.150	0.170
Rack	0.124	0.154	0.175

(b) A 100 mm dia shaft operating at 2000 rev/min is supported by means of a 150 mm long full journal hearing which is subjected to a radial load of 43 kN. Assume ($\mu N/P$) 30 x 10^{-6}. Determine

(i) the coefficient of friction using McKee equation which is given by

$f = 0.326(\mu N/P)D/C + K.$

take D/C = 1000, K = 0.002.

(ii) bearing pressure in MN/m^2.

(iii) heat generated.

(10)

4. (a) What are principal planes?

(5)

(b) Direct tensile stresses of 120 MN/m^2 and 70 MN/m^2 act on a body on mutually perpendicular planes. What is the magnitude of shearing stress that can be applied so that the major principal stress at the point does not exceed 135 MN/m^2? Determine the value of minor principal stress and the maximum shear stress.

(15)

(c) State the limitation of Euler's formula for calculating critical load on columns.

(5)

(d) A hollow cast iron column of 300 mm external dia and 220 mm internal dia is used as a column 4 m long with both ends hinged. Determine the safe compressive load the column can carry without buckling using Euler's formula and Rankine's formula.

$E = 0.7 \times 10^5$ N/mm^2, Factor of safety = 4, Rankine constant a = 1/1600, Crushing stress f_3 = 567 N/mm^2.

(15)

SECTION C

5. (a) A medium force fit H_7p_6 is specified for an assembly of a hand wheel on a shaft of 50mm nominal dia. Calculate

(10)

(i) the dimensions of hole (ii) the dimensions of shaft

(iii) maximum interference (iv) minimum interference

Given the following:

Nominal size		Limits of tolerance for p_6 shaft in micron	
Over	Upto and including	e5 +	e +
40	50	42	26
50	65	51	32

		Limits of tolerance for H_7 hole in microns	
		E_S	E_1
30	50	25	0
50	80	30	0

(b) Explain TIG (tungsten inert gas welding) with reference to

(i) Principles of the process

(ii) Equipment used

(iii) Applications

(10)

(c) Explain briefly how parts are manufactured by shell moulding giving an example.

(10)

(d) With reference to cubic crystal sketch the following (111) (111)

(10)

6. (a) The following equation for tool life was obtained for H.S.S. tool $VT^{0.13} f^{0.6} d^{0.3} = C$.

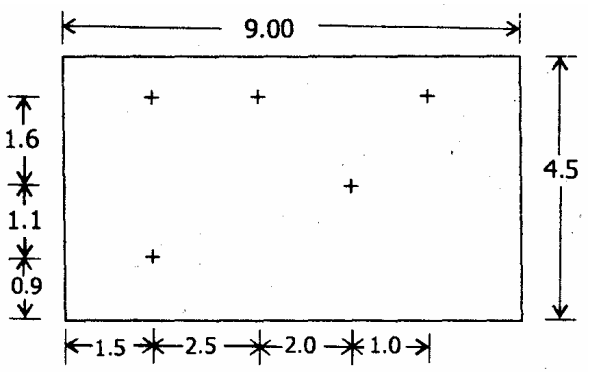
A 60 mm tool life was obtained using the following cutting conditions.

V = 40 m/min, f = 0.25 mm, d = 2.0 mm. Calculate the effect on tool life if speed, feed and depth of cut are together increased by 25% and also if they are increased individually by 25%;

where f = feed, d = depth of cut; V = speed.

(10)

(b) A part program is to be written to drill the holes in the work part shown below. The part is 10mm thick. The dia of drill is ϕ 10.0.



Dimensions are in cm.

Dimensions are in cm.

(i) Define the x and y axes for the job.

(ii) Write manual part programming using word address format and an absolute position system. The words that must be specified for the particular drill press are n- x- y- and m-words. The speed and feed are manually set by the operator.

(10)

(c) Define an Industrial Robot. Sketch four important basic configurations of Robots used.

(10)

(d) Differentiate between Gear bobbing and Gear shaping with reference to various relative motions and applications.

(10)

7. (a) Write a flow chart for choosing the largest of three distinct numbers x, y and z.

(10)

(b) What is an inventory ? A company uses a certain component X at the rate of 5000/year. The cost/item is Rs. 20 and it costs Rs. 200 to place an order. The annual carrying cost of inventory is 10% of the price of the item. Storage cost is negligible. Assume zero safety stock. Calculate the Economic Order Quantity (EOQ).

(10)

(c) Subgroups of 5 item each are taken from a manufacturing process at regular intervals. A certain quality characteristics is measured, and $\bar{X}$ and R values are computed for each subgroup.

After 25 subgroups $\sum \bar{X}=357.50$ $\sum R=8.80$ Compute control chart limits. All points on both charts fall within these limits. If the specification limits are 14.40 ± 0.40 what conclusions can you draw about the ability of the existing process to produce items within these specifications ? Suggest possible ways in which the situation could be improved.

$A_2 = 0.58$, $D_3 = 0$, $D_4 = 2.1\,l$, $d_2 = 2.326$

(10)

(b) Solve the following linear programming problem graphically.

$2x_1 + 3x_2 \leq 6$

$x + 4x_2 \leq 4$

$x_1, x_2 \leq 0$

Max $Z = x_1 + 1.5x_2$

(10)