I.E.S. (Conv.) - 1987

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) Two identical bodies of constant heat capacity are at the same initial temperature T_1. A refrigerator operates between these two bodies until one body is cooled to the temperature T_2. If the bodies remain at constant pressure and undergo no change of phase, obtain an expression for the minimum amount of work required to achieve this.

   (b) Describe the method used to determine the calorific value of a solid fuel. Explain how the cooling correction is made in the method.

   (c) The diameter and stroke of a gas engine cylinder are 18 cm and 30 cm respectively. The ratio of expansion is 5 the pressure and temperature of the mixture at the beginning of compression are 1.04 kgf/cm^2 and 100°C respectively. Find the index of the compression process and the weight of the mixture in the cylinder, if the pressure at the end of compression is 7 kgf/cm^2. Also calculate the work done and beat transferred during the process, indicating the direction of flow. Assume, R = 29.3 kgf-m/kg-°K and ratio of specific heats equal to 1.4 for the mixture.

2. (a) What are the four major factors which tend to produce or prevent detonation? What specific actions tend to reduce the possibility of detonation?

   (b) Explain how the following methods of propulsion are different from each other:

   (i) Turbojet (ii) Turboprop (iii) Rocket.

   (c) The following data were obtained during the trial of a single cylinder 2-stroke cycle diesel engine:

   Cylinder bore 23 cm; stroke 45 cm; RPM 350; fuel consumed 0.3 kg/mm with a calorific value of 10000 kcal/min; area of indicator diagram 6.0 cm^2 length of diagram 7.8 cm; spring constant 8.5; load on the brake drum 115 kgf at 1.25 m radius; cooling water used 18 kg/mm; temperature of water entering and leaving 18°C; air fuel ratio 28; exhaust gas temperature 410°C; mean specific heat of exhaust gases 0.25.

   Calculate: IHP, BHP, mechanical efficiency, indicated thermal efficiency and brake thermal efficiency.

   Also draw up a heat balance sheet on minute basis.

3. (a) What are the advantages of using forced circulation over free circulation in high pressure boilers?

   Explain, with the help of a neat sketch, the principle of working of the Benson boiler.

   (b) Explain the phenomenon of supersaturated flow of steam in a nozzle.

   (c) The steam enters a single-stage impulse turbine at 380 m/sec and the blade speed is 170 m/sec. The steam flow rate is 2.2 kg/sec and turbine develops 150 h.p. Assume the blade velocity coefficient to be 0.8. For an axial discharge of steam, find (i) nozzle angle, (ii) blade angle and (iii) diagram efficiency.

4. (a) Obtain expressions for stagnation temperature and stagnation density in terms of Mach number and the respective initial values for a compressible isentropic fluid flow past an immersed body.

(b) An open cycle constant pressure gas turbine plant operates with a pressure ratio of 6.5. The temperatures at the inlet to the compressor and turbine are 17°C and 820°C respectively. Assume: specific heat at constant pressure of air and gas to be 0.24 and 0.258 respectively; ratio of specific heats for air and gas to be 1.4; calorific value of fuel 10600 kcal/kg; efficiency of compressor and turbine to be 0.86 and 0.92 respectively.

Calculate: (i) HP of the plant for air circulation of 6 kg/sec; (ii) Thermal efficiency of the plant; (iii) Air/fuel ratio; (iv) Specific fuel consumption.

Take the mass of the fuel into account.

5. (a) Obtain an expression for the average heat transfer coefficient for a fluid condensing over a vertical plate, clearly indicating the assumptions made.

(b) Oil is heated from 22°C to 56°C by passing through a tube of 4 cm in diameter. Find out the length of the tube required, for an oil flow rate of 60 kg/mm, if the surface temperature of the tube wall is maintained at 100°C. Assume the following properties of oil at mean temperature:

p = 895 kg/m3 Cp = 0.52 kcal/kg-°C;

K = 0. 13 kcal/hr-m-°C; v = 0.40 X 10^{-6} m^2/sec.

6. (a) Explain the principle of working of a desert cooler, giving a neat sketch represent the process on a psychrometric chart. What are the advantages and disadvantages of this compared to a window air conditioner?

(b) A vapour compression refrigeration machine, with Freon-12 as refrigerant, has a capacity of 20 tons of refrigeration operationg between -28°C and 26°C. The refrigerant is sub cooled bu 4°C before entering the expression value and the vapour is superheated by 5°C before leaving the evaporator. The machine has a six-cylinder single-acting compressor with stroke equal to 1.25 times the bore. It has a clearance of 3% of the stroke volume.

Determine: (i) Theoretical power required (ii) COP (iii) Volumetric efficiency (iv) Bore and stroke of cylinder. The speed of the compressor is 1000 r.p.m.

Saturated Temp. °C	**Saturated Pressure kgf/cm^2**	**v_g m^3/g**	**h_f kcal/kg**	**h_g kca1/kg**	**s_f kcal/kg-°K**	**f_g kcal/kg-°K**
-28	1.1149	0.1492	93.98	133.77	0.977	1.139
26	6.8175	0.027	106.01	139.7	1.0207	1,1334

Specific heat of liquid refrigerant = 0.23 kcal/kg-°K

Specific heat of superheated vapour = 0.147 kcal/kg-°K

7. (a) The resisting force F of a plane during flight can be considered as dependent upon the length of air craft 1, velocity v, air viscosity u, air density p, and bulk modulus of air K. Express the functional relationship between these variable using dimensional analysis. Explain the physical meaning of the dimensionless groups.

(b) Obtain an expression for the work done per second by water on the runner of a Pelton wheel. Also obtain an expression for the maximum efficiency of the pelton wheel giving the relationship between the jet speed and bucket speed.

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

(a) Governing of impulse turbines

(b) Nuclear fuels

(c) Heat transfer through fins

(d) Cooling load estimation

(e) Boundary layer theory

(f) Comparison of centrifugal and axial flow compressors.

I.E.S. (Conv.) - 1987

MECHANICAL ENGINEERING

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

PAPER - II

SECTION A

1. (a) Define the draw ability of sheet metal.

(b) List the defects observed in extrusion of metals having low ductility.

(c) Write the type of fit (in symbols as per ISI specifications) that you would recommend for the following:

(i) Fig between cylinder and piston of an IC engine (petrol).

(ii) Fit between shaft and journal bearing of a turbo generator.

(d) How does forging strengthen the cast metal? List the points.

(e) Two beams of same rectangular cross-section having one side double the other side are used under similar loads, but one beam is supported on shorter side and the other on wider side of cross-section. Determine the ratio of maximum stresses in the two cases. Loads produce only bending.

(f) Draw the Goodman straight line and the Soderberg straight line for designing under fatigue loads.

(g) A thick cylinder is loaded by internal pressure only. Draw the circumferential and radial stress distributions along the radius of cylinder.

(h) Give approximate composition of green sand for CO2 moulding process.

(i) List the following tool materials in order of decreasing hardness:

(i) High speed steel (ii) Diamond (iii) Cubic boron nitride (iv) Ceramic tool material (v) Sintered tungsten carbide.

(j) Draw roll pressure distribution on roll surface in rolling of plates.

(k) In which of the following cases the cutting speed is higher?

(i) Machining for minimum cost of production

(ii) Machining for maximum production rate.

(l) Write the specifications (as per ISI) of a grinding wheel suitable for grinding of hardened carbon steel.

(m) List the names of four different types of feeders suitable for feeding of small parts.

(n) Give names of four principal machines which are generally employed in a flexible manufacturing system.

(o) Give four applications of robots in manufacturing.

(p) Give two examples involving change in the shape of component due to manufacturing requirement.

(q) List the functions ofariserin a casting.

(r) Draw an operating characteristic curve for single sampling attributes plan and indicate on it the producer’s risk and consumer’s risk.

(s) List four methods of forecasting the demand of a manufactured product.

(t) Some of the symbols used in process charts are given in Fig. 1 below. Write the operations they represent.

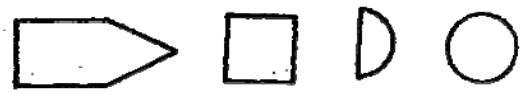

Fig. 1

SECTION – B

2. (a) A thick wailed cylindrical vessel with internal radius r_1 = 0.25m and external radius r_2 = 0.35m, has rigid end plates welded to its two ends (Fig. 2). It is subjected to a tensile load F=1000 kN through the end plates, a twisting moment T = 100 kN-m, and, and internal pressure p = 60 MPa. Determine the principal stresses and the absolute maximum shear stress on the inside surface of the vessel. Neglect the end effect.

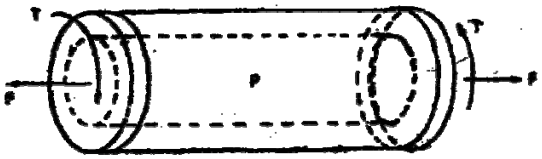

Fig. 2

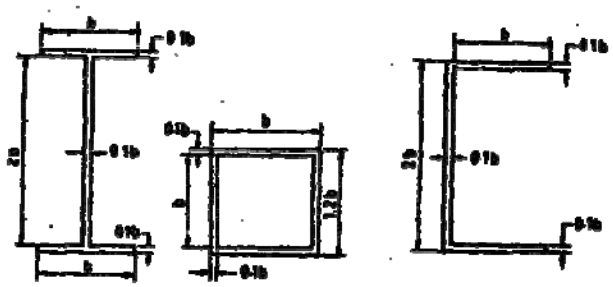

Fig. 3.

(b) The cross-sections of three pin-ended columns of same length and material for which Euler critical load theory is applicable are shown in Fig. 3. The wall thickness of sections in all the three cases is equal to 0.1b. The areas of the three cross-sections are also same, Compare the Euler critical loads for the three sections. Which is the best cross-section of the three?

(c) In leaf springs for automobiles a number of thin strips are used. Why do not we use a single thick strip?

3. (a) A drilling machine gearbox has to have six speeds based of R10 series, with maximum output speed of 1800 r.p.m. the input speed to the gearbox is also 1800 r.p.m. The gearbox has three shafts. There are three speed changes between the input shaft and intermediate shaft and two speed changes between the intermediate and output shafts.

(i) Determine the designed gear ratios.

(ii) Determine the number of teeth in each gear pair.

(iii) Determine the gear ratios based on the number of teeth in each gear-pair.

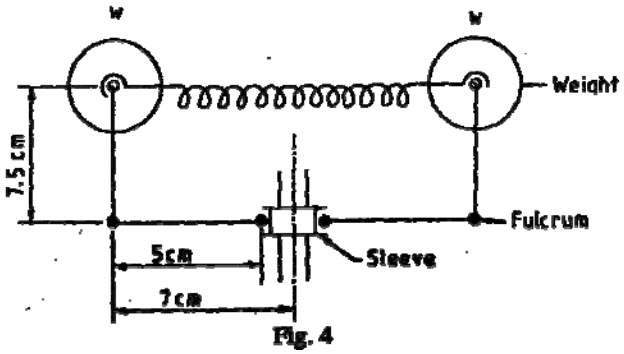

Fig. 4

(b) A centrifugal governor shown in Fig. 4 has two masses each of weight w connected by a helical spring. The arms carrying the weights are parallel to the axis of rotation at the speed of 900 r.p.m. If the speed is increased by 1%, it requires a force of 3 kgf to maintain the sleeve at the same position. Determine—

(i) the weight w of masses;

(ii) the stiffness of spring and its initial extension if the sleeve moves by 1 cm for a change of speed of 250 r.p.m.

(c) In analysis of a mechanism what is a kinetically equivalent system? What conditions should it satisfy to be a kinetically equivalent system?

4. (a) A bar of circular cross-section is subjected to alternating tensile forces varying from a minimum of 200 kN to a maximum of 500 kN. It is to be manufactured of a material with an ultimate tensile strength of 900 MPa and an endurance limit of 700 MPa. Determine the diameter of bar using safety factors of 3.5 related to ultimate tensible strength and 4.0 related to endurance limit and a stress concentration factor of 1.65 for fatigue load. Use Goodman straight line as basis for design.

(b) Compare the Maximum Shear Stress Theory and the Octahedral Shear Stress Theory of failure in uniaxial tension and plane strain conditions.

(c) Select a suitable bali-bearing subjected to following loads:

Radial load of 600 kgf at 150 r.p.m. for 25% of time.

Radial load of 750 kgf at 600 r.p.m. for 20% of time.

Radial load of 200 kgf at 200 r.p.m. for 55% of time.

The loads are steady. The outer ring remains stationary. The bearing has to bave an expected average life of 2500 hours. The shaft diameter can be adjusted to the bearing selected. The data given below may be used:

No. SKF	Inner Dia.mm	Outer Dia.mm	Width mm	Basic static	Capacity kgf Dynamic	Max. RPM
6007	35	62	14	880	1250	13000
6008	40	68	15	980	1320	10000
6009	45	75	16	1270	1630	10000
6010	50	80	16	1370	1700	8000
6011	55	90	18	1800	2200	8000
6012	60	95	18	1930	2280	8000
6013	65	100	18	2120	2400	8000
6014	70	110	20	2550	3000	6000

SECTION – C

5. (a) For a production turning operation, the records show that at the number of components produced depends on the spindle speed and feed as given below:

No. of Components Produced	Spindle Speed r.p.m.	Feed mm/rev.
100	180	0.125
120	180	0.1
80	200	0.125

Determine the number of components that could be produced at a spindle speed of 250 r.p.m. and feed of 0.08 mm/rev.

(b) Explain the process of age (precipitation) hardening. Illustrate your answer with the help of phase diagram of Al-Cu alloy.

(c) How will you carry Out the following alignment tests on a horizontal milling machine?—

(i) Perpendicularity of column ways with Table.

(ii) Parallelism of spindle axis with transverse movement of Table.

(iii) Axial float of spindle.

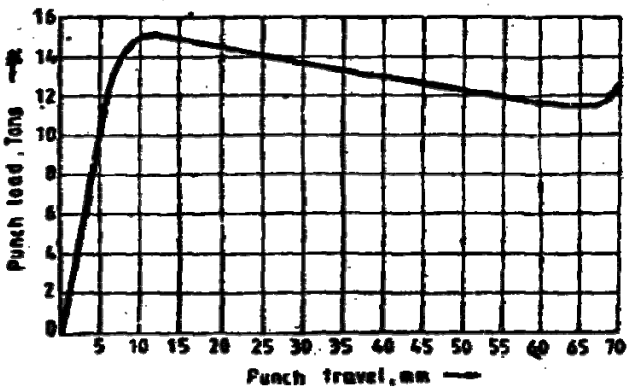

Fig. 5

6. (a) In a forward extrusion process the punch load v/s. punch travel curve is shown in Fig. 5. Determine the coefficient of friction between the billet and the cylinder wall.

Derive the expression used in the above calculation. The cylinder diameter is 100 mm and yield strength of material being extruded is 10 kgf/mm^2.

(b) With the help of freehand diagrams show the following thermo-forming processes for forming of polymers:

(i) Vaccum forming (ii) Pressure forming (iii) Blow forming.

(c) In drawing of cup shaped components from sheet metal blanks, some of the defects that may occur are shown in Fig. 6. Given brief the causes for each of these defects.

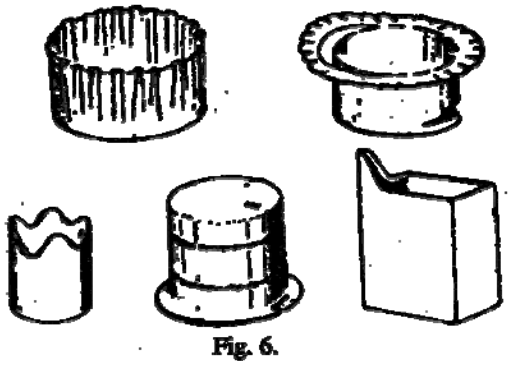

Fig. 6.

7. (a) Table 1 gives the different activities associated with a project and their durations. Draw the network diagram and determine the critical path. Also determine the critical path time.

Table—1

Beginning	Ending Day

I j

Activity	Event		Duration Day
	Beginning (i)	Ending (j)	
A	1	2	47
B	2	3	43
C	1	3	80
D	1	4	33
E	4	7	33
F	1	5	21
G	5	8	37
H	1	8	50
I	3	6	22
J	6	9	22
K	9	11	86
L	8	10	22
M	10	11	22
N	11	12	21
O	12	13	63
P	7	11	150

(b) Thirty identical machines are being used by a manufacturing concern. On the average a machine runs for 25 days after repair between two consecutive breakdowns. The average cost due to loss of production is rupees 200 per breakdown. If standby machines are used, the daily cost per machine is rupees 40.

Determine the optimum number of standby machines. A constant failure rate may be assumed.

(c) Figure 7 shows a system with redundancy. Calculate the reliability of the system for an operating period of 1000 hours if the failure rates of components are given by 4×10^{-6} per hour for P, 1×10^{-5} per hour for Q and 3×10^{-6} per hour for R.

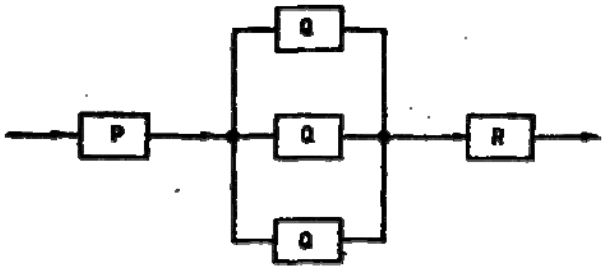

Fig. 7.