MECHANICAL ENGINEERING

PAPER - I

Time Allowed: Three Hours **Maximum Marks: 300**

Candidates should attempt Questions 1 and 5 which are compulsory, and any THREE of the remaining questions selecting at least ONE question from each Section.

If any data considered insufficient, assume suitable value. Newton may be converted into kg using the equality 1 kilonewton (1 kN) = 100 kg, if found necessary.

SECTION A

1. Answer any three of the following (each answer should not exceed 200 words):

(20 x 3 = 60)

(a) Explain clearly the difference in the nature of unbalance caused by primary and secondary disturbing force in case of a reciprocating mass. What is the essential difference between unbalance caused by a reciprocating mass and that caused by a revolving mass? How will you achieve the complete balance in the case of a multi-cylinder in line engine?

(b) Differentiate between kinematic analysis and synthesis. What is the significance of Chebyshev spacing points and how can you obtain them? Draw and explain the working of any one mechanism generating exact straight line.

(c) Define Effort and Power in relation to Governors. Obtain the expressions for these in the case of a Porter Governor.

(d) What is the classical Reynolds Equation for one dimensional fluid flow based on Hydrodynamic lubrication theory? What are the assumptions made in arriving at this equation? Explain the significance of Sommerfeld Number, Temperature Rise and Minimum Film Thickness fro assessing a bearing performance.

2. (a) A solid circular uniformly tapered shaft of length *l*, with a small angle of taper is subjected to a torque T. The diameter at the two ends of the shaft are d and 1.2 d. Determine the error introduced if the angular twist for a given length is determined on the basis of the uniform mean diameter of the shaft.

(20)

(b) A close coiled helical spring is of 80 mm mean coil diameter. The spring extends by 37.75 mm when loaded axially by a weight of 500 N. There is an angular rotation of 45° when this spring is subjected to an axial couple of magnitude 20.0 Nm. Determine the poisson's ratio for the material of the spring.

(20)

(c) A circular bar of diameter d is bent at right angle. It is fixed at one end and a load W is applied at the other end as shown in the figure. Determine the deflection under the load W if E & G are Young's and shear Moduli of the material.

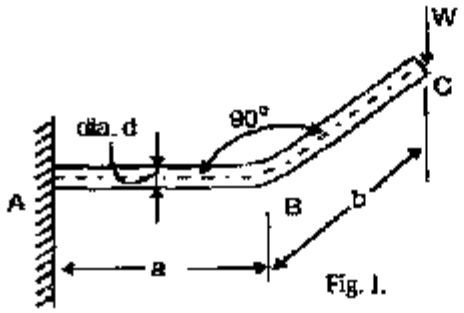
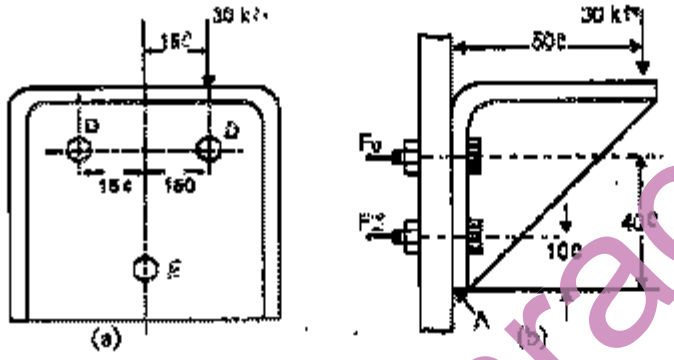


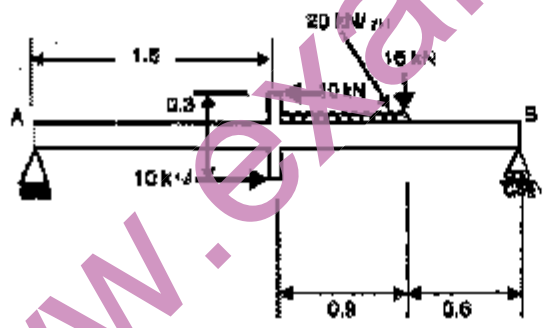
Fig. 1.

3. (a) A steel bracket is bolted to a column by three similar bolts as shown in the figure. It is subjected to an eccentric load of 30 kN as indicated. Determine a suitable minimum diameter for the bolts using a factor of safety of 5.0. Assume the bracket and the attached plate to be rigid. Take the allowable stresses for the bolt material in tension as 600 MN/m^2 and in shear as 350 MN/m^2.



(30)

(b) A simply-supported beam is subject to the loading as shown in the figure. Calculate the deflection at a section 2.0 m from the end A Assume E = 70 GN/m^2 and I = 830 cm^4.



(30)

4. (a) The figure shows a schematic of an indicator mechanism. The arm pivoted at point O has a mass moment of inertia I and is constrained to move about O by two-spring-mass systems K_1-m_1 an K_2-m_2 and by another spring K_3, as shown. Obtain an expression for natural frequency of small oscillations of the mechanism.

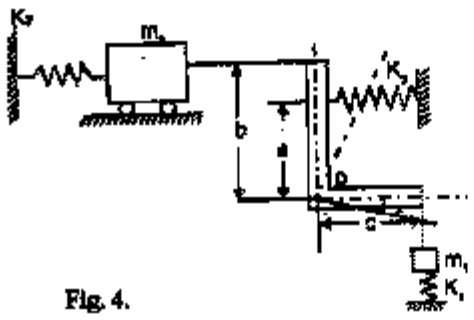


Fig. 4.

(b) A shaft and a disc system consists of a rotating shaft of length 0.5 m supported at its ends by self-aligning bearings and a disc of mass 10 kg mounted midway between the bearings. The diameter of the shaft is 20 mm and the disc has an eccentricity of 0.05 mm. Assume mass density of shaft as 7840 kg/m^3 and modulus of elasticity of shaft material as 210 GPa. Considering the shaft to be simply supported and the deflection shape function to be sinusoidal, determine the critical speed of the system taking into account the distributed mass of the shaft. Also, determine the dynamic bearing reactions at resonance when a 2 percent damping is assumed to be present.

(40)

SECTION B

5. Answer any three of the following (Each answer should not exceed 200 words).

(20 x 3 = 60)

(a) Sketch and discuss the defects in a lattice structure of a crystalline material.

(b) Draw a sketch of the rolling operation for a strip and indicate the forces and stresses during rolling. Discuss the aspects of friction and velocity during the process.

(c) Discuss the possible modes of failure of a cutting tool. For a lathe tool, show the flank and crater wears.

(d) Distinguish between Quality Control and Quality Assurance with particular reference manufacturing. Which is done first and why?

6. (a) Explain the mechanism of electric discharge machining. What is wire cut EDM? Indicate its special application. What are the basic requirements of a dielectric fluid?

(30)

(b) Distinguish between form error and surface roughness for an engineering component. How are these caused? How is surface finish measured and explain any one of its measure and the units used.

(30)

7. (a) A company has to manufacture 1,50,000 brackets in a year. It orders raw material for the brackets in lots of 40,000 units from a supplier. It costs Rs. 40 to place an order and estimated inventory carrying costs are 20% of the item cost, which is Rs. 0.15. Calculate the variation (in %) in their order quantity from optimal, and what this variation cost.

(20)

(b) Justify the use of jigs and fixtures in large batch production. Briefly discuss the design of a jig required for drilling a hole of 5 mm in the centre of a 10 mm thick M.S. plate of size 100 x 100 mm.

(20)

(c) There are 'NSTUD' students in a class whose roll numbers are given in an array 'NROLL' and the marks obtained in the final examination are given in array 'TOTAL'. Write a program, in FORTRAN, to read roll numbers and corresponding marks of all the students and arrange them in order of merit. Assume the value of 'NSTUD' as 40.

(20)

8. (a) The final product of firm has a requirement that it must weigh exactly 150kg. The two raw materials used in the manufacture of this product are A, costing Rs. 2 per unit, and B costing Rs 8 per unit. Each unit of A and B weighs 5kg and 10kg respectively. At least 14 units of B and no more than 20 units of A must be used. How much of each type of raw material should be used for each unit of the final product if cost is to be minimised?

(b) Consider a project with following precedence requirements and estimated times:

Activity	*Time in weeks*	*Immediate Predecessor*
A	3	-
B	5	-
C	7	-
D	3	C
E	7	A, B
F	3	E, D
G	2	D
H	2	F, G

Draw the CPM network and find the critical path.

(20)

(c) Define Value Engineering and explain its role in a manufacturing enterprise. List down the questions which need to be answered when carrying out value analysis for a product. Take a suit able example to illustrate your reply.

(20)

MECHANICAL ENGINEERING

PAPER - II

Time Allowed: 3 Hours **Maximum marks: 300**

Candidates should attempt Questions 1 and 5 which are compulsory, and any three of the remaining questions selecting at least one questions from each Section.

If any data is considered insufficient, assume suitable value.

Newton may be converted to kg using the equality 1 kilonewton (1 kW 100 kg, if found necessary.

SECTION A

1. Answer any three of the following part (answer to each part should not exceed 200 words):

(a) Discuss the requirements of fuel for spark ignition (SI) engines. In the light of these compare ethanol and methanol as alternate fuels for automotive SI engines.

(20)

(b) Show that when a gas expands behind a piston according to the law PV^n = constant, the heat transfer, change in internal energy and work done are in the ratio $(\gamma - n)(n - 1) : (\gamma - 1)$ and that the effective specific heat C for an expansion of this kind is times its specific heat at constant volume C_v.

(20)

(c) What are the major pollutants in evaporative emissions blow by emission and exhaust emission from an automobile? Describe a suitable method for controlling evaporative emissions.

(20)

(d) Compare thermal, hydel and nuclear power plants from the point of view of (i) initial cost, (ii) operation cost, (iii) maintenance cost and (iv) environmental impact. What are their site selection considerations?

(20)

2. (a) Knocking in SI engine is due to auto-ignition of End charge while knocking in CI engine is due to auto ignition of the 'First charge. In the light of this show in a tabular form the effect of various engine operating parameters on knocking is SI and CI engines.

(25)

(b) An eight cylinder petrol engine is to deliver 160 b.h.p. at a piston speed 750 m per minute with an indicated thermal efficiency of 23 per cent. The stroke to bore ratio is 1.25 the volumetric efficiency is 85 per cent (1.0 kg/cm^2 and 40° C intake condition) and mechanical efficiency is 83 per cent Assume petrol contains 10,200 kcal of heat kcal of heat of combustion per kg and requires 14 kg of air per kg for complete combustion. The engine uses a mixture having 10 percent excess air.

Calculate the diameter of the cylinder and stroke, the brake specific fuel consumption and the brake mean effective pressure.

(35)

3. (a) Heat is supplied to a perfect gas which is flowing through a parallel passage. Show that if friction is negligible p $(1 + \gamma M^2)$ is constant along the passage. Hence show that

$$\frac{T_0^{1/2}\left(1+\gamma M^2\right)}{M\left(1+\frac{\gamma-1}{2}M^2\right)^{1/2}}$$

is also constant. Assume that the gas velocity is uniform over any cross-section.

(30)

(b) Sketch Rayleigh line on Pressure-Specific Volume diagram and on Enthalpy-Entropy diagram. Prove that for Rayleigh line conditions.

$$\frac{V_2}{V_1}=\frac{\left(1\gamma M_2^2\right)}{\left(1+\gamma M_2^2\right)M_1^2}$$

(30)

4. (a) Discuss copressor stall on the basis of blade angle of attack.

(15)

(b) Discuss the relative merits of axial-flow and centrifugal-flow compressors.

(15)

(c) An axial-flow compressor takes in 1000 m^3/min of free air at 0.7 kg/cm^2 and 5° C. The blades are of aerofoil type, having chord area 19.25 cm^2 and blade length 6.75 cm. The blade ring mean diameter is 60 cm and rotational speed is 6000 rpm. There are 50 blades on each blade ring and the blades occupy 10% of the axial area of flow. Taking values of C_L and C_D and 0.6 and 0.05 respectively at zero angle of incidence and assuming isentropic compression and axial inlet, calculate (i) the pressure rise pe blade ring and (ii) cheoretical horsepower per stage.

(30)

SECTION B

5. Answer any three parts out of the following four parts of this compulsory question. Each part of the question must he answered briefly to the point, in not more than 200 words.

(a) What are the special features in the design of high pressure high duty boilers? Discuss the advantages and disadvantages of forced circulation boilers as compared to natural circulation boilers.

(b) Explain dropwise condensation and film condensation. Why heat transfer rate is higher in dropwise condensation than in film condensation?

(20)

(c) Discuss the essential differences in working principles of heat pump refrigerating machine and heat engine. Describe a summer air conditioning system with ventilation.

(20)

(d) Show by methods of dimensions that the volume rate of flow of a gas through a sharp edged orifice is given by

$$Q = d^2\sqrt{\frac{p}{p}}\phi\left(\frac{v}{d}\right),\quad \sqrt{\frac{p}{p}}$$

where d is the diameter of the orifice, p is the pressure difference between the two sides of the orifice, p and v are the density and kinematic viscosity of the gas respectively.

(20)

6. (a) Explain why freon refrigerants are being phased out. Name any proposed substitute refrigerant and give its relevant properties as compared to freon-12

(b) A 15 ton Freon refrigeration plant has twin cylinder single acting compressor having bore 1.5 times stroke and operating at 960 rpm. The temperature of the refrigerant sub-cooled as liquid in the condenser is 248 K while the temperature of the refrigerant superheated as gas in the evaporator is 268 K. The condenser temperature is 303 K. Using the refrigerant properties tabulated below, determine.

(i) Mass of refrigerant circulated per minute

(ii) Theoretical kilo-watt power required to operate the plant

(iii) the theoretical COP of the plant

(iv) Heat removed in the condenser

(v) The compressor bore and stroke.

Assume average liquid specific heat as 0.963 kJ/kg K and average vapour specific heat as 0.615 kJ/kg K.

Saturation Temp.	Absolute pressure	Specific volume m^3/kg	Enthalpy of liquid kJ/kg	Enthalpy of vapour kJ/kg	Entropy of liquid kJ/kgK	Entropy of vapour kJ/kg K
t,K	P(bar)	V_g	h_f	h_g	S_f	S_g
263	2.19	0.0767	26.9	183.2	0.1080	0.7020
303	7.45	0.0235	64.6	199.6	0.2399	0.6854

(40)

7. (a) Explain the tents fin efficiency and fin effectiveness. Derive the expressions for these for the fin which is insulated at the end. Discuss the conditions Mien installation of fins on a heat transfer surface will not necessarily increase heat transfer rate.

(25)

(b) The cylinder of art engine is 1 in long and has an outside diameter of 6 cm. The outside surface temperature of the cylinder is 200°C when the ambient temperature is 30°C. The film coefficient of beat transfer is 25 W/m^2 K. The cylinder is provided with 12 longitudinal straight fins of 0.1 cm thickness and 3 cm length. The thermal conductivity of cylinder and fin material is 75W/mk. Assuming that the fins have insulated tips, determine.

(i) percentage increase inheat dissipation due to addition of fins.

(ii) the temperature at the centre of the fin and

(iii) find efficiency and fin effectiveness.

(35)

8. During the trial of coal fired boiler plant producting steam at 40 bar pressure and 350°C temperature, the steam produced per kg of coal fired was found to be 9.18 kg. The dry coal analysis gave 84% carbon. 4%-hydrogen, 7% oxygen and 5% ash. Moisture is coal used was 1.5%, carbonin ash was nil. The calorific value of dry coal was 32700 kJ/kg. The volumetric analysis of dry flue gases gave

12.3% carbon dioxide, 7.7% oxygen and 80% nitrogen. The feed water temperature at entry to economiser was 27° C and that at exit 150°C. The temperatures of flue gas entering and leaving air pre-heater were 280°C and 160°C respectively while temperature of air leaving preheater was 110°C and at entry 15°C.

Determine (i) boiler efficiency,

(ii) efficiency of heat transmission in air heater.

Draw up a heat balance for the complete boiler plant in kJ/kg of dry coal using a datum of 15°C. Take C_p for air and dry flue gas as 1.005 kJ/kg°C, partial pressure of steam vapour and its specific heat as 0.07 bar and 2.01 kJ/kg°C respectively.

(60)