# MECHANICAL ENGINEERING

## PAPER - I

## SECTION A

1. Answer any four of the following (each answer should conform to a limit of around 150 words):

(a) Mention the conditions required for a two mass system to be dynamically equivalent to a rigid mechanical component. Why sometimes is a hypothetical correction couple applied on the two mass system to make it dynamically equivalent to a rigid body? Find the position of centre of percussion of a compound pendulum from its centre of gravity. What is the significance of the concept of centre of percussion for a batsman playing cricket?

(6 + 4 = 10)

(b) What is meant by haunting of governor? Explain briefly the causes of its occurrence. Justify with reasons, whether it is more severe in case of unstable governor or isochronous governor

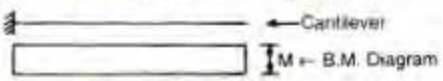
(10)

(c) (i) A connecting rod in I.C. engine is designed as a column, with an I-section. Designers take moment of inertia of the cross-section about one axis equal to 4 times that taken about the perpendicular axis. Why?

(ii) Why is it considered that the hollow shaft under torsion is lighter than a solid one, if other parameters are the same? (6 + 4 = 10)

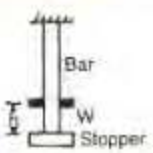
(d) (i) Draw a Mohr's circle of stress for a round bar which is shrunk fit by a hub, with brief explanation.

(ii) A cantilever is loaded and the bending moment diagram is rectangular as shown in Figure. What will be the shape of the shear force diagram? (5 + 5 = 10)




(e) With reference to Figure, neglect the weight of the bar and stopper. A load W is dropped from a height h. Given W = 1.0 kN. area of cross- section of the bar = 20 mm$^2$. Find the instantaneous stress developed in the bar when the weight W is dropped from a height $h = 0$.

(10)

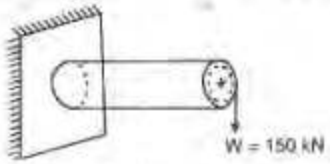



2. (a) A machine weighing 68 N is mounted on a set of springs, whose equivalent spring stiffness, K = 1070 N/cm and damping factor, $\xi = 0.2$ arranged vertically on a rigid foundation. A piston within the machine weighing 2.0 N has a vertical reciprocating motion, with a stroke of 8.0cm and a crank shaft with a speed of 3000 rpm. Assuming the motion to be simple harmonic, determine:

(i) The amplitude of vibration in the vertical direction of the machine.

(ii) The transmissibility ratio and the force transmitted to the foundation. The phase lag between the transmitted force and the exciting force. (15)

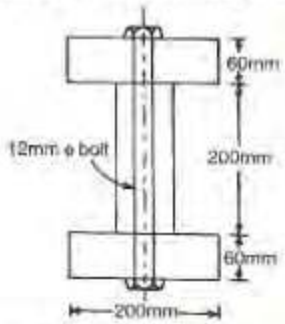
(b) A thin cylindrical shell is made of M.S. Its dimensions are : mean diameter 1.6 m, length 2 m and thickness of shell 1.2 cm. The ends are closed by flat rigid discs. It is subjected to an internal pressure of 2.4 MPa. It is fixed at one end and loaded by a weight W = 150 kN hanging on a rope as shown in Figure.




Find the maximum stress developed in the shell. Which theory of failure is used for such shells ? If the yield stress of M.S. is taken as 600 MPa, what is the factor of safety using the above theory of failure?

(15)

(c) Three planks each 200 mm × 60 mm are bolted together by 12 mm dia. bolts to form an I section as shown in Figure. The beam carries a central point load of 25 kN. If the shear stress in the bolts is not to exceed 80 MPa, find the pitch of the bolts. Neglect the reduction in area caused by holes drilled in the beam. (10)




3. (a) The firing order in a 6 cylinder vertical four stroke inline engine is 1-2-4-6-5-3. The piston stroke is 100 mm and the length of each connecting rod is 200. The pitch distance between the cylinder centre lines are 100 mm, 100 mm, 150 mm, 100 mm and 100 mm respectively. The reciprocating mass per cylinder is 1.0 kg and the engine runs at 3000 rpm. Determine the out-of-balance primary and secondary forces and couples on the engine. Is it the best firing order? If yes, why? What will be the consequence for other firing orders? (15)

(b) A thick cylinder 1.0 m inside diameter is to be designed for an internal pressure of 4.8 MPa. Calculate:

(i) The thickness if the maximum shearing stress is not to exceed 21 MPa.

(ii) The increase in volume, due to internal pressure if the cylinder is 7.0 m long with closed ends. neglect any constraints due to ends.

Take E = 200 GPa and Poisson's ratio = 1/3. (15)

(c) Mention the unique characteristics of polymers or plastics that distinguish them from metals. State the general applications of extrusion of plastics. (6 + 4 = 10)

4. (a) A single cylinder vertical engine has a bore of 30.5 cm, a stroke of 40 cm, and a connecting rod 80 cm long. When the piston is at its quarter stroke and moving downwards, the net pressure on it is 65 N/cm$^2$.

(i) If the speed of the engine is 250 rpm and the total equivalent mass of the reciprocating parts is assumed to be 135 kg. find the net- turning moment on the crank-shaft at the above condition without considering the mass of the connecting rod.

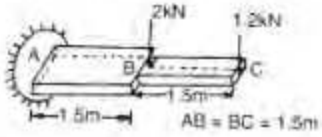
(ii) If the actual mass of the reciprocating parts is 90 kg and that of connecting rod is 120 kg. determine the actual turning moment available at the crank-shaft for the same

instant. The C.G. of the connecting rod is 50cm from the small end and the radius of gyration about its centroidal axis is 30 cm.

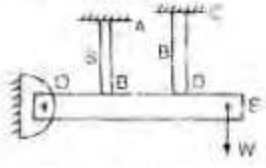
(iii) Find out the percentage of error in the approximate calculation as in (i).

(10+3+2=15)

(b) A cantilever ABC of length 3.0 m carries two concentrated loads of 2.0 kN and 1.2 kN at B and C as shown in Figure below. The cross- section of the cantilever is given below. For AB portion, breadth is 12 cm and for BC portion, breadth is 6cm. Depth is uniform all through and is 10 cm. E for beam material may be taken as 200 GPa. Find the slope and deflection at the free end 'C' of the beam. 1.2kN (14)




(c) As shown in Figure, OR is a rigid beam, hinged at 0 and kept horizontal by two vertical supports AR and CD.




Data given for the system are as follows:

| Compo -nent | Material | Length | Diameters | E | α |
|---|---|---|---|---|---|
| AB | Steel | 1.2m | Solid bar of 5 mm dia. | 200 GPa | 12×10⁻⁶/°C |
| CD | Brass | 1.5 m | Hollow bar 10 mm internal dia. and 15 mm external dia. | 110 GPa | 20×10⁻⁶/°C |

If hot gases pass through the brass tube to raise its temperature by 150°C, find the load supported by both the vertical bars, given OB = BD = DIE. Assume that before assembly, the brass bar is 1 mm too short and W=10 kN.

(11)

## SECTION B

5. Answer any four of the following (each answer should conform to a limit of around 150 words):

(a) State the basic purposes of application of linear programming and the assumptions made for such application. (10)

(b) How does a cutting tool fail? What properties should the modern cutting tool materials essentially possess? (3 + 7 = 10)

(c) State the detrimental effects and possible causes of vibration in straight turning of steel rods by carbide inserts in centre lathes. (4 + 6 = 10)

(d) Compare extrusion with wire drawing process *w.r.t.* their working principle, essential properties for the work materials and general applications. Also state by which processes joint less steel tubes can be manufactured in large quantity. (6 + 4 = 10)

(e) Show the flow chart in order to write the programme in 'C' for designing a tensile rod, *i.e.*, to find out its diameter, *d*, subjected to a load, *P* using usual notations and also for optimising the same for a given length, L and for four different materials whose yield point stresses are $\sigma_a, \sigma_b, \sigma_c$ and $\sigma_d$ taking corresponding factor of safety as $K_a$, $K_b$, $K_c$ and $K_d$ respectively to minimize the weight. Density of the material may be taken as $\sigma_a, \sigma_b, \sigma_c$ and $\sigma_d$.

(10)

6. (a) (i) What should be the diameter of the punch and die to be used for blanking and piercing in a 't' mm thick metal sheet, if the diameter of both the blanks and pierced holes is 'd' and total clearance is 'c'?

(ii) Determine the minimum diameter of the punch that can safely pierce holes in a sheet, if the compressive strength of the punch material and shear strength of the sheet metal are $\sigma$ and $\tau_s$ respectively.

(4 + 6 = 10)

(b) (i) Name the instruments by which diameter of cylindrical holes can be measured.

(ii) Determine the dimensions of the GO and NO GO portions of the gauge to be used for checking diameter of rods finished to size $25^{+0.020}_{-0.040}$ *mm*. (5+10 = 15)

(c) The following information are given about a PERT network

| Activity | | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| Predecessor | : | — | — | — | A | C | B,D,E | A | C |
| (Time in weeks) | *a* : | 1 | 2 | 3 | 2 | 4 | 5 | 2 | 0 |
| | *m* : | 3 | 3 | 4 | 9 | 5 | 6 | 4 | 3 |
| | *b* : | 5 | 4 | 5 | 10 | 6 | 13 | C | 6 |

Draw the network. Calculate critical path. What is the probability of completing the project in 20 weeks or less? (16)

7. (a) (i) State briefly the basic difference between electrodischarge machining (EDM) and electro-chemical machining(ECM) *w.r.t.* material removal mechanism, medium, tool material and critical process parameters.

(ii) How much current flow will be required to remove material at the rate, 6 $cm^3$/min from a pure iron plate by ECM if the atomic weight, valency and density of iron are 56 g, 2 and 8 g/$cm^3$ respectively? (5 + 10 = 15)

(b) ABC company has to supply 30,000 switches per year to its customer. This demand is fixed and known. The customer uses its items in assembly operations and has no storage place/space. A storage cost of Rs.10/unit its incurred if the company fails to deliver the required units. The set-up cost per run in Rs. 3,500.00 Determine;

(i) The optimum run size, q.

(ii) The optimum level of inventory at the beginning of any period.

(iii) The optimum scheduling period.

(iv) The minimum total expected annual cost. (10)

(c) A short length of tube 40 mm internal diameter and 50 mm external diameter failed in compression at a load of 240 kN. When a 2.0 m length of the same tube was tested as a strut with fixed ends, the load at failure was 158 kN. Assuming that $f_c$ in Rankine's formula is

given by the first test, find the value of the constant $\alpha$. Find also the crippling load of this tube if it is 3 m long with one end fixed and the other hinged.

Using Euler's formula, find out the length of the fixed ended column when it has equal chances of buckling as well as yielding E = 200 GPa. (15)

8. (a) (i) For machining which work materials use of CBN and diamond tools are techno-economically suitable?

(ii) How much time will be required to drill a through hole of diameter 20 mm in a 18 mm thick steel plate at drill speed, 200 rmp and feed 0.2 mm/rev, if the helix angle and point angle of that drill be 30° and 120° respectively? Assume approach and overrun = 1 mm.

(5 + 10 = 15)

(b) State the purpose of using jigs and fixtures in batch production by machining and also mention the factors that are considered during designing a jig for aiding machining.

(5+10= 15)

(c) What are super alloys? Discuss in brief the compositions, properties and applications of these alloys in practice.

(10)

# MECHANICAL ENGINEERING

## PAPER - II

## SECTION A

1. Answer any four parts:

(a) Explain why PMMK I and PMMK II devices are not practicable. (Perpetual Motion Machine Kind) (10)

(b) A reversible Heat engine A absorbs energy from a reservoir at temperature $T_1$ and rejects energy to a reservoir at temperature $T_2$. A second engine B absorbs the same amount of energy as rejected by the engine A from the reservoir at temperature T2 and rejects energy to a reservoir at temperature $T_3$. What is the relation between $T_1$, $T_2$ and $T_3$ if:

(i) The efficiencies of both the engines A and B are the same and

(ii) The work delivered by both the engines is the same?

(c) Distinguish between Octance and Cetane rating offuels. Explain how they are determined. What is the Cetane rating of diesel oil marketed in India?

(10)

(d) Compare the phenomenon of detonation in spark ignition engine with that of knocking in compression ignition engines.

(10)

(e) In a one shell one tube pass heat exchanger, the hot fluid enters at 800°C and leaves at 500°C while the cold fluid enters at 100°C and leaves at 300°C. Find the Log-Mean Temperature Difference (L.M.T.D.) if the Heat Exchanger is arranged for (i) parallel flow and (ii) counter flow. Derive the expressions of L.M.T.D. for both the above cases.

(10)

2. (a) What are the requirements of the fuel for ST. engine? Discuss the suitability of ethanol and methanol as alternative fuels for SI. engines.

(15)

(b) A two pass surface condenser receives 27500 kg of steam per hour at a pressure of 0.04 $kg/cm^2$ and dryness fraction 0.92. All the steam is condensed to 27.5°C by coiling water which enters the condenser at 13.5°C and leaves at 24.5°C. The condenser tubes are 1.85 cm outside diameter and 1.0 mm thick and water flows through these tubes with a speed of 1.5 m/sec. Assuming the overall coefficient of heat transfer as 3,000 $Kcal/m^2$-hr-deg. find:

(i) Surface area required

(ii) Length and number of tubes in each pass.

(25)

3. (a) What are the stages during which combustion occurs in a diesel engine ? Why diesel knock occurs and how it can be controlled?

(15)

(b) A four stroke single cylinder oil engine has a bore of 300 mm and stroke 460 mm and runs at 200 rpm. The fuel oil has a composition by mass of 87% Carbon and 13% Hydrogen. It is consumed at the rate of 6.75 kg/hr. The volumetric composition of dry exhaust gases is 7%

$CO_2$, 10.5% $O_2$ and 82.5% $N_2$. Atmospheric temperature and pressure are 17°C and 100 kN/m$^2$ respectively.

Determine:

(i) The actual quantity of air supplied/kg of fuel and

(ii) Volumetric efficiency of the engine.

Take R for air as 0.287 kJ/kg-K

(25)

4. (a) Explain how the IHP developed by individual cylinders of a multicylinder engine is determined by Morse test.

(10)

(b) The following data were obtained from a test on a single cylinder 4-stroke oil engine:

Cylinder bore = 15 cm, Stroke = 25 cm, Area of indicator diagram = 450 sq. mm, Length of indicator diagram = 50 mm, Indicator spring rating 1.2 mm for a pressure of 9.81 N/cm$^2$. Engine speed = 40 rpm, Brake torque = 225 Nm, Fuel consumption = 3 kg/hr, Calorific value of fuel = 44,200 kJ/kg. Cooling water flow rate = 4 kg/mm., Cooling water temperature rise = 42°C, Specific heat of cooling water = 4.187 kJ/kg-K.

Determine:

(i) The mechanical efficiency,

(ii) Brake thermal efficiency,

(iii) Specific fuel consumption and

(iv) Draw heat balance in kW.

(30)

## SECTION B

5. Answer any four parts:

(a) Explain vapour absorption refrigerating system using Solar power as heating source.

(10)

(b) What are the hazardous effects of Nuclear waste and explain any one method of waste disposal.

(10)

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

(10)

(d) (i) Explain clearly geometric, kinematic and dynamic similarities. State atleast two governing parameters for each kind of similarity. (5)

(ii) Give the advantages of Model analysis. (5)

(e) Explain what do you understand by specific speed of a turbo machine. Give its importance.

A 2500kW gas turbine is running at a speed of 18000 rpm. The entry and exit conditions of the gas are: $T_1$ = 1100 K, $P_1$ = 60 bar, $P_2$ = 30 bar.

Determine the specific speed.

Take $\gamma = 1.4$, R = 287 J/kg-K, $C_p$ = 1.005 kJ/kg-K. (10)

6. (a) Explain clearly Fanno flow. With the help of basic equations explain how Fanno line can be plotted on the h-s diagram. Hence discuss the effects of friction on flow parameters. (15)

(b) Air flows in an insulated duct with a Mach number of 3.0. The initial temperature and pressure are 573 K and 15 bar respectively.

Determine:

(i) The temperature and pressure at a section of the duct where the Math number has dropped to 1.5,

(ii) The distance between these two points if the duct diameter is 15 cm and friction factor is 0.003.

(iii) What will be the maximum length of the duct to avoid choking?

Use the following table: (15)

| M | $p/p^*$ | $T/T^*$ | $\frac{4f\ L\ max}{D}$ |
|---|---|---|---|
| 3.0 | 0.2182 | 0.4286 | 0.5222 |
| 1.5 | 0.6065 | 0.8276 | 0.1360 |

7. (a) Discuss the salient points of difference between impulse and reaction turbines. What is meant by degree of reaction? (10)

(b) Steam, with absolute velocity of 360 m/sec., enters the stage of an impulse turbine provided with a single row wheel. The nozzles are inclined at 20° to the plane of the wheel. The blade rotor having diameter of 95.5 cm rotates with a speed of 3000 rev./ minute. Determine:

(i) Suitable inlet and outlet angles for the moving blade so that there is not axial thrust on the blades. It may be assumed that friction in blade passages is 19% of the kinetic energy corresponding to relative velocity at inlet to blades. (10)

(ii) Power developed in blading for a steam flow of 1.0 kg/sec. (10)

(iii) Kinetic energy of steam finally leaving the stage. (10)

8. (a) Define the following terms:

(i) WET

(ii) DPT

(iii) Relative humidity

(iv) Sensible heat factor

(v) Comfort zone. (10)

(b) An Air-conditioning plant is to be designed for a small office for winter condition. Outdoor condition: 10°C DET and 8°C WBT. Required indoor condition : 20°C DTB and 60% R.H.

Amount of air circulation : 0.3 m3/minlperson.

The seating capacity of the office is 50. The required condition is achieved first by heating and then by adiabatic humidifying.

Find:

(i) Capacity of heating coil in kW and the surface temperature required if the bypass factor of the coil is 0.32.

(ii) The capacity of the humidifier. (30)