2018-19  
B.E. (AUTUMN SEMESTER) EXAMINATION  
MECHANICAL ENGINEERING  
MACHINE DESIGN  
EME-317

Maximum Marks: 60  
Credits: 04  
Duration: Two Hours

Answer all the questions.  
Assume suitable data if missing.  
Notation used have their usual meaning.

Q.No.  

1(a) What are different types of welding processes? Also state the limitations of welded joints.  

1(b) A welded connection of steel plates, as shown in Fig. 1, is subjected to an eccentric force of 10 kN. Determine the throat dimension of the welds, if the permissible shear stress is limited to 95 N/mm². Assume static conditions.  

Fig. 1

OR

1(b') A circular beam, 50 mm in diameter, is welded to a support by means of a fillet weld as shown in Fig. 2. Determine the size of the weld, if the permissible shear stress in the weld is limited to 100 N/mm².  

Fig. 2

2(a) Explain the variation of coefficient of friction (μ) with zN/p for sliding contact bearing in McKee’s plot.  

2(b) Discuss the various steps involved in design procedure of journal bearing.  

OR
2(b') A transmission shaft rotating at 720 rpm and transmitting power from the pulley P to the spur gear G is shown in Fig. 3. The belt tensions and the gear tooth forces are as follows:

\[ P_1 = 498 \text{ N}, \quad P_2 = 166 \text{ N}, \quad P_3 = 497 \text{ N}, \quad \& P_4 = 181 \text{ N}. \]

The weight of the pulleys is 100 N. The diameter of the shaft at bearings B₁ and B₂ is 10 mm and 20 mm respectively. The load factor is 2.5 and the expected life for 90% of the bearings is 8000h. Select single row deep groove ball bearings at B₁ and B₂.

![Fig. 3](image)

3(a) Derive the relation of torque transmitting capacity for a Cone clutch and show that the cone angle (\( \alpha \)) is greater than 11.3°.

3(b) A differential band brake, as shown in Fig. 4, has a drum diameter of 600 mm and the angle of contact is 240°. The brake band is 5 mm thick and 100 mm wide. The coefficient of friction between the band and the drum is 0.3. If the band is subjected to a stress of 50 MPa, find:

a. The least force required at the end of a 600 mm lever, and
b. The torque applied to the brake drum shaft.

![Fig. 4](image)

4(a) Explain the process and procedure of Nipping in leaf spring with the help of suitable line diagram.

4(b) An eccentric cam, 100 mm in diameter, rotates with an eccentricity of 10 mm. The roller follower is held against the cam by means of a helical compression spring. The force between the cam and the follower varies from 100 N at the lowest
position to 350 N at the highest position of the follower. The permissible shear stress in the spring wire is recommended as 30% of the ultimate tensile strength. Design the spring from static consideration and determine the factor of safety against fluctuating stresses. Neglect the effect of inertia forces.

OR

4(b') A semi-elliptical leaf spring consists of two extra full-length leaves and six graduated-length leaves, including the master leaf. Each leaf is 7.5 mm thick and 50 mm wide. The centre-to-centre distance between the two eyes is 1 m. The leaves are pre-stressed in such a way that when the load is maximum, stresses induced in all the leaves are equal to 350 N/mm². Determine the maximum force that the spring can withstand.

5(a) Power is transmitted from a pair of helical gears. Hence, derive the components of total tooth force. Also show these forces on helical gear.

5(b) It is required to design a pair of spur gears with 20° full-depth involute teeth consisting of a 20 teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 KW, 1450 rpm electric motor. The starting torque of the motor can be taken as 150% of the rated torque. The material for the pinion is plain carbon steel Fe 410 (Sₘₜ = 410 N/mm²), while the gear is made of grey cast iron FG 200 (Sₘₜ = 200 N/mm²). The factor of safety is 1.5. Design the gears based on the Lewis equation and using velocity factor to account for the dynamic load. (Lewis form factor for 20 and 50 teeth are 0.32 and 0.408).

### Mechanical properties of oil-hardened and tempered spring steel wire and valve spring wire (unalloyed)

<table>
<thead>
<tr>
<th>Wire diameter d (mm)</th>
<th>Minimum tensile strength (N/mm²)</th>
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<th>VW</th>
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**Recommended series of module (mm)**

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<table>
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</table>

### Dimensions and Static and dynamic load capacities of single-row deep groove ball bearing

<table>
<thead>
<tr>
<th>Principal dimensions (mm)</th>
<th>Basic load ratings (N)</th>
<th>Designation</th>
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</thead>
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<tr>
<td>d</td>
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2018-19
B.E. (AUTUMN SEMESTER) EXAMINATION
MECHANICAL
HEAT AND MASS TRANSFER
EME-323

Maximum Marks: 60  Credits: 04  Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>Differentiate between thermal conductivity and thermal diffusivity. A steel pipe having internal diameter of 2 cm, outer diameter of 2.5 cm and thermal conductivity of 50 W/mK carries hot water at 90°C. Heat transfer coefficient between the inner surface of steel pipe and hot water is 600 W/m²K. An asbestos insulation with thermal conductivity of 0.2 W/mK and thickness 2 cm is put on the steel pipe. Heat is lost from the outer surface of the asbestos insulated pipe to the surrounding air at 20°C, heat transfer coefficient for the outer surface of the insulation being 10 W/m²K. Determine the rate of heat transfer per meter length of the pipe.</td>
<td>[08]</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a')</td>
<td>For a plane wall subjected to uniform volumetric heat generation and exposed to a fluid at same temperature at both the sides, derive an expression for temperature distribution within the wall and prove that the heat generated is equal to the heat lost from the sides. Assume one dimensional case.</td>
<td>[08]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(b)</td>
<td>For a fin of rectangular cross section and infinite length, derive the expressions for temperature profile and heat transfer rate through the fin.</td>
<td>[07]</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(b')</td>
<td>Two very long rods of the same diameter, one made of brass (k=107 W/m-K) and other made of copper (k=400 W/m-K) have one of their ends inserted into the furnace. Both of the rods are exposed to the same environment. At a distance 105 mm away from the furnace end, the temperature of the brass rod is 120 °C. At what distance from the furnace end the same temperature would be reached in copper rod.</td>
<td>[07]</td>
</tr>
</tbody>
</table>

contd... 2.
2(a) Prove that for a body whose thermal resistance is zero, the temperature required for cooling or heating is given by: \( \frac{t-t_a}{t_i-t_a} = \exp \left[ -B_i F_o \right] \), where symbols have usual meanings.

2(b) What is the radiation shield? Consider two large parallel plates one at 727 °C with emissivity \( \varepsilon_1 = 0.8 \) and other at 227 °C with emissivity \( \varepsilon_2 = 0.4 \). An aluminium radiation shield with emissivity, \( \varepsilon_3 = 0.05 \) on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield.

3(a) Explain the hydrodynamic and thermal boundary layers over a flat plate during forced convection. How the thickness of both the layers are related.

3(b) Water is heated while flowing through a 1.5cm x 3.5cm rectangular cross section tube at a velocity of 1.5 m/s. The entering temperature of the water is 30°C, and the tube wall is maintained at 90 °C. Determine length of the tube required to raise the temperature of water to 70°C. Dittus-Boelter equation: \( \text{Nu}_d = 0.023 \text{Re}_d^{0.8} \text{Pr}^{0.4} \).

Properties of water at the mean bulk temperature of 60°C are: \( \rho = 985.5 \text{ kg/m}^3 \), \( C_p = 4.18 \text{ kJ/kg K} \), \( v = 0.517 \times 10^{-6} \text{ m}^2/\text{s} \), \( k = 0.654 \text{ W/mK} \), \( \text{Pr} = 3.26 \).

OR

3(b’) A vertical plate 2m x 2m is maintained at constant temperature of 150 °C in the still surrounding air of 30 °C. Calculate the rate of heat transfer from the plate.

You may use: \( \text{Nu} = 0.15 (Gr \text{Pr}^{1/3} \).
Properties of air at film temperature are:
\( \rho = 0.972 \text{ kg/m}^3 \), \( C_p = 1.009 \text{ kJ/kg} \cdot \text{K} \), \( k = 0.0313 \text{ W/m-K} \), \( \text{Pr} = 0.69 \), \( v = 16.0 \times 10^{-6} \text{ m}^2/\text{s} \).

4(a) Define heat exchanger effectiveness and derive its relation for parallel flow heat exchanger in terms of heat capacity ratio and number of transfer units.

OR

4(a’) Define Fick’s law of diffusion and derive the general mass diffusion equation.

4(b) In a shell and tube cross flow heat exchanger water flows through a copper tube 20 mm ID and 23 mm OD, while oil flows through the shell. Water enters at 22 °C and comes out at 35 °C while oil enters at 80 °C and comes out at 60 °C. The water and oil side heat transfer coefficients are 4500 W/m²K and 1250 W/m²K respectively. If the length of the tube is 2.5m, calculate the overall heat transfer coefficient and the heat transfer rate.
2018-19
B.E. (AUTUMN SEMESTER) EXAMINATION
MECHANICAL
FLUID MECHANICS – II
EME332

Maximum Marks: 60  Credits: 04  Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Use of Mathematical Formula Sheets and Compressible flow charts are allowed.

Q.No.  Questions  M.M.  [05]
1(a)  For parallel flow between two parallel plates, Express \( (\overline{V}, \overline{V}) \overline{V} \) and \( \nabla^2 \overline{V} \).

1(b)  Consider steady incompressible, homogenous, parallel, laminar flow of viscous fluid pumped upwards between two vertical walls of Length ‘L’. The distance between the walls is ‘h’ and gravity acts as shown in Figure below such that L>>h. Assume an applied pressure gradient is also driving the flow. Pressure is \( P_0 \) at (0,0).
   i. Derive velocity and pressure field so generated.
   ii. Calculate the applied pressure gradient, for which there is no flow volumetric flow rate generated.

OR

1(b)' The general relation for instantaneous rotation rate of an infinitesimal material line at some point in a 2D flow domain is:

\[
\omega = \frac{\partial v}{\partial x} \cos^2 \theta + \left( \frac{\partial v}{\partial y} - \frac{\partial u}{\partial x} \right) \sin \theta \cos \theta - \frac{\partial u}{\partial y} \sin^2 \theta
\]

(a) Obtain the expression for instantaneous shear strain rate between a pair of mutually perpendicular material lines. Obtain the orientation of the pair that experience maximum instantaneous shear strain rate and the corresponding maximum value.
(b) For a Uni-directional, incompressible flow \( \vec{V} = u(x,y,t) \hat{i} \), find the angle or orientation of the pair of mutually perpendicular material lines that experience zero instantaneous shear strain rate.

2(a) For an incompressible flow over a uniform flat plate, use momentum integral equation and approximate velocity profile given below to obtain expressions for boundary layer thickness

contd...
\( \delta(x) \), Coefficient of skin friction and drag.

\[
\frac{u}{U_\infty} = A + B \sin \left( C \frac{y}{\delta} \right)
\]

2(b) Water of kinematic viscosity \((\nu)\) equal to \(9.27 \times 10^{-6} \text{ m}^2\text{s}^{-1}\) is flowing steadily over a smooth flat plate at zero angle of incidence, with a velocity of \(1.524 \text{ m/s}\). The length of the plate is \(0.3048 \text{ m}\).

(i) Calculate the thickness of the boundary layer at \(0.1524 \text{ m}\) from the leading edge.
(ii) Boundary layer rate of growth at \(0.1524 \text{ m}\) from the leading edge.
(iii) Total drag coefficient on the plate.

3(a) Describe characteristics of incompressible homogeneous turbulent flows.

3(c) Consider Navier Stokes equation for an incompressible flow given below:

\[
\frac{\partial \vec{V}}{\partial t} + (\vec{V} \cdot \vec{V}) \vec{V} = -\vec{\nabla} P + \mu (\nabla^2 \vec{V})
\]

Use Reynolds decomposition and perform averaging of the above equation to obtain the governing equation mean velocities. Also identify the extra terms.

4(a) Discuss the conditions under which we can assume compressible or incompressible flow.

4(b) Air is expanded through a convergent-divergent nozzle from a large chamber in which the pressure and temperature are \(300 \text{ kPa}\) and \(300\text{ K}\) respectively. A normal shock wave occurs at a point in the nozzle where the Mach number is 2.5. The air is then brought to rest in a second large chamber. Find the pressure and temperature in this second chamber. Clearly state the assumptions you have made in arriving at the solution.

OR

4'(a) Air is expanded from a convergent-divergent nozzle from a large reservoir in which the pressure and temperature is \(400 \text{ kPa}\) and \(35\text{ C}\), respectively. The nozzle exit Mach number 2.7 and throat area are 0.08 \(\text{ m}^2\) respectively. Use \(\gamma = 1.4\), \(R = 287 \text{ kJ/kg K}\). Find:

(i) The flow rate through the nozzle under design conditions.
(ii) The design back-pressure and the temperature of the air leaving the nozzle with this back pressure.
(iii) The discharge velocity from the nozzle under design conditions.
(iv) At what back-pressure will there be a normal shock at the exit plane of the nozzle?
(v) The lowest back-pressure for which there is only subsonic flow exists in the nozzle.

4'(b) The pressure ratio across a normal shock wave that occurs in air is 1.5. Ahead of the shock wave, the pressure is \(100 \text{ kPa}\) and the temperature is \(15\text{ C}\). Find the velocities ahead and behind the stationary shock wave. Also find the pressure and temperature behind the shock wave.
Answer all the questions.
Assume suitable data is missing
Notations used have their usual meanings

Q.No. | Marks
--- | ---
1 (a) Explain different types of productivity measures in brief with their mathematical formulae. What are the possible factors affecting productivity? | 05
1(b) With the help of suitable examples differentiate between order qualifiers and order winners. What is Hill framework for operations strategy formulation; explain different steps of Hill framework. | 07
2(a) Briefly discuss different types of basic Layout designs and differentiate between product and process layouts. | 05
2(b) A new location for a manufacturing facility is being considered. The facility has frequent relationships with its five major suppliers and since the supplied material is bulky and transportation costs are high the closeness to the five suppliers has been determined as the major factor for the facility location. The current coordinates of the suppliers are S1=(1,1), S2=(5,2), S3=(2,8), S4=(4,4) and S5=(8,6). The cost per unit distance traveled is the same for each supplier, but the number of trips per day between the facility and each of its suppliers are 5,6,2,4 and 8. Find a new location for the facility which minimizes the transportation cost and calculate the total weighted distance for the new location. OR

2'(a) Briefly explain different types of flexibilities in FMS with the possible factors affecting them. | 05
2'(b) A small engineering project consists of 9 activities. Three time estimates for each activity are given in table below.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Optimistic time</th>
<th>Most likely time</th>
<th>Pessimistic time</th>
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</table>

Draw the network diagram and mark EST, LFT and critical path on the network diagram.

3(a) What are the primary risk factors for developing a musculoskeletal disorder? Mention the names of different risk reduction techniques in ergonomics. [05]

3(b) Classify the different recording techniques of method study and briefly explain the steps involved in method study. [07]

4(a) What do you understand by Inventory? Briefly discuss the basic functions of inventory in an organization. [05]

4(b) Briefly explain the basic EOQ model of the inventory and drive the formula for the economic order quantity? OR [07]

4'(a) What are the basic costs associated with the inventory management, briefly explain? [05]

4'(b) ABC Ltd. uses EOQ logic to determine the order quantity for its various components and is planning its orders. The Annual consumption is 80,000 units, Cost to place one order is Rs. 1,200, Cost per unit is Rs. 50 and carrying cost is 6% of Unit cost. Find EOQ, No. of order per year, Ordering Cost and Carrying Cost and Total Cost of Inventory. [07]

5(a) Briefly explain the quality of design, quality of conformance and quality of performance? [05]

5(b) The Western Jeans Company produces denim jeans. The company wants to establish a p-chart to monitor the production process and maintain high quality. The company has taken 20 samples (one per day for 20 days), each containing 100 pairs of jeans (n = 100), and inspected them for defects, the results of which are as follows. [07]

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<tr>
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<td>20</td>
<td>18</td>
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</table>

Construct the p-chart for the process considering 3-sigma limit and determine when the process might be out of control.