2010-2011
M.TECH. (III SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
FINITE ELEMENT METHODS
(ME-675)

Maximum marks: 75
Duration: Three Hours

Answer five questions.
Missing data, if any, assume suitably.
Symbols used have their usual meanings.

1. Consider the thin plate shown in figure-1. The plate has a uniform thickness \( t = 2.5 \text{ cm} \)
   Young's modulus \( E = 200 \text{ GPa} \), and weight density \( 7850 \text{ kg/m}^3 \). In addition to self
   weight, the plate is subjected to a point load \( P = 450 \text{ N} \) at its mid point. Model the
   plate with two finite elements. Assemble the structural stiffness matrix \( K \) and global
   load vector \( F \). Evaluate the stresses in each element.

2. An axial load \( P = 300 \times 10^3 \text{ N} \) is applied at \( 20^\circ \text{C} \) to the rod as shown in figure-2.
   The temperature is then raised to \( 60^\circ \text{C} \)
   (a) Assemble \( K \) and \( F \) matrices
   (b) Determine the nodal displacements
       Take two elements only.

3. Consider the rod (a robot arm) as shown in figure 3, which is rotating at constant
   angular velocity \( \omega = 30 \text{ rad/s} \). Determine the axial stress distribution in the rod, using
   two quadratic elements. Consider only the centrifugal force. Ignore bending of rod.
   Take \( \rho = 7800 \text{ kg/m}^3 \), \( E = 200 \text{ GPa} \), \( A = 4 \text{ cm}^2 \), length \( L = 105\text{cm} \).

4.(a) For the plane truss, derive the elemental stiffness matrix \( K \) in terms of usual
     notations.

(b) For the pin-jointed configuration shown in figure-4, determine the stiffness values
     \( K_{11}, K_{12} \) and \( K_{22} \) of the global stiffness matrix.

5. For the beam and loading shown in figure 5, determine the (i) slopes at nodes 2 & 3 (ii) the vertical deflection at the mid point of the distributed load. Take two finite
    elements.

6.(a) Determine the Jacobian \( (J) \) and \( B \)-matrix for the triangular element shown in
     figure-6.

(b) Explain constant strain triangle (CST) concept. Plot the shape functions using
    CST.

......2.
7. (a) Figure-7 shows a four node quadrilateral. The \((x, y)\) coordinates of each node are given in the figure. The element displacement vector \(q = [0, 0.20, 0, 0.15, 0.10, 0, 0.05]^T\). Find the following:

(i) the \(x, y\) coordinate of a point \(P\), whose location in the master element is given by \(\xi = 0.5\) and \(\eta = 0.5\) and

(ii) the \(u, v\) displacement of point \(P\).

(b) Using a \(2 \times 2\) rule, evaluate the integral \(\iint_A (x^2 + xy^2)\, dx\, dy\) by Gaussian quadrature, whose \(A\) denotes the region in figure-7.

8. A metallic fin, with thermal conductivity \(K = 360\, \text{W/m} - ^\circ\text{C}\), 0.1 m thick and 10 cm long extends from a plane wall whose temperature is \(235^\circ\text{C}\). Determine the temperature distribution and amount of heat transferred from the fin to the air at \(20^\circ\text{C}\) with \(h = 9\, \text{W/m}^2 - ^\circ\text{C}\). Take width of the fin to be 1 m. Take three finite elements.

Encl. figures
2010-2011
M.TECH. (III SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
(INDUSTRIAL AND PRODUCTION ENGINEERING)
FACILITY PLANNING AND PLANT ENGG
(ME-721)

Maximum Marks: 75
Duration: Three Hours

INSTRUCTIONS
1. Answer any FIVE questions.
2. Assume suitably any data not supplied.

1. (a) Discuss how product design, process design, and schedule design are related to facilities design.

(8 marks)

1. (b) Explain the use of any one of the following in facilities design.
- Affinity diagram, Interrelationship diagraph, Tree diagram.

(7 marks)

2. A company is to design manufacturing cells in a GT layout. The machine part matrix is shown in Figure-Q2 below. Use DCA to form cells and, if conflicts exist, propose alternative approaches for resolving the conflicts.

Contd.......2
3. Explain, with the help of examples and diagrams, various kinds of flow patterns used within departments and between departments. Why is the flow planning necessary for effective facilities planning?

   (15 marks)

4. Activity relationships are shown in Figure-Q4. First, construct a block layout assuming unit area for each activity, and then adjust the layout with the given areas.

   (15 marks)

Contd........3
5. Four equal sized machines are served by a linear bidirectional track as shown in Figure-Q5 below. Each machine block dimension is 30 x 30. The product routing information and required production rate are given in the Table-Q5 below. Perform one iteration of the pair-wise exchange method to improve the given layout. Assume that the pickup/delivery stations are located at the midpoint of the machine edge along the AGV track.

![Figure-Q5](image)

<table>
<thead>
<tr>
<th>Product</th>
<th>Processing Sequence</th>
<th>Weekly Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BDCAC</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>BDAC</td>
<td>700</td>
</tr>
<tr>
<td>3</td>
<td>DBDCAC</td>
<td>900</td>
</tr>
<tr>
<td>4</td>
<td>ABCA</td>
<td>200</td>
</tr>
</tbody>
</table>

TABLE-Q5 (15 marks)

6. The activity relationships are shown in Figure-Q6 below. Construct a graph-based relationship diagram and develop the layout using area requirements given.

![Figure-Q6](image)

<table>
<thead>
<tr>
<th>area</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell A</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cell B</td>
<td>12</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cell C</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell D</td>
<td>12</td>
<td>8</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell E</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cell F</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure-Q6 (15 marks)

Contd.........4
7. A company has six retail stores in the city of Delhi. The company needs a new warehouse to service its retail stores. The location of the stores and the expected delivery per week from the warehouse to each store are given in Figure-Q7. Assume that travel distance is rectilinear and that after each delivery the truck must return to the warehouse. Determine the location of the warehouse for minimum distance.

<table>
<thead>
<tr>
<th>Store</th>
<th>Location</th>
<th>Expected deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1,0)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>(2,5)</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>(3,8)</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>(1,6)</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>(-5,-1)</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>(-3,-3)</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure-Q7

8. A company is planning on locating its distribution centres. The company has narrowed down its choice to five facilities that can be rented. The monthly cost of meeting the customers demand and rental cost are summarised in Figure-Q8 below. Determine which facilities should be rented such that the overall cost is minimised.

<table>
<thead>
<tr>
<th>Customer</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500</td>
<td>500</td>
<td>3600</td>
<td>10000</td>
<td>8000</td>
</tr>
<tr>
<td>2</td>
<td>1800</td>
<td>6000</td>
<td>5400</td>
<td>12000</td>
<td>7200</td>
</tr>
<tr>
<td>3</td>
<td>5000</td>
<td>500</td>
<td>4700</td>
<td>15000</td>
<td>6500</td>
</tr>
<tr>
<td>4</td>
<td>2800</td>
<td>2600</td>
<td>4800</td>
<td>6000</td>
<td>7000</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>1500</td>
<td>9000</td>
<td>8000</td>
<td>6300</td>
</tr>
<tr>
<td>Rental cost</td>
<td>5000</td>
<td>7000</td>
<td>6000</td>
<td>2000</td>
<td>8000</td>
</tr>
</tbody>
</table>

Figure-Q8
2010-2011
III Semester M. Tech. Examination
Mechanical Engineering (Thermal Sciences)
Engine Emissions Control (ME 764/746)

Maximum Marks 75
Duration: Three Hours

(i) Attempts any Five Questions
(ii) All Questions are of Equal Marks
(iii) Use of Property Tables and Charts is allowed
(iv) All Symbols have Usual meaning

1. As per the legislations, what are the emissions for SI and CI engines, respectively? Explain in detail the concept of various emissions standards for controlling the emissions. 5 + 10

2. Describe in detail the combustion phenomenon of a conventional SI engine and explain basic mechanism of the formation of NO, UHC and CO by using the concept of combustion chemistry. 15

3. Describe in detail the concept of ROHR curve and explain the mechanism of the formation of rather excessively high amount of NO and TPM in HSDI diesel engine. 15

4. What is the concept of MPFI system as it is currently being used in modern SI engine? Explain the significance in detail of using MPFI system for simultaneously reducing emissions of NO, UHC and CO in a Lean Burn engine. 15

5. What is the concept of Premixed Burning after the completion of Ignition Delay in HSDI diesel engine? Explain in detail the concept of simultaneously reducing emissions of NO and TPM from a modern CRDI diesel engine. 15

6. (a) Explain various concepts of reducing flame temperature for controlling the emissions of NO in a modern diesel engine? (b) Explain the concept of HCCI Combustion for simultaneously controlling the emissions and improving the thermal efficiency in a modern engine? 8 + 7

7. Write detailed notes on any five (a) Sources of UHC in IC engines (b) Use of VCO Nozzles in HSDI diesel engines (c) Thermal Reactor in HSDI diesel engines (d) Turbochargers in HSDI diesel engines (e) Two Way vs Three Way Catalyst in SI Engines (f) Light-Off Temperature of a converter. 3 each

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