1. An auto-parts warehouse in Flespeck, Texas, has requested that a new layout be designed for their main warehouse located in metropolitan Flespeck. The warehouse has 10 major activity "centers." The activity relationships for the warehouse are summarized in the given figure 1. Design a block layout using the SLP approach. The following numerical values are assigned to the closeness ratings: A=10000; E=1000; I=100; O=10; U=0 and X=-10000.

![Diagram of warehouse layout]

2. Given the initial layout, flow matrix, and cost matrix shown in Figure 2, use the craft scoring method and procedure TWOWAYX to obtain a final layout.

[Diagram of warehouse layout]
3.(a) The demand for an item is 12000 per year and shortage is allowed. If the unit cost is Rs. 15/- and the holding cost is Rs. 20/- per year per unit, determine the optimum total yearly cost. The cost of placing one order is Rs. 6000/- and the cost of one shortage is Rs. 100 per year.

3.(b) Explain any two of the following terms in inventory theory:
   (i) Lead Time  (ii) Reorder Level  (iii) Safety Stock

4. The activities along with their dependency relationships are given below the table.

<table>
<thead>
<tr>
<th>Activity</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Predecessor</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>A,B</td>
<td>A,B</td>
<td>C,D,E</td>
<td>C,D,E</td>
</tr>
<tr>
<td>Duration(days)</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

(i) Draw the network and find the project completion time.
(ii) Calculate the Total float for each activity.

OR

4'. The time estimates (in days) for the activities of a PERT network are given below.

<table>
<thead>
<tr>
<th>Activity</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Predecessor</td>
<td>_</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>D,E</td>
<td>B</td>
<td>H</td>
<td>G,I</td>
</tr>
<tr>
<td>Optimistic Time</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>1.5</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Most Probable Time</td>
<td>5</td>
<td>4.5</td>
<td>3</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Pessimistic Time</td>
<td>12</td>
<td>15</td>
<td>14</td>
<td>22</td>
<td>8</td>
<td>5</td>
<td>4.5</td>
<td>15</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

(i) Draw the network and determine the critical path.
(ii) What is the expected time to complete the project?
M.TECH. (AUTUMN SEMESTER) EXAMINATION
MECHANICAL ENGINEERING (INDUSTRIAL & PRODUCTION)
ME751: WELDING SCIENCE

Maximum Marks: 60  Credits: 04  Duration: Two Hours

Assume data suitably, if required.
Notations used have their usual meaning.

1(a) Define the basic components of WELDING SYMBOL with a neat sketch. Explain common types of weld joint and its applications.  [06]

OR

1(a') Explain the effects of alloying of various elements on welding of carbon alloy steel.  [06]

1(b) Explain in detail about heat flow in welding and effect of welding process parameters on heat flow such as travel speed and temperature gradient.  [06]

OR

1(b') What is cold pressure welding? Discuss the mechanism of cold pressure welding. Write down the limitations of cold pressure welding.  [06]

2(a) Discuss the different techniques to control the weld grain structure in order to improve the mechanical properties of weldment.  [06]

2(b) Define the Partial Melting Zone and Explain the penetration mechanism of PMZ.  [06]

OR

2(b') Explain with neat sketches the typical residual stress distribution and distortion in weldment and its remedies.  [06]

3(a) Describe Schaeffler and Delong diagrams for predicting ferrite levels in austenitic stainless steel welds.  [06]

3(b) Explain the various forces affecting the transfer of material in welding? Also describe in brief the different modes of metal transfer in welding?  [06]

OR

3(a') Define weldability and discuss the weldability of aluminium alloys, copper alloys and steels.  [06]
3(b') Discuss the weld metal chemical inhomogeneities: micro and macro segregation and remedies of macro segregation.

4(a) Explain the working principle of diffusion welding with its stages. Discuss also diffusion welding of titanium alloy.

4(b) Define metal thermal spray process and its applications. Differentiate between HVOF and Plasma spray process for metal coating.

5 Write short notes with specific application on:
   1. Laser beam welding
   2. Hot gas welding for plastics
   3. Two-wire arc spray coating process
   4. Hot cracking
1. (a) Fill in the blanks to complete following statements.
   i. \((u \times v) \times w = (u \cdot w) v\) ......  
   ii. \(A^{-T}\): \(A\) is a constant and its numerical value is ......  
   iii. \(\overline{A^{-1}} = ... \overline{A} ...
   \)
   iv. \(\frac{\partial (\text{tr}I)}{\partial A} = ......\), where \(I\) is second order identity tensor.
   v. For a second order orthogonal tensor \(Q(t)\), \(QQ^T\) is a ...... tensor.

OR

(a') Following statements are not correct. Rewrite them after correction. Do not just write the negative of the given statement.
   i. Divergence of fifth order tensor is a fifth order tensor.
   ii. Normal vector to a surface \(\phi(x, y, z) = 0\) is obtained by taking the divergence of \(\phi\)
iii. According to Cayley-Hamilton theorem, any symmetric second order tensor can be represented by its eigenvalues and corresponding eigenvectors forming an orthonormal basis.

iv. $\frac{\partial \text{tr} A}{\partial A} = A$

v. $(A \otimes A)$ is first order tensor if $A$ is a second order tensor.

(b) Determine the eigenvalues and eigenvectors of tensor $A = e_1 \otimes e_2 + e_2 \otimes e_1$

2. (a) Consider the motion of a continuum body given by $x = X_1 (1 + \alpha t^3) e_1 + X_2 e_2 + X_3 e_3$. Determine displacement, velocity and acceleration fields in both descriptions. Verify $\mathbf{l} = \mathbf{F} \mathbf{F}^{-1}$ for the given motion, where $\mathbf{l}$ and $\mathbf{F}$ are velocity gradient and deformation gradient tensors, respectively. Also, determine the time rate of change of a unit vector $e_1$ in the deformed configuration.

OR

(a') i. Prove $dV = \text{det}(\mathbf{F})dV$, where $dV$ and $dV$ are infinitesimal volume elements in current and reference configuration, respectively, while $\mathbf{F}$ represents deformation gradient.

ii. Write Right and Left Cauchy-Green strain tensors, Green Lagrange strain tensor and Euler-Almansi strain tensor in terms of deformation gradient. Also derive the relation between Euler-Almansi and Green Lagrange strain tensors.

(b) Deformation gradient of a continuum is given as

\[
\begin{bmatrix}
2 & 0 & 0 \\
0 & 1/2 & 0 \\
0 & 0 & 3
\end{bmatrix}
\]

Evaluate Right Cauchy-Green tensor and its eigenvalues and eigenvectors. Determine Right stretch tensor and rotation tensor.

3. (a) Define Cauchy traction vector and first Piola-Kirchhoff traction vector. Derive the relation between Cauchy and PK-1 stress tensors.

OR

cont'd on 3,
(a') Motion of a body is given as \( x = -6X_2 e_1 + 1/2X_1 e_2 + 1/3X_3 e_3 \) and Cauchy stress tensor at a point \( x \) is given as

\[
\begin{bmatrix}
\sigma_1 \\
\sigma_2 \\
\sigma_3
\end{bmatrix} = \begin{bmatrix}
0 & 0 & 0 \\
0 & 50 & 0 \\
0 & 0 & 0
\end{bmatrix} \text{ kN/m}^2.
\]

Determine Cauchy traction vector and first Piola-Kirchhoff traction vector acting on a plane normal in \( e_2 \) direction in deformed configuration.

(b) Determine principal stresses and principal directions of Cauchy stress tensor

\[
\begin{bmatrix}
\sigma_1 \\
\sigma_2 \\
\sigma_3
\end{bmatrix} = \begin{bmatrix}
0 & 30 & 40 \\
30 & 0 & 0 \\
40 & 0 & 0
\end{bmatrix} \text{ kN/m}^2.
\]

Evaluate principal stress invariants of \( \sigma \). If the deformation of the body is given as \( x = (X_1 + X_2 + 1/2X_3)e_1 + X_2 e_2 + X_3 e_3 \), determine first and second Piola-Kirchhoff stress tensors. Also, obtain the Cauchy traction vector on surface \( x_1^2 + x_2^2 + x_3^2 = 3 \) at point \( x_1 = 1, x_2 = 1, x_3 = 1 \).

4. (a) Derive the expression

\[
\frac{\partial \rho}{\partial t} + \text{div}(\rho v) = 0,
\]

using conservation of mass. Here, \( \rho \) stands for spatial density, and \( v \) is for spatial velocity. \( \text{div}(\bullet) \) denotes divergence with respect to spatial coordinates, while \( t \) is for time.

(b) Using balance of linear momentum, derive Cauchy’s first equation of motion in spatial description i.e.

\[
\text{div}\sigma + b - \rho \dot{v} = 0,
\]

where, \( \rho \) is density in current configuration, \( v \) is spatial velocity and \( b \) represents spatial body force term. \( \sigma \) denotes Cauchy stress tensor.

\[\text{Contd... 4}\]
(b') i. Cauchy stress tensor as a function of spatial coordinates \((x_1, x_2, x_3)\) is given as

\[
\begin{bmatrix}
\alpha & 0 & 0 \\
0 & x_2 + \alpha x_3 & \Phi(x_2, x_3) \\
0 & \Phi(x_2, x_3) & x_2 + \beta x_3
\end{bmatrix}
\]

where \(\alpha\) and \(\beta\) are scalar constants. Find scalar valued function \(\Phi(x_2, x_3)\) so that \(\text{div}\sigma = 0\).

ii. Show that under hydrostatic stress state, for isochoric motion, external mechanical power is zero if kinetic energy is conserved.