2(a) What are the salient features of CIM/S? What are flexible manufacturing systems?

2(b) What is flexibility? Explain various manufacturing flexibility types and also explain the measures of two most important types in FMS context.

2(c) Outline key design and planning decisions required in FMS.

3 An FMS consists of four stations. Station 1 is load/unload station with one server. Station 2 performs drilling operations with three servers (three identical CNC drilling machines). Station 3 performs milling operations with two servers (two identical CNC milling machines). Station 4 is an inspection station with two servers that performs inspections on a sampling of parts. The stations are connected by part handling system that has two work carriers and whose mean transport time = 3 minutes. The FMS produces four parts A, B, C, and D. The part mix fractions and process routings of the four parts are presented in the table below. Determine (a) maximum production rate of the FMS, (b) corresponding production rate of each part, (c) utilization of each station in the system, and (d) the overall FMS utilization.
Answer any five questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. | Question                                                                                                                                                                                                 | M.M. |
-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
1(a) | “AJM is not recommended to machine ductile materials”. Comment.                                                                                                                                            | [04]  |
1(b) | Discuss the effects of grain size, abrasive flow rate, stand-off distance, and nozzle pressure on MRR in AJM.                                                                                              | [08]  |
2(a) | What are the different mechanisms of material removal in USM? Also state the assumptions made in the theory proposed by Shaw.                                                                              | [04]  |
2(b) | A cylindrical impression of 10mm diameter and 2mm deep is to be made on a WC specimen. Feed force is constant, and is equal to 5N. Average diameter of grains in the slurry is 10µm. Tool oscillates with the amplitude of 30µm at 20 kHz. Abrasive and water ratio in the slurry is 1. Hardness of WC is 7000 N/mm² and that of copper tool is 1500 N/mm². Calculate the time required to complete the job. Assuming $K_1=0.3$, $K_2=1.8 \text{ mm}^2$, $K_3=0.6$, and abrasive density is 3.8 gm/cm³. | [08]  |
3(a) | Differentiate between Abrasive flow finishing and Magnetic Abrasive finishing.                                                                                                                              | [06]  |
3(b) | Write the factors that affect the performance of WJM process. Discuss their effects in brief.                                                                                                               | [06]  |
4(a) | Define the following terms:                                                                                                                                                                                | [04]  |
      | (i) Duty cycle                                                                                                                                                                                            |      |
      | (ii) Critical resistance                                                                                                                                                                                |      |
      | (iii) Relative electrode wear                                                                                                                                                                          |      |
      | (iv) Dielectric strength                                                                                                                                                                                  |      |
4(b) | Derive an expression used for determining metal removal rate in EDM process.                                                                                                                                | [08]  |
5(a) Explain the mechanism of material removal during ECG and how it is different from ECM.

5(b) The composition (\% by weight) of Nimonic 75 alloy is given in the following table:

<table>
<thead>
<tr>
<th>Element</th>
<th>Ni</th>
<th>Cr</th>
<th>Fe</th>
<th>Ti</th>
<th>Si</th>
<th>Mn</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by weight</td>
<td>72.0</td>
<td>20.0</td>
<td>5.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>A (gm)</td>
<td>58.71</td>
<td>51.99</td>
<td>55.85</td>
<td>47.9</td>
<td>28.09</td>
<td>54.94</td>
<td>63.5</td>
</tr>
<tr>
<td>Z</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Density (gm/cm³)</td>
<td>8.9</td>
<td>7.19</td>
<td>7.86</td>
<td>4.51</td>
<td>2.33</td>
<td>7.43</td>
<td>8.96</td>
</tr>
</tbody>
</table>

Calculate MRR (specific and volumetric) when a current of 2000 A is used.

6(a) What are the desirable properties of electrolyte used in Electrochemical Machining?

6(b) Explain the Electro Stream Drilling (ESD) process. What are its applications?

7(a) Explain the working principle of EBM process. Make the necessary sketch.

7(b) Discuss the process performance of Laser beam machining (LBM). Also give its applications.
Maximum Marks: 60  
Credits: 04  
Duration: Three Hours

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

Q.No. Question M.M.
1(a) Define the term stress analysis and the conditions where it is used. [04]

OR

1(a') What do you mean by temporary birefringence and under what condition it occurs. [04]

1(b) Discuss the various methods of obtaining the plane polarized light and its uses. [08]
2(a) Describe with neat sketches the arrangement of optical elements in a circular polariscope. [06]
2(b) Explain the linear or plane polarizer and its various applications. [06]

OR

2'(a) What are the important properties of an ideal photoelastic material? Give names of the important photoelastic materials. [06]
2'(b) Define the following terms: (i) Figure of merit (ii) Sensitivity Index (iii) Time edge effect. [06]
3(a) Explain how stresses and strains are determined by photoelastic coatings. List the various assumptions made. [06]

OR

3(a') Explain in brief the reinforcing effects of birefringent coatings and under what conditions it is considered. [06]
3(b) An epoxy coating is bonded to an aluminium specimen. Determine (i) Stress sensitivity (ii) Strain sensitivity (iii) Material fringe value $f_e$. Take
\[ E^s = 0.7 \times 10^5 \text{ N/mm}^2, \quad \nu^s = 0.32, \quad E^c = 3.15 \times 10^3 \text{ N/mm}^2, \quad \nu^c = 0.36, \quad f_o = 10.36 \text{ N/mm}^2/\text{mm/ fringe}, \quad h^c = 2.54 \text{ mm} \]

4(a) How do you calibrate coating for a biaxial state of stress and discuss its practical applications.

OR

4(a') Discuss the crack patterns which can be obtained under various combination of Stresses. Illustrate your answer by giving sketches.

4(b) If the threshold strain is 740 \( \mu \text{m/m} \), what is the corresponding state of stress in the coating during calibration of the coating with \( E^c = 0.7 \text{ GPa} \), \( \nu^c = 0.36 \)

5(a) Explain the characteristics of a strain gauge and its applications.

OR

5(a') What do you mean by strain rosette and how the rosette analysis can be simplified?

5(b) A delta rosette yields the following strain indications:
\[ \varepsilon_a = -845 \mu \text{m/m}, \quad \varepsilon_b = 1220 \mu \text{m/m} \quad \text{and} \quad \varepsilon_c = 710 \mu \text{m/m} \]
Calculate the maximum principal strain direction, the principal stresses and maximum shear stress.
Take \( E = 200 \text{ GPa} \), \( \nu = 0.285 \)
2013-14
M.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
CONVECTIVE HEAT TRANSFER
ME-646

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer any four questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.  Question  M.M.
1   Derive the generalised viscous energy equation for laminar boundary layer during forced
Convection and hence, obtain the 2-D energy equation for axi-symmetric flow in a circular
tube.  [15]

2   Explain the criteria for fully developed velocity and temperature profiles in a circular tube.
Also identify the conditions for the laminar hydrodynamic entry length. Assuming heat
conduction only in the radial direction, obtain temperature distribution relation for
the constant wall temperature and fully developed flow in a circular tube.  [15]

3   Obtain the similarity solutions for local Nusselt number and temperature distribution
in the laminar thermal boundary layer formed by a liquid metal flowing at a constant
free stream velocity over a semi-infinite plate maintained at a constant temperature.  [15]

4   The boundary layer equation for the variable free stream velocity over a curved
surface is given as: \( \frac{d^2 \delta}{v \, dx} + \frac{2 \delta}{v \, R \, dx} \frac{d \delta}{dx} = 0.44 - 5.68 \frac{\delta^2}{v} \frac{dU}{dx} \)
Obtain the relation and estimate the Momentum thickness, \( \delta \), at a distance \( x=1.0 \) m
from the leading edge if the surface radius of curvature, \( R=15 \times 10^3 \) m and the free stream
velocity, \( U=8x \). Take viscosity of the fluid =1.68 x 10^{-5} m^2/s.  [15]

5   With the help of a neat diagram, explain different regimes of forced boiling in a
vertical tube and indicate the variation of heat transfer coefficient from the sub-
cooled region up to the superheated region. Also, differentiate between the forced
and natural flow boiling phenomena. Define incipience of boiling, Jacob Number and
Bond Number.  [15]

6   Showing expected velocity and temperature profiles for laminar flow over a heated
surface, briefly discuss the phenomenon of natural convection. With suitable
assumptions, obtain a relation for heat transfer during free convection over a constant
temperature vertical flat plate.  [15]
1(a) Use composite transformation to fix the triangle \[
\begin{bmatrix}
1 & 0 & -1 \\
0 & 1 & 0 \\
0 & 1 & 0
\end{bmatrix}^T
\]
inside the square \[
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 1 & 0
\end{bmatrix}^T
\]
so that its base coincides with the bottom edge of square, and the top vertex touches the middle of the top edge of the square.

1(b) Show that the transformation matrix for reflection about an arbitrary line \(y = mx + c\) is given by:
\[
\begin{bmatrix}
1 - m^2 & 2m & 0 \\
1 + m^2 & 1 + m^2 & 0 \\
2m & 1 - m^2 & 0 \\
2mc & 1 + m^2 & 2c \\
1 + m^2 & 1 + m^2 & 1
\end{bmatrix}
\]

OR

1'(a) Discuss transformation of a unit square using a general 2 x 2 transformation matrix and derive the relationship between its area before and after the transformation.

1'(a) Consider two lines \(L1: y = c\) and \(L2: y = mx + c\) which intersect at point \(C\) on \(y\)-axis. A point \(P(x_1, y_1)\) is first reflected through \(L1\) and subsequently through \(L2\).
Show that this is equivalent to rotating the point \(P\) about the intersection point \(C\) by \(2\theta\), where \(\theta\) is the angle between \(L1\) and \(L2\).

2(a) Find the normalization transformation that maps a window whose corners are \((2,2), (10,6), (8,10)\) and \((0,6)\) onto a viewport which is the entire normalized device screen.
2013-2014
II Semester M. Tech. Examination
Mechanical Engineering (Thermal Sciences)
I. C. Engines (ME 648)
Maximum Marks 60  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. Explain in detail the classification of Engines generally used in automobiles.  12
2. Describe in detail the concept of combustion, which actually controls emissions of NO, UHC and CO in a MPFI SI engine.  4x3
3. Explain in detail the concept of diesel combustion by using ROHR curve and describe the mechanism of the formation of rather excessively high amount of NO and TPM in HSDI diesel engine  12
4. (a) Explain the concept of Direct Injection (DI) in SI Engine.  6
(b) Explain why DI-SI engine is more efficient than MPFI Engine?  6
5. What is the disadvantage of long Ignition Delay in HSDI diesel engine? Explain in detail the advantage of using multiple injections in a CRDI System for simultaneously reducing emissions of NO and TPM in a modern diesel engine.  12
6. Explain in detail various designs of combustion chambers generally used in (a) DI Diesel Engines (b) IDI Diesel Engines.  8
4
7. Write detailed notes on any four (a) 3-Way Converter (b) 2-Way Oxidation Converter (c) Turbocharger (d) Thermal Reactor (e) Use of VCO Nozzles in HSDI diesel engines (g) OHC engines.  3x4
<table>
<thead>
<tr>
<th>Part</th>
<th>Part Mix ( p_i )</th>
<th>Operation ( k )</th>
<th>Description</th>
<th>Station ( i )</th>
<th>Process Time ( t_{ijk} ) (min)</th>
<th>Frequency ( f_{ijk} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.1</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Drill</td>
<td>2</td>
<td>15</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Mill</td>
<td>3</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Inspect</td>
<td>4</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Unload</td>
<td>1</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>B</td>
<td>0.2</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Mill</td>
<td>3</td>
<td>25</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Drill</td>
<td>2</td>
<td>16</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Mill</td>
<td>3</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Inspect</td>
<td>4</td>
<td>15</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Unload</td>
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<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
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<td>1</td>
<td>Load</td>
<td>1</td>
<td>5</td>
<td>1.0</td>
</tr>
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<td></td>
<td></td>
<td>2</td>
<td>Mill</td>
<td>3</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Inspect</td>
<td>4</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Unload</td>
<td>1</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>D</td>
<td>0.4</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>5</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Drill</td>
<td>2</td>
<td>25</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Inspect</td>
<td>4</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Unload</td>
<td>1</td>
<td>3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Give a typical architecture of the shop floor control in a FMS environment? Show how an operations scheduling module will typically evolve a good schedule for the following case. Assume day 10 on the shop floor calendar. Three jobs J1, J2 and J3 are waiting for the final operation on a Machine Z. The process times and due dates are given below. Use average manufacturing lead-time and aggregate lateness as the performance criterion and evolve a good schedule. Justify any other assumption.
5 Define simulation. Explain briefly different components of discrete-event simulation. Consider the case of a mixed model flexible manufacturing line configured for two products P1 and P2, requiring sequence of operations as M1 followed by M2 and then followed by M3. Assume infinite buffers in front of each machine along with sufficient inventory of raw parts sequenced as P1-P2-P1-P2... in the input buffer of M1. All times are in minutes. Justify any other assumptions made. Both P1 and P2 are required at the output, to be packaged together as a Batch before shipment. Show how discrete-event simulation can help to determine the following.

i) Time Between Batches (TBB)

ii) Improvement in TBB, when efficiency of Machine M2 is increased by 20%.

<table>
<thead>
<tr>
<th></th>
<th>Processing Time</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>J2</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>J3</td>
<td>15</td>
<td>30</td>
</tr>
</tbody>
</table>

6(a) What is the importance of material handling system in FMS? An automated guided vehicles system has an average travel distance per delivery=250m and an average empty travel distance=200m. Load and unload times are each 25 s and the speed of the AGV= 2 m/s and traffic factor=0.9. How many vehicles are needed to satisfy a delivery requirement of 45 del./hr. Assume Availability=0.95.

6(b) 'Group Technology is a logical approach to product and facility planning'. Discuss. Develop the form code (first five digits) in the Opitz System for the part shown in

contd...
the figure below. Dimensions are in mm. Refer to Table 1.

7(a) What do you mean by cellular manufacturing? Consider the part-machine incidence matrix given in the table below. Form the part family and machine group. Comment on your findings.

<table>
<thead>
<tr>
<th>Machine</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

7(b) Using the notation scheme for defining robot configurations draw diagrams of the following robots: i) TRL ii) OOL iii) TRR and iv) TLO. Name the type of robot obtained by these notations.

7(c) Discuss briefly various applications of robots in manufacturing industry.
For question No. 6(b)

**Table 1**

<table>
<thead>
<tr>
<th>Digit 1</th>
<th>Digit 2</th>
<th>Digit 3</th>
<th>Digit 4</th>
<th>Digit 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part class</td>
<td>External shape, external shape elements</td>
<td>Internal shape, internal shape elements</td>
<td>Plane surface machining</td>
<td>Auxiliary holes and gear teeth</td>
</tr>
<tr>
<td>0</td>
<td>L/D ≤ 0.5</td>
<td>Smooth, no shape elements</td>
<td>No hole, no breakthrough</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.5 &lt; L/D &lt; 3</td>
<td>No shape elements</td>
<td>No shape elements</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>L/D ≥ 3</td>
<td>Thread</td>
<td>Surface plane and/or curved in one direction, external</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Stepped to one end or smooth</td>
<td>Functional groove</td>
<td>External plane surface related by graduation around the circle</td>
<td>Axial, not on pitch circle diameter</td>
</tr>
<tr>
<td>4</td>
<td>Stepped to both ends</td>
<td>No shape elements</td>
<td>External groove and/or slot</td>
<td>Axial on pitch circle diameter</td>
</tr>
<tr>
<td>5</td>
<td>Thread</td>
<td>No shape elements</td>
<td>External spline (polygon)</td>
<td>Radial, not on pitch circle diameter</td>
</tr>
<tr>
<td>6</td>
<td>Functional groove</td>
<td>Thread</td>
<td>External plane surface and/or slot, external spline</td>
<td>Axial and/or radial and/or other direction</td>
</tr>
<tr>
<td>7</td>
<td>Functional cone</td>
<td>Functional cone</td>
<td>Internal plane surface and/or slot</td>
<td>Axial and/or radial on PCD and/or other directions</td>
</tr>
<tr>
<td>8</td>
<td>Operating thread</td>
<td>Operating thread</td>
<td>Internal spline (polygon)</td>
<td>Spur gear teeth</td>
</tr>
<tr>
<td>9</td>
<td>All others</td>
<td>All others</td>
<td>Other gear teeth</td>
<td>Bevel gear teeth</td>
</tr>
<tr>
<td>0</td>
<td>No auxiliary hole</td>
<td>Axial and/or radial and/or other direction</td>
<td>With gear teeth</td>
<td>All others</td>
</tr>
<tr>
<td>Q.No.</td>
<td>Question</td>
<td>M.M.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(a)</td>
<td>How the level of muscular effort and muscle fatigue can be evaluated on the basis of Electromyographic recordings? Write also the formula used for the normalisation of EMG data.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(b)</td>
<td>Explain the procedure to evaluate STRAIN INDEX in a task where workers sit and polish door handles on grinding machine.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2(a)</td>
<td>Describe the importance of respiratory response in the assessment of workload in Manual Material Handling tasks.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2(b)</td>
<td>Give details about the standard recommendations for adaptability and comfort in Chair Design.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3(a)</td>
<td>How do we categorise the physically challenged persons for the requirement of Wheel chair design? Give the steps used in selection of options in a wheel chair.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3(b)</td>
<td>Discuss the effects of factors responsible for the change in Choice reaction time. What is Fitt's Law to calculate Movement time?</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4(a)</td>
<td>Give the recommendations for Rotatory controls with Rotator displays in same plane and also in different planes.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4(b)</td>
<td>Briefly explain about at least three methods of coding used in Displays &amp; Controls.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5(a)</td>
<td>What is compatibility? Explain various types of compatibility.</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5(b)</td>
<td>Under what situations, signal detection theory can be applied in an industrial environment? Explain the concept of Noise and Response criterion in signal</td>
<td>[06]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

contd...
detection theory.

6(a) What is the criteria for the measurement of mental workload? Differentiate between primary and secondary task measures.

6(b) What are the various visual capabilities which may be important for the design of visual displays? Explain any two.

7(a) Under what circumstances auditory displays would be preferred over visual displays? Differentiate between cutaneous senses and olfactory senses.

7(b) List and explain the factors that affect the level of energy consumption on a particular task.

8(a) Name the various approaches used for assessing Manual Material Handling capabilities and for setting recommended work load limits. Explain the biomechanical approach.

8(b) How can the exposure of workers to Hand arm vibration be reduced? Explain the approaches used in this regards giving suitable example.
Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer any five questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.  Question  M.M.
1(a) Derive an expression for the overall efficiency of ‘n’ number of cycles coupled in series. What will happen if there is heat loss between cycles? [06]
1(b) Discuss the working of a Binary vapour cycle. Why mercury is chosen along with water as one of the working fluid? [06]
2(a) Carry out thermodynamic analysis of Boiling Water Reactor. [06]
2(b) Discuss the working of Loop type and Pool type of Liquid Metal Fast Breeder Reactor. [06]
3(a) A pressurized water reactor has inlet and exit water at 290 and 390 °C, respectively. It has a 30 m³ vapour pressurizer which is normally 60% full of water at a pressure of 140 bar. A case of an insurge occurred during which 0.25 m³ of water entered the pressurizer from the primary circuit hot leg, 0.05 m³ entered through the spray, and 50 kWh was added by the electric heaters. Determine the internal energy of the pressurizer contents before and after the event. Ignore heat losses to the ambient. [06]
3(b) With a neat sketch, discuss the working of Steam Injected Gas Turbine cycle (STIG) [06]
4(a) Discuss the working of Combined cycle with a heat recovery boiler. [06]
4(b) An hourly load duration curve of a gas turbine power plant is a straight line from 45000 kW to 5000 kW. The load is taken by a power plant which consists of 02 units of 20000 kW each and 01 unit of 10000 kW. Determine the load factor of the contd...
5(a) Discuss the working of a Fluidized bed combustion boiler. What are its merits? Can it be used in a combined system. If yes, draw the block diagram.

5(b) Discuss the working of Compressed air energy storage system. Has it been developed anywhere in India?

6(a) What do you understand by equivalent evaporation of boiler? With neat sketch, discuss the working of a Benson boiler.

6(b) Discuss the advantages and disadvantages of Diesel engine power plant over gas turbine plant.

7(a) Discuss the requirements and the typical geometry of a Gas turbine combustion chamber.

7(b) An open cycle constant pressure gas turbine plant consists of two compressors with perfect inter-cooling and a two stage turbine with a re-heater. Air enters at 1 bar and 15 °C. The maximum pressure ratio and the maximum temperature of the cycle are limited to 5 and 800 °C, respectively. The reheating takes place at 2.3 bar to 800 °C. The isentropic efficiencies of each compressor and each turbine are 0.8 and 0.9, respectively. The calorific value of the fuel is 42 MJ/kg.

Take $C_p = 1.005 \text{ kJ/kgK}$ and $\gamma = 1.4$ for air.

Neglecting the pressure and heat losses, for an air flow rate of 25 kg/s, calculate

(i) the overall thermal efficiency of the plant

(ii) the air-fuel ratio

(iii) the specific fuel consumption

(iv) the power output of the plant
Question

1(a) Describe the stick-slip phenomenon using a suitable sliding drive system. Derive the equation of motion for the driven mass for small velocity variations. Draw the acceleration, velocity and displacement curves for the mass.

1(b) A machine drive system is represented with a mass of 300 kg and a stiffness of 150KN/m of the system. The slide ways coefficient of friction is measured at various constant speeds. The result shows that coefficient of friction varies linearly from 0.13 at 0.002 m/s and 0.12 at 0.004 m/s. The design is based on constant speed data. Calculate the minimum value of dashpot coefficient at a drive speed of 0.003 m/s, if the overall damping ratio for the system in regard to small transient oscillation is to be at least 0.2.

2(a) Derive the equation for governing the pressure distribution in a hydrodynamic film of a short journal bearing. Also, obtain the relation for the load carrying capacity for this bearing.

2(b) The following data is given for a journal bearing:
Journal diameter = 3 cm, Bearing length = 6 cm, Radial clearance = 0.002 cm,
Journal speed = 2000 rpm, Eccentricity ratio = 0.8, Inlet pressure = 0.3 MPa,
Location of inlet hole = 220°, Viscosity of lubricant at operating temp. = 25CP.
Determine the location as well as magnitude of maximum and minimum pressure and also the maximum pressure intensity in the bearing.

3(a) Drive the expressions for the pressure distribution, load capacity and frictional force in an inclined pad slider bearing.

3(b) Estimate the operating speed and power loss of a slider bearing with 10 pivoted shoes with the following data:
Ratio between outside and inside diameter = 2.5, Inside diameter = 49 cm, Load carried = 1 MN, Angle subtended by each shoe = 30°, Viscosity of the lubricant at the operating temperature = 10 CP, Minimum film thickness of the lubricant film = 0.005 cm

4(a) Using the expression, \( Q = \frac{(-A_p b h^3)}{(12 \mu_1 l)} \) for the flow rate of an incompressible fluid through a rectangular slot, drive the equations for load carrying capacity and frictional losses for the case of an hydrostatic thrust bearing.
4(b) A hydrostatic thrust bearing of a vertical engine has the following data: [6]
Thrust load = 450 N, Shaft diameter = 400 mm, Recess diameter = 250 mm, Shaft speed = 750 rpm, Viscosity of the lubricant = 30 CP, Film thickness = 0.15 mm, Specific gravity and specific heat of the lubricating oil is 0.86 and 2 KJ / kg °C respectively. Determine
(i) supply pressure (ii) flow requirements (iii) pumping loss (iv) frictional loss (v) temperature rise of the lubricant oil.

5 Describe load carrying phenomenon of squeeze film bearings. List eight different conditions of dynamic loading. Derive the Reynolds equation governing the pressure distribution for a dynamically loaded journal bearing.

6(a) Two circular flat plates of radius, R, are approaching each other. Find the expressions of the load carrying capacity and time, t, required to reduce the oil film thickness from \( h_1 \) to \( h_2 \). [6]

6(b) A 125 mm diameter pad is supported on a flat circular plate by a lubricant film of thickness 0.025 mm. It is loaded by a force of 25 KN. In what period of time, the thickness decreases to \( 1/10 \) of the original value. The viscosity of the lubricant oil film at the operating temperature is 23 m Pa-s. [6]

7 State Darcy’s law for velocity of flow through porous medium. Derive the Reynolds’s equation for pressure distribution in a finite porous journal bearing. [12]

Apply this equation to determine the load carrying capacity in a short porous journal bearing.

8(a) Discuss thermal effects in hydrodynamic lubrication. How the pressure distribution is modified in case of long journal bearing due to thermal wedge. [8]

8(b) Write some characteristics of gas lubricated bearing. What are their advantages and disadvantages? [4]
1. (a) What do you mean by composite materials, discuss its needs and importance. Further give the classifications of Composite materials. (6)

1. (b) Discuss the following in brief;
(i) Fibrous composite materials (ii) Laminated composite materials
(iii) Particulate composite materials (iv) Plastic based Laminates (6)

2. By considering the characteristic of a lamina and how they respond to applied stresses, explain in brief the Stiffness, Compliance and Engineering Constants for orthotropic materials. Also discuss the Restrictions on Engineering Constants for Isotropic materials. (12)

3. (a) Why do the Strength criterion is important for macromechanical behaviour of a lamina? Discuss in brief the Biaxial Strength criteria for an orthotropic lamina with the help of different curves for failure envelope and failure criteria for metals. (6)

3. (b) Why failure criterion are used for macromechanical behaviour of a lamina. Further discuss any two of the following for Bi-axial loading,
(i) The maximum Strain failure criterion
(ii) Tsai-Hill failure criterion
(ii) Tsai- Wu Tensor failure criterion (6)

4. What is the mechanics of materials approach to stiffness? Is there any assumption required? If yes, then discuss it; further state that how the assumption is made useful for the determination for (any two) of the following.
(i) Young’s Moduli (E₁ and E₂ )
(ii) Poisson’s Ratio (γ₁)
(iii) Shear Modulus (G₁₂) (12)

...contd 2
5. (a) What is the Elasticity approach to stiffness for micromechanics of a lamina. Discuss in detail the Bounding techniques of elasticity.
   (6)
5. (b) Explain with the help of equations any one of the following,
   (i) Lower bound on Apparent young’s modulus.
   (ii) Upper bound on Apparent young’s modulus.
   (6)

6. What is a laminate, how a laminate responds to forces and moments. Explain any two of the following,
   (i) Strain and stress variation in a Laminate.
   (ii) Resultant Laminate Forces and moments.
   (iii) Thermal and Mechanical Stress analysis.
   (12)

7. (a) What is the response of laminated plates to bending, buckling and vibration. Give the basic restrictions, assumptions and consequences of governing equations for bending, buckling and vibration of laminated plates.
   (6)
7. (b) Explain and derive the relation for deflection of simply supported laminated plates under distributed transverse load. Show that the deflections satisfies the governing differential equations and boundary conditions for any one of the following
   (i) Antisymmetric cross-ply laminated plates
   (ii) Antisymmetric angle-ply laminated plates.
   (6)

8. What do you mean by vibration of simply supported laminated plates? Further discuss, how the free vibration frequencies and mode shapes will be determined for specially orthotropic laminated plates.
   (12)
with lower left corner at (2,2)

2(b) Generate a parametrically represented circle having its centre at (5, 3) and a radius of 5 units.

3 Rotate a cube ABCDEFGH about its diagonal pointing away from the origin by 45 degrees. The coordinates of the vertices of the cube are given by:

\[
\begin{bmatrix}
A \\
B \\
C \\
D \\
E \\
F \\
G \\
H
\end{bmatrix} =
\begin{bmatrix}
2 & 1 & 2 & 1 \\
3 & 1 & 2 & 1 \\
3 & 1 & 1 & 1 \\
2 & 1 & 1 & 1 \\
2 & 2 & 2 & 1 \\
3 & 2 & 2 & 1 \\
3 & 2 & 1 & 1 \\
2 & 2 & 1 & 1
\end{bmatrix}
\]

4(a) Define perspective transformations and perspective projections. Find out single point perspective projection of a three dimensional point P onto \( z = z^* = 0 \) plane at \( P^* \), from a centre of projection at \( z_c \) on the z-axis and thus show that as the centre of projection approaches infinity, an axonometric projection onto the \( z = 0 \) plane results.

4(b) Show that the three point perspective transformation can be obtained by concatenation of three single point perspective transformations, one for each of the coordinate axes.

OR

4' A cube with length of side unity is placed so that the corner lies on the origin and the adjacent edges are along three mutually perpendicular positive coordinate directions. Perform three point perspective projection on the \( z = 0 \) plane with centres of projections \( x = -10, y = -10 \) and \( z = 10 \) on the respective coordinate axes.

5 Derive the expressions for natural coordinates in a Constant Strain Triangle (CST) element. Show that they are nothing but area coordinates.
Q.No. Question

1(a) Name the various allowances incorporated in the patterns for castings. Discuss the reasons for the provision of each allowance in the patterns. [02]

1(b) Total liquid volumetric shrinkage and total solid volumetric shrinkage of an aluminium alloy are 9% and 6% respectively. Calculate the dimensions and draw the diagram of the pattern, the core (if necessary) and riser for casting shown in the figure below. Draw the figure of the mould assembly showing the mould cavity, the core (if needed), gating system and the riser. [10]

All the dimensions are in mm.

Fig. 1

2(a) What is shell moulding process? Discuss (i) the ingredients of sand mixture (ii) metallic pattern and (iii) curing of sand in shell moulding. Discuss the steps undertaken in shell moulding process. [08]

2(b) Discuss the mechanization of shell moulding process. [04]

OR

2'(a) What are the ingredients of gating system? Discuss their functioning. Discuss pressurized and non-pressurized gating system. Discuss the measures taken to avoid aspiration effect in the gating system. [06]
2'(b) Differentiate between a riser, a runner and a down sprue. Design a riser for the casting shown in figure no. 1. Ensure and justify solidification of molten metal.

3(a) What is meant by nucleation and grain growth of molten metal in mould cavity? Discuss the solidification of aluminium-silicon eutectic alloy in the mould cavity.

3(b) What is meant by shrinkage pipe during solidification of molten metal? Define "centre line shrinkage resistance". Discuss its effect on the nucleation and growth of grains during solidification of an alloy. Discuss its effect (if any) on mushy stage formation and dendritic growth during solidification of molten metal.

4 Discuss the melting procedure of aluminium and its alloy. Explain drossing and gas absorption during their melting. Explain their fluxing and flushing. Discuss moulding sand for aluminium castings. Discuss the fabrication of cores and inserts in aluminium casting.

5 Give chemical composition of cast iron. Discuss the effect of the ingredients on the properties of grey cast iron, white cast iron and ductile cast iron. Define carbon equivalent in cast iron. Discuss the functioning and melting procedure of cast iron in cupola. Give the effect of well depth on the temperature of molten metal. Mention a typical composition of the charge during its melting in cupola furnace.

OR

5' Differentiate between plain carbon steel and alloy steel. Discuss the effect of permeability and moisture content on the steel castings. Explain the green sand moulding defects in steel castings. Discuss the precautions taken in making cores for steel castings. Discuss the importance of melting in quality steel castings. Enumerate the types of furnaces used in the melting of steel casting.
Maximum Marks: 60
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>
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<tbody>
<tr>
<td>1(a)</td>
<td>Discuss the attenuation of Solar radiation by the atmosphere.</td>
<td>[04]</td>
</tr>
<tr>
<td>1(b)</td>
<td>Show that the daily extraterrestrial solar radiation on a horizontal surface can be given by [ H_o = \frac{24}{\pi} I_{sc} \left( 1 + 0.033 \cos \frac{360 \pi n}{365} \right) \left( \omega \sin \phi \sin \delta + \cos \phi \cos \delta \sin \omega_s \right). ] Clearly mention the meanings of the symbols used.</td>
<td>[06]</td>
</tr>
<tr>
<td>1(b')</td>
<td>Write the construction and working of the instrument used for measurement of global solar radiation.</td>
<td>[06]</td>
</tr>
<tr>
<td>2</td>
<td>Derive the expression for the temperature at any position ( y ) in the flow direction of a liquid flat plate solar collector, if the useful energy per gain unit length in the flow direction is given by [ Q_u = W F' \left[ S - U_L (T_f - T_a) \right] ] where [ F' = \frac{1}{W U_L \left( \frac{1}{U_L [F(W-D)+D]} + \frac{1}{h_f \pi D_s} + \frac{1}{C_b} \right)} ] Find the collector efficiency factor and fin efficiency of a flat plate solar collector of area ( 2 \text{ m} \times 1 \text{ m} ), made out of 1 mm steel sheet bonded with 20 mm diameter copper tubes on the underside. The bond width is also 20 mm and the tubes are 100 mm apart. The bond conductance is 15 W/m°C. Inlet temperature of water is 60°C and ambient temperature 25°C. Heat transfer coefficient between the tube wall and water is 300 W/m²°C. Thermal conductivity of steel is 47.6 W/m°C. Overall heat loss coefficient is 8.83 W/m²°C. Intensity of solar radiation is 750 W/m². The thickness of the tube may be neglected.</td>
<td>[10]</td>
</tr>
<tr>
<td>3(a)</td>
<td>What is meant by selective coatings? Write its advantages. How selective surfaces are achieved?</td>
<td>[04]</td>
</tr>
</tbody>
</table>
3(b) Discuss the effect of various parameters on the performance of flat plate collector.

OR

3(b') Describe the thermal test procedure of a box type solar cooker.

4(a) Calculate solar temperature for bare and blackened glazed surface for the following parameters. \( \alpha = \tau = 0.9, \ h_b = 6 \text{ W/m}^2\text{ °C}, \ h_i = 3 \text{ W/m}^2\text{ °C}, \ k_{\text{wall}} = 0.9 \text{ W/m °C}, \ L_{\text{wall}} = 10 \text{ cm}, \ I(t) = 600 \text{ W/m}^2, \ T_a = 25 \text{ °C}, \ L_g = 3 \text{ mm}, \ k_g = 0.9 \text{ W/mK}. \)

4(b) Write down an expression for energy balance equation for the bare surface exposed to sun's ray.

4(c) What are direct, indirect and isolated gains? Discuss with diagrams.

5(a) Calculate the performance of a conventional solar air heater with the following data:

- Length of collector = 2.1 m,
- Width of collector = 1.1 m,
- Length of absorber plate = 2 m,
- Width of absorber plate = 1 m,
- Spacing between absorber and bottom plate = 1.5 cm,
- Air flow rate = 200 kg/h,
- Air inlet temperature = 50 °C,
- Ambient temperature = 20 °C,
- Solar flux incident on the collector face = 950 W/m²,
- \( (\alpha \tau)_{\text{av}} = 0.85, \ \varepsilon_p = \varepsilon_b = 0.95, \)
- Top loss coefficient = 6.2 W/m²K,
- Bottom loss coefficient = 0.8 W/m²K.

Properties of air at 55 °C are as follows:

- \( \rho = 1.077 \text{ kg/m}^3, \ C_p = 1.005 \text{ kJ/kgK}, \ \mu = 19.85 \times 10^{-6} \text{ Ns/m}^2, \ k = 0.0287 \text{ W/mK}. \)

Use \( \text{Nu} = 0.0158 \text{ Re}^{0.8} \) and \( f = 0.079 \text{ Re}^{-0.25}. \)

5(b) Show that for concentrating collectors

\[
Q_u = A_s \left[ S - \frac{U_L}{C} (T_{pm} - T_a) \right]
\]

where \( C = (A_d/A_p) \) is the concentration ratio.

6 Draw a schematic diagram of a single slope solar still and write the energy balance equations for different components of the still.

OR

6' Draw a schematic diagram of a well mixed sensible heat liquid storage tank and write the set of energy equations for its analysis.

DATA SHEET

\[
\cos \theta = \sin \delta \sin \phi \cos \beta - \sin \delta \cos \phi \sin \beta \cos \gamma + \cos \delta \cos \phi \cos \beta \cos \omega + \cos \delta \sin \phi \sin \beta \cos \gamma \cos \omega + \cos \delta \sin \beta \sin \gamma \sin \omega
\]