2014-2015
M.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING (INDUSTRIAL & PRODUCTION ENGG.)
QUALITY MANAGEMENT
ME622

Maximum Marks: 60 Credts: 04 Duration: Three Hours

Answer any FIVE questions.
Assume suitable data/information, if missing.
Notations used have their usual meaning.
Use of statistical tables is allowed.

Q.No. Question M.M.
1 What is meant by quality costs? Give a detailed account of costs related to quality [12]
   involved in a firm that manufactures consumer items, say mobile phones.

2(a) For the following distributions, write briefly under what situations each one of them [06]
is most preferably used.

Hyper-geometric, Geometric, Exponential, Gamma, Weibull, Binomial.

2(b) What is a sampling distribution? If a population is normally distributed, what will be [06]
   the type of its sampling distribution? How will you estimate a 95% confidence
   interval of the mean of such a population based on a sample of size 20?

3 A process was not being monitored by any control chart in the past but the worker [12]
   was instructed to pick 10 units of the product randomly out of the production of
   each day, measure a particular dimension, calculate the mean of dimensions and
   their standard deviation and record them. The data for the last 20 days is given
   below:

<table>
<thead>
<tr>
<th>Day</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.87</td>
<td>0.458</td>
</tr>
<tr>
<td>2</td>
<td>100.13</td>
<td>0.814</td>
</tr>
</tbody>
</table>

continued... 2
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>99.93</td>
<td>0.808</td>
</tr>
<tr>
<td>4</td>
<td>100.59</td>
<td>1.002</td>
</tr>
<tr>
<td>5</td>
<td>99.74</td>
<td>0.739</td>
</tr>
<tr>
<td>6</td>
<td>100.30</td>
<td>0.506</td>
</tr>
<tr>
<td>7</td>
<td>100.15</td>
<td>0.343</td>
</tr>
<tr>
<td>8</td>
<td>100.12</td>
<td>0.767</td>
</tr>
<tr>
<td>9</td>
<td>99.97</td>
<td>0.843</td>
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<td>11</td>
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<td>0.676</td>
</tr>
<tr>
<td>14</td>
<td>100.28</td>
<td>0.508</td>
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<tr>
<td>15</td>
<td>100.29</td>
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<tr>
<td>16</td>
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<td>0.633</td>
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<td>19</td>
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</tr>
<tr>
<td>20</td>
<td>99.56</td>
<td>0.353</td>
</tr>
</tbody>
</table>

Set up X-bar and R charts based on the above data so that monitoring may start immediately.

4 Answer the following with examples: [12]

i. What are operating characteristics of an X-bar chart and how are they used?

ii. Some people claim that a process may be in statistical control and yet produce a large number of defectives. Give your comments either justifying or refuting this claim.

iii. What is the idea behind group control charts? What is the mechanism of setting and using such charts?

iv. What is the meaning, significance and implications of type-I and type-II errors in hypothesis testing.

contd... 3
The only data available about a process are the means of 20 samples of size 30 each. The minimum of these means is 9.845 and maximum is 10.133. The standard deviation of these means comes out to be 0.0558. The design specifications of the measured characteristic are $10 \pm 0.8$. Perform process capability analysis of this process and describe what you expect as the best scenario and the worst scenario in terms of defectives produced. What possible steps may be taken to improve the process capability?

6(a) A manufacturing system produces 4% defectives on an average. A single sampling plan $n=25$, $c=0$ with rectifying inspection is being used for final inspection of lots of 400. The market expectation is 1.4% defectives at the maximum and the customers do not tolerate even one lot worse than 1.4%. Is the plan adequate? If not, what would be your suggestion?

6(b) What purpose do special control charts such as cumulative-sum (CUSUM) and exponentially weighted moving average (EWMA) charts serve and how?

7 A system is made up of three components connected in series. The first component can fail even when not operating while the other two components cannot fail in the idle state. When any component fails its repair starts immediately. Using the usual notations determine the availability expression for this system.
Assume data suitably, if required. 
Notations used have their usual meaning.

1(a) Develop a model for calculating Material Removal Rate (MRR) in an AJM process and thus explain the effect of important process parameters on MRR. [10]

1(b) During AJM, the mixing ratio used is 0.2. Calculate mass ratio if the ratio of density of abrasive and carrier gas is equal to 20. [05]

2(a) Derive an equation suggested by Shaw to obtain volumetric material removal rate considering both “throwing” and “hammering” mechanisms in USM. [10]

2(b) What are transferred and non-transferred modes of operation of plasma torches? Explain the phenomenon of “Double Arcing” in PAM and list the possible reasons associated with it. [05]

3(a) With the help of neat sketches, explain the mechanism of material removal rate in EDM. Also derive governing equation for surface roughness. [10]

3(b) Explain the following terms with respect to EDM process (i) duty factor (ii) relative electrode wear (iii) heat affected Zone (iv) time constant (v) critical resistance in RC circuit. [05]

OR

3'(a) With the help of neat sketches, explain the working principle of Electric Discharge grinding (EDG) and Wire Electric Discharge Machining (WEDM) processes. [10]

3'(b) LBM and EDM both are thermal processes. However, it is found that the first one results in more thermal damage to the machined component than the second one. Is it true? Justify your answer. [05]
4(a) With the help of suitable mathematical model, explain the self-regulating feature of the ECM process. Also, deduce the relationship for electrolyte temperature change for a given feed rate of tool. [10]

4(b) An alloy consists (% by weight): Nickel (72%), Chromium (20%), Iron (5%), Titanium (0.5%), Copper (0.5%), Silicon and Manganese (1.0% each). Determine chemical equivalent and density of the alloy. Calculate MRR (in grams) for a current value of 100 A at 100% current efficiency. [05]

<table>
<thead>
<tr>
<th>Metal</th>
<th>Atomic Wt. (g)</th>
<th>Valency</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>2</td>
<td>8.9</td>
</tr>
<tr>
<td>Chromium</td>
<td>51.99</td>
<td>2</td>
<td>7.19</td>
</tr>
<tr>
<td>Iron</td>
<td>55.85</td>
<td>2</td>
<td>7.86</td>
</tr>
<tr>
<td>Titanium</td>
<td>47.9</td>
<td>3</td>
<td>4.51</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Silicon</td>
<td>28.09</td>
<td>4</td>
<td>2.33</td>
</tr>
<tr>
<td>Manganese</td>
<td>24.31</td>
<td>2</td>
<td>1.74</td>
</tr>
</tbody>
</table>

OR

4′(a) Explain in brief the effect of the following parameters on IEG in an ECM process. [10]

(i) Electrolyte Conductivity

(ii) Electrolyte temperature

4′(b) With the help of suitable diagrams, briefly explain any Two of the following processes. [2*2.5]

(i) Electrochemical Honing

(ii) Abrasive Flow Machining

(iii) Electrochemical de-burring

(iv) Laser Beam Cutting
1(a) What is a Grashoff chain? Explain all possible kinematic inversions from a Grashoff Chain. (05)

1(b) Figure 1 shows an offset slider crank mechanism. Body 1 is the fixed link or the ground, body 2 is the crankshaft, body 3 is the connecting rod, and body 4 is the slider block at B. The mechanism has one degree of freedom, which is taken here to be the angular orientation of the crankshaft $\theta_2$. Two coordinate systems have been assigned to the system. The position vector of point B on the connecting rod is expressed as

$$\vec{r}_{B_3} = \vec{R}_3 + T\vec{u}_{B_3}$$

![Figure 1](image)

where the $\vec{R}_3$ is the position vector of the reference point A in the global coordinate system $(X,Y)$ and $T$ is the transformation matrix from the connecting coordinate system $(X_3,Y_3)$ to the global coordinate system $(X,Y)$ and $\vec{u}_{B_3}$ is the position vector of point B in the $(X_3,Y_3)$ coordinate system.

(a) Write the various elements of the matrix T.

(b) Express the angular orientation of the connecting rod and the location of the slider
block in terms of the degree of freedom $\theta_2$.
(c) Determine the angular velocity and acceleration of the connecting rod and the velocity and acceleration of the slider block in terms of the angular velocity $\dot{\theta}_2$ and angular acceleration $\ddot{\theta}_2$ of the crankshaft.
(d) What are the various possible singular configurations of the above mechanism for $h=0$.

2.(a) The spatial RSSR (revolute, spherical, spherical, revolute) mechanism shown in Figure 2 consists of four bodies. Body 2 is connected to body 1 at O by a revolute joint, body 3 is connected to body 2 at A by a spherical joint, body 4 is connected to body 3 at B by a spherical joint, and body 4 is connected to body 1 at C by a revolute joint. Find the total number of constraint equations and the number of system degrees of freedom.

![Figure 2](image1)

2.(b) For the RSSR mechanism, derive the displacement equation and from it, deduce the expressions for the displacement of
(a) Planner 4R linkage moving in the XY plane.
(b) 4R spherical mechanism.

3. Determine the number of the degrees of freedom for the open chain system shown in Figure 3. Develop equations of motion for the system and find joint reaction forces and torque at the given orientation.

4. Find link orientations and velocities for the RSSC spatial linkage shown in figure 4 for $\gamma = 30^\circ$, $\theta = 45^\circ$, and crank angular velocity $\omega_1=50$ rad/s counter clockwise. Take $r_o = 200$ mm, $r_1 = 100$ mm, and $r_2 = 300$ mm. Use vector approach.

\textit{Contd...}
5.(a) Explain Bloch's method for synthesis of planar mechanism.

5.(b) Synthesize a four bar planar mechanism to generate $y = \log_{10} x$, $[x \in 1, 10]$. The input crank length is 50 mm and is to rotate from $45^\circ$ to $105^\circ$ while the output link moves from $135^\circ$ to $225^\circ$. Use three accuracy points with Chebyshev's spacing.

6. Synthesize an RSSR mechanism to generate symmetric function $y = x^{1.5}$, $[x \in -1, 1]$ with three accuracy points with proper choice of parameters.

7. Figure 5 shows a special RSSP mechanism in which the axis of translation (in the YZ plane) of the P-pair through point B intersect the axis of the R-pair at O2. The angle $\alpha_1$ is given to be 30°. Synthesize this mechanism to generate $y = x^2$, $[x \in -1, 1]$, with five accuracy points $x_1=0$, $x_2=1/2$, $x_3=1$, $x_4=-1/2$, $x_5=-1$, where $s_4$ represents $y$ and $\theta_2$ represents $x$. Assume $\Delta \theta_2=180$, as $x$ goes from -1 to 1 and $s_4=7.5$ as $y$ goes from 0 to 1. The displacement equation for the mechanism is

$$s_4^2 + l_2 s_4 \sin \theta_2 + l_2^2 - l_3^2 = 0$$

contd...
M. TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
MACHINE DESIGN
EXPERIMENTAL STRESS ANALYSIS
ME-634

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) Discuss in brief: Plane, Circular and Elliptical Polarised light. [06]

Further, explain the arrangements of optical elements in the plane and circular polariscope.

1(b) Explain the stress optic law and derive a relation between the material fringe value in terms of strain \( f_e \) and relative retardation \( N \).

OR

1' Derive the equations for light passing through a stressed model in a circular polariscope with the polarizers and quarter wave plates in crossed position using trigonometric representation for the light wave. Under what condition does the extinction occur? [12]

2(a) What is meant by compensation technique? Discuss in brief the Tardy method of compensation to obtain the fractional fringe order. [08]

2(b) Discuss in brief the isoclinic and isochromatic fringe patterns. Further, explain their significance in experimental stress analysis. [04]

3(a) Establish a relation between the circuit sensitivity and gage factor for a Wheat stone bridge circuit with:

i. Only one active gage in one of the arms
ii. One active and one dummy gage
iii. Active gages in all the four arms

3(b) Strain rosette shown in Figure 1 is placed on the surface of a structure and upon loading the readings obtained are also shown. Calculate principal strains, their orientation and the maximum shearing strain. [06]

contd...
4 (a) Explain the stress-optic law for photoelastic coatings. Derive the relationship between the stress and strain material fringe values.

OR

4 (a') Explain any two of the following:
   i. Scattering of light
   ii. Scattered light polariscope
   iii. Elements of holography

4 (b) Determine the correction factor $F_{CR}$ needed to account for reinforcing effects of the coating for a plane stress specimen fabricated from steel, if
   \[ \frac{h^C}{h^S} = 0.5 \quad (i) \quad \text{and} \quad \frac{h^C}{h^S} = 0.3 \]
   Take $E^S = 200 \text{ GPa}$; $\nu^S = 0.3$; $E^C = 2.5 \text{ GPa}$; $\nu^C = 0.35$.

5 (a) Explain in brief the brittle coating method. What are the advantages & limitations of this method?

OR

5 (a') What are the assumptions made while analysing brittle coatings? Derive the expressions for coating stresses in brittle coating.

5 (b) If the threshold strain in a brittle coating is $500 \ \mu \varepsilon$, determine the corresponding state of stress in the coating during calibration for
   \[ (i) \quad \text{A resin based coating with } E^C = 1.4 \text{ GPa}; \nu^C = 0.42 \]
   \[ (ii) \quad \text{A ceramic based coating with } E^C = 70 \text{ GPa}; \nu^C = 0.25 \]
Question 1(a) Using the following form of the Navier-Stokes equation for an incompressible and homogenous flow with velocity $U$:

$$\frac{DU}{Dt} = -\nabla\left(\rho + \Phi\right) + \nu \nabla^2 U; \ \nabla \Phi \text{ is body force}$$

Obtain the equation for circulation as given below along a closed contour $C$ in the flow field shown in (figure-1) below:

$$\frac{DF}{Dt} = -\nu \oint_C \nabla \times \Omega \cdot dx$$

Here $F$ is circulation along contour $C$, $\Omega$ is vorticity and symbol $X$ represents vector multiplication. Derive from the above equation the Kelvin’s Circulation Theorem for inviscid/ irrotational flow. Use vector identities, if required, provided with Question 2(b).
1(b) An infinite straight vortex filament of strength \( \Gamma \) extends from \(-\infty \) to \( \infty \) as shown below (figure-2).

Using Biot-Savart Law show that the velocity at a field point \( r \) due to this vortex filament is:

\[
V(r) = \frac{\Gamma}{4\pi} \int_{-\infty}^{\infty} \frac{ds \times (r-s)}{|r-s|^2}
\]

Symbol \( \times \) is vector multiplication and \( e \) is the direction of \( ds \times r_1 \).

2. (a). For a viscous flow the circulation of a line vortex \( \Gamma(r,t) = 2\pi r u_\theta(r,t) \) decays with time governed by the following equation of motion in cylindrical polar coordinate system in azimuthal (\( \theta \)) direction:

\[
\frac{\partial u_\theta}{\partial t} = \nu \left[ \frac{\partial^2 u_\theta}{\partial r^2} + \frac{1}{r} \frac{\partial u_\theta}{\partial r} - \frac{u_\theta}{r^2} \right]
\]

Using the above equation obtain the following expression for the viscous decay of line vortex:

\[
\frac{\partial \Gamma}{\partial t} = \nu \left[ -\frac{1}{r} \frac{\partial \Gamma}{\partial r} + \frac{\partial^2 \Gamma}{\partial r^2} \right]
\]

Use the boundary conditions: \( \Gamma(r,0) = \Gamma_0 \) and \( \Gamma(0,t) = 0 \) for \( t > 0 \).

(b). Starting with the Navier-Stokes equation for an incompressible \( \nabla \cdot U = 0 \) and homogenous flow as given below:

\[
\frac{\partial U}{\partial t} + U \cdot \nabla U = -\nabla \left( \frac{p}{\rho} + \Phi \right) + \nu \nabla^2 U
\]

\( \nabla \Phi \) is body force. Derive the vorticity equation in the following form:

Contd...3.
\[
\frac{D\Omega}{Dt} = (\Omega \cdot \nabla)U + \nabla \nabla \cdot \Omega
\]

Use the following vector identities if required:

\[
(\mathbf{u} \cdot \nabla)\mathbf{u} = \nabla (\mathbf{u} \cdot \mathbf{u}) - \mathbf{u} \times (\nabla \times \mathbf{u})
\]

\[
\nabla^2 \mathbf{u} = \nabla (\nabla \cdot \mathbf{u}) - \nabla \times (\nabla \times \mathbf{u})
\]

\[
\nabla \times (\mathbf{u} \times \Omega) = \mathbf{u} (\nabla \cdot \Omega) - \Omega (\nabla \cdot \mathbf{u}) + (\mathbf{u} \cdot \nabla)\Omega - (\mathbf{u} \cdot \nabla)\Omega
\]

Explain also the mechanisms of stretching and turning of vortex lines.

3(a) Using Blasius Integral Laws derive expressions for the drag force \(D\) and lift force \(L\) on an object placed in a flow field. Further, using the complex potential for a circular cylinder of radius \(R\) with circulation \(\Gamma\) placed in uniform flow \(U\) obtain forces and moment on the cylinder and show that the lift force acting on the cylinder is independent of the its geometry.

3(b) Obtain the following mapping function using Schwarz-Christoffel transformation that maps the upper-half of \(\zeta\)-plane to the flow in a right-angled bend given in figure-3:

\[
\frac{dz}{d\zeta} = K (\zeta - b)^{3/2} (\zeta - 1)^{-1/2} (\zeta - 1)^{-1}
\]

\(K\) and \(b\) are constants. Using the above mapping show that:

\[
K = -\frac{l_1}{\pi} \text{ and } b = -\frac{l_2^2}{l_1^2}
\]

![Figure 3](image)

4(a) Show that the complex potential given below represents flow in a sector whose

[06] Contd... 4.
interior angle is $\pi/n$ (where $n > 1$) shown in (figure-4). Show also that the polar velocity components ($u_r$ and $u_\theta$) are given as:

$$u_r = u C r^{n-1} \cos \theta \quad \text{and} \quad u_\theta = -u C r^{n-1} \sin \theta$$

where $C$ is a constant.

4(b) For a flow past an ellipse at an angle of attack $\alpha$ to the x-axis (figure-5) the mapping function is given below:

$$z = \zeta e^{i\alpha} + \frac{c^2}{\zeta e^{i\alpha}} \quad \text{where} \quad l = a + \frac{c^2}{a} \quad \text{and} \quad m = a - \frac{c^2}{a}$$

c is constant. Here $l$ and $m$ are the semi-major and semi-minor axes of the ellipse and ‘$a$’ is the radius of the cylinder in $\zeta$ plane. $U$ is the uniform flow velocity. Show that the forces on the ellipse in $x$ and $y$ directions are zero while the moment acting on it is given by:

$$M = -\frac{\rho U^2}{2} (l^2 - m^2) \pi \sin 2\alpha$$

5(a) Consider the flow of incompressible fluid through an elliptical pipe with $a$ and $b$ as the semi-major and semi-minor axes (figure-6):

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$
After integrating the governing equation for flow through the above pipe obtain the velocity distribution in the pipe. Show also that the flow rate for a given dp/dz along the axis in z-direction is:

\[
Q = \frac{\pi \frac{dp}{dz} ab^3}{4\mu dz (a^2 + b^2)}
\]

5(b) For turbulent flow in a 2-D channel of width 2h (in y-direction) and with x-axis placed along the centre-line, obtain the following form of the Universal Velocity Profile (proposed by von Karman) for \( \bar{u} \) for a fully developed flow in the x-direction:

\[
\frac{U_{\text{max}} - \bar{u}}{u_x} = -\frac{1}{x} \left[ \ln \left( 1 - \frac{y^2}{4h} \right) + \frac{y}{h} \right] \quad \text{where} \ x = 0.4 \text{ and } u_x = \left( \frac{f_w}{\rho} \right)^{1/2}
\]

\( U_{\text{max}} \) is the maximum velocity and \( u_x \) is the friction velocity.

6. The velocity profile for the flow in the wake of a flat plate at zero incidence is shown in (figure-7) where \( u_1 = (U_{\infty} - u) \) is the velocity difference in the wake region. From the boundary layer equations derive the following equation of flow in the wake region:

\[
U_{\infty} \frac{\partial u_1}{\partial x} = \nu \frac{\partial^2 u_1}{\partial y^2} \quad \text{with} \ y = 0; \ \frac{\partial u_1}{\partial y} = 0 \quad \text{and} \ y = \infty: \ u_1 = 0
\]

Take \( \eta = y \sqrt{\frac{U_{\infty}}{\nu \infty}} \) and \( u_1 = U_{\infty} C (\frac{x}{l})^{-1/2} g(\eta) \). \( l \) is the plate length

and show that the flow in the wake region is governed by the following relation:

\[
g'' + \frac{1}{2} \eta g' + \frac{1}{2} g = 0 \quad \text{with} \ \eta = 0; \ g' = 0 \quad \text{and} \ \eta = \infty: \ g = 0
\]

Also taking:

\[
\int_{-\infty}^{\infty} g(\eta) d\eta = \int_{-\infty}^{\infty} \exp(-\frac{1}{4} \eta^2) d\eta = 2\sqrt{\pi} \quad \text{and} \ 2D = 1.328 \ b \rho U_{\infty}^2 \sqrt{\frac{\nu l}{U_{\infty}}}
\]

where \( D \) is drag on the plate wetted on one side (Expression used from Blasius solution of boundary layer on a flat plate) obtain the following equation of velocity difference in the wake region:
\[ \frac{u_1}{U_\infty} = \frac{0.664}{\sqrt{\pi}} \left( \frac{x}{l} \right)^{-1/2} \exp \left\{ -\frac{y^2 U_\infty}{4vx} \right\} \]

**Figure 7**

Write brief notes on any THREE of the following:

(a) Laminar 2-D jet flow

(b) Doublet

(c) Kutta condition for flow over bodies with sharp trailing edge at small angle of attack

(d) Helmholtz Theorems

(e) Shear stress type of turbulence models
1. With suitable assumptions, obtain the Integral Energy Equation for steady axial fluid flow over a body of revolution whose temperature and free stream velocity vary in an arbitrary manner. With neat diagrams and appropriate relations, explain the various thicknesses of the laminar momentum and temperature boundary layers. [15]

2. Derive the energy equation for flow through circular tube subjected to constant wall heat flux and hence, obtain the equations for temperature distribution and Nusselt number. Identify the conditions for the laminar hydrodynamic and thermal entry lengths and determine the hydrodynamic and thermal entry lengths when engine oil at a bulk temperature of 100°C flows through a smooth tube having 10 mm diameter at a velocity of 1 cm/s. Give specific comments on the result. Take properties of the engine oil as: \( \rho = 840.01 \text{ kg/m}^3, \ C_p=2219 \text{ kJ/kgK}, \ n = 0.2030 \times 10^{-4} \text{ m}^2/\text{s}, \)
\( k= 0.137 \text{ W/mK} \) and \( Pr= 276 \). [15]

3. Using similarity solutions, obtain relations for temperature distribution and local Nusselt number for laminar thermal boundary layer over a semi-infinite plate under the conditions of constant free stream velocity and surface temperature. [15]
Air at 300 Kelvin and one atmospheric temperature \( (\nu = 1.68 \times 10^{-5} \text{ m}^2 / \text{s}) \) flows over a curved surface, whose local radius of curvature varies as \( R = 10 \times x^2 \) and the free stream velocity changes as \( U = 3x \). Using the following relation for the momentum transfer over the given surface:

\[
\frac{U \frac{d\delta_2^2}{dx}}{v} + \frac{2\delta_2^2 U}{v} \frac{dR}{dx} = 0.44 - 5.68 \frac{\delta_2^2}{v} \frac{dU}{dx}
\]

determine the numerical value of momentum thickness, \( \delta_2 \) at a distance \( x = 1.5 \text{ m} \) from the leading edge.

5. Describing the Boussinesq approximation in free convection equations, obtain the similarity solutions for laminar free convection over a constant temperature vertical flat plate. Show that \( \text{Nu} \text{Gr}^{-\frac{1}{4}} = -\frac{1}{\sqrt{2}} \theta'(0) \) where, \( \theta(\eta) = (T - T_\infty) / (T_w - T_\infty) \)

Also, give the significance of Grashof number.

6. With the help of P-V-T diagram, explain superheated liquid and supersaturated vapour. What is incipience of boiling? Describe the criteria for bubble nucleation on a heated surface having cavities of different sizes. Obtain the relations for vapour quality and void fraction and hence, derive the expressions for pressure drop in two phase flow based upon the homogeneous and separated flow models.
2014-2015
Winter 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 role of:
   (a) Premixed Combustion in Spark Ignition Engines.  6
   (b) Non Premixed Combustion in Compression Ignition Engines.  6

2. (a) Describe in detail the concept MPFI system for simultaneously controlling high emissions of NO, UHC and CO in a conventional SI engine. (b) Describe the role of λ sensor in MPFI system.  12

3. Explain in detail the process of diesel combustion by using the Rate of Heat Release curve for the formation of excessively high amount of NO and TPM in HSDI diesel engine?  12

4. (a) Explain the concept of Gasoline Direct Injection (GDI) in SI Engine.  6
   (b) Explain why GDI-SI engine is more efficient than MPFI Engine?  6

5. What is the disadvantage of Premixed Burning after the completion of Ignition Delay in HSDI diesel engine?  12

6. 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

7. Write detailed notes on any four (a) 3-Way Converter (b) 2-Way Oxidation Converter (c) Turbocharger (d) Thermal Reactor (e) Use of 3x4 VCO Nozzles in HSDI diesel engines (f) OHC engines.
Answer any Five questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) Justify and/or refute the following, with examples. [08]
"Time based competitiveness in dynamic and variety driven production systems, demands that computers be used to improve the efficiency of all activities. Hence FMS is the key to the success for CIMS."
1(b) Explain CIM from different perspectives. [04]

2(a) What are Flexible Manufacturing Systems (FMS)? Show the relationships between various manufacturing flexibility types and also explain the measures of two most important types in FMS context. [06]
2(b) How the application of material handling system does affects the performance of FMS? Show with the help of at least three schematics the use of material handling equipment in FMS. State some typical primary material handling equipment used in FMS. [06]

3(a) With respect to robot, explain the following: [06]
i) Degree of freedom, ii) Accuracy, iii) Repeatability, iv) Sensors, v) Spatial resolution and vi) Work envelope
3(b) Four jobs are to be scheduled through a certain workcenter. The following table gives data regarding the due date (values given are in terms of the production calendar day) and remaining process time. In the shop floor calendar, the current date is day 10. Use the ‘lowest critical ratio’ and ‘shortest processing time’ rules to establish the sequence. Evaluate the results using the criteria of average manufacturing lead time and aggregate job lateness. Plot the results on time chart. [06]
<table>
<thead>
<tr>
<th>Job</th>
<th>Remaining process time (days)</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>C</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>D</td>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>

An FMS consists of four stations. Station 1 is load/unload station with one server. Station 2 performs turning operations with three servers (three identical CNC turning machines). Station 3 performs drilling operations with two servers (two identical CNC drilling machines). Station 4 is an inspection station with one server 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 = 4.0 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. The operation frequency at the inspection station \( f_{ijk} \) is less than 1 to account for the fact that only a fraction of the parts are inspected. 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.

<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>0.2</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Turn</td>
<td>2</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Drill</td>
<td>3</td>
<td>15</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>2</td>
<td>1.0</td>
</tr>
<tr>
<td>B</td>
<td>0.1</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Drill</td>
<td>3</td>
<td>15</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Turn</td>
<td>2</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Drill</td>
<td>3</td>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Inspect</td>
<td>4</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Unload</td>
<td>1</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>0.3</td>
<td>1</td>
<td>Load</td>
<td>1</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Drill</td>
<td>3</td>
<td>15</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>2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Contd. - 3.
5(a) Outline key design, planning, scheduling and control decisions required in FMS. [05]

5(b) The table below shows the data regarding the processing some jobs on three machines MI, MII, and MIII. The order of processing is MI-MII-MIII. Determine the sequence that minimizes the total elapsed time (T) required for completing the jobs. Also evaluate T and idle time of MI, MII and MIII.

<table>
<thead>
<tr>
<th>Jobs</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>MI</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>10</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>MII</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>MIII</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

6(a) Explain with help of a suitable example the 'Next Event Time Advance Approach' used in discrete event simulation technique. [05]

6(b) Two different part types arrive at the system for processing. Part type 1 arrives according to normal distribution with a mean of 11 hours and standard deviation of 2 hours. These arriving parts wait in the queue until a machine is available to process them for first operation. The processing time follows a triangular distribution with parameters 5, 6, and 8 hours. Part Type 2 arrives according to an exponential distribution with mean of 15 hours. These parts wait in the queue until the same machine is available to process them for first operation. The processing time follow a triangular distribution with parameters 3, 7 and 8 hours. After being processed by the first machine, all parts are sent for processing to a second machine for second operation which has processing time distribution as triangular with parameters of 4, 6 and 8 hours. State clearly the ARENA modules you will use with information for each module needed to develop the complete simulation model for this system. Also develop the flow chart showing the flow of information in the system. [07]

7(a) Give various applications of Group Technology FMS domain. Show the difference between mono-code and poly-code with the help of suitable examples. [04]

7(b) Define the term simulation. Consider the case of mixed model flexible manufacturing line configured for two products P1 and P2, with the required
sequence of operations as M1, followed by M2 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.

<table>
<thead>
<tr>
<th>Parts</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M1</td>
</tr>
<tr>
<td>P1</td>
<td>10</td>
</tr>
<tr>
<td>P2</td>
<td>12</td>
</tr>
</tbody>
</table>

i) Time Between Batches (TBB)

ii) Improvement in TBB, when efficiency of Machine M2 is increased by 20%
2014-15
M. TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
INDUSTRIAL & PRODUCTION
ERGONOMICS
ME-658

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer any five questions.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) To what extent are the industries aware of the ergonomics in the present scenario? Does the ergonomics check list really helpful for the preliminary investigations of working conditions? What may be the general ergonomics checklist for the work place design? [06]

1(b) What are the various causes of development of risks for work related musculoskeletal disorders. Suggest a design alteration in an equipment of your choice to reduce to prevalence of WMSDs: [06]

2 (a) Explain the theory of signal detection in the context of information. [04]

2 (b) What is Compatibility? Discuss human information process system in the context of compatibility. [04]

2 (c) List and explain the basic approaches for measuring mental workload. [04]

3 (a) Explain the information processing model of memory. How the sensory memory is different from short term memory. [06]

3 (b) Under what conditions analogue displays are preferred over digital displays? What are the basic features of quantitative displays? [06]

4 (a) A manufacturing industry wishes to replace its existing work station with new’ Sit-Stand workstation’ that enables workers to work in either a sitting or standing position. List the Anthropometric variables that would be needed to design the...
work station. Would you prefer to use the general anthropometric data or the data supplied by the company?

4 (b). What are the various causes of Low back pain? Can a system be designed to prevent the occurrence of the low back pain?

5 (a) What do you mean by Job demands? Discuss the fitness for work. [06]

5 (b) List the factors which may be used for making Metabolic Equivalent of task (MET) calculations, by giving a suitable example. [06]

6 A worker lifts cartons weighing 20 kg and having an area of 30 cm² from a conveyer to a pallet. The worker grasps the middle of each carton as there are no handles. The centre of gravity of the load is 50 cm from the lumbar spine. The height of the pallet adjusts automatically to 80 cm and the height of the conveyer is 70 cm above the floor. The worker turns by 45° each time a carton is transferred. The worker performs 5 lifts per minutes for 1 hour per day. Calculate RWL and LI using the NIOSH lifting equation given below,

\[ \text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \]

Where \(\text{LC} = 23\) kg, \(\text{HM} = 25/H\), \(\text{VM} = 1 - 0.0032A\), \(\text{FM} = 0.8\), \(\text{CM} = 1\) for good coupling, 0.95 for fair coupling and 0.9 for poor coupling.

Assume any data if required.

Comment on the safety of the task. Suggest how the safety of the task can be improved.

7 Write short notes on any three of the following: [04x3]

(i) Factors affecting Manual material handling system.

(ii) Effect of Illuminations on human performance

(iii) Factors influencing shift work and the guide lines used for the design of shift work system.

(iv) Effect of hand arm and whole body vibrations on physiological performance of the worker?
1(a) What do you understand by power plant economics? Discuss the factors affecting economics of generation and distribution of power.

1(b) What do the following terms mean: HRSG, CCHP, Tri-generation, CAES, Pumped hydro, Hydrograph. Write twenty words for each of them.

2(a) Derive a general expression for the overall efficiency of a combined cycle having N number of cycles in series and in parallel.

2(b) Draw block diagram of Steam Injected Gas Turbine cycle (STIG). What are its advantages?

3 Carry out thermodynamic analysis of Pressurized Water Reactor (PWR) and Gas Cooled Reactor (GCR)

4 In a cogeneration binary cycle, superheated steam enters the turbine with a mass flow rate of 5 kg/s at 40 bar, 440°C and expands isentropically to 1.5 bar. Half of the flow is extracted at 1.5 bar and used for industrial process heating. The remaining steam passes through a heat exchanger which serves as the boiler of the R-12 cycle and the condenser for the steam cycle. The condensate leaves the heat exchanger as saturated liquid at 1 bar, where it is combined with the return flow from the industrial process at 60°C and 1 bar, before being pumped isentropically to the steam generator. The R-12 cycle is an ideal Rankine cycle with refrigerant
entering the turbine at 16 bar, 100°C and saturated liquid leaving the condenser at 9 bar. Determine a) the rate of heat transfer in the steam generator, b) the net power output of the binary cycle and c) the rate of heat transfer to the industrial process.

5 Explain in detail the different Energy Storage Methods.

6(a) Draw and discuss the performance characteristics of a gas turbine plant showing the effect of the following parameters with pressure ratio on the thermal efficiency of the cycle:

(i) regenerator effectiveness
(ii) turbine inlet temperature
(iii) combined intercooling-regeneration-reheat processes

6(b) What are the advantages of Intercooling and Reheating in a Gas Turbine Plant? Derive an expression for the thermal efficiency of a GTP having Intercooler, Regenerator and Reheater by taking into account the component efficiencies. Also draw relevant schematic and T–s diagrams.

7(a) Discuss the advantages and disadvantages of Gas Turbine Power Plant over Steam Power Plant

7(b) A gas turbine draws-in air from atmosphere at 1 bar and 283 K and compresses it to 5 bar with an isentropic efficiency of 80%. The air is heated to 1200 K at constant pressure and then expanded through two stages in series back to 1 bar. The high pressure turbine is connected to the compressor and produces just enough power to drive it. The low pressure stage is connected to an external load and produces 80 kW of power. The isentropic efficiency is 85% for both stages. Calculate the mass flow of air, the inter-stage pressure of the turbines and the thermal efficiency of the cycle. Take, for compressor $\gamma = 1.4$ and for turbine $\gamma = 1.33$, $R = 0.287 \text{ kJ/kgK}$ for both. Neglect the increase in mass due to fuel addition.
Question 1 (a)
What are the possible causes of friction? Show that the modified adhesion theory of friction predicts large scale junction growth and high coefficient of friction.

Question 1 (b)
Discuss adhesion theory of metals with contaminant films. Write the condition of gross sliding and hence derive the expression for coefficient of friction. Plot the coefficient of friction against relative strength of the interface and discuss some salient features.

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

Question 3 (a)
Derive the equations for the determination of pressure distribution and load capacity for step slider bearing.

Question 3 (b)
The data for a particular inclined slider bearing are given as follows.
Length of the bearing = 8 cm, width of the bearing = 6 cm, velocity of slider = 2 m/s.
Viscosity of the lubricant at the operating temperature = 100CP, Minimum film thickness of the lubricant film = 0.002 cm, Maximum film thickness of the lubricant film = 0.006 cm. Estimate the load capacity and power loss in the bearing.

Question 4 (a)
Derive the expression for the flow rate of an incompressible fluid through a rectangular slot. Derive the expression for the flow rate and load capacity for a conical hydrostatic bearing.

Question 4 (b)
The hydrostatic thrust bearing of a generator consist of 6 pads. The total thrust is
900KN and the film thickness is 0.05 mm. The viscosity of the lubricant is 59 CP. Neglecting the flow over the corners, each pad can be considered as a circular area of 500 mm and 100 mm outer and inner diameters respectively. Calculate the supply pressure and flow requirement in l/mm.

5 Describe the load carrying phenomenon of squeeze film bearings. In a journal bearing, the journal does not rotate but is approaching the bearing surface, find

(i) the expression of load carrying capacity.

(ii) time taken to move a distance from $\varepsilon - \varepsilon_1$ to $\varepsilon - \varepsilon_2$.

6(a) State Darcy's law and write the principle of operation of porous metal bearing.

6(b) Derive the generalized Reynolds equation governing the pressure distribution for a porous metal bearing.

7(a) Describe thermal wedge in hydrodynamic lubrication. Considering thermal effects, obtain the Reynolds equation governing the pressure distribution in a long journal bearing.

7(b) What are gas lubricated bearings. For the case of isothermal condition, derive the Reynolds equation governing the pressure distribution for a long bearing.
2014-15
M.TECH. (WINTER SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
MECHANICS OF COMPOSITE MATERIALS
(ME-682)

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) | What are the composite materials? Categorize these materials on the basis of size and shape of the reinforcement. | [06]
1(b) | State and derive rule of mixture considering longitudinal strength and stiffness. | [06]
2(a) | Evaluate the transverse modulus $E_2$ of a composite lamina using both strength of material approach and Halpin-Tsai relationship using $\xi = 1$ with the following properties. $E_{2f}=14.8$ GPa, $E_m=3.45$ GPa, $\theta_m=0.36$, $V_f=0.65$. | [06]
2(b) | Draw and explain stress-strain relationship of the composite and its component. Derive the fraction of load carried by fibre in a unidirectional lamina in terms of usual notation. | [06]
3(a) | Derive the transformation matrix $[T]$ used in $\{\sigma\}_{1,2} = [T] \{\sigma\}_{x,y}$ for a unidirectional stressed lamina in terms of usual notations. | [06]
3(b) | A high strength composite has the following elastic constants $E_1=145$ GPa, $E_2=12$ GPa, $E_6=6$ GPa and $\theta_{12}=0.25$. Determine the transformed reduced stiffness matrix for the lamina with ply angle $\theta=45^\circ$. | [06]
4(a) | The reduced stiffness matrix of a lamina is given by:

$$
\begin{pmatrix}
181.8 & 2.897 & 0 \\
2.897 & 10.34 & 0 \\
0 & 0 & 7.17
\end{pmatrix}
$$

GPa

Contd….2.
Determine $E_1$, $E_2$, $G_{12}$ and $\theta_{12}$ of the orthotropic lamina?

4(b) What are the types of laminates for the following structure? Mention which elements [A], [B], [D] are zero.

a) $[\pm 45/\pm 45]$

b) $[30/-45/-30/45]$

c) $[0/90/0/90]$

d) $[0/90]$

5 Determine the stiffness matrices [A], [B] and [D] for a laminate $(0^0/90^0)$ for ply thickness $d=0.125\text{mm}$ with the following material properties:

$E_1=140\text{ GPa}$, $E_2=10\text{ GPa}$, $E_6=5\text{ GPa}$ and $\theta_{12}=0.3$.

6 State basic assumptions used in classical laminate plate theory and derive equilibrium equation of a laminated plate subjected to arbitrary transverse load $q$ in terms of stress and moment resultants.

7(a) Discuss various failure modes of long aligned fibre reinforced composite material subjected to compressive load in fibre direction. Also draw sketches to illustrate these modes.

7(b) An angle ply lamina made of S glass/epoxy has the following properties in the principal fibre direction.

$F_{11}=1280\text{ MPa}$, $F_{1C}=622\text{ MPa}$, $F_{21}=49\text{ MPa}$, $F_{2C}=245\text{ MPa}$, $F_6=69\text{ MPa}$, $E_1=35\text{ GPa}$

$E_2=7\text{ GPa}$, $E_6=3\text{ GPa}$, $\theta_{12}=0.3$.

A tensile load of $\sigma_x=2\text{ MPa}$ is applied at an angle $60^0$ to the principal fibre direction. Check the safety of the laminate as per maximum stress theory and Tsai-Hill theory.

8 Write short notes on the following:

a) Application of composites

b) Fibres and whiskers.

c) Manufacturing of FRP composites.

d) Tsai-Hill failure criteria for fibre reinforced composite.

e) The boundary conditions for bending of symmetric angle ply laminates for simply supported edges.
Question

1(a) A polygon defined by vertices in the order: \((x, y), (3x, y), (3x, 3y), (x, 3y)\), is to be transformed so that its area is to be reduced to half (without changing the aspect ratio or centroid) and the diagonal passing through \((x, 3y)\) and \((3x, y)\) becomes parallel to the \(x\)-axis. What are the transformations required to do this? Write down the transformation matrix for each step.

1(b) Derive the concatenated transformation matrix if three pure reflection transformations through the three mutually perpendicular coordinate planes are applied successively to an object. Show that it results in reflection through the origin.

OR

1'(a) Show that there is one-to-one correspondence between points on the line \(AB\) and the transformed line \(A^*B^*\) when line \(AB\) is operated on by a general \(2 \times 2\) transformation matrix.

1'(b) Show that the translation of a point \(P\) to \(P''\) produced by two successive half-turns about different points \(A\) \((m, n)\) and \(B\) \((p, q)\) is equal to twice the directed distance from \(A\) to \(B\). Draw a sketch in support of your answer.

2(a) Discuss viewing transformation and show that for this transformation, \(s_x = s_y\) if and only if \(a_w = a_v\), where \(s_x, s_y\) are the scaling factors in \(x\) and \(y\) directions respectively and \(a_w, a_v\) are the aspect ratios of window and viewport respectively.
2(b) Generate a parametrically represented parabolic segment in the first quadrant for $1 \leq x \leq 4$ for the parabola given by $x = a\theta^2 = \theta^2$, $y = 2a\theta = 2\theta$ with 10 points on the segment.

3 Apply 3D geometric transformations to make the given tetrahedron ABCD rotate about the x-axis, making it erect with its base ABC resting on the $xz$ plane. Next magnify it four times about a fixed point $P(1, 1, 2)$.

$$
[A] = \begin{bmatrix}
0 & 0 & 0 & 1 \\
2 & 0 & 0 & 1 \\
1 & \sqrt{5} & 0 & 1 \\
1 & 1 & 1 & 1
\end{bmatrix}
$$

OR

3' What is the sequence of transformations required for reflecting an object through an arbitrary plane? Consider an arbitrary reflection plane passing through a point $P(x_0, y_0, z_0)$ with $(c_x, c_y, c_z)$ as the direction cosines of the normal to the reflection plane. Find the matrices of all the sequential transformations for reflecting an object through this plane. Draw figures in support of your answer.

4 Find the trimetric projection for the computer display of a cube formed by a $\phi = 30^\circ$ rotation about the y-axis, followed by a $\theta = 45^\circ$ rotation about the x-axis and then parallel projection onto the $z = 0$ plane. The position vectors for the cube are:

$$
[X] = \begin{bmatrix}
0 & 0 & .1 & 1 \\
1 & 0 & 1 & 1 \\
0 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 \\
1 & 0 & 0 & 1 \\
1 & 1 & 0 & 1 \\
0 & 1 & 0 & 1
\end{bmatrix}
$$

5(a) Explain the following terms:

Nodes, primary nodes, secondary nodes and internal nodes.

5(b) Derive expressions for natural coordinates in a 4 noded tetrahedron element. Show that it results into volume coordinates.
1(a) Name the various types of patterns used for making castings. Discuss various pattern materials.

1(b) Total liquid volumetric shrinkage and total solid volumetric shrinkage of an aluminium alloy are 6.6% and 5% 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) and the riser. Justify the location of the riser provided by you.

All the dimensions are in mm.
2(a) What is gating system in metal casting? Discuss the function of ingredients of the gating system. 

2(b) Design the gating system with riser, chill and/or exothermic materials (if required) for the following product:

All dimensions are in mm.

3(a) What is meant by nucleation and grain growth of molten metal in mould cavity? Explain the formation of (i) wholly columnar grains, (ii) partially columnar and partially equi-axed grains and (iii) partially columnar and partially equi-axed grains. 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 sand mould and chill mould. Discuss its effect (if any) on mushy stage formation and dendrites growth during solidification of an alloy.

OR

3' Explain riser, chill and use of exothermic material in sand casing. Discuss open riser, blind riser, external riser and internal riser. Discuss with the help of neat sketches the effect of location of riser on its size. Also explain the end affect and effect of chill on the location of riser.

4 Define dross in aluminium casting. Explain the hydrogen pick-up in aluminium molten metal. Discuss fluxing and flushing in aluminium casting. Discuss moulding
sand for aluminium castings. Discuss the fabrication of cores and steel inserts in aluminium casting.

5 Give chemical composition spheroidal graphite iron. Define carbon equivalent in cast iron. Explain the effect of shape and size of graphite on the properties of S.G. iron. Discuss the role of magnesium on the formation of S.G. iron. Discuss the effect of sulphur content on the S.G. iron.

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.
2014-15
M.TECH. (WINTER SEMESTER) EXAMINATION
(THERMAL SCIENCES)
SOLAR ENERGY
ME-763

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)  
Explain: solar time, selective coatings, threshold intensity of solar radiation and collector efficiency factor.  
[06]

1(b)  
With the help of a neat sketch show the main components of a flat plate solar collector and write the names of the materials used for each component. Also, discuss the methods for improving the efficiency of flat plate solar collectors.  
[09]

2  
With appropriate diagrams, derive the relation for useful heat gain in terms of the heat removal factor and fluid inlet temperature for a liquid flat plate solar collector. Write the assumptions made.  
[15]

OR

2'  
Describe the thermal test procedure of box type solar cookers and evaluate the performance parameters of a box type solar cooker having aperture area 0.25 m² with the following experimental observations:

No Load Test:

<table>
<thead>
<tr>
<th>Time</th>
<th>I(W/m²)</th>
<th>T_p°C</th>
<th>T_a°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00</td>
<td>778</td>
<td>126</td>
<td>35</td>
</tr>
<tr>
<td>11:20</td>
<td>788</td>
<td>129</td>
<td>36</td>
</tr>
<tr>
<td>11:40</td>
<td>832</td>
<td>132</td>
<td>37</td>
</tr>
<tr>
<td>12:00</td>
<td>864</td>
<td>135</td>
<td>38</td>
</tr>
<tr>
<td>12:20</td>
<td>886</td>
<td>137</td>
<td>39</td>
</tr>
<tr>
<td>12:40</td>
<td>886</td>
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<tr>
<td>13:00</td>
<td>886</td>
<td>140</td>
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<tr>
<td>13:20</td>
<td>853</td>
<td>138</td>
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</tr>
<tr>
<td>13:40</td>
<td>842</td>
<td>137</td>
<td>37</td>
</tr>
</tbody>
</table>

contd...
Observation of Load Test (with 2 litres of water):

<table>
<thead>
<tr>
<th>Time</th>
<th>I(W/m²)</th>
<th>T_w(°C)</th>
<th>T_a(°C)</th>
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</thead>
<tbody>
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<td>10:20</td>
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<td>54</td>
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<tr>
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<tr>
<td>13:20</td>
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<td>98</td>
<td>38</td>
</tr>
</tbody>
</table>

3(a) Calculate solar temperature for wetted, and glazed roof for I(t)=300 W/m². Given α(wetted)=0.9, αr(glazed)=0.8, T_a=32 °C, h₁=66 W/m²K, U_t=6.7 W/m²K. [05]

3(b) Derive an expression for the rate of net heat transferred into a room having south wall as double glazed wall. [05]

3(c) Draw a schematic diagram of a double slope solar still and write down the energy balance equations for different components of it. [05]

OR

3(c)' Draw a schematic diagram of a cabinet dryer and write down the energy balance equations for different components of it. [05]

4(a) Derive an expression for outlet air temperature for a conventional solar air heater. [08]

4(b) Discuss various types of concentrating collectors. [07]

OR

4(b') Discuss various thermal energy storage systems. [07]