Maximum Marks: 60  Duration: 02 Hours

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

1(a) Discuss:
(a) Open Loop & Closed loop system
(b) Time-variant & time-invariant system

1(b) Write the demerits of a closed loop system. Also explain whether a washing machine is a closed loop system or an open loop system.

2(a) For the block diagram shown in figure-1, find C/R by block diagram reduction technique

\[ \text{Figure-1} \]

2(b) Define node, forward path, transmittance and loop in the context of SFG

OR

2(b') Obtain the transfer function of the SFG in figure-2 using Mason’s gain formula.

\[ \text{Figure-2} \]
3(a) Obtain the state space representation of the circuit shown in figure-3.

\[
\begin{align*}
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} &= 
\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 10 & -2 & -3 \end{bmatrix}
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + 
\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \\
y &= \begin{bmatrix} 3 & 4 & 1 \end{bmatrix}
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}
\end{align*}
\]

3(a') Examine the observability of the system given by:

3(b) Define Controllability and Observability.

4(a) The open loop transfer function of a unity feedback system is given by:

\[ G(s) = \frac{K}{s(1+sT)} \]

Where, \( K \) & \( T \) are positive constants. By what factor should the amplifier gain be reduced so that the peak overshoot of unit step response of the system is reduced from 80% to 30%?

4(b) Explain absolute and relative stability.

4'(a) The open loop transfer function of a unity feedback control system is given by:

\[ G(s) = \frac{k}{s(s+2)(s+3)} \]

Sketch the root locus.

4'(b) A step force of 1000 N is applied to the mass \( M \) of the mechanical system shown in figure-4 at \( t = 0 \). The parameters of the system are: \( M = 1000 \) kg; \( B = 10,000 \) N/(m/sec); and \( k = 100,000 \) N/m. The initial conditions are: \( y(0) = \dot{y}(0) = 0 \).
Obtain the following parameters: damping ratio ($\xi$), un-damped natural frequency ($\omega_n$), and damped natural frequency ($\omega_d$).

5 Sketch the Nyquist plot of the transfer function

$$G(s) = \frac{100}{(s+2)(s+5)}$$
Maximum Marks: 60

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Keep your answers brief and specific

Q No. Question M.M.

1(a) Draw a line diagram to show how the welded joint is designated. [03]

(b) A bracket, as shown in Fig. 1, carries a load of 20 kN. Find the size of the weld if the allowable shear stress is not to exceed 80 MPa. [09]

Fig. 1

25 kN

2(a) Write expression for Sommerfeld number. Draw the line diagram for pressure profile in a sliding contact bearing and show the following parameters on it: $h_0$, $e$, $p_{\text{max}}$, $c$, $\theta_{\text{max}}$, $\theta_{\text{p0}}$, $\phi$. [03]
(b) Select a suitable ball bearing to operate at 1500 rpm, and is acted upon by 8000 N radial load and 5000 N thrust load. The inner ring rotates & the load is steady. The shaft diameter is 45 mm and life expectancy is 500 hrs. (refer: Table 1a & 1b)

Table 1a:

<table>
<thead>
<tr>
<th>Series</th>
<th>Bearing No</th>
<th>Bore mm</th>
<th>C₀</th>
<th>C</th>
<th>Max rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>6209</td>
<td>45</td>
<td>17750</td>
<td>24910</td>
<td>8000</td>
</tr>
<tr>
<td>Medium</td>
<td>6309</td>
<td>45</td>
<td>29225</td>
<td>40700</td>
<td>8000</td>
</tr>
<tr>
<td>Heavy</td>
<td>6409</td>
<td>45</td>
<td>45600</td>
<td>57400</td>
<td>45000</td>
</tr>
</tbody>
</table>

Table 1b:

<table>
<thead>
<tr>
<th>$F_a/e_o$</th>
<th>$e$</th>
<th>$F_a/(VF_I) \leq e</th>
<th>X_1</th>
<th>Y_1</th>
<th>X_2</th>
<th>Y_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.110</td>
<td>0.30</td>
<td>1.00</td>
<td>0</td>
<td>0.56</td>
<td>1.45</td>
<td></td>
</tr>
<tr>
<td>0.17</td>
<td>0.34</td>
<td>1.00</td>
<td>0</td>
<td>0.56</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>0.38</td>
<td>1.00</td>
<td>0</td>
<td>0.56</td>
<td>1.15</td>
<td></td>
</tr>
</tbody>
</table>

3(a) Write the names of different types of brakes. In a block brake with short shoe which of the condition is chosen while designing: (symbols have usual meaning).
   (i) $a > \mu c$
   (ii) $a = \mu c$
   (iii) $a < \mu c$

(b) Deduce that the torque transmitting capacity of a centrifugal clutch is given by:

\[
(M_c)_f = \frac{\mu m z r a (\omega_f^2 - \omega_i^2)}{1000}
\]

OR

3'(a) A centrifugal clutch transmitting 20 kW at 750 rpm consists of four shoes. The clutch is to be engaged at 500 rpm. The inner radius of drum is 165 mm while the radius to the centre of gravity of the shoes in engaged position is 140 mm, the coefficient of friction is 0.3. Calculate the mass of each shoe.

(b) A multi disk clutch consists of five steel plates and four bronze plates. The inner and outer diameters of friction disks are 75 mm and 150 mm respectively. The coefficient of friction is 0.1 and the intensity of pressure is limited to 0.3 N/mm². Assuming uniform wear theory, calculate
   a) The required operating force
   b) The power transmitting capacity at 750 rpm

4(a) Write briefly the process and purpose of nipping in leaf spring. Draw a line diagram to support your answer.

(b) Helical compression spring is made of hard drawn wire of 18 SWG. The outer
diameter of the spring is 12.5 mm. Estimate torsional yield strength of the material, static load corresponding to yield strength, spring index, deflection due to this static load, if number of turns is 13.5, solid length of the spring and possibility of buckling if end are squared. Use following data for calculations:

<table>
<thead>
<tr>
<th>18 SWG</th>
<th>E</th>
<th>G</th>
<th>m</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>d = 1.219 mm</td>
<td>198.6 kN/mm²</td>
<td>80.7 GPa</td>
<td>0.190</td>
<td>1783 MPa</td>
</tr>
</tbody>
</table>

5(a) Write different types of gears. What factors are considered while deciding the type of the gear for an application? [03]
(b) Write the design steps for spur gear. [09]

OR

5' Derive Lewis equation for beam strength of gear teeth. What is Lewis form factor. Explain on what considerations gears are designed? [12]
Answer all the questions. 
Assume suitable data if missing. 
Notations used have their usual meaning.

Q.No.  Question  M.M.

1(a)  A rectangular fin of length 30 cm, width 30 cm and thickness 2 mm is attached to a surface at 300 °C. The fin is made of aluminium (k=204 W/m-K) and is exposed to air at 30 °C with heat transfer coefficient as 5 W/m²·K. Assuming the insulated fin tip, determine the temperature of the fin at 20 cm from the base.

1(b)  An electric wire of length 1 m and diameter 20 mm having specific electric resistance $10^{-4}$ Ohm·m, is insulated at critical thickness of insulation with thermal conductivity k=0.12 W/m·K. The surrounding air temperature is 25°C and $h=30 W/m^2·K$. If the insulation has a maximum allowable temperature of 200°C, what is the maximum possible current that may be passed by the wire?

OR

1'  Prove that for a body whose thermal resistance is zero, the temperature required for cooling or heating is given by: $\frac{t-t_a}{t_i-t_a} = \exp\left[-B_iF_o\right]$, where symbols have usual meanings.

A thermocouple junction which can be approximated as 1 mm diameter sphere is used to measure a gas stream of temperature 200 °C. Junction is at initially 25 °C. Determine how long will it take for the thermocouple junction to read 199 °C. Properties of thermocouple junction are $C_p=320$ J/kg°C, $k=35$ W/m·K, $\rho=8500$ kg/m³. The heat transfer coefficient between the junction and gas stream is 210 W/m²·K.

2(a)  Explain the physical mechanism of natural convection with the help of examples and neat sketches.

$\text{contd.} \ldots 2.$
2(b) Air at 15°C flows over a flat plate at a velocity of 3 m/s. The plate is maintained at a temperature of 85 °C. Width of the plate is 50 cm. Calculate the local heat transfer coefficient and heat transfer from the plate at 50 cm from the leading edge. You may use: 
\[ Nu = 0.332Re_x^{1/2} Pr^{1/3} \]
Properties of air at 50 °C are:
\[ \rho = 1.093 \frac{kg}{m^3}, C_p = 1.005 \frac{kJ}{kg - K}, k = 0.02824 \frac{W}{m - K}, Pr = 0.698, \nu = 17.95 \times 10^{-6} m^2/s \]

OR

2'(a) A vertical plate 2m x 2m is maintained at constant temperature of 150 °C in the still surrounding air of 30 °C. Calculate the rate of heat transfer from the plate. You may use: 
\[ Nu = 0.15 (GrPr)^{1/3} \]
Properties of air at film temperature are:
\[ \rho = 0.972 \frac{kg}{m^3}, C_p = 1.009 \frac{kJ}{kg - K}, k = 0.0313 \frac{W}{m - K}, Pr = 0.69, \nu = 16.0 \times 10^{-6} m^2/s \]

2'(b) Describe various types of boiling with practical examples.

3(a) State Kirchhoff's law and Wien's displacement law of radiation.

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

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

OR

4' Water enters a parallel flow heat exchanger at 22 °C with a flow rate of 815 kg/min. While oil enters at 115 °C with a flow rate of 490 kg/min. The overall heat transfer coefficient is 1000 W/m²K and heat exchanger area is 12 m². Find the exit temperature of the two fluids and effectiveness of heat exchanger. Assume specific heat of water as 4.2 kJ/kg K and that of oil as 3.6 kJ/kg K.

5 Define Fick's law of diffusion and derive the general mass diffusion equation.
2016-17  
B.E. (AUTUMN SEMESTER) EXAMINATION  
MECHANICAL  
FLUID MECANICS – II  
EME332  

Maximum Marks: 60  
Credits: 04  
Duration: Two Hours

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

Q.No.  
1  Steady Uniform \((U)\) flow over a flat plate exists. The flat surface is porous in nature and fluid is being drawn off into the porous surface such that the normal velocity at the surface is \(V\). Fluid (kinematic viscosity, \(\nu\)) may be assumed as Newtonian and viscous, but also incompressible. Using the configuration shown in Figure 1, solve the Navier-Stokes equation by explicitly stating the assumptions made to show that the velocity distribution is \(u(y) = U(1 - e^{-y})\).

![Figure 1](image_url)  

\(v(x,0)=V\)

2  For a flow over a flat plate with zero pressure gradient, starting from dimensional form of Navier-Stokes equation, derive the Prandtl’s Boundary Layer Equation.

OR

2'(a)  Following are parametric forms of three velocity profiles over a stationary surface:

\[(i) \frac{u}{u_\infty} = \frac{3y}{2\eta} - \frac{1}{2} \left(\frac{y}{\eta}\right)^3 ; (ii) \frac{u}{u_\infty} = -\frac{3y}{2\eta} + \frac{1}{2} \left(\frac{y}{\eta}\right)^3 + \left(\frac{y}{\eta}\right)^4 ; (iii) \frac{u}{u_\infty} = \frac{y}{\eta} - \frac{1}{2} \left(\frac{y}{\eta}\right)^3 - 2 \left(\frac{y}{\eta}\right)^4\]

Check whether the above boundary layers adheres to or detaches from the surface.
2'(b) Water with a uniform free stream velocity of 1.8 m/s flows past a flat plate of length L=10 cm. Find the thickness of the velocity boundary layer at a location x = 5 cm. At the same location, find the fluid velocity at a distance y = 0.0245 cm away from the surface. Calculate drag on the plate per meter depth into the plane of the paper. For water \( \rho = 983.1 \text{ kg/m}^3, v = 0.4748 \times 10^{-6} \text{ m}^2/\text{s}.

\[
\eta = y/\sqrt{\frac{\nu x}{U_\infty}}
\]

<table>
<thead>
<tr>
<th>( \eta )</th>
<th>( f )</th>
<th>( f'(\eta) = \frac{u}{U_\infty} )</th>
<th>( f''(\eta) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.33206</td>
</tr>
<tr>
<td>1.2</td>
<td>0.23795</td>
<td>0.39378</td>
<td>0.31659</td>
</tr>
<tr>
<td>2.0</td>
<td>0.65003</td>
<td>0.62977</td>
<td>0.26675</td>
</tr>
<tr>
<td>5.0</td>
<td>3.28329</td>
<td>0.99155</td>
<td>0.01591</td>
</tr>
</tbody>
</table>

3. Explain Reynolds Decomposition of Turbulent flow and derive Reynolds Averaged Navier-Stokes Equation.

4(a) Explain the operation of the converging-diverging nozzles under the effect of different back-pressures. Show with graph the pressure distribution inside the nozzle for different back-pressures.

4(b) Air flows isentropically in a converging-diverging nozzle with a throat area of 2 cm\(^2\). At section 1, the pressure is 101 kPa, \( T_1 = 300 \text{ K} \), and \( V_1 = 744 \text{ m/s} \). Determine \( A_1 \) and the mass flow. Also comment on weather Nozzle is choked or not.

**OR**

4(b') A pitot static tube is placed in subsonic air flow. The static pressure and temperature in the flow are 64 kPa and 300K respectively. The difference between the pitot and static pressures is measured and found to be 36 kPa. Find the air velocity (a) assuming an incompressible flow and (b) assuming compressible flow

5 Prove that Shock can only occur in Super sonic conditions and are only compressive in nature.

**OR**

5' What do you understand with the terms Fanno Line and Rayleigh curve? Describe the flow of compressible fluid in a constant area duct with heat transfer and derive the relationships for increase in flow property with change in Mach number.
Maximum Marks: 60
Duration: Two Hours

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

Q.No.   Question                                                                                     M.M.
1(a)    Explain productivity. Describe the various types of the productivity with formulae. [5]
1(b)    What is product design and product development? Describe the stages of a product life cycle. [7]
2       Calculate the critical path of the project given below and calculate the free and total float of non critical activities. [12]

<table>
<thead>
<tr>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>$t_0$</th>
<th>$t_m$</th>
<th>$t_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>--</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>B</td>
<td>--</td>
<td>8</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>--</td>
<td>1.5</td>
<td>7</td>
<td>0.5</td>
</tr>
<tr>
<td>D</td>
<td>A</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>A</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>E,B</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>G</td>
<td>E,B</td>
<td>8</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>H</td>
<td>C</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>D,F</td>
<td>6</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>J</td>
<td>D,F</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>K</td>
<td>G,H</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>L</td>
<td>G,H</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>M</td>
<td>J,K</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>L</td>
<td>6</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

3       What is work measurement and its functions? Describe, using practical numerical example, any one work measurement technique. [12]
3'(a) What do you mean by capacity planning? Explain its strategies with examples.

3'(b) Discuss operational scheduling in manufacturing industry environment. Describe the principles of operational scheduling.

4(a) At present a company is purchasing an item X from outside suppliers. The consumption is 10,000 units/year. The cost of the item is Rs. 5 per unit and the ordering cost is estimated to be Rs. 100 per order. The cost of carrying inventory is 25% of the unit cost. If the consumption rate is uniform, determine the economic purchasing quantity and total variable cost.

4(b) In the problem 4(a) assume that company is going to manufacture the item with the equipment that is estimated to produce 100 units per day. The cost of the unit thus produce is Rs. 3.50 per unit. The setup cost is Rs. 150 per setup and the inventory carrying charge is 25% of the unit cost. How has your answer changed?

5 What are the techniques to find out the initial basic feasible solution to the transportation problems? Determine the initial basic feasible solution to the following transportation problem by using NWCM and LCM.

<table>
<thead>
<tr>
<th>Destination</th>
<th>D1</th>
<th>D1</th>
<th>D1</th>
<th>D1</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>21</td>
<td>16</td>
<td>15</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>S1</td>
<td>17</td>
<td>18</td>
<td>14</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>S1</td>
<td>32</td>
<td>27</td>
<td>18</td>
<td>41</td>
<td>19</td>
</tr>
</tbody>
</table>

| Demand      | 6  | 10 | 12 | 15 |

OR

5'(a) What do you mean by quality? Name the various quality control tools.

5'(b) Explain Pareto diagram and cause and effect diagram.