1. Answer any three parts of the following: [5,5,5]

(a) Use the method of iteration to solve the equation \( xe^x = 1 \), starting with \( x = 1 \). Perform four iterations, taking the readings up to four decimal places.

(b) Derive the Newton-Raphson procedure for finding the cube root of a real number \( N \). Use it to find the cube root of 18 correct to two decimals, assuming 2.5 as the initial approximation.

(c) Solve the following equations by Gauss-Seidel method of iteration:
\[
\begin{align*}
5x + 4y - 10z &= 65 \\
6x + y + z &= 105 \\
4x + 8y + 3z &= 155
\end{align*}
\]
Give only three iterations.

(d)(i) Solve by Gauss-elimination method the equations \( 2x + y + 4z = 12, 8x - 3y + 2z = 20, 4x + 11y - z = 33 \).

(ii) Show that the following sequence
\[
X_{n+1} = \frac{1}{8} X_n (6 + \frac{3a}{x_n^2} - \frac{x_n^2}{a})
\]
has convergence of third-order with the limit \( \sqrt{a} \).

2. Answer any three parts of the following: [5,5,5]

(a) Using Newton’s divided difference formula find (i) \( f(5) \) and (ii) \( \int f(x)dx \) from the following data:
\[
\begin{array}{cccccc}
 x & 0 & 2 & 3 & 4 & 7 & 9 \\
 f(x) & 4 & 26 & 58 & 112 & 466 & 922
\end{array}
\]

(b)(i) Using Newton’s forward difference formula, find the cubic polynomial which takes the following values
\[
y(0) = 1, y(1) = 0, y(2) = 1 \quad \text{and} \quad y(3) = 10.
\]
Hence obtain \( y(4) \).

(ii) Prove the following with the usual notation:
\[
h D = \sinh^{-1}(\mu D)
\]
End...2,
The following table gives the velocity \( v \) of a particle at time \( t \):

\[
\begin{array}{cccccccc}
\text{t (second)} & 0 & 2 & 4 & 6 & 8 & 10 & 12 \\
\text{\( v \) (metres/sec)} & 4 & 6 & 16 & 34 & 60 & 94 & 136
\end{array}
\]

Find by Simpson's \( \frac{1}{3} \) - rule the distance moved by the particle in 12 seconds and also the acceleration at

(i) \( t = 1 \) sec,
(ii) \( t = 2 \) seconds.

(d) Determine \( a, b \) and \( c \) such that the quadrature formula

\[
\int_0^h f(x) \, dx = h \left\{ a f(0) + bf \left( \frac{h}{3} \right) + cf(h) \right\}
\]

is exact for polynomials of as high order as possible.

3. Answer any three parts of the following: [5,5,5]

(a) Using Taylor's series method, obtain the solution of \( \frac{dy}{dx} = 3x + y^2 \) and \( y = 1 \) when \( x = 0 \). Find the value of \( y \) for \( x = 0.1 \) correct to four places of decimals.

(b) Using Modified Euler's method, find the value of \( y \) when \( x = 0.1 \) given that \( y(0) = 1 \) and \( y' = x^2 + y \). Take \( h = 0.05 \) and give only two iterations at each step.

(c) Apply the fourth order Runge-Kutta method, to find an approximate value of \( y \) when \( x = 0.2 \) given that \( y' = x + y \), \( y(0) = 1 \). Take \( h = 0.2 \).

(d) Using finite difference method, solve the boundary value problem

\[
y'' - 64y + 10 = 0 \text{ with } y(0) = y(1) = 0. \text{ Compute the value of } y(0.5).
\]

Take \( h = \frac{1}{4} \)

4. (a) Solve graphically \( \text{Max } Z = 2x_1 + 3x_2 \) subject to

\[
x_1 + x_2 \leq 12, \quad x_1 + 2x_2 \leq 18, \quad x_1, x_2 \geq 0.
\]

(b) Solve the following Linear programming problem by Simplex method

\[
\text{Max } Z = 3x_1 + 2x_2
\]

Subject to \( x_1 + x_2 \leq 4, \quad x_1 - x_2 \leq 2, \quad x_1, x_2 \geq 0. \)

(c) Find the dual of the following Linear programming problem

\[
\text{Max } Z = 2x_1 + 3x_2 + x_3 \text{ subject to } 4x_1 + 3x_2 + x_3 = 6, \quad x_1 + 2x_2 - 5x_3 = 4, \quad x_1, x_2, x_3 \geq 0.
\]

OR

Contd...3,
A firm manufactures three products A, B and C. The profits are Rs. 3, Rs. 2 & Rs. 4 respectively. The firm has two machines $M_1$ and $M_2$ and below is the required processing time in minutes for each machine on each product.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>$M_1$</td>
<td>4</td>
</tr>
<tr>
<td>$M_2$</td>
<td>2</td>
</tr>
</tbody>
</table>

Machine $M_1$ and $M_2$ have 2000 and 2500 Machine minutes respectively. The firm must manufacture 100 A's, 200 B's and 50 C's but not more than 150 A's. Set up a LPP to maximize profit.
B.TECH. AUTUMN (V SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
KINEMATICS OF MACHINES (ME-314)
Credits: 05

Maximum Marks: 60

Duration: Three Hours

Attempt all questions.
Assume suitable data if missing.

Q.1 (a) What do you mean by inversion of a mechanism? Explain with sketches of all the
inversions of single slider crank mechanism. Where these inversions are used? (3)
(b) Describe Hart's mechanism with a neat sketch and prove that the tracing point describes a
straight line path. (5)
(c) Describe with a neat sketch the working of Davis steering gear mechanism. Also prove
that for Davis steering gear, \( \tan \alpha = \frac{w}{2l} \)

Where, \( w \) distance between pivots
\( l \) wheelbase
\( \alpha \) inclination of track arm to the longitudinal axis. (4)

Q.2 In a toggle mechanism as shown in figure (1), D is constrained to move on a horizontal
path. The dimensions of various links are: AB = 200mm, BC = 300mm, OC = 150mm
and BD = 450mm. The crank OC is rotating in counter-clockwise direction at a speed of
180 rpm, increasing at the rate of 50 rad/s\(^2\). Find, for the given configuration
(i) Velocity and acceleration of D (12)
(ii) Angular velocity and angular acceleration of link BD.

OR
Q.2' In a quick return mechanism as shown in figure (2), the driving crank OA is 60mm long and rotates at a uniform speed of 200 rpm in the clockwise direction. For the position shown find
(i) Velocity at the ram R
(ii) Acceleration at the ram R
(iii) Acceleration of the sliding block A along the bar CD.

Q.3 (a) Synthesize a four bar function generator to solve the equation \( y = \frac{1}{x}, \ 1 \leq x \leq 3 \) using Chebyshev spacing for three precision points. Given \( \varphi_0 = 30^\circ, \psi_0 = 200^\circ \) and \( \Delta \varphi = \Delta \psi = 90^\circ \). Assume the length of the fixed link as 10cm.

(b) Design a slider crank mechanism such that \( \varphi_{12} = 30^\circ, \varphi_{23} = 50^\circ, S_{12} = 25cm, S_{23} = 20cm \). The input crank moves in a clockwise sense while the output slider moves away from the fixed pivot \( O_2 \).

Q.4 (a) Derive equations to describe the displacement diagram of a cam that rises with parabolic motion from a dwell to another dwell such that the total lift is \( L \) and the cam rotation angle is \( \beta \). Plot the displacement diagram and the first-, second- and third order kinematic coefficients with respect to cam rotation.

(b) A symmetrical circular arc cam operates a flat faced follower. The minimum radius of the cam is 40 mm and nose radius is 8 mm. The total angle of action is \( 150^\circ \) and the cam lifts the follower by 24mm.

(i) Calculate the main dimensions of the cam.

(ii) If the speed of the cam is 420 rpm, find the acceleration of the follower at the start of rise and at the apex of nose.

OR

Q.4' (a) With the help of a neat diagram explain the cam terminology.

(b) A disc cam operates an offset roller follower. The offset of the follower axis is 10mm towards the right and its lift is 18 mm. Least radius of the cam is 25 mm and the diameter of the roller is 15mm. The follower rises with cycloidal motion for \( 80^\circ \) of cam rotation followed by a dwell period of \( 90^\circ \), and then descends for the next \( 120^\circ \) of cam rotation with parabolic motion. Draw the cam profile taking any suitable scale.
Q5 (a) What is interference in gears? Derive an expression for the minimum number of teeth required on the wheel and pinion to avoid interference. (6)

(b) An epicyclic gear train is shown in figure (3). The number of teeth on gears A and B are 80 and 200 respectively. Determine the speed of the arm if
(i) Gear A rotates at 100 rpm clockwise and gear B at 50 rpm counter-clockwise.
(ii) Gear A rotates at 100 rpm clockwise and gear B is stationary. (6)

---

Fig. Attached
Figure 1

Figure 2

Figure 3

CD=300 mm, DR=400 mm
1. (a) Discuss the problems in Engineering Design. 
(b) Write the different welding processes and explain Thermit Welding in detail. 
(c) A shaft of rectangular cross-sections is welded to a support by means of fillet weld as shown in Fig. (1). Determine the size of the weld, if the permissible shear stress in the weld is limited to 80 MPa. 

2. (a) Explain in brief the single block or shoe brake and derive the relation for the braking torque when the fulcrum point is below the line of action of forces on the shoe, if the brake drum rotates in clockwise and counter clockwise directions. 
(b) A single block brake has a torque capacity of 45Nm as shown in Fig. (2). The coefficient of friction of the timing material is 0.40 and the permissible pressure is 0.80N/mm². The diameter of the brake drum is 430mm. Take width of the lining equal to its length. Determine. 
(i) Dimensions of the brake 
(ii) Actuating force 
(iii) Resultant lining pin reaction 
(iv) Rate of heat generated if the drum rotates at 125 rpm. 

2'. (a) Explain in brief a single plate clutch. Also derive the relation for Torque transmitting capacity of single plate clutch by using uniform pressure theory. 
(b) A cone clutch with cast iron surfaces and coefficient of friction of 0.25 is to transmit 32KW at 525rpm. The maximum diameter is limited to 320mm. The cone pitch angle is 15° and the average pressure is limited to about 350K.N/m². 
Determine 
(i) The face width. 
(ii) The force required to hold the clutch in engagement. Assume uniform wear. 

Contd.....2
3. (a) What do you mean by Nipping of the Leaf spring. Also derive the relations for the nip and the stress developed in the full lengths leaves.

(b) An automobile single plate clutch is used to transmit 150KW at 450rpm. The friction plate has 60mm outer diameter and 35mm inner diameter. The coefficient of friction 0.3. Find the force required to engage the clutch and the wire diameter of the springs if six springs are used. Also find total number of turns free length; spring constant and pitch of the spring. Use spring index as 5, active number of turns 6, St = 800 MPa and G = 81370 MPa. Ends of the springs are squared and ground.

4. (a) Explain pressure generation mechanism in hydrodynamic bearings and also write the lubrication assumptions while deriving Reynold’s equation governing the pressure distribution.

(b) A sleeve bearing is 32mm in diameter and 32mm long. The shaft rotates at 1750rpm and subjects the bearing to a radial load of 1100N. The diametral clearance is 40μm. Using SAE 30 oil at an inlet temperature of 50°C. Find

(i) the temperature rise and average temperature of the lubricant
(ii) the minimum film thickness and
(iii) the power lost due to friction.

OR

4'. (a) Define basic static load rating, basic dynamic load rating, rating life and write the equation determining AFBMA rating for static load for deep groove ball bearings.

(b) Radial deep groove ball bearings are to be selected for locations at O and B, to support the overhung counter shaft shown in Fig. (3). The belt tensions shown are parallel to each other. The tension on the loose side on pulley A is 20 percent of the tension on the tight side. Shaft speed is 720rpm. The bearings are to have a reliability of 99 percent corresponding to a life of 24Kh. Use an application of unity. Find the dynamic load capacities of the bearings at O and B so that it can be selected from the manufactures catalogue.

5. (a) Power is being transmitted through a pair of helical gears. Hence, derive the expressions for the components of the total tooth force acting on the gear.
(b) A 12 tooth pinion has a module of 2mm and drives a 64 tooth gear. The gears have a face width of 25mm and are hobbed using a pressure angle of 20° and a dedendum 1.25m. The pinion is cut from BS070M20 steel and gear is made of BS150 Cast iron. Both driving and driven machinery are subjected to slightly unsteady loading. Use a factor of safety n = 1.5, 50 percent reliability, below average mounting conditions a pitch line velocity of 3.8m/s, find the power capacity of this gear set based on contact stress. \[ C_p = 174\sqrt{\text{MPa}} \].

OR

(b') A 20° full depth spur pinion is transmitting 20kW at 1440rpm to gear. The gear ratio is 2.5 and number of teeth on pinion is 20. The teeth are generated with rack cutter. The loading is smooth in both driving and driven gear. The material of the pinion is plain carbon steel (\(\sigma_p = 136.67\) MPa) while the gear is made of gay cast iron (\(\sigma_p = 66.67\) MPa). Design the gears using Lewis equation.

Recommended modules (mm):
1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 16, 20, 25, 32, 40, 50.

[Figure Attached]
### LIFE AND RELIABILITY MODIFICATION FACTORS

<table>
<thead>
<tr>
<th>Cycles of Life</th>
<th>Life Factor</th>
<th>Reliability</th>
<th>Reliability Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^4$</td>
<td>1.5</td>
<td>Up to 0.99</td>
<td>0.80</td>
</tr>
<tr>
<td>$10^5$</td>
<td>1.3</td>
<td>0.99 to 0.999</td>
<td>1.00</td>
</tr>
<tr>
<td>$10^6$</td>
<td>1.1</td>
<td>0.999 up</td>
<td>1.25 up</td>
</tr>
<tr>
<td>$10^8$ up</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OVERLOAD CORRECTION FACTOR

<table>
<thead>
<tr>
<th>Source of Power</th>
<th>Uniform</th>
<th>Moderate Shock</th>
<th>Heavy Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>1.00</td>
<td>1.25</td>
<td>1.75</td>
</tr>
<tr>
<td>Light shock</td>
<td>1.25</td>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>Medium shock</td>
<td>1.30</td>
<td>1.75</td>
<td>2.25</td>
</tr>
</tbody>
</table>

### DAD DISTRIBUTION FACTORS

<table>
<thead>
<tr>
<th>Characteristics of Supports</th>
<th>Face width, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50</td>
<td>1.2</td>
</tr>
<tr>
<td>50-150</td>
<td></td>
</tr>
<tr>
<td>150-225</td>
<td></td>
</tr>
<tr>
<td>225-400 up</td>
<td></td>
</tr>
<tr>
<td>Over 2.0</td>
<td></td>
</tr>
</tbody>
</table>

*Note: DAD stands for Dynamic Axial Deflection.*
INSTRUCTIONS TO THE EXAMINEES

(i) Answer all questions.
(ii) The symbols have their usual notations.
(iii) Use of property table is permitted.
(iv) Assume suitable data if required.

1(a). Define fin efficiency and fin effectiveness. Giving significance of Biot Number, explain the limitations in applying fins on a heat transfer surface.

1(b). A rod is connected to two plates at its ends having temperatures $T_1$ and $T_2$. The rod is exposed to an environment with convection coefficient $h$ and temperature $T_e$. Obtain an expression for temperature distribution in the rod and hence, the location where there will be minimum temperature.

OR

1'(a). Obtain the expression for Critical Insulation thickness. State its importance in the insulation of current carrying conductors and steam carrying pipes.

1'(b). Mention some of the practical systems having internal heat generation. During the ripening process of oranges, the energy released is estimated as $563 \text{ W/m}^3$. If the orange is assumed to be homogenous sphere of diameter $80 \text{ mm}$ with $k=0.15 \text{ W/mK}$, compute temperature at the center of the orange and the heat flow from the outer surface,

(i) if the external surface temperature is $2^\circ\text{C}$.

(ii) if instead of the external surface temperature, the ambient air having $h=12 \text{ W/m}^2\text{K}$ is at $2^\circ\text{C}$ temperature.

2. Derive the Integral form of Energy Equation for the forced convection laminar boundary layer over a flat plate and solve it by using suitable temperature and velocity profiles.

OR

2'. Describe the phenomenon of boiling and differentiate between

(i) Sub-cooled and Saturated boiling

(ii) Pool and Forced boiling.

With the help of a neat diagram, explain various regimes of Pool Boiling of water over a heated wire. Also, explain critical heat flux and burn out point.

3. Using the concept of radiosity and irradiation of diffuse surfaces, obtain the relation for radiant heat transfer between two long concentric cylinders.

Three thin walled long circular cylinders 1, 2 and 3 of diameters 15cm, 25cm and 35cm, respectively, are arranged concentrically. Temperature of the innermost cylinder (emissivity, $\varepsilon_1=0.05$) is $80K$ and that of the outer most cylinder (emissivity, $\varepsilon_3=0.2$) is $300K$ while emissivity of inner and outer surfaces of the cylinder 2 is $\varepsilon_2=0.1$. Assuming vacuum in the annular spaces, determine the steady state temperature attained by the cylinder 2.
<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(a)</td>
<td>Define solid angle and intensity of radiation. Show that emissive power, ( E_b = \pi I_b ).</td>
</tr>
<tr>
<td>3(b)</td>
<td>Explain radiation shape factor and obtain its relation between two bodies. Using the relation for shape factor between the sun and earth, find the value of solar constant if the sun emits 90% radiation. Take the diameters of earth and sun equal to ( 12.8 \times 10^6 ) m and ( 13.76 \times 10^8 ) m, respectively and their mean distance as ( 14.86 \times 10^{10} ) m. Estimate the temperature of the sun using Wein's displacement law, if the maximum solar radiation entering the earth's atmosphere is at wavelength of 0.5 ( \mu \text{m} ).</td>
</tr>
<tr>
<td>4(a)</td>
<td>Explain fouling factor. What is its effect on the overall heat transfer coefficient.</td>
</tr>
<tr>
<td>4(b)</td>
<td>It is desired to condense 40000 kg/h of dry and saturated steam at a pressure of 0.05 bar (saturation temperature = 32.76°C) in a single pass steam condenser. The cooling water enters the tube at 20°C and leaves at 26°C. The tube has an inner diameter of 25 mm and outer diameter of 27.5 mm. The thermal conductivity of the tube material is 110 W/m K, and the film heat transfer coefficient of water and steam side are 7090 and 5930 W/m²K respectively. Neglecting the scale resistance, calculate the surface area of the tubes required and the heat transfer rate. If the length of tube is 3 m, find the number of tubes.</td>
</tr>
<tr>
<td>5(a)</td>
<td>Obtain an expression for total mass transfer during isothermal evaporation from the surface of water in a deep tank and subsequent diffusion through a stagnant air layer.</td>
</tr>
<tr>
<td>5(b)</td>
<td>If the Dry and Wet Bulb temperatures of the atmospheric air are 32.2°C (DBT) and 18.3°C (WBT) respectively, determine relative humidity of the air.</td>
</tr>
</tbody>
</table>
1. (a) Show that the pressure force/vol on a fluid particle, \( \frac{-\nabla p}{\rho_0} \), in an incompressible homogeneous flow is irrotational in character.

(b) Figure 1 shows a uniform flow approaching a steadily rotating circular cylinder. Determine, using inviscid theory

(i) the location of stagnation pts.

(ii) the magnitude and direction of the force/length on the cylinder.

(c) A circular cylinder with three holes (pressure ports) in placed in a uniform approaching stream as shown in Figure 2. Using inviscid theory, show that (assume \( \alpha < \theta \))

(i) \( p_3 - p_1 = 2 \rho_0 \int_0^2 \sin \theta \sin 2\alpha \).

(ii) If the cylinder is rotated or aligned slightly in the appropriate direction, the pressure \( p_1 \) & \( p_3 \) can be made equal. In this setting the pressures are recorded as, \( p_1 = p_3 = \bar{p} \) and \( p_2 = \rho_0 \). Show that \( \rho_0 - \bar{p} = 2 \rho_0 \int_0^2 \sin^2 \theta \).

(iii) For \( \theta = 45^\circ \), obtain the relations for \( U_0 \) and \( \alpha \) in terms of \( p_1, p_3, \bar{p}, \rho_0 \) and \( \rho_0 \).

2. (a) Figure 3 shows a regular shock reflection at a plane wall. If the Mach number and pressure upstream of the incident shock are 2.5 and 100 KPa, respectively, obtain the values of the Mach number and pressure downstream of the reflected shock.

(b) Air flow from a large tank through a well insulated 12 mm diameter pipe. If the air enters the pipe at \( M_1 = 0.25 \) and leaves at \( M_2 = 0.7 \), determine;

(i) Length of pipe

(ii) the additional length of pipe needed to cause sonic state at exit.

(iii) The % age reduction in the mass flow rate if the pipe is 60 cm longer than length required to cause sonic state at exit, provided same condition exist in the supply chamber. \((\gamma = 1.4, C_p = 1.004 \text{ KJ/Kg})\)
2. (a) Figure 4 shows the flow of air at a pressure and temperature of 50KPa and –20°C at a Mach number of 3.0 in a duct. The upper wall turns sharply at point A through an angle of 5° leading to the formation of oblique shock wave. This oblique shock wave strikes the lower wall of the duct exactly at point B where the lower wall turns away from the flow through an angle of 2°. Find
(i) the distance AB if the duct width is 0.7 m.
(ii) the Mach number, pressure and temperature behind the reflected wave.

(b) Air enters a constant area duct at \( M = 0.2 \) and stagnation temperature = 120°C. Determine:
(i) the maximum temperature achievable under these conditions at exit and the corresponding Mach Number at exit.
(ii) the amount of heat transfer/mass required to achieve the maximum temperature at exit.
(iii) the amount of heat transfer/mass required to achieve sonic state at exit.

3. (a) What is meant by length and time scales in a turbulent flow.

(b) Differentiate clearly between an Ensemble-average and a time-average of a turbulent flow variable. Under what conditions(s) the Ensemble-average and a time-average of a turbulent flow variable at a point is likely to be equal.

(c) Consider a turbulent boundary layer flow of air (\( v = 15 \times 10^{-6} \text{ m}^2/\text{s} \)) over a flat plate of length 20 cm aligned parallel to the flow. The free stream velocity is 100 m/s. Carry out an order of magnitude analysis to estimate the largest and smallest time and length scales (along flow direction) of the turbulent flow at a distance of 12 cm from the leading edge.

(d) Consider two turbulent flow variable \( \phi_1 \) and \( \phi_2 \). Using Reynold’s decomposition for a statistically stationary turbulent flow show that, \( \overline{\phi_1 \phi_2} = \overline{\phi_1} \overline{\phi_2} + \phi_1' \phi_2' \)

4. (a) For two neighbouring points in an element of fluid under strain, explain the four component motions in which the total motion of the element can be decomposed into. Write the expression for these motions.

(a’) Write 3-D Navier-Stokes’ equations in Cartesian coordinates and convert these into Non-Dimensional form. With the help of these equations explain the significance of Reynolds number of flow.

(b) Obtain the governing equation and the following velocity profile for the flow between two parallel plates \( h \) distance apart with the lower plate fixed and the upper plate moving with a uniform velocity \( U_0 \) (Couette Flow)
\[
u = \left( \frac{y}{h} \right) U_0 - \frac{h^2}{2\mu} \frac{dp}{dx} \left( \frac{y}{h} \right) \left[ 1 - \frac{y}{h} \right]
\]
(b') A fluid is contained between two concentric cylinders with the outer cylinder rotating with a speed of 150 rpm and the inner cylinder is at rest. The radii of the outer and inner cylinders are 12.0 and 10.0 cm respectively and the length of cylinders is 25.0 cm. Find the torque on the inner cylinder. Take kinematic viscosity of fluid $v = 100.0 \times 10^{-6}$ m$^2$/s and $\rho = 1000$ kg/m$^3$.

(c) (i) A two-dimensional jet hits a plane wall as shown in the figure. The consequent flow pattern is called stagnation in plane flow or Hiemenz flow. For this flow obtain the following governing equation:

$$\phi'' + \phi'' - \phi^3 + 1 = 0$$

with the boundary conditions:

$$\eta = 0; \, \phi'(0) = 0 = \phi(0); \, \eta = \infty: \phi'(\infty) = 1$$

(ii) Using the numerical solution of the Hiemenz flow given below obtain value of velocities $u$ and $v$ and the shear stress at a distance $x = 0.1$ m, $y = 0.005$m away from the stagnation point. Take kinematic viscosity of the fluid $v = 25.0 \times 10^{-6}$ m$^2$/s and $a = 1.0$/s. Assume any value not given.

5. (a) Laminar boundary-layer is formed over a flat plate kept at zero angle of incidence with the incoming stream having a velocity $U_0 = 20$ m/s. The kinematic viscosity of the fluid is $v = 20.0 \times 10^{-6}$ m$^2$/s. Using the numerical solution of the Blassius equations $f'' + \frac{1}{2} f \cdot f'' = 0$ taking $u = U_c f'(\eta)$ given below, find the following at a distance of 0.5 m from the leading edge:

(i) $x$-direction velocity $u$ at a distance $y = 0.001$ m away from the plate,
(ii) maximum shear stress, $\tau_0$,
(iii) boundary-layer thickness $\delta$.  

contd... 4
OR

(a') For the problem given above in 5(a), integrate the continuity equation and obtain the following expression for the maximum value of the transverse velocity $v_\infty$:

$$v_\infty = 0.8604 U_\infty \sqrt{\frac{v}{x U_\infty}}$$

Also calculate $v_\infty$ at a distance of 0.6 m from the leading edge.

(b) Explain the mechanism of separation of boundary-layer. Illustrate the concept by the help of diagram and also by the profiles of velocity, velocity gradients $\left(\frac{\partial u}{\partial y}\right)$ and $\left(\frac{\partial^2 u}{\partial y^2}\right)$ in boundary-layer before the onset of separation and at the point of separation.

(c) Using the following approximate expression for the velocity profile in the boundary-layer over a flat plate at zero angle of incidence, obtain with the help of Von-Karman momentum-integral equation – the velocity profile, the displacement thickness and the skin-friction coefficient:

$$\frac{u}{U_\infty} = A + B \left(\frac{y}{\delta}\right) + C \left(\frac{y}{\delta}\right)^2 + D \left(\frac{y}{\delta}\right)^3,$$

where $\delta$ is boundary-layer thickness.
1.a  A company is considering the purchase of a new piece of testing equipment that is expected to produce $8000 additional income during the first year of operation, this amount will probably decrease by $500 per year for each subsequent year of ownership. The equipment costs $20000 and will have an estimated salvage value of $3000 after 8 years of use. For an interest rate of 15% compounded quarterly, determine whether the investment is economically justified or not. Use present worth method.

OR

1.a'  A standby electric power generator was purchased 6 years ago for $8000. At that time it was expected that the equipment would be used for 15 years and would have a salvage value of 10 percent of the first cost. The generator is no longer needed and is to be sold for $2500. Using an interest rate of 14% compounded monthly, determine the difference between the anticipated and actual equivalent annual costs.

1.b  A proposed mill in an isolated area can be furnished with power and water by a gravity feed system. A stream high above the mill will be tapped to provide flow for water needs and power requirements by connecting it to the mill with a ditch-and-tunnel system or with a wood-and-concrete flume that winds its way down from the plateau. Either alternative will meet current and future needs, and both will utilize the same power generating equipment. The ditch-and-tunnel system will cost $500000 with an annual maintenance cost of $2000. The flume has an initial cost of $200000 and a yearly maintenance cost of $12000. In addition, the wood portion of the flume will have to be replaced every 10 years at a cost of $100000. Compare the alternatives on the basis of capitalized costs with an interest rate 8% per year.
2.a. Differentiate between:
   i. Defender and Challenger
   ii. Demand Pull inflation and Cost Push Inflation
   iii. Declining balance and double declining balance methods of depreciation

2.b. 4 projects are to be compared on the basis of benefit cost criteria. Each project has an expected life of 50 years and is to be evaluated with a tax free interest rate of 10%. Data for the project, in rupees, are as follows:

<table>
<thead>
<tr>
<th>Proposal</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost (Rs.)</td>
<td>150,000</td>
<td>200,000</td>
<td>310,000</td>
<td>450,000</td>
</tr>
<tr>
<td>Annual Maintenance Cost (Rs.)</td>
<td>8,000</td>
<td>10,000</td>
<td>5,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Estimated Annual Benefits (Rs.)</td>
<td>35,000</td>
<td>30,000</td>
<td>59,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Salvage Value (Rs.)</td>
<td>2500</td>
<td>2000</td>
<td>4000</td>
<td>4500</td>
</tr>
</tbody>
</table>

On the basis on an incremental B/C ratio analysis select the appropriate alternative.

**OR**

2. b'. A machine was purchased 3 years ago for Rs. 40,000. It is proposed to replace it with a new machine which will cost Rs. 34,500 and is expected to reduce the operating costs. Costs and salvage values for the two machines are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Defender D</th>
<th>Challenger C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operating cost (Rs.)</td>
<td>Salvage Value (Rs.)</td>
</tr>
<tr>
<td>0</td>
<td>12500</td>
<td>12500</td>
</tr>
<tr>
<td>1</td>
<td>3400</td>
<td>7000</td>
</tr>
<tr>
<td>2</td>
<td>3900</td>
<td>4000</td>
</tr>
<tr>
<td>3</td>
<td>4600</td>
<td>2500</td>
</tr>
<tr>
<td>4</td>
<td>5600</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>2600</td>
<td>2000</td>
</tr>
<tr>
<td>6</td>
<td>2600</td>
<td>15000</td>
</tr>
</tbody>
</table>

Should a replacement be made if the required rate of return is 15% and the services of the machine will be needed for only 4 more years?
3.a. How do different managers require different skills and roles in an organization? Explain using practical examples.

3.b. What are the environmental and ethical issues considered important in the context of management? Give examples.

4.a. Differentiate between tactical goals and operational goals in the context of an organization.


4.c. Leadership and management are related but they are not the same. Do you agree? Giving suitable examples support your answer.

OR

4'.a. Explain the leadership grid in the context of behavioral approach to leadership

4'.b. List the benefits and limitations of job specialization. Explain any two approaches used to counter the problem associated with job specialization.

4'.c. Why is motivation important in organization? State the essential elements of any motivation theory.

5.a. What is first order exponential smoothing method of making forecast?
Demand for part number 2710 was 200 in April, 50 in May and 150 in June. The forecast for April was 100 units. With a smoothing constant of 0.2 and using first order exponential smoothing, what is the July forecast?

5.b. A company orders a certain automobile part periodically and delivery is instantaneous. Annual demand estimated to be 2160 units is constant. The cost of the part/unit and procurement cost per order are $8 and $9 respectively while the carrying charge per unit time is estimated to be 15% of the cost of the part. What quantity should be ordered and when?

5.c. What is Pareto's analysis and how it is used in industry? Explain with an example.
1(a) Explain the difference between orientational, electronic and ionic polarizations in brief.

(b) Define static dielectric constant and obtain the relation \( P = \varepsilon_0(\varepsilon_r-1) E \).

(c) What is piezoelectricity? Give two examples of piezoelectric materials. Draw hysteresis curve for ferroelectric material and discuss it briefly.

OR

(c') The electronic polarizability of the Ar atom is \( 1.8 \times 10^{-39} \text{ F.m}^2 \). What is the static dielectric constant of Ar gas at 1 atmospheric pressure at room temperature (300K)?

[Given: \( k_B = 1.38 \times 10^{-23} \text{ J/K} \) and \( \varepsilon_0 = 8.854 \times 10^{-12} \text{ F/m} \)]

2(a) What is dipolar relaxation? Obtain the relation for orientational polarization in alternating fields.

(b) Explain the diffusion process in semiconductors and find a relation for diffusion current per unit area for \( n \) and \( p \) type semiconductors.

(c) An intrinsic Si sample is doped with donors from one side such that \( N_d = N_c \exp(-ax) \).

(i) Find an expression for \( E(x) \) at equilibrium over the range for which \( N_d >> n_i \).

(ii) Evaluate \( E(x) \) when \( a = 4 \text{ (\mu m)}^{-1} \).

3(a) How ferromagnetism is explained on the basis of exchange interaction? Give a brief account of Weiss theory of ferromagnetism.

(b) The magnetic field in a diamagnetic material is \( 1000 \text{ Am}^{-1} \). Calculate the magnetization and flux density of the material if its susceptibility is \(-0.4 \times 10^{-5}\).

(c) Distinguish between hard and soft magnetic materials. Give two examples for each.
4(a) Derive the London's equations and explain the term coherence length.

(b) A d.c. voltage of 1μV is applied across a Josephson junction. Calculate the frequency of the Josephson current generated. [Given: \( h = 6.63 \times 10^{-34} \text{ J.s} \)]

(c) Discuss briefly the potential applications of superconductors.

4(a') Explain d.c. Josephson effect. Show that the super current of superconducting pairs across the junction depends on the phase difference.

(b') A superconductor sample has a critical temperature of 3.722 K in zero magnetic field of 0.0305 T at 0 K. Evaluate the critical field at 2 K.

(c') Discuss the thermodynamics of superconducting transition in detail.