Maximum Marks: 60

Note: Answer all the questions.

1. (a) Answer any TWO parts:
   (i) Find the Laplace transform of \( t^2 e^t \sin 4t \).
   (ii) Find the inverse Laplace transform of \( \frac{1}{(s^2 + 2s + 5)} \).
   (iii) Evaluate \( \int_1^\infty \left( \frac{1}{s(s^2 - 4)} \right) \) by convolution theorem.

(b) Solve the following differential equation by Laplace transform method:
    \( (D^2 - 2D + 3) x = 0; \quad x_0 = 0, \quad Dx + 1 \text{ at } t = 0, \quad x - 1 \text{ at } t = \pi/8 \).
    OR

(b') A steel ball of mass \( m \) falls from rest under gravity in a liquid which resists the motion with a force \( mk \) times the velocity. Determine the motion at any time \( t \).

(c) Find the Laplace transform of period function:
    \[ f(t) = \begin{cases} 1 & 0 < t < c \\ 2c - t & c < t < 2c \end{cases} \]

2. (a) Find the value of \( n \) for which vector field \( r^n \hat{r} \) will be solenoidal. Also find whether the vector field \( r^8 \hat{r} \) is irrotational or not.
    OR

(a') A vector field is given by
    \[ \vec{F} = (y \sin z - \sin x) \hat{i} + (x \sin z + 2yz) \hat{j} + (xy \cos z - y^3) \hat{k}. \]
    Show that the field \( \vec{F} \) is irrotational and find the scalar potential \( \phi \).

(b) Find the directional derivative of \( \phi = x^2 - 2y^2 + 4z^2 \) at the point \((1, 1, -1)\) in the direction \( 2\hat{i} + \hat{j} - \hat{k} \). Also, find the maximum value of directional derivative at \((1, 1, -1)\).

(c) If \( \vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \).
   (i) Find \( \nabla \| \vec{r} \| \).
   (ii) Show that \( \text{div} (r\phi) = 3\phi + \vec{r} \cdot \nabla \phi \).

Contd....2
3. (a) If \( \vec{A} = (3x^2 + 6y)\hat{i} - 14xz\hat{j} + 20xz^2\hat{k} \), evaluate \( \int_{C} \vec{A} \cdot d\vec{r} \) from \((0, 0, 0)\) to \((1, 1, 1)\).

along the following paths:

(i) \( x = t, \quad y = t^2, \quad z = t^3 \)

(ii) the straight lines from \((0, 0, 0)\) to \((1, 0, 0)\) then to \((1, 1, 0)\) and then to \((1, 1, 1)\).

(b) Use divergence theorem to evaluate the surface integral.

\[
\int_{S} \left( x^2 \, dy \, dz + x^2 y \, dz \, dx + x^2 z \, dy \, dx \right),
\]

where \( S \) is the sphere \( x^2 + y^2 + z^2 = 1 \).

(c) Verify Green's theorem in the plane for \( \int_{C} (xy + y^2) \, dx + x^2 \, dy \), where \( C \) is the closed curve of the region bounded by \( y = x \) and \( y = x^2 \).

OR

(c') Verify Stoke's theorem for the function \( \vec{F} = x^2\hat{i} + xy\hat{j} \) integrated round the square in the plane \( z = 0 \) and bounded by the lines \( x = 0 \), \( y = 0 \), \( x = 2 \) and \( y = 2 \).

4. (a) If \( f(z) = u + iv \) is an analytic function of \( z = x + iy \) and \( u - v = e^z (\cos y - \sin y) \), find \( f(z) \) in terms of \( z \).

OR

(a') Show that the function:

\( u(x, y) = 3x^2y + 2x^2 - y^2 - 2y^2 \) is harmonic. Find the conjugate harmonic function \( v \) and express \( u + iv \) as an analytic function of \( z \).

(b) Use Cauchy integral formula to evaluate

\[
\int_{C} \frac{\sin^2 z}{(z - \frac{\pi}{6})} \, dz, \quad \text{where} \quad C : |z| = 1.
\]

(c) Use Cauchy's residue theorem to evaluate

\[
\int_{C} \frac{z^3 - 3}{z^3 + 2z + 5} \, dz, \quad \text{where} \quad C : |z + 1 - i| = 2.
\]
2014 - 2015
B.TECH. WINTER (IV SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
NUMERICAL METHODS & OPTIMIZATION
(AM 232)
Credits : 04

Maximum Marks: 60
Duration: Three Hours

Note: Answer all the questions.
Programmable calculators are not allowed.
Do all the calculations up to four decimal places.

1. (a) Solve, by Newton-Rapson method, the following equation

\[ 3x - \cos x - 1 = 0. \]

Correct up to 4 decimal places.

OR

(a) Find a real root of \( x^3 + x^2 - 100 = 0 \) using general iteration method with 3 iterations.
Take \( x_0 = 4.2 \).

(b) Solve the following systems of linear equations by Gauss-Seidel method. Perform 3 iterations.

\[
\begin{align*}
2x + y + 4z & = 12 \\
8x - 3y + 2z & = 20 \\
4x + 11y - z & = -33
\end{align*}
\]

(c) The equation \( x^2 + ax + b = 0 \) has two real roots \( \alpha \) and \( \beta \). Show that the iteration method

\[ x_{k+1} = -\frac{(ax_k + b)}{x_k} \]

is convergent near \( x = \alpha \) if \( | \alpha | > | \beta | \) and that \( x_{k+1} = -\frac{(b)}{(x_k + a)} \) is convergent near \( \alpha \) if \( | \alpha | < | \beta | \). Show also that the iteration method \( x_{k+1} = -(x_k^2 + b)/a \) is convergent near \( x = \alpha \) if \( 2 | \alpha | < | \alpha + \beta | \).

2. (a) The following data represent the function \( f(x) = \cos (x + 1) \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>0.0</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td>0.5403</td>
<td>0.3624</td>
<td>0.1700</td>
<td>-0.6292</td>
</tr>
</tbody>
</table>

Estimate \( f(0.5) \) using Newton's backward difference interpolation. Compare with the exact value.

(b) A curve is drawn through points given in the following table:

<table>
<thead>
<tr>
<th>( x )</th>
<th>1.1</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>2.0</td>
<td>2.4</td>
<td>2.7</td>
<td>3.2</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Find (i) the radius of curvature \( \rho = \frac{(1 + (y')^2)^{3/2}}{y''} \) at \( x = 1.5 \)

(ii) The volume of the solid of revolution obtained by revolving the curve about the \( x \)-axis between the points \( x = 1.0 \) and \( x = 3.0 \).
(b') Derive two point Gauss formula

\[ \int_{-1}^{1} f(x) \, dx = \lambda_0 f(x) + \lambda_1 f(-x). \]

Apply this formula to evaluate

\[ \int_{\frac{\pi}{2}}^{\pi} \frac{\cos 2x}{1 + \sin x} \, dx. \]

(c) Prove the following with usual notations:

\[ \Delta = \frac{1}{2} \delta^2 + \frac{1}{8} \sqrt{1 + \frac{\delta^2}{4}}. \]

3. (a) Given the initial value problem \( y' = x^2 + y^2, \ y(0) = 0 \). Determine the first three non-zero terms in the Taylor series for \( y(x) \) and hence find the value for \( y(1) \).

OR

(a') Solve the initial value problem

\[ \frac{dy}{dx} - \frac{y}{x} = \frac{1}{x^2}, \ y(1) = 1.0 \]

using R. K. method of fourth order. Evaluate \( y(1.1) \).

(b) Solve boundary value problem

\[ y'' = xy, \ \ y(0) + y'(0) = 1, \ y(1) = 1 \]

with \( h = \frac{1}{2} \) using finite difference method.

4. (a) A manufacturer produces both interior and exterior paints from two raw materials \( M_1 \) and \( M_2 \). The following table provides the basic data of the problem:

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Tons of raw material per ton of paint</th>
<th>Maximum daily availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_1 )</td>
<td>Exterior paint: 6 Interior paint: 4</td>
<td>24</td>
</tr>
<tr>
<td>( M_2 )</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Profit per ton (Rs.1000)</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

A market survey indicates that the demand for interior paint is more than one ton. Also, the maximum daily demand for interior paint is 2 ton. Formulate the problem as a linear programming problem and solve it for maximum profit by graphical method.

OR

Contd....
(a) Construct the dual of the following linear programming problem and then solve it graphically.
Minimize \[ z = 10x_1 + 15x_2 \]
subject to the constraints
\[ 5x_1 + 7x_2 \geq 80 \]
\[ 6x_1 + 11x_2 \geq 100 \]
\[ x_1, x_2 \geq 0 \]

(b) Solve following L.P. by Simplex method.
Maximize \[ z = 3x_1 + 2x_2 \]
subject to the constraints
\[ 2x_1 + x_2 \leq 10 \]
\[ x_1 + 3x_2 \leq 6 \]
\[ x_1, x_2 \geq 0. \]
Maximum Marks : 60

Note: Attempt ALL Questions, Symbols and abbreviations used have their usual meanings. Assume suitable value for missing data, if any.

1. (a) Differentiate between Flat Rate Tariff and Two Part Tariff.
(b) Explain, how the power factor of a single phase inductive load can be improved using capacitors.

OR
(b') A 24 kVA, 2400/240 V two winding transformer is to be connected as autotransformer with windings to be connected in series addition and load to be supplied at 240 Volts. Determine,
(i) the kVA rating of autotransformer.
(ii) the kVA transferred inductively as well as conductively.

2. (a) Draw and explain the working of a three point starter of a D.C. Shunt Motor.
(b) Mentioning the assumptions, derive the e.m.f. and torque equations of a D.C. Motor from first principles.

OR
(b') A 250 Volts D.C. shunt motor has armature and field resistances of 0.5 and 250 Ohms respectively. When driving a load, the torque of which is constant, the motor takes a current of 50 A and runs at 500 r.p.m. It is desired to raise the speed of the motor to 750 r.p.m. What resistance should be added in the shunt field circuit, assuming the magnetization curve to be straight line.

3. Attempt any two of the following:

(a) Why is a 3-phase synchronous motor not self-starting? What methods are generally used to start the synchronous motor?
(b) Describe in brief the construction of a hysteresis motor and show that it develops a running torque both at synchronous and asynchronous speed.
(c) Explain simply why a universal motor can operate from ac as well as dc supplies.

4. (a) Explain the principle of operation of a 3-phase induction motor.
(b) Derive the expression for torque developed by a 3-phase induction motor. Draw a typical torque-slip characteristic and deduce the condition for maximum torque.
(b') A 3-phase, 460 V, 100 hp, 50 Hz, four-pole induction motor delivers rated output power at a slip of 5%. Determine the:

(a) Synchronous speed and motor speed.  
(b) Speed of the rotating air gap field.  
(c) Frequency of the rotor circuit.  
(d) Slip rpm.  
(e) Speed of the rotor field relative to the:  
(i) Rotor structure.  
(ii) Stator structure.  
(iii) Stator rotating field.  
(f) Rotor induced voltage at the operating speed, if the stator-to-rotor turns ratio is 1:0.5.

5. (a) (i) Define turn-on and turn-off times for an SCR. Also draw these two characteristics.  
(ii) Mention various mechanisms by which SCR can be triggered into conduction.  

(b) What is a DC Chopper? Draw the Step up DC Chopper circuit. Describe the principle of its operation. Derive an expression for its average output voltage.

OR

(b') A single phase full bridge SCR rectifier feeds power to a Resistive Load. Draw the waveform of source voltage, load voltage and load current with firing signal given at an angle \( \alpha \). Also obtain the expression for average load voltage and r.m.s load voltage across load in terms of source voltage and firing angle \( \alpha \).
2014 - 2015
B.TECH. WINTER (IV SEMESTER) EXAMINATION
(ELECT./CHEMICAL/MECH./PETRO-CHEMICAL ENGINEERING)
COMMUNICATION SKILLS
(HU – 202)
Credits: 04

Maximum Marks: 40
Note: Answer all questions.
All questions carry equal marks.

Duration: Three Hours

UNIT – I

1. Write a persuasive letter to the prospective buyers of luxurious flats being developed in Greater Noida with all modern facilities. Try to convince the buyer with interesting and attractive offers.

OR

Write a job application and create your CV in response to an advertisement that you recently saw in a national newspaper.

UNIT – II

2. Define and draft any two of the following business messages assuming appropriate business situations:

(a) Tender and Bid
(b) e-mail
(c) Press Notice
(d) Memo

UNIT – III

3. Make notes or write an abstract of the following passage:

The real estate sector continues to confront liquidity issues owing to subdued demand and restricted debt funding. However, private equity (PE) funds have continued to gain strength as an alternate source of funding. PE fund inflows into the real estate sector in the first quarter of calendar 2015 grew 8% per cent to Rs. 5,168 crores, of which the residential sector attracted 63 per cent.

A study by real estate consultancy Cushman & Wakefield attributed the increase to improved market sentiments and higher investments in residential and commercial office assets.

The report said Chennai was the only city to see investment in commercial office space in first quarter of 2015. However, it said leased office assets such as IT parks and IT-SEZs are likely to gain significant interest from foreign investors “due to low risk, owing to high occupancy levels and with stable rental yields, and significant potential for capital value appreciation. In addition, the introduction of REITs (real estate investment trusts) in India is likely to boost investments as investors now have an exit route.”

During the period, residential assets recorded the second highest PE investment since 2008 with total value of investments in residential sector 4.5 times more than the year ago figure at Rs. 2,752 crores. The total investment in commercial office assets was at Rs. 2,416 crores, up 68 per cent. It was the third highest investment in the commercial office sector since 2008.

With improving macro-economic conditions, enabling policy environment, recovering demand, attractive valuations and increasing capital requirements of the Indian real estate sector, PE funds are likely to increase their investments in the next few years,” Sanjay Dutt, Executive Managing Director, South Asia, Cushman & Wakefield said in a statement.

“However, the PE funds are likely to take only calculated risks and collaborate strictly with renowned developers to protect their investments.”

The report said that although the number of deals during the quarter fell to 16 from 18, average deal size more than doubled to Rs. 320 crore from Rs. 150 crore.
UNIT - IV

4. How will you maximize your performance in a job frequently asked questions in job interviews? Attempt to answer two of such questions.

OR

Write the transcript of a telephonic conversation you had with the student advisor of a foreign university discussing your prospect of admission for M.S. and also the different options available for financial support there.

UNIT - V

5. Generate a group discussion choosing ONE of the following topics with at least FOUR participants:

(a) Reservation in jobs is doing more harm than good for the country.
(b) Privatization of health care will improve the quality of health care facility.
(c) Government should give more incentives to the farmers to ensure food security.
1.(a) The atomic packing efficiency of a crystal is 68%, and the closest distance of approach between the neighbouring atoms is 2.62 Å. Calculate the density of the crystal if the mass of its constituent atom is 50.04 amu.

1.(b) What are Miller Indices? Determine the Miller Indices for the following unit cell.

1.(c) What is a screw dislocation? Show Burgers circuit and Burger vector on a crystal having screw dislocation.

2.(a) Explain the term Mechanical Properties of Engineering materials.

2.(b) Differentiate between strength and toughness.

2.(c) List some important properties and uses of Cast Iron.

2.(d) What are TTT diagrams? Show the quenching process on it.

OR

3. Write a detailed note on alloys steels discussing the effects of various alloying elements on properties of steel.

3. What is heat treatment and for what purpose it is done? Explain the following heat treatment processes in detail:
   I. Hardening   II. Case hardening   III. Flame hardening

OR

3'. Explain in detail iron-carbon equilibrium diagram indicating the different phases. Also explain the following terms:
   I. Cementite   II. Ferrite   III. Austenite   IV. Pearlite

4.(a) What is the diameter of an originally 30-mm diameter solid steel ball when it is subjected to a hydrostatic pressure of 5 GPa? Take v = 0.3 and E = 200GPa for the steel.

4.(b) A thin glass plate with an elliptical crack of length ‘2C’ is subjected to a tensile load. Show that the average applied stress at which the crack will spread is inversely proportional to the square root of half crack length.

4.(c) Draw the neat curves of stress Vs number of stress cycles for structural steel and aluminium alloys and label the same. Determine the design parameters for the same.

5. Explain the term corrosion. Explain in detail the acid theory and chemical attack theory of corrosion.

OR

5'. Write short notes on:
   I. Galvanizing II. Tinning III. Inorganic coatings   IV. Organic coatings
1(a) Sketch the conventional representation of the following:
   (i) Filling materials
   (ii) Aluminium and its alloys
   (iii) Bearings
   (iv) External screw thread

1(b) Sketch the following locking devices, with proportions marked, taking the bolt diameter as 25 mm:
   (a) Locking with pin
   (b) Locking by castle nut

1(c) List 5 important editing commands in AutoCAD and mention their applications.

1(d) How do the ORTHO and OSNAP options in AutoCAD assist us in sketching?

2 Draw the sectional elevation and left end view of a Bench Vice assembly for which the part details are shown in Figure 1.

OR

2* Assemble the parts and draw the sectional elevation and right end view of the Tail Stock assembly for which the part details are shown in Figure 2.
MOVING JAW with GUIDE (C.I.)

BODY (C.I.)

PEG (Steel)

SCREW with COLLAR (M.S.)

Fig. 1: BENCH VICE

Contd... 3.
2014-15
B.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
MACHINE DESIGN I
ME 212

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) What do you mean by machine design? Explain the basic procedure for design of mechanical component. [06]
1(b) What is meant by working stress and how it is calculated from the ultimate or yield strength. What factors are considered for selecting the factor of safety. [06]

OR

1(b') A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000 N·m and a torque T. If the yield strength of steel is 200 MPa, find the maximum value of this torque without causing yielding of the shaft according to the maximum shear stress theory. [06]

2(a) What do you mean by endurance strength of a material? How do the size and surface finish factors affect the endurance strength. [06]
2(b) Explain any three of the following:
(i) theoretical stress concentration factor, (ii) stress concentration, (iii) notch sensitivity, and (iv) temperature factor. [06]

OR

2(b') A transmission shaft made of steel having ultimate tensile strength 440 MPa subjected to reversed torsional moment. The shaft diameter is 30 mm. There is a step in the shaft. The theoretical stress concentration factor, notch sensitivity factor, surface finish factor, size factor, and reliability factor are 1.8, 0.86, 0.82, 0.85 and 0.868 respectively. Determine the endurance limit for reversed torsional moment.

contd ... 2
3(a) It is required to design a square key for fixing a gear on the shaft which transmits 10 kW power at 720 rpm. The shaft and key are both made of steel (\(S_y = 360\, \text{MPa}\)) and the factor of safety is 3.

3(b) Design a maff coupling for a shaft transmitting 25 kW at 250 rpm. The allowable shear stress for steel shaft is 50 MPa and for the cast iron maff it is 12 MPa. The allowable shear and crushing stresses for the key's material are 40 MPa and 80 MPa.

OR

3' A shaft transmitting 25 kW at 125 rpm from gear \(G_1\) to gear \(G_2\) is mounted on two bearings \(B_1\) to \(B_3\) as shown in figure 4. Pitch circle diameters of gears \(G_1\) and \(G_2\) are 300 mm and 750 mm respectively. Determine the suitable diameter of the shaft. Take permissible shear stress as 100 MPa.

4 Explain the procedure used to determine the diameter of bolts in eccentically loaded bolted joint.

5(a) Prove that the centrifugal tension in the belt drive is
\[
T_c = m v^2
\]
Where \(T_c\), \(m\), and \(v\) have their usual meanings.

5(b) Derive the relation for the ratio of driving tensions of a \(v\)-belt.

OR

5(b') An engine running at 150 rpm drives a line shaft by means of a belt. The engine pulley is 750 mm diameter and pulley on the line shaft is 450 mm. A 900 mm diameter pulley on the line shaft drives a 150 mm diameter pulley keyed to a dynamo shaft. Find the speed of dynamo shaft when there is no slip.
Maximum Marks: 60

Duration: Three Hours

Q.1(a) Explain with neat sketch the Double Slider Crank Chain. Also explain the mechanism used in Elliptical Trammel. (06)

Q.1(b) Describe with neat sketch the working of Davis Steering gear mechanism and also prove that for Davis Steering gear

\[ \tan \theta = \frac{w}{2l} \]  

where \( \theta, w \) and \( l \) have their usual meanings. (06)

OR

Q.1(b') For a Hooke’s joint connecting the driving and the driven shafts prove that the condition for maximum or minimum angular acceleration is given by

\[ \cos 2\theta = \frac{2\sin^2 \theta}{(2+ \sin^2 \theta)} \]  

Q.2 The crank of a slider crank mechanism is 480 mm and connecting rod is 1600 mm long. The crank rotates at a uniform angular velocity of 20 rad/sec, clockwise. When the crank has turned 60° from the Inner Dead Centre (IDC) position, determine,

1. The acceleration of the connecting rod and
2. Acceleration of the slider (12)

OR

Q.2' The lengths of crank and connecting rod of a horizontal reciprocating engine are 100 mm and 500 mm respectively. The crank is rotating at 400 rpm. When the crank has turned 30° from the IDC position, find analytically,

1. The acceleration of the piston

Contd...
(ii) Velocity of the piston

(iii) Angular velocity of the connecting rod

(iv) Angular acceleration of the connecting rod and

(v) Position of the crank from IDC for zero acceleration of the piston.

Q.3 (a) (i) What is machine design? Give its classification also discuss the design considerations.

(ii) Discuss the different types of Plain carbon steel on the basis of percentage of carbon. How will you designate the steels on the basis of chemical properties?

(iii) What do you mean by Principal stresses in machine design; also give the relations for different principal stresses.

OR

Q.3 a’ (i) Explain the Endurance limit and Fatigue life. Further discuss the high cycle Fatigue and state that how it is helpful in determining the fatigue strength and the life in terms of number of cycles.

(ii) What is cumulative fatigue damage; discuss any one Theory/Rule used to explain the cumulative fatigue damage.

(iii) What is Notch sensitivity?

Q 3 (b) In a tensile test on bar of mild steel the following observations were made;

Original diameter of the bar = 35mm, Gauge length = 60 mm,

Load at limit of proportionality = 84 KN, Extension at 84 KN load = 0.065 mm

Load at yield point = 87 KN, Maximum load = 156 KN

When the two parts were fitted together after being broken, the length was found to be 65mm and neck was 20mm. Determine (i) Young’s modulus (ii) Yield stress (iii) Ultimate tensile stress

(iv) percentage elongation and (v) Percentage reduction in area.

Q.4 (a) Explain any Two of the following;

(i) Law of Gearing  (ii) Length of path of contact.

(iii) Interference in Involute Gears

Q.4 (b) Two mating gears of 20° pressure angles have 22 and 44 involute teeth of module 10 mm.

The addendum on each wheel is to be made of such a length that the line of contact on each side of the pitch point has half the maximum possible length. Determine

(i) The addendum height for each gear (ii) The length of path of contact

(iii) The length of Arc of contact (iv) The Contact Ratio.

Q.5 Explain any three of the following;

(i) The process used to make a riveted joint Leak Proof.

(ii) Failure of the Riveted joints.

(iii) Locking Devices (any three in detail).

(iv) Self Locking and Overhauling of the screw.
2014-2015
B. TECH. Winter Semester Examination
(Mechanical)
Fluid Mechanics-I
(ME231)

Maximum Marks: 60
(Credits: 04)
Duration: Three Hours

NOTE: Answer all the questions, symbols have their usual meaning.
Assume suitable data if missing.
Use of tables, flow functions for computation of compressible flow is allowed.
Moody's diagram and sheets of mathematical identities is permitted.
Clearly write all the assumptions before starting the solution.

1(a). The velocity distribution for laminar flow between the parallel plates is given by
\[
\frac{u}{u_{\text{max}}} = 1 - \left( \frac{y^2}{h^2} \right)
\]
Where 'h' is the distance separating the plates and the origin is placed midway
between the plates. Consider a flow of water at 15°C (\(\mu = 0.001\)), with \(u_{\text{max}} = 0.3\text{m/s}\)
and \(h = 0.5\text{mm}\). Calculate the shear stress on the upper plate by the fluid and give its
direction. Sketch the variation of shear stress across the channel.

1(b). Gates in the Poe Lock at Sault Ste. Marie, Michigan, close a channel \(W = 34\text{ m wide},
L = 360\text{ m long},\ and \(D = 10\text{ m deep}\). The geometry of one pair of gates is shown in Fig.
1; each gate is hinged at the channel wall. When closed, the gate edges are forced
together at the center of the channel by water pressure. Evaluate the force exerted by
the water on gate A. Determine the magnitude and direction of the force components
exerted by the gate on the hinge. (Neglect the weight of the gate.)

![Fig 1]
2(a). Given a velocity field \( \vec{V} = x^2 \hat{i} + 2xy \hat{j} \) and the temperature field \( T \) (in °C) = 3xty, with \( x \) and \( y \) in m and \( t \) in s. Determine with working:

i. if the flow field is incompressible.
ii. if the flow field is rotational.
iii. acceleration at the point \((1m, 1m)\) at \( t = 1 \) s.
iv. the rate of change of temperature with time of a particle moving in the flow at \((1m, 1m)\) and \( t = 2s \).
v. the rate of change of temperature with time as measured by a thermometer which is fixed at \((1m, 1m)\) and \( t = 2s \).

2(b). Consider a flow with velocity components \( u = 2(3x^2 - z^2), v = 0, w = x(x^2 - 3z^2) \).

(a) Is this a one-, two-, or three-dimensional flow?
(b) Demonstrate whether this is an irrotational flow.
(c) If possible, derive a stream function for this flow.

OR

2(b). A two-dimensional flow field is given by \( \vec{V} = Axy \hat{i} + By^2 \hat{j} \) where \( A = 1m^{-1}s^{-1}, B = -0.5m^{-1}s^{-1} \). Find the volumetric strain rate at \((x, y) = (1, 1)\). Also find the circulation about a square whose corners are given by \( a(0, 0), b(1, 0), c(1, 1), d(0, 1) \).

3.(a). Given a flow with circular streamlines (anticlockwise) as shown in figure below (figure 3). Explain with reasons if

i. \( \frac{\partial \vec{V}}{\partial x} = 0? \)
ii. Assuming steady, incompressible and inviscid flow can pressure be determined between points A and B using Bernoulli's Equation?
iii. Assuming steady, incompressible and inviscid flow can pressure be determined between points A and C using Bernoulli's Equation?

![Figure 3](image)

3.(b). When a uniform stream flows past an immersed thick cylinder, a broad low-velocity wake is created downstream, idealized as a V shape in figure 4. Pressure \( p_1 \) and \( p_2 \) are approximately equal. If the flow is two-dimensional and incompressible, with width \( b \)
into the paper, derive a formula for the drag force \( F \) on the cylinder. Rewrite your result in the form of a dimensionless drag coefficient based on body length \( C_d = \frac{F}{\rho b L U^2} \).

![Diagram of converging streamlines](image)

**Figure 4**

**OR**

3'(a). Figure 5 shows a pair of converging streamlines in a two-dimensional incompressible flow. Choose an appropriate control volume and apply mass conservation to show that the fluid between the two streamlines must be decelerating in the flow direction.

![Diagram of converging streamlines](image)

**Fig 5**

3'(b). Consider the reservoir and disk flow system with the reservoir level maintained constant. Flow between the disks is started from rest at \( t=0 \). Evaluate the rate of change of volume flow rate at \( t=0 \), if \( r_i = 50 \text{ mm} \).

![Diagram of reservoir and disk flow system](image)

**Fig 6**
4(a). An engineer who took college fluid mechanics on a pass-fail basis has placed the static pressure hole far upstream of the stagnation probe, as in Figure 7, thus contaminating the pitot measurement ridiculously with pipe friction losses. If the pipe flow is air at 20°C and 1 atm and the manometer fluid is Meriam red oil (SG = 0.827), estimate the air centerline velocity for the given manometer reading of 16 cm. Assume a smooth-walled tube with a Darcy’s friction factor $f = 0.02$.

4(b) The pipe flow in Figure 8 is driven by pressurized air in the tank. What gauge pressure, $p_1$, is needed to provide a 20°C (μ=0.001) water flow rate $Q = 60 m^3/h$?

OR

4(c). The three water-filled tanks shown in Figure 9 are connected by pipes as indicated. If minor losses are neglected, determine the flow rate in each pipe.
5. Ideal gas, $\gamma = 1.4$, exits a large container at stagnation pressure $p_i = 2$ bar and stagnation temperature $T_i = 500$ K through a Laval nozzle (throat $A_e$), which is connected via a pipe of constant area ($A_d = 5A_e$) with another large container. In the divergent part of the nozzle at $A_i = 2A_e$, a normal shock is developed. With the exception of the normal shock and mixing within the second container, the flow is considered isentropic.
   a) Find the Mach numbers $M_1, M_2$, the pressures $p_1, p_2$, and the temperatures $T_1, T_2$ upstream and downstream of the normal shock.
   b) Calculate the Mach number $M_3$, pressure $p_3$, and temperature $T_3$ inside the pipe.
   c) Determine the stagnation temperature $T_4$ and pressure $p_4$ in the second container.

OR

5(a). Consider a “rocket cart” propelled by a jet supplied from a tank of compressed air on the cart. Initially, air in the tank is at 1.3 MPa (abs) and 20°C, and the mass of the cart and tank is $M_c = 25$ kg. The air exhausts through a converging nozzle with exit area $A_e = 30 \text{ mm}^2$. Rolling resistance of the cart is $F_r = 6 N$; aerodynamic resistance is negligible. For the instant after air begins to flow through the nozzle:
   a) Compute the pressure at the nozzle exit plane.
   b) Evaluate the mass flow rate of air through the nozzle.

5(b). A converging-diverging nozzle is designed to operate with an exit Mach number of 1.75. The nozzle is supplied from an air reservoir at 6.9 MPa. Assuming one-dimensional flow, calculate:
   i. Maximum back pressure to choke the nozzle
   ii. Range of back pressure over which a normal shock will appear in the nozzle
   iii. Back pressure for the nozzle to be perfectly expanded to the design Mach number
   iv. Range of back pressure for supersonic flow at the nozzle exit plane.
1. (a) Differentiate between necessities and luxuries. Explain the law of supply and demand with suitable examples. [06]

1. (b) An investment of Rs. 1,05,815.4 can be made in a project that will produce a uniform annual revenue of Rs. 53,000 for 5 years and then have a salvage value of Rs. 30,000. Annual disbursements will be Rs. 30,000 each year for operation and maintenance costs. The company's minimum attractive rate of return is 10%. Show whether it is a desirable investment by using the present worth method. [06]

OR

1. (b') The machines shown below have been proposed for a certain manufacturing operation. Determine which should be selected if the company's MARR is 19% per year and the decision is to be based on a comparison of their equivalent uniform annual costs. [06]

<table>
<thead>
<tr>
<th></th>
<th>Machine I</th>
<th>Machine II</th>
</tr>
</thead>
<tbody>
<tr>
<td>First cost, $</td>
<td>15,000</td>
<td>29,000</td>
</tr>
<tr>
<td>Annual cost, $/year</td>
<td>7,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Life, yrs.</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Salvage value, $</td>
<td>3,500</td>
<td>4,200</td>
</tr>
</tbody>
</table>

2. Attempt any two questions from the following [06]

2. (a) What is Inflation? List its causes? Ten years ago, a chemical company installed a heat exchanger in its plant for $10,000. The company is considering replacing the heat exchanger because maintenance costs have been increasing. The estimated maintenance costs for the next 5 years are as follow:

<table>
<thead>
<tr>
<th>Year</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1,000</td>
</tr>
<tr>
<td>2.</td>
<td>1,200</td>
</tr>
<tr>
<td>3.</td>
<td>1,400</td>
</tr>
<tr>
<td>4.</td>
<td>1,600</td>
</tr>
<tr>
<td>5.</td>
<td>1,800</td>
</tr>
</tbody>
</table>

Whenever the heat exchanger is replaced, the cost of removal will be $1,500 more.
than the heat exchanger is worth as scrap metal. The replacement the company is
considering has an equivalent annual cost (EAC) = $900 at its most economic life.
Should the heat exchanger be replaced now or not if the company’s minimum
attractive rate of return MARR is 20%?

2. (b) What are the various criteria for performing a cost benefit analysis?
Cash flows of a 4-year project are represented in the table below

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments $</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent Costs $</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Income $</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td></td>
</tr>
</tbody>
</table>

Conduct a cost-benefit analysis to conclude whether this project should be
approved or not if discounted with a 10% interest rate?

2. (c) What is meant by depreciation? Give the reasons for declining value of an asset.
An asset has a first cost of $25000 and an expected salvage value of $4000 after
12 years. Calculate using double declining methods, the depreciation for the
fourth year and the book value at the end of fifth year.

3. (a) Explain the classical and the administrative model of decision making. What are
the similarities and differences between them? Use a suitable example from the
industry to illustrate your point.

3. (b) A farmer wants to buy a new combine harvester rather than hire a custom
harvester. The total fixed costs for the desired combine are $21,270 per year. The
variable costs (not counting the operator's labor) are $8.75 per hour. The farmer
can harvest 5 acres per hour. The custom harvester charges $16.00 per acre. How
many acres must be harvested per year to break-even?

4. What do you understand by the term “Job design”? Explain the job characteristic
approach of job design.

OR

4'. Explain Maslow's theory of motivation. Suppose you are a manager at an
automobile company. How would you ensure that the various needs (as identified
by Maslow) of your subordinates are met?

5. Suppose you are a project manager at Infosys. In your team there are six
engineers. Knowledge of a new software package is necessary for completing
your project. You are tasked with designing a training program. What different
steps would you take to ensure that the training program you designed would be
successful? You can show those steps in the form of a flow chart.