SECTION - A

There are FOUR questions in this section. Answer any THREE.

1. (a) Derive the elastic Euler's buckling formula for pin ended columns. Draw the column strength curve (i.e. critical stress versus slenderness ratio curve) for pin ended columns and differentiate between long columns and short columns.

(b) Determine the longest unsupported length 'L' of a pin-ended column with a cross-section shown in Fig. 1, that can safely carry a compressive load of 280 kN. The column is made up with built up steel I section. Given: \( f_y = 350 \text{ MPa}, E = 200 \text{ GPa} \).

2. (a) A concrete dam has the profile shown in Fig. 2. If the density of concrete is 2400 kg/m\(^3\) and that of water is 1000 kg/m\(^3\), determine the maximum compressive stress on section m-n if the depth of water behind the dam is \( h = 20 \text{ m} \). Also, find the height of the dam to avoid tension at base.

(b) Each member of the truss as shown in Fig. 3 is made of aluminium and has the cross-sectional area as shown. Determine, the strain energy of the truss for the given loading. Use \( E = 72 \text{ GPa} \).

3. (a) Using the AISC/ASD column formulas design a solid round section column 5.0 meter long to carry 360 kN concentric load. The column is fixed at one end and pinned at the other. Given: \( f_y = 350 \text{ MPa} \) and \( E = 200 \text{ GPa} \).

(b) Determine the maximum bending stresses at the corners A, B, C, D of the cantilever loaded as shown in Fig. 4. Also, locate the line of zero stress.

4. (a) Find the allowable force that the triple-row riveted butt joint (as shown on Fig. 5) can transmit. Also, find the efficiency of the joint. All rivets are nominally 22 mm in 25 mm diameter holes. The allowable stresses (AISC) are 150 MPa in tension, 100 MPa in shear and 335 MPa in bearing.

(b) Find the size of the two welds required to attach a plate to a machine as shown in Fig. 6, if the plate carries a vertical force of 100 kN. Use, E 70 electrodes, \( F_{tu} = 483 \text{ MPa} \) and AWS allowable shear = \( 0.3 \times F_{tu} \).
5. (a) Derive the second order differential equation for deflection of beam, stating all assumptions. (15)
(b) Using direct integration method, determine the equation of the elastic curve for the beam with loading shown in Fig. 7. Also find the location and magnitude of the maximum deflection of the beam. (20)

6. (a) For the beam shown in Fig. 8—
   (i) Calculate the stress at points A and B of the beam. Draw infinitesimal elements at each of the points and clearly show the direction and magnitude of the stress acting on them. (10+10=20)
   (ii) Using the method of Mohr's circle, transform the stresses at point B, into stresses acting on the plane at an angle of 30° with the horizontal axis.
(b) What are the failure theories for ductile materials. Describe the maximum shear stress theory. (15)

7. (a) For the beam shown in Fig. 9, using moment-area theorem, calculate
   (i) The deflection and rotation at the free end of the beam. (20)
   (ii) Find the maximum deflection between supports at A and B.
(b) The magnitude and sense of the stresses at a point are shown in Fig. 10. Determine the principal stresses and show their sense on a properly oriented element. (15)

8. (a) Determine the tension in each segment of the cable and the cable's total length as shown in Fig. 11. (Neglect self weight of the cable). (15)
(b) The cable AB is subjected to a uniform loading of 200 N/m. If the weight of the cable is neglected and the slope angles at A and B are 30° and 60°, respectively, determine the curve that defines the cable shape and the maximum tension developed in the cable (Fig. 12). (20)
Fig. 1  Q. 1(b)

Fig. 2  Q. 2(a)

Fig. 3  Q. 2(b)

Fig. 4  Q. 3(b)
Fig. 7 Q. 5(b)

Fig. 8 Q. 6(a(ii))

Fig. 9 Q. 7(a-ii)

Fig. 10 Q. 7(b)
Fig. 11
Q. 8(a)

Fig. 12
Q. 8(b)
SECTION – A

There are FOUR questions in this section. Answer any THREE.

Symbols used have their usual meaning.

1. (a) Prove that the area of the triangle formed by joining the mid-point of one of the non-parallel sides of a trapezium to the extremities of the opposite side is half of that of the trapezium. (15)

(b) If \( a, b, c \) are non-coplanar vectors then prove that the following four points are coplanar:

\[- a + 4b - 3c, 3a + 2b - 5c, - 3a + 8b - 5c, - 3a + 2b + c.\] (10)

(c) Give the geometrical interpretation of the scalar triple product. (10)

2. (a) Show that acceleration of a particle moving along a curve is a vector in the plane of the tangent and normal having \( \frac{d^2s}{dt^2} \) and \( k \left( \frac{ds}{dt} \right)^2 \) as its tangential and normal components respectively. (20)

(b) Find \( \nabla^2 (r^2r) \) where \( r \) is the position vector. (15)

3. (a) Find the angle of intersection at the point \((-3,0,-5)\) of the spheres

\[x^2 + y^2 + z^2 + 6x - 5y + 2z - 29 = 0 \text{ and } x^2 + y^2 + z^2 - 34 = 0\] (10)

(b) Show that the gradient of a scalar function \( f \) is a vector along the normal to the level surface whose magnitude is the greatest rate of change of \( f \). (10)

(c) Find curl of \( F \) where \( F = (x^2 - y^2 + 2xz)i + (xz - xy + yz)j + (z^2 + x^2)k \). Also comment on the orthogonality of the vectors given by curl \( F \) at the points \( P(1,2,-3) \) and \( Q(2,3,12) \) respectively. (15)

4. (a) State and verify Green's theorem in the plane for \( \int_C (2x - y^3)dx - xydy \) where \( C \) is the boundary of the region enclosed by \( x^2 + y^2 = 1 \) and \( x^2 + y^2 = 3 \). (20)

(b) Evaluate \( \iint_S F \cdot n \, dS \) for \( F = 4x \, i + y \, j + z \, k \) where \( S \) is the surface of the plane \( 3x + 2y + z = 6 \) which lies in the first octant. (15)
5. (a) Calculate mode and quartiles from the following distribution of the ages of 50 children.

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>0–4</th>
<th>4–8</th>
<th>8–12</th>
<th>12–16</th>
<th>16–20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children</td>
<td>8</td>
<td>10</td>
<td>20</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

(b) The mean and standard deviations calculated from 20 observations are 15 and 10 respectively. If an additional observation 36, left out through oversight, be included in the calculations, find the correct mean and standard deviation.

(c) Two cricketers scored the following runs in the several innings. Find who is better run-getter and who is more consistent player?

<table>
<thead>
<tr>
<th>A</th>
<th>42</th>
<th>17</th>
<th>83</th>
<th>59</th>
<th>72</th>
<th>76</th>
<th>64</th>
<th>45</th>
<th>40</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>28</td>
<td>70</td>
<td>31</td>
<td>0</td>
<td>59</td>
<td>108</td>
<td>82</td>
<td>14</td>
<td>3</td>
<td>95</td>
</tr>
</tbody>
</table>

6. (a) The following is the distribution of commissions (in taka) earned during a week by 100 sales persons.

<table>
<thead>
<tr>
<th>Commissions (in taka)</th>
<th>50–100</th>
<th>100–150</th>
<th>150–200</th>
<th>200–250</th>
<th>250–300</th>
<th>300–350</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales persons</td>
<td>15</td>
<td>20</td>
<td>30</td>
<td>18</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

Find $\beta_1$ and $\beta_2$ and hence comment on the nature of the distribution.

(b) Following table gives the data on the fertilizer used and yield of corn.

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>0.3</th>
<th>0.6</th>
<th>0.9</th>
<th>1.2</th>
<th>1.5</th>
<th>1.8</th>
<th>2.1</th>
<th>2.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield of corn</td>
<td>10</td>
<td>15</td>
<td>30</td>
<td>35</td>
<td>25</td>
<td>31</td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

Fit a regression of yield of corn on fertilizer. Find the yield of corn when fertilizer is 2.5.

7. (a) A box contains 100 transistors, 20 of which are defective. 10 transistors are selected for inspection. Find the probability that

(i) all 10 are defective
(ii) all 10 are nondefective
(iii) at least one is defective
(iv) at most three are defective.
(b) Telephone calls enter a switch board on the average of two in every three-minute interval. What is the probability of five or more calls arriving in a nine-minute period? (10)

(c) Define normal distribution. Verify that the area under the normal curve is 1. (9)

8. (a) A committee consists of nine students of which 2 are from first year, 3 from second year and 4 from third year. What is the chance that a student from each year is removed from the committee? (9)

(b) A pair of dice is thrown. Find the probability that sum of the points on the two dice is 10 or greater if a 5 appears on the first die. (10)

(c) A sample of 226 students is taken from a large population. The mean weight of these students is 115 pounds and the standard deviation 10 pounds. Can it be reasonably regarded that the population mean weight is 120 pounds at 5% level of significance? (16)
SECTION – A

There are FOUR questions in this section. Answer any THREE.

1. (a) Distinguish between classical hydrodynamics and hydraulics. Prove Newton's equation of viscosity. (6+10=16)

(b) A fluid of absolute viscosity 10 poise flows past a flat plane and has a velocity 1.20 m/s at the vertex which is 30 cm from the plate surface. Make calculations for the velocity gradients and shear stress at points 10 and 20 cm from the boundary. Assume a parabolic velocity distribution. (12)

(c) A 2 cm wide gap between two vertical plane surfaces is filled with an oil (S = 0.9) of dynamic viscosity of 3.4 N.s/m². A metal plate (1.25 m × 1.25 m × 0.2 cm) weighing 40 N is placed midway in the gap as shown in figure 1. Find the force required if the plate is to be lifted up with a constant velocity of 0.25 m/s. (18½)

2. (a) Write down the necessary condition for cavitation to occur in pipe flow. (8)

(b) Draw qualitative hydraulic grade line and energy line for a horizontal layout of pipe of length L connecting two reservoirs. For the 1st L/3 length, the pipe gradually converges followed by divergence for the remaining length. (8)

(c) A pipeline with a pump leads to a nozzle as shown in figure 2. Find the flow rate when the pump develops a head of 21 m. Assume that the head loss in the 20-cm diameter pipe may be expressed by \( h_L = 5V^2/2g \), while the head loss in the 12-cm diameter pipe is \( h_L = 11V^2/2g \). Sketch the energy line and the HGL, and find the pressure head at the suction side of the pump. Assume \( \text{pipe diameter} \leq 6 \text{ cm} \) (18)

(d) A 20 cm diameter pipe leading water from a reservoir ends in a nozzle of exit diameter of 10 cm at elevation of 90.00 m as shown in figure 3. The water surface in the reservoir is at elevation 110.00 m. The energy loss in the system can be assumed to be 12 times the velocity head in the pipe. Calculate discharge. (12½)

3. (a) State the relations between absolute and relative velocities with a neat sketch. (7)
(b) A pipe bend placed in a horizontal plane tapers from 50 cm diameter at inlet to 25 cm diameter at outlet. An oil of density 850 kg/m³ enters the reducing bend horizontally and gets turned through 45° clockwise direction as shown in figure 4. Measurements indicate that when oil flows at the rate of 0.45 m³/s, the pressure of 40 kN/m² at the inlet section drops to 23 kN/m² at the exit section due to frictional effects. Make calculations for the magnitude and direction of the resultant force on the bend.

(c) A Reaction Turbine has \( r_1 = 1.6 \) m, \( r_2 = 1.2 \) m, \( \beta_1 = 50^\circ \), \( \beta_2 = 140^\circ \), and thickness of 0.4 m parallel to the axis of rotation. With a guide vane angle of 20° and a flow rate of 12.0 m³/s, calculate the required speed of the runner for smooth flow at inlet. For this condition also calculate:

(i) Torque exerted on the runner
(ii) Power developed
(iii) Energy extracted from each Newton of fluid.

4. (a) List the major and minor losses in pipes.

(b) Two reservoirs with a difference in water surface elevation of 8 m are connected by a pipeline ABC which consists of two pipes AB and BC joined in. Pipe AB is of 10 cm in diameter, 20 m long and has a value of \( f = 0.022 \). Pipe BC is of 18 cm in diameter, 25 m long and has a value of \( f = 0.015 \). The junctions with the reservoirs and between the pipes are sharp. Calculate discharge including all minor losses.

(c) For the network shown in figure 5, the head loss is given by \( h_L = KQ^2 \). The k-values for each pipe and the discharges (l/s) into or out of the various nodes are shown in the figure. Determine the flow in each pipe after applying corrections twice by Hardy Cross method.

(d) For a pipe network shown in figure 6, the pipes are all new cast iron \( (e = 0.22 \text{ mm}) \). For a total discharge of 0.80 m³/s, determine the head loss from B to C. Given \( v = 1.2 \times 10^{-6} \text{ m}^2/\text{s} \). Use Moody diagram (figure 7) for friction factor.

SECTION-B

There are FOUR questions in this section. Answer any THREE.

5. (a) Write short notes on--

(i) Streak line (ii) Convective acceleration (iii) Flow net

Contd .......... P/3
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Contd... Q. No. 5

(b) A fluid flows between two converging plates (Figure 8) which are 0.5 m wide and the velocity varies according to the expression:

\[ v = \frac{V_{\text{max}}}{h_0} \left( \frac{2h}{h_0} - \frac{h}{h_0} \right) \]  \hspace{1cm} (14)

For values of \( h_0 = 50 \text{ mm} \) and \( V_{\text{max}} = 1 \text{ m/s} \), determine—

(i) the total flow between the plates
(ii) the mean velocity of the initial section where \( h = h_0 \)
(iii) the mean velocity for the section where \( h = 20 \text{ mm} \).

\[ \text{Figure 8 for Question No. 5(b)} \]

(c) A two-dimensional flow field is defined by \( u = xt^2 \) and \( v = 5yt \). When the fluid passes the point \((1,1)\) at \( t = 2 \), determine—

(i) the equation of stream line and pathline
(ii) the velocity of fluid at that point
(iii) the convective acceleration and local acceleration at that point.

6. (a) Derive the general expression for the variation of pressure in a static fluid with proper description of the underlying assumptions.

(b) Determine the horizontal and vertical forces per meter width on the Tainter gate as shown in Figure 9. Also find the locations of these forces.
(c) A model of a flood control-gated structure is 1.2 m wide and weighs 2224 N (Figure 10). The gate is pivoted at 0 and its center of gravity is 36 cm to the right and 27 cm above 0. For what values of water depth above the pivot point will the gate remain closed? Neglect friction of the pivot and thickness of the gate.

![Figure 10 for Question No. 6(c)](image)

7. (a) What is similitude? State the conditions for which the flow will achieve dynamic similarity and true similarity. (12)

(b) The flow over a spillway is 150 m³/s. For dynamic similarity, what should be model scale if the model flow rate is 1.25 m³/s. The force on a certain area of the model is measured to be 5 N. What would be force on the corresponding area of the prototype? (14)

(c) The pressure drop for turbulent flow in a pipe depends upon velocity, diameter, length, density, viscosity, roughness height and gravity. Determine the general form of the equation for pressure drop using dimensional analysis. (20)

8. (a) Briefly discuss the measuring mechanism of the following devices—

(i) Falling-sphere type viscometer (ii) Pitot-static tube (iii) Hot-wire anemometer

(b) A rotational viscometer is constructed of two concentric cylinders of height 25 cm. The outer diameter of inner cylinder is 9.9 cm while the inner diameter of the outer cylinder is 10.1 cm. When a torque of 7 N.m is applied to the outer cylinder, it was found to rotate at 1 revolution per 3.5 s. Find the viscosity of the fluid. Neglect mechanical friction. (14)
(c) A double U-tube manometer as shown in Figure 11 is connected between the two horizontal pipelines carrying water and oil \( s = 0.9 \). Neglecting the weight of air, determine—

(i) the pressure difference between the water pipe and the oil pipe
(ii) the pressure at the water pipe if the pressure at the oil pipe is 200 kN/m\(^2\).
SECTION - A
There are FOUR questions in this section. Answer any THREE.

1. (a) Find a root (up to four decimal points) for the following transcendental equation using the Secant method.
   \[ x \tan x - 1 = 0 \]  
   (10)

(b) Find a root (up to four decimal points) for the following polynomial equation using the Regular Falsi method.
   \[ x^5 - 3x^2 - 100 = 0 \]  
   (10)

(c) Derive the Newton-Raphson iterative formula for solving \( f(x) = 0 \).
   (3 \frac{1}{2})

2. (a) Solve the following system of linear equations using the Gauss-Seidal iterative method. (Do minimum four iterations).
   \[
   \begin{align*}
   2x_1 + x_2 + x_3 &= 5 \\
   3x_1 + 5x_2 + 2x_3 &= 15 \\
   2x_1 + x_2 + 4x_3 &= 8 
   \end{align*}
   \]  
   (10)

(b) Solve the following nonlinear system of equations using the Newton-Raphson method. (Do at least three iterations).
   \[
   \begin{align*}
   \sin x + 3\cos x &= 2 \\
   \cos x - \sin y &= -0.2 
   \end{align*}
   \]  
   (10)

(c) Distinguish between "Consistency" and "Convergency" in brief.
   (3 \frac{1}{2})

3. (a) Solve \( y(0.1) \) and \( y(0.2) \) for the following ordinary differential equation using the Fourth-order Runge-Kutta method. (use 0.1 as a discretization interval)
   \[ y = 3y - 4e^{-x}; \ y(0) = 1 \]  
   (10)

(b) Solve \( y(0.4) \) for the following ordinary differential equation using the Taylor series method. (use 0.2 as a discretization interval)
   \[ y = x^2 + y^2; \ y(0) = 0 \]  
   (10)

(c) Differentiate between rounding error and truncation error.
   (3 \frac{1}{2})
4. (a) Solve the following system of linear equations using LU decomposition method. (10)
\begin{align*}
3x + 2y + z &= 10 \\
2x + 3y + 2z &= 14 \\
x + 2y + 3z &= 14
\end{align*}

(b) Derive generic formulas to find $\sqrt[3]{a}$ and $a^{-1}$ using the Newton-Raphson method. (10)

(c) Distinguish between explicit and implicit scheme. (3½)

SECTION – B

There are FOUR questions in this section. Answer any THREE.

5. (a) A function is given by $f(x) = 1 + 2x + 3x^2 + 4x^3$. (i) Using the values of the function and its derivatives at $x = 1$, determine the values of the function at $x = 1.01, 1.10, \text{ and } 1.50$ with the help of the Taylor series expansion and compare these values with the actual values of the function. (ii) Taking $\Delta x = 0.01, 0.10$ and $0.50$, determine the % of error of forward, backward and central differences of the first derivative and of the second derivative with respect to the point where $x = 1$. (iii) Sate the effect of $\Delta x$ on the % of error. (12½)

(b) Derive the expressions of Newton-Gregory interpolation formula for equal interval. What do you understand by Newton-Gregory backward difference formula? (11)

6. (a) Using the following table, find $f(x)$ as a polynomial in powers of $(x-6)$. (12)

<table>
<thead>
<tr>
<th>$x$</th>
<th>-1</th>
<th>0</th>
<th>2</th>
<th>3</th>
<th>7</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F(x)$</td>
<td>-11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>141</td>
<td>561</td>
</tr>
</tbody>
</table>

(b) Evaluate $\int_0^1 e^{-x^2} \, dx$ by Simpson's rule with ten equal intervals. (11½)

7. (a) The following results were obtained in the calibration test of a current meter. (8)

<table>
<thead>
<tr>
<th>No. of revolutions/sec (N)</th>
<th>0.40</th>
<th>1.10</th>
<th>1.60</th>
<th>2.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity in m/s (v)</td>
<td>1.50</td>
<td>4.90</td>
<td>6.83</td>
<td>8.98</td>
</tr>
</tbody>
</table>

Determine the calibration constants $a$ and $b$ in the equation $v = a + bN$ by theory of least squares.
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Contd... Q. No. 7

(b) The table below gives the values of distances traveled by a car at various time intervals during the initial running.

<table>
<thead>
<tr>
<th>Time, t(sec)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance, s(km)</td>
<td>10.0</td>
<td>14.5</td>
<td>19.5</td>
<td>25.5</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Estimate the velocity at time $t = 5$ sec, $7$ sec and $9$ sec. Also calculate the acceleration at $t = 7$ sec.

c) Evaluate $\int_{1.8}^{3.4} e^x \, dx$ using the trapezoidal rule correct to three decimal places with $h = 0.2$.

8. (a) Given the following set of data points, obtain the table of divided differences. Use the table to estimate the value of $f(1.5)$.

<table>
<thead>
<tr>
<th>i</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_i$</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>$Y_i=f(x_i)$</td>
<td>0</td>
<td>7</td>
<td>26</td>
<td>63</td>
<td>124</td>
</tr>
</tbody>
</table>

(b) Fit a regression plane to fit the following set of data:

<table>
<thead>
<tr>
<th>X</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Z</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

(c) Prove that the truncation errors for the forward and backward differences are of the first order, and that for the central difference is of the second order.
SECTION - A

There are FOUR questions in this section. Answer any THREE.

1. (a) Analyze the merits and demerits of nationalism. (11 ½)
   (b) Discuss various types of sovereignty with examples. (12)

2. (a) What are the different kinds of executive? Describe the role of executive in a state. (11 ½)
   (b) Describe the nature of presidential form of government. (12)

3. (a) Describe different methods for acquiring citizenship. (11 ½)
   (b) Analyze the prerequisites for good government. (12)

4. (a) Examine the strengths and weaknesses of democracy. (11 ½)
   (b) Briefly analyze the problems of governance in South Asian countries. (12)

SECTION - B

There are FOUR questions in this section. Answer any THREE.

5. (a) Discuss the significance of Language Movement of 1952. (11 ½)
   (b) What was the impact of Great Mass Upsurge of 1969? (12)

6. (a) Define bureaucracy. Why has bureaucracy overdeveloped in past colonial states? (11 ½)
   (b) Discuss the functions of local government with special reference to Bangladesh. (12)

7. (a) Analyze the characteristics of the constitution of Bangladesh. (11 ½)
   (b) Describe the principles of the foreign policy of Bangladesh. (12)

8. (a) Make a brief discussion on the political system of United States of America. (11 ½)
   (b) What is United Nations Organization? What are the principal organs of United Nations Organization? (12)