SECTION - A
There are FOUR questions in this section. Answer any THREE.

1. (a) Why does the numerical solution of any engineering problem always deviate from the true solution? Discuss briefly.
   (8)

(b) What do you mean by catastrophic cancellation in context to numerical computation? Give a suitable example.
   (5)

(c) Consider the polynomial, \( f(x) = x^3 - 5x^2 + 6x + 0.55 \).
   (7)

Evaluate the polynomial \( f(1.37) \) using (i) three-digit arithmetic with chopping and (ii) three-digit arithmetic with rounding. Comment on your results.

(d) In the experiment of a cantilever beam as shown in Fig. for Q. 1(d), the maximum deflection can be calculated as

\[
\delta = 10^3 \times \frac{F L^3}{3EI} \text{ mm}
\]

where \( F \) is the applied load on the beam, \( L \) is the length of the cantilever beam, \( E \) is the modulus of elasticity of beam material and \( I \) is the moment of inertia. The uncertainties associated with the experimental measurement are given below:

\[
\begin{align*}
F &= 200 \pm 10 \text{ N} \\
L &= 2 \pm 0.1 \text{ m} \\
I &= 2 \times 10^{-7} \pm 6 \times 10^{-9} \text{ m}^4
\end{align*}
\]

Estimate the error in the calculation of beam deflection, \( \delta \) using second-order error analysis. Take \( E = 200 \times 10^9 \text{ Pa} \) (Assume exact)

Contd .......... P/2
2. (a) Consider the equation \( x^2 = 1.0 + \log x \). Use Newton's method to find a root of the equation with initial guess \( x_0 = 1.5 \). Ensure that the result is correct up to five significant digits. (12)

(b) It is known that the Newton's method of root finding converges quadratically. Confirm this statement using error analysis of above problem given in Q. 2(a). (10)

(c) Continue Q. 2(a) but with initial guess of \( x_0 = 0.7 \). Interpret your result graphically. (5)

(d) Formulate Secant method from Newton's method of root finding. Graphically show the iterative progress of Secant method for root finding. (8)

3. (a) Solve the following system of linear equations correct to three significant figures by Gauss-Siedel method, (15)

\[
\begin{bmatrix}
45 & 2 & 3 \\
-3 & 22 & 2 \\
5 & 1 & 20
\end{bmatrix}
\begin{bmatrix}
x_1 \\
x_2 \\
x_3
\end{bmatrix}
= 
\begin{bmatrix}
58 \\
47 \\
67
\end{bmatrix}
\]

Take initial values of unknowns as \((0, 0, 0)^T\). (15)

(b) Find the inverse of the following matrix in order to solve a system of linear equations in the form of \([A] \{x\} = \{b\}; \) where the symbols have their usual meaning. (15)

\[
A = \begin{bmatrix}
2 & 0 & 1 \\
3 & 2 & 5 \\
1 & -1 & 0
\end{bmatrix}
\]

(c) What do you mean by "ill-conditioned" systems in the context of linear system of equations? (5)

4. (a) Mention the techniques to improve the solutions of Gaussian elimination method for the solution of system of linear equations. (5)

(b) Suppose there are \( m \) numbers of data points in a least-squares curve fit where the dependent variable \( y \) is related to independent variable \( x \) in the following form:

\[ y = a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n \]

Then what should be the order, \( n \) of the approximated curve to fit all such \( m \) data points? Derive the matrix form of normal equations needed to solve for the above coefficients \( a_i \)'s in least-squares approximation. (15)

(c) The velocities measured at various points along the boundary layer in free convection over a vertical plate are given (in non-dimensional form):

<table>
<thead>
<tr>
<th>( i )</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_i )</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>( y_i )</td>
<td>0.00</td>
<td>1.05</td>
<td>0.85</td>
<td>0.35</td>
<td>0.10</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Fit a second-order polynomial to the data. (15)

Contd ............. P/3
There are **FOUR** questions in this section. Answer any **THREE**.
Symbols have their usual meaning.

5. (a) Describe the classical form of the Fourth-order Runge-Kutta method for solving ordinary differential equations. With necessary illustrations, give the mathematical and graphical interpretations of the method. 

(b) Another form of the fourth-order Runge-Kutta method, known as 'Gil form' is given by

\[ y_{i+1} = y_i + \frac{1}{6} \left[ k_1 + (2 - \sqrt{2})k_2 + (2 + \sqrt{2})k_3 + k_4 \right] \]

where, \( k_1 = hf(x_i, y_i) \)

\[ k_2 = hf\left(x_i + \frac{h}{2}, y_i + \frac{k_1}{2}\right) \]

\[ k_3 = hf\left(x_i + \frac{h}{2}, y_i + \left(\sqrt{2} - 1\right)\frac{k_1}{2} + \left(2 - \sqrt{2}\right)\frac{k_2}{2}\right) \]

\[ k_4 = hf\left(x_i + h, y_i - \sqrt{2}\frac{k_2}{2} + \left(1 + \frac{\sqrt{2}}{2}\right)k_3\right) \]

How will you interprete this Gil form?

Apply this Gil form of fourth-order Runge-Kutta method to obtain 1st three-steps solutions of the following initial-value problem with a step size of \( h = 1 \).

\[ \frac{dx}{dt} - x = t; \quad x(1) = 1 \]

6. The following table shows the measured values of volume \( v \) (in cubic inches) and the pressure \( P \) (in pounds per square inch) of a gas during its expansion.

<table>
<thead>
<tr>
<th>( v )</th>
<th>0.75</th>
<th>1.00</th>
<th>1.25</th>
<th>1.50</th>
<th>1.75</th>
<th>2.00</th>
<th>2.25</th>
<th>2.50</th>
<th>2.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P )</td>
<td>89.8</td>
<td>68.7</td>
<td>55.0</td>
<td>45.8</td>
<td>39.3</td>
<td>34.4</td>
<td>30.5</td>
<td>27.5</td>
<td>26.0</td>
</tr>
</tbody>
</table>

Estimate the total work done by the gas using a suitable numerical technique that satisfies following conditions of accuracy:

(a) Truncation error of \( O(h^2) \)

(b) Truncation error of \( O(h^4) \)

(c) Truncation error of \( O(h^6) \)

Also estimate the error bounds for the result in (a).
7. (a) "Although Simpson's $\frac{1}{3}$ rule of integration is based on passing a quadratic polynomial through three evenly spaced points, actually gives the exact result if $f(x)$ is a cubic polynomial" – justify the statement with necessary mathematical explanation. What conclusion can you draw when the above fact is compared to the corresponding cases of Trapezoidal and Simpson's $\frac{3}{8}$ rules? (15)

(b) Determine the maximum step sizes and the corresponding minimum number of divisions required to guarantee five decimal place accuracy in the numerical integration of the function

$$f(x) = \exp(-x^2)$$
from $x = 0.2$ to $x = 1.5$ using

(i) Simpson's $\frac{1}{3}$ rule of integration
(ii) Simpson's $\frac{3}{8}$ rule of integration. (20)

8. (a) Derive finite difference formulae for the following derivatives of a function: (17)

(i) central-difference form of the second derivative with an error of $O(h^4)$.
(ii) forward-difference form of the first derivative with an error of $O(h^2)$.

(b) 'Eigen-value solution of engineering problems – explain the concept. Describe two numerical approaches for determining the characteristic equation of a homogeneous set of algebraic equations. (18)
L-2/T-2/ME

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-2/T-2  B. Sc. Engineering Examinations 2012-2013
Sub: ME 243 (Mechanics of Solids)
Full Marks: 210  Time: 3 Hours

The figures in the margin indicate full marks.
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION - A
There are FOUR questions in this Section. Answer any THREE.

1. (a) The compound shaft as shown in Fig. 1(a) is attached to two rigid supports. For the bronze segment $AB$, the diameter is 75 mm, $\tau \leq 60$ MPa, and $G = 35$ GPa. For the steel segment $BC$, the diameter is 50 mm, $\tau \leq 80$ MPa, and $G = 83$ GPa. If $a = 2$ m and $b = 1.5$ m, compute the maximum torque $T$ that can be applied.

(b) A rigid bar, pinned at point $O$, is supported by two identical springs as shown in Fig. 1(b). Each spring consists of 20 turns of 0.75 inch diameter wire having a mean diameter of 6 inch. Determine the maximum load $W$ that may be supported if the shearing stress in the springs is limited to 20 ksi.

2. (a) A thick-walled cylinder contains a fluid at a pressure of 10 MPa. The internal diameter of the cylinder is 300 mm. Determine the wall thickness required if the shearing stress is limited to 80 MPa.

(b) If an element is subjected to the state of stress as shown in Fig. 2(b), find the principal stresses and the maximum in-plane shearing stresses. Also, determine the stress components on planes whose normals are at $45^\circ$ and $135^\circ$ with the $x$-axis. Show all results on complete sketches of the appropriate elements.
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3. (a) A hollow circular column of 20 cm external and 16 cm internal diameter is 5 m long and fixed at both of its ends. It is subjected to a load of 12000 kg at an eccentricity of 2 cm from the geometrical axis. Determine the maximum stress induced in the column section. Use $E = 1.2 \times 10^6$ kg/cm$^2$. 

(b) Design a reinforced concrete beam with balanced stress-reinforcement to resist a bending moment of 100 kNm. Consider the allowable stress in concrete is $f_c = 12$ MPa and that in steel is $f_s = 150$ MPa. Assume $d = 1.5$ and $n = 8$. 

4. (a) A C-frame is subjected to a load $P$ as shown in Fig. 4(a). Determine the maximum load $P$ that can be applied if the allowable normal stress in section a-a is 150 MPa. Use curved beam’s formula.

(b) Briefly discuss on failure theory for each of the following types of materials: (i) brittle materials, (ii) ductile materials.

SECTION – B

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

5. (a) The tank shown in Fig. for Q. No. 5a is fabricated from steel plate of allowable tensile stress 60 MPa. If the internal pressure is 20 MPa. What should be minimum thickness of the steel plate?

(b) In the Fig. for Q. No. 5(b) there is a gap between the aluminum bar and the rigid slab that is supported by two copper bars. At temperature 20°C the gap is 0.2 mm. neglecting the mass of the slab, calculate the stress in each rod when the temperature in the assembly is increased to 140°C.
6. (a) Draw the shear force and bending moment diagram for the beam shown in Fig. for Q. No. 6(a). Also write the equations for shear force and bending moment.

(b) In the figure for Q. No. 6(b), a rigid beam with negligible weight is pinned at one end and attached to two vertical rods. The beam was initially horizontal before the load \( W = 15 \text{kN} \) was applied. Find the vertical movement of \( W \).

7. A beam carries loads as shown in the Fig. for Q. No. 7. The cross-sectioned seen of the beam is also shown in the Fig. Calculate the maximum bending stress and maximum shearing stress in the beam.

8. (a) Determine the value of \( EI \) midway between the supports for the beam loaded as shown in Fig. for Q. No. 8(a) by double integration method.

(b) Determine the deflection interns of \( EI \) at a distance 2 m from the support by area moment method for the beam as shown in the Fig. for Q. No. 8(b).
SECTION – A

There are FOUR questions in this section. Answer any THREE.
Symbols used have their usual meaning.

1. (a) (i) Explain complex number and its representation in Cartesian and in polar form. Give examples and show in graphs. (ii) Prove the triangle inequalities of complex numbers \( |z_1 + z_2| \leq |z_1| + |z_2| \) and \( |z_1 - z_2| \geq ||z_1| - |z_2|| \). (20\%)

(b) Find four roots of the equation \( z^4 + 2\sqrt{3} + 2i = 0 \) in rectangular coordinates, exhibit them geometrically, and point out which is the principal root. (11)

(c) Find a bilinear transformation which maps the upper half of the \( z \) plane into the unit circle in the \( w \) plane in such a way that \( z = i \) mapped into \( w = 0 \) while the point at infinity mapped into \( w = -1 \). (15)

2. (a) Define analytic function and harmonic function. Show that \( u(x, y) = \frac{3}{y} + 2x^2 - y^2 \) is harmonic in some domain and find its harmonic conjugate \( v(x, y) \). Express \( f(z) = u + iv \) in terms of \( z \). (23)

(b) Evaluate \( \int_C dz \) from \( z = 0 \) to \( z = 4 + 2i \) along the curve \( C \) given by (i) \( z = t^2 + it \); (ii) the line from \( z = 0 \) to \( z = 2i \) and then from \( z = 2i \) to \( z = 4 + 2i \). (23\%)

3. (a) State and prove Cauchy's Integral formula. (16\%)

(b) Use Cauchy's Integral formula to evaluate \( \int_C \frac{\cos z}{z(z^2 + 8)} \) dz; where \( C \) is the boundary of the square defined by the lines \( x = \pm 2 \) and \( y = \pm 2 \), described in the positive sense. (15)

(c) Determine the poles of the function \( f(z) = \frac{1}{z(z-2)^4} \), find residue at each pole and then evaluate \( \int_C \frac{1}{z(z-2)^4} \) dz, where \( C \) is the positively oriented circle \( |z - 2| = 3 \). (15)

4. Workout the following two integrals using residues and contours: (23\%+23)

(i) \( \int_0^\infty \frac{dx}{x^4 + 1} \)  
(ii) \( \int_0^\infty \frac{\sin x}{x} \) dx

Contd .......... P/2
MATH 263 (ME)

SECTION - B

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

5. Solve the following partial differential equations
   (a) \( p + 3q = 5z + \tan(y - 3x) \) \( \text{(10)} \)
   (b) \( 2(px + qy + z) = p^2y \) \( \text{(12)} \)
   (c) \( px + qy = z\sqrt{1 + pq} \) \( \text{(12)} \)
   (d) \( pz - qz = z^2 + (x + y)^2 \) \( \text{(12} \frac{2}{3}) \)

6. Solve the following higher order PDEs
   (a) \((2D_x^2 - D_x D_y - 6D_y^2)z = e^{x-y}x^2y \) \( \text{(16)} \)
   (b) \((3D_x + D_y - 1)(2D_x - 3D_y + 2)(D_x + 4D_y - 3)z = \sin(2x + y) \) \( \text{(18} \frac{2}{3}) \)
   (c) \((x^2D_x^2 - y^2D_y^2)z = x^2y \) \( \text{(12)} \)

7. (a) Expand \( f(x) = x, 0 < x < 2 \) in a half range sine series and cosine series.
   (b) Find the finite Fourier sine transform and finite Fourier cosine transform of the 
       function \( f(x) = x^2 \), where \( 0 < x < l \). \( \text{(22)} \)

8. (a) Use finite Fourier transform to solve \( \text{(20)} \)

\[ \frac{\partial u}{\partial t} = 2 \frac{\partial^2 u}{\partial x^2}, \quad 0 < x < 4, \quad t > 0, \quad u(0, t) = 0, \quad u(4, t) = 0 \]
\[ u(x, 0) = 3 \sin \pi x - 2 \sin 5\pi x \]

Give a physical interpretation of the solution.

(b) A circular plate of unit radius, whose faces are insulated, has half of its boundary kept 
    at constant temperature \( u_1 \) and the other half at constant temperature \( u_2 \). Find the steady 
    state temperature of the plate. \( \text{(26} \frac{2}{3}) \)

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SECTION – A

1. (a) 'Sociology is a general science of a society' - Explain this statement on the basis of the nature of sociology. (10)
   (b) Describe the four factors that contributed to the development of sociology as an independent discipline. (15)
   (c) Discuss conflict theoretical perspective of sociology. (10)

2. (a) What is meant by social norm? Explain why culture is considered as a normative system of a society. (20)
   (b) Critically discuss Karl Mark's analysis of technology and ideology of a society. (15)

3. (a) What do you understand by globalization? Describe the background factors of globalization. (10)
   (b) How does mass media play the gatekeeping role in a society? (10)
   (c) Discuss the process of poverty reduction in the context of Bangladesh. (15)

4. Write short notes on any three of the following: (35)
   (a) Types of socialization.
   (b) Social mobility.
   (c) System's of social stratification.
   (d) Cooley's looking glass self theory.

SECTION – B

5. (a) Critically discuss the world system theory of development. (10)
   (b) Describe essential differences between crime and deviance. (10)
   (c) Write down the consequences of rural-urban migration in Bangladesh. (15)

6. (a) What are the negative impacts of capitalism on society. (10)
   (b) Write down different evolutionary stages of city on the basis of Mumford's theory. (15)
   (c) Explain the various stages of demographic transition theory. (10)
HUM 201

7. (a) How do you define human ecology and man-made environment? (10)
(b) Define green house gases: How do you define environmental justice? (10)
(c) Briefly discuss the potential consequences of global warming. (15)

8. Write down short notes on any THREE of the following (35)
(a) Juvenile delinquency
(b) Nuclear family
(c) Electronic media
(d) Fatalism.
SECTION - A

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

1. (a) Mention two suitable techniques for inspection of materials to identify internal and surface defects. With diagrams describe the ultrasonic testing to identify a defect in a finished product. (17)

(b) Name three important characteristics of martensitic transformation of steel. (11)

(c) Describe in short the effect of tempering temperature on the hardness, toughness and residual stress of a quenched high carbon steel part. (7)

2. (a) Discuss the differences in microstructures and properties one would expect if hypereutectoid steel is annealed and normalized from the same temperature. (10)

(b) "Annealed hypoeutectoid steel has higher pro-eutectoid constituents compared to normalized hypoeutectic steel" - Explain. (8)

(c) Is it possible to determine the approximate carbon content of a normalized steel from microscopic study? Explain. (7)

(d) Give a comparative account on carburizing and nitriding processes of surface hardening method. (10)

3. (a) What is coring? (7)

(b) For a Fe-C alloy containing 1.2 wt% C at a temperature. Just below the eutectoid determine the following:

(i) The fraction of total ferrite and cementite phases. (18)

(ii) The fraction of proeutectoid cementite and pearlite.

(iii) The fraction of eutectoid cementite and pearlite.

In Fe-Fe₃C diagram Fe₃C contains 6.67% C. The solubility of ferrite is about 0.025% at eutectoid temperature. Eutectoid point is at 0.76% C.

(c) Describe the microstructural changes that would occur when a 0.35% carbon steel is slowly cooled from fully austenitic region to room temperature. (7)

(d) Draw the room temperature microstructure of eutectoid (0.76% C) steel. (3)

Contd ........... P/2
MME 291

4. (a) How can one produce a low sulphur steel from high sulphur and phosphorus pig iron in an electric arc furnace? Explain the process with all steps and possible chemical reactions.

(b) What are the meanings of the terms 'deoxidation' and 'recarburization'? Why are those two steps performed at the end of a steel making processes?

SECTION – B

5. (a) Draw a neat sketch of the iron blast furnace. Give the chemistry of iron making process, indicating clearly how and where different impurities are picked up by the iron produced in the blast furnace.

(b) Why is blast furnace gas cleaned? Mention the functions and principle of each component of blast furnace gas cleaning system.

6. (a) Give the difference between 'malleable' and 'nodular' cast irons. Mention how ferritic malleable cast iron is produced.

(b) Mention some advantages of non-ferrous metals over the ferrous metals.

(c) Pure aluminium can be strengthened by alloying with copper. Explain this effect in detail in Al-Cu binary alloy by age hardening principles and mechanism.

7. (a) Differentiate between elastic and plastic deformation and hence show that elastic deformation is a atomic scale phenomena.

(b) Name different strategies for strengthening of metals and explain in detail the mechanism of strain hardening of metals. Why and how the restoration of ductility is carried out after strain hardening.

8. (a) Compare fatigue and creep failures.

(b) Explain how fatigue occurs in various stages.

(c) Describe the effect of temperature and applied stress on the creep failure of metals.

(d) Illustrate the factors that reduce the creep failure of metals and name few metallic materials that are resilient to creep.
SECTION – A
There are FOUR questions in this Section. Answer any THREE.

1. (a) Make a comparative discussion on Society and State. (15)
   (b) Analyze the relationship between nationalism and internationalism. (20)

2. (a) Classify democrat form of government with relevant examples. (15)
   (b) Examine the nature and functions of political parties in a modern state. (20)

3. (a) Write down the characteristics of sovereignty. (10)
   (b) Distinguish between 'Legal Rights' and Moral Rights.
   (c) Discuss the functions of the legislature in a state.

4. Write short notes on any three (3) of the following:
   (a) Unitary State
   (b) Ideal Type of Bureaucracy
   (c) Great Mass Upsurge of 1969
   (d) Written Constitution

SECTION – B
There are FOUR questions in this Section. Answer any THREE.

5. (a) Make a comparative analysis on Democracy and Dictatorship. (15)
   (b) Define local government. Discuss the problems of local government of Bangladesh. Do you have any suggestions for solving these problems? (20)

6. (a) Discuss the political system of United Kingdom. (15)
   (b) Critically evaluate the role of United Nations in ensuring world peace. (20)

7. (a) Describe the amendment procedure of Bangladesh constitution. Briefly discuss the 13th and 15th amendments to Bangladesh Constitution. (b) Analyze the principles of Bangladesh foreign policy.

8. Write short notes on any three (3) of the following:
   (a) Popular sovereignty
   (b) Civil Society
   (c) Language Movement
   (d) Parliamentary Democracy