1. (a) In the context of centrifugal and axial-flow pumps, explain the significance of:
   (i) Specific Speed, (ii) Shutoff Head (iii) NPSH (iv) Pump Priming. (4x3=12)

   (b) Write down the salient features of "Characteristic-curve of a centrifugal pump at various speeds of rotation with contours of equal efficiency". (6)

   (c) A pump is installed to deliver water from a reservoir of surface elevation zero to another of elevation 90 m. The 30 cm-diameter suction pipe \( (f = 0.020) \) is 30 m long and the 25 cm-diameter discharge pipe \( (f = 0.026) \) is 1,500 m long. The pump characteristic at 1,200 rpm is defined by \( h_p = 115 - 9000 Q^2 \) where \( h_p \), the pump head, is in meters and \( Q \) is in \( m^3/s \). Compute the rate at which this pump will deliver water under these conditions assuming the setting is low enough to avoid cavitation. (17)

2. (a) List the factors or phenomena which must be taken into consideration in the course of Model-Study. (5)

   (b) Describe the significance and application of the following dimensionless numbers: (3x3=9)
   (i) Reynolds Number (ii) Mach Number (iii) Weber Number

   (c) Explain briefly the benefits and limitation of Dimensional Analysis. (6)

   (d) Derive an expression for the flow rate \( q \) over the spillway shown in the accompanying figure per foot of spillway perpendicular to the sketch. Assume that the sheet of water is relatively thick so that surface-tension effects may be neglected. Assume also that gravity effects predominate so strongly over viscosity that viscosity may be neglected. (15)
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3. (a) A viscous fluid is in laminar flow in a slit formed by two identical parallel vertical walls (area of each: \( L \times W \)) a distance 2\( \beta \) apart. Assume that the flow is in the downward direction under the combined action of pressure and gravitational forces. Make a differential momentum balance and obtain the expressions for the distributions of momentum flux and velocity.

(b) Write down technical notes on—
   (i) Equation of Continuity
   (ii) Equation of Motion

4. (a) Select the specific speed of the pump or pumps required to lift 425 L/s of water 114 m through 3000 m of 90 cm-diameter pipe (\( f = 0.020 \)). The pump rotative speed is to be 1750 rpm. Consider the following cases: single pump, three pumps in series, two pumps in parallel.

(b) Describe the working principle, operation and application of the following measurement devices:
   (i) Hot-Wire Anemometer
   (ii) Falling-share Viscometer
   (iii) Piezometer Ring

(c) Write a short note on "Venturi Tube".

SECTION – B

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

5. (a) A smooth pipe consists of 52 ft of 9 in pipe followed by 310 ft of 18 in pipe with an abrupt change of cross section at the junction as in Fig. for Q. 5(a). The entrance is flush and the discharge is submerged. If it carries water at 90°F, with a velocity of 19 fps in the smaller pipe, what is the total head loss?

Contd ………. P/3
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Contd... Q. No. 5

(b) What is surface tension? Show that for lifting force created by surface tension to the gravity, the capillary rise is given by,

\[ h = \frac{2\alpha \cos \theta}{r \gamma} \]

Notations have usual meaning.

(c) What are body forces and surface forces?

6. (a) Derive Newton's equation of viscosity.

(b) Calculate the pressure at point A of manometer shown in Fig. for Q. 6(b).

(c) Derive necessary equation for bourdon gauge and piezometer column.

7. (a) A tank of oil has a right triangular panel near the bottom as shown in Fig. for Q. 7(a). Find:
   (i) Hydrostatic force on the panel.
   (ii) Position of the center of pressure.

(b) In a fire fighting system, a pipe line with a pump leads to a nozzle as shown in Fig. for Q. 7(b). Find the flowrate when the pump develops a head of 80 ft, given that we may express the frictional head loss in the 6-in diameter pipe by \( h_f = \frac{5V_a^2}{2g} \) and the frictional head loss in the 4-in diameter pipe by \( h_f = \frac{12V_a^2}{2g} \). Find:
   (i) Power delivered to the water by the pump, and
   (ii) Power of the jet.

8. (a) Water at 60°F flows through the new 10-in diameter cast iron pipe sketched as in Fig. for Q. 8(a). The pipe is 5000 ft long, its entrance is sharp-cornered but nonprojecting and \( \Delta Z = 260 \) ft. Find the flow rate.
   For cast iron, \( \varepsilon = 0.00085 \) ft.
   For square-edged entrance: \( k_e = 0.5 \)

(b) Assume the flow to be frictionless in the siphon shown in Fig. for Q. 8(b), where \( a = 3 \) ft, \( b = 12 \) ft. Find the rate of discharge in cfs and the pressure head at B if the pipe has a uniform diameter of 3 in.
Table 8.2 Loss coefficients for sudden contraction

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<th>$D_2/D_1$</th>
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<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
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<td>0.00</td>
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Table 8.3 Values of loss factors for pipe fittings

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<td>10</td>
</tr>
<tr>
<td>Angle valve, wide open</td>
<td>5</td>
</tr>
<tr>
<td>Close-return bend</td>
<td>2.2</td>
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<tr>
<td>T, through side outlet</td>
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<td>Short-radius elbow</td>
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<td>Medium-radius elbow</td>
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<td>Long-radius elbow</td>
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<td>0.42</td>
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<td>Gate valve, wide open</td>
<td>0.19</td>
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<tr>
<td>Half open</td>
<td>2.06</td>
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</table>
Figure 7.13 Moody diagram. (From L. F. Moody, Trans. ASME, Vol. 66, 1944.)
1. (a) The overhanging beam ABC as shown in the Fig. 1(a) carries a concentrated load and a uniformly distributed load. (i) Derive the shear force and bending moment equations; (iii) Draw the shear force and bending moment diagrams. Neglect the weight of the beam.

(b) Construct the shear force and bending moment diagrams for the beam as shown in the Fig. 1(b) by the area moment method. Neglect the weight of the beam.

2. (a) The simply supported beam of circular cross section as in Fig. 2(a) carries a uniformly distributed load of intensity $w_0$ over two-thirds of its length. What is the maximum allowable value of $w_0$ if the working stress in bending is 50 MPa?
(b) A 600-lb/ft uniformly distributed load is applied to the left half of the cantilever beam ABC as shown in the Fig. 2(b). Determine the magnitude of force $P$ that must be applied so that the displacement at A is zero.

3. (a) Determine the value of $E_Iy$ midway between the supports for the beam loaded as shown in the Fig. 3(a).

(b) A simply supported beam reinforced at the top and bottom by the steel plates as shown in the Fig. 3(b) carries a uniformly distributed load of 25 kN/m over its entire span of 5 m. If $n = 15$, determine the maximum stresses in timber and steel.

4. Select the lightest W shape for a fixed ends column of length 6 m that carries an axial load of 145 kN. Use AISC column specifications. Yield strength $\sigma_y = 360$ MPa and modulus of elasticity $E = 200$ GPa.

(Property table of W-shape has been attached with the question)
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SECTION – B

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

5. (a) A rigid bar is suspended by two vertical rods, as shown in Fig. 5(a). The bar remains horizontal before applying the load P. Find the vertical displacement at the point of application of load. Consider \( P = 60 \) kN.

(b) For a thin-walled cylinder, subjected to internal pressure only, show that the value of tangential stress is twice the value of longitudinal stress.

6. (a) At room temperature (20°C) a 0.5 mm gap exists between the ends of two rods, as shown in Fig. 6(a).

At a later time when the temperature reaches 140°C, determine the normal stresses developed in both the rods.

(b) A thick-walled steel cylinder of internal diameter 120 mm contains fluid of pressure 40 MPa. The yield strength of the cylinder material is 350 MPa. Determine the wall thickness of the cylinder considering a safety factor of 2.5 against any yielding in the cylinder.

7. (a) Two solids steel shafts connect three pulleys, as shown in Fig. 7(a). Using \( G = 80 \) GPa, determine the angle through which pulley A rotates with respect to (i) pulley B, (ii) pulley C.

(b) A C-frame is subjected to load P, as shown in Fig. 7(b). Determine the maximum load P that can be applied if the allowable normal stress is 150 MPa. Consider the problem as a curved beams problem.

8. (a) An element is subjected to the state of stress, as shown in Fig. 8(a). Find the principal and the maximum shear stresses and also the stress components on a plane at 30° in the anticlockwise direction from the x-axis.

(b) A rigid bar, hinged at one end is supported by two identical springs, as shown in Fig. 8(b). Each spring consists of 20 turns of 10-mm wire having a mean diameter of 150 mm. Compute the maximum shearing stress in the springs.
### Properties of W Shapes (Wide- Flange Sections)

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<th>Depth, $h$ (mm)</th>
<th>Width, $b$ (mm)</th>
<th>Thickness, $t$ (mm)</th>
<th>Flange Thickness, $t$ (mm)</th>
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</table>
**Fig. 5(a)**

Bronze
- $E_B = 600\text{GPa}$
- $A_B = 600\text{mm}^2$
- $L_B = 2.5\text{m}$

Steel
- $E_S = 200\text{GPa}$
- $A_S = 300\text{mm}^2$
- $L_S = 3.5\text{m}$

**Fig. 6(a)**

Aluminum
- $A = 200\text{ mm}^2$
- $E = 70\text{ GPa}$
- $\alpha = 33 \times 10^{-6}/\text{°C}$

Stainless steel
- $A = 800\text{ mm}^2$
- $E = 190\text{ GPa}$
- $\alpha = 18 \times 10^{-6}/\text{°C}$

**Fig. 7(a)**

**Fig. 7(b)**

**Fig. 8(a)**

$60\text{MPa}$

$40\text{MPa}$

$30\text{MPa}$

$-2\text{m}$

$2\text{m}$

$2\text{m}$

$10\text{kg}$

**Fig. 8(b)**

$30\text{MPa}$
L-2/T-2/CHE

Date: 25/01/2017

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
Sub: HUM 103 (Economics)

Full Marks: 210  Time: 3 Hours

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

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SECTION – A

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

1. (a) Write down the statement of application of Euler's theorem in the theory of distribution of production. How can you show the exhaustion of factor income according to Euler's theorem? (10)

   (b) Discuss the various internal economies of scale of production. (10)

   (c) What are the conditions of profit maximization? Deduce mathematically. (5)

   (d) Define optimization. How can optimization be achieved? Why is optimization necessary with reference to the production of a firm? (10)

2. (a) Make a comparative discussion between perfect competition and monopolistic competition. (5)

   (b) Explain the short run equilibrium of a firm under monopoly market. (10)

   (c) What is meant by the shut-down point of production? Graphically explain the shut-down point of production of a firm under perfect competition. (10)

   (d) Given the following total revenue (TR) and total cost (TC) functions for a firm

       \[ TR = 1400Q - 7.5Q^2 \]
       \[ TC = Q^3 - 6Q^2 + 140Q + 750 \]

       Where \( Q \) is quantity of output.

       (i) Set up the profit function

       (ii) Find out the quantity which will make the profit maximum

       (iii) Calculate the maximum profit and verify that is maximized. (10)

3. (a) Explain the concepts of gross national production (GNP), gross domestic product (GDP) and net national product (NNP). (5)

   (b) Discuss any two methods of measuring national income of a country. (10)

   (c) Briefly explain the various difficulties in the measurement of national income. (10)

   (d) Calculate national income from the following information:

       \[ GNP = Tk. 17,000 \text{ crore} \]
       \[ \text{Depreciation} = Tk. 9,500 \text{ crore} \]
       \[ \text{Indirect tax} = Tk. 12,500 \text{ crore} \]
       \[ \text{Subsidy is 25% of indirect tax} \]

   Contd ........... P/2
4. (a) According to Amartya Sen, the process of economic development can be seen as a process of expanding capabilities of people. Briefly discuss Amartya Sen's view on economic development preceded by evolution of development economics. 

(b) Explain 'Rostow's linear stage growth model' with examples and limitations. 

(c) Critically explain Harrod-Domar growth model. 

SECTION-B

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

5. (a) Using the axiom of diminishing marginal utility draw the demand curve of the consumer. 

(b) Describe the assumptions of the cardinal approach to utility analysis. What is the basic difference between the cardinal and ordinal approaches to utility analysis? 

(c) 'What to produce', 'how to produce' and 'whom to produce' are the three fundamental economic problems. Do you agree that these problems are universal? Give reasons in favour of your answer. How are these problems solved in a capitalist economy? 

6. (a) What do you understand by 'change in quantity demanded' and 'change in demand'? 

(b) Briefly describe the factors that determine the size of the coefficient of price elasticity of demand? 

(c) Let, the demand function of a commodity Y is given by

\[ Q_{dy} = 1895 - 33P_y + 5.8P_x - 7P_z + 0.006M \]

Where price of Y (P_y) is Tk. 80, price of X (P_x) is Tk. 110, price of Z (P_z) is Tk. 100 and the level of income (M) is Tk. 80000. Find the income and cross-price elasticities of demand for commodity Y. What kind of commodity is Y? Define the relationship between Y and Z based on the results you have obtained. 

7. (a) Development process in the surplus-labour nations can largely be explained by Lewis two-sector model. What does this model of economic development emphasize? Critically examine the model. 

(b) Consider a Solow economy with the production function

\[ Y = A^K \theta L^B \quad (\alpha < 1, \beta > 0) \]

Contd ………. P/3
which is characterised by constant returns to scale. Here $Y$, $K$, $L$, $A$ and $AL$ stand for output, capital, labour, technology and effective labour respectively. Moreover, consider that technology and labour grow at constant rates $'g'$ and $'n'$ respectively.

(i) Express the production function in per effective labour term

(ii) Show that there is diminishing marginal returns to the capital per effective labour.

(iii) Find out the Solow equation $(\dot{y} = sy - (n + g + \delta) y)$ of dynamics of economy and explain it graphically.

(c) Define LDC, developing and developed countries.

8. Write short notes on any THREE of the following

(a) Factors affecting supply for a commodity
(b) Substitution effect and income effect of a price change
(c) Marginal rate of substitution (MRS)
(d) The optimum consumption point of a consumer under indifference curve approach.
SECTION – A

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

1. (a) What are heterocyclic compounds? Give classification of heterocyclic compounds. (3+7=10)
(b) Describe the process of commercial preparation of tetrahydrofuran from 1, 4-butenediol. (8)
(c) How furfural undergoes the following chemical process?
   (i) Benzoin condensation (ii) Cannizzaro reaction (8)
(d) Show the structural elucidation of indigo. (9)

2. (a) Explain with mechanism Frédé-Craft's alkylation reaction and mention its limitations. (10)
(b) Show the general mechanism of electrophilic aromatic substitution with examples. (12)
(c) What happens when benzene is treated with the followings:
   (i) Chlorine in presence of sunlight (9)
   (ii) Air in presence of vanadium-pentoxide
   (iii) Fuming sulphuric acid
(d) With reference to aromatic disubstitution, explain the term ortho-para directors. (4)

3. (a) Prove the following statements: (3×3=9)
   (i) Pyridine has a ring structure with five carbons and one nitrogen
   (ii) Pyridine contains a tertiary nitrogen
   (iii) Pyridine exhibits aromatic character.
(b) What happens when pyridine is treated with (3×3=9)
   (i) C₄H₅Li at 110°C
   (ii) KNO₃ and H₂SO₄ at 300°C
   (iii) Peracetic acid
(c) Write down the structures of the following compounds: (3+6=9)
   (i) Saccharin (ii) Cyclamate (iii) Nectarin
What is saccharin? How will you prepare saccharin starting from toluene?
(d) Provide a suitable synthesis for each of the following dyes and also mention their uses: (8)
   (i) Butter yellow (ii) Methyl orange

4. (a) Mention the various methods for the detection of alkaloids. (7)
(b) Show the biosynthesis of the alkaloid harmine. (6)
(c) Explain the procedure of estimating N-alkyl and C-methyl groups quantitatively by Herzig-Meyer and Kuhn-Roth method. (10)
(d) Briefly discuss how the structure of conine was established. (12)
5. (a) What is conformation? Draw all conformational isomers of n-butane with the help of Newman projection and show their stability with an energy profile diagram.  
(b) Show the synthesis of n-pentane using the Corey-House alkane synthetic method. 
(c) Show the preparation of but-2-ene with mechanism using the following reactions. 
   (i) Dehydration of alcohol 
   (ii) Wittig reaction 
   (iii) Boord et al. synthesis. 
(d) Give structures and names of the products expected from the reactions of 3-methyl but-1-ene with the following reagents. 
   (i) H$_2$O$_2$, HBr  
   (ii) Br$_2$, H$_2$O  
   (iii) O$_3$; Zn, H$^+$ 

6. (a) Explain why alkynes are more acidic than alkenes and alkanes. 
(b) Show the preparation of Butyne-2 and Hexyne-3 from acetylene. 
(c) Give the preparation of the following compounds from acetylene. 
   (i) Isoprene  
   (ii) Butadiene  
   (iii) Vinylacetate  
   (iv) Vinylchloride 

7. (a) Give the factors favouring the SN$_1$ and SN$_2$ reactions. 
(b) Solvolysis of an alkylhalide is SN$_1$ reaction. Explain with mechanism. 
(c) Of the following statements, which are true for nucleophilic substitutions occurring by the SN$_2$ mechanism? Justify your answer with example. 
   (i) The reaction shows second order kinetics 
   (ii) The probable mechanism involves only one step 
   (iii) Carbocations are intermediates. 
   (iv) The absolute configuration of the product is opposite to that of the reactant when an optically active substrate is used. 

8. (a) What are arene compounds? 
(b) Give two methods of preparation of arene compounds. 
(c) Explain why nitro (NO$_2$) group is m-directing and deactivating group in electrophilic aromatic substitution reaction. 
(d) Give the preparation of the following compounds: 
   (i) p-Toluic acid from Toluene 
   (ii) m-Bromophenol from nitrobenzene 
   (iii) m-Bromoaniline from nitrobenzene 
   (iv) p-Nitroaniline from aniline