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

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) Explain the various internal and external economics of scale of production.
   
   (b) Discuss the nature of demand curve under monopoly market. Explain the short-run equilibrium of a firm under monopoly market.
   
   (c) Calculate the profit maximizing level of output and maximum profit from the following total revenue (TR) and total cost (TC) functions
   
   \[ TR = 1200Q - 2Q^2 \]
   \[ TC = Q^3 - 61.25Q^2 + 1538.5Q + 2000 \]

2. (a) Illustrate the assumptions of perfect competition.
   
   (b) Define the concept of long-run. Show how would you derive long-run average cost (LAC) curve of a firm from its short-run average cost curves. Why is LAC curve often called the planning curve?
   
   (c) What are the arguments in favour of non-equality between savings and investment? Describe how J.M. Keynes proved that savings and investment are equal.

3. (a) Explain the concepts of national income, GNP, GDP and NNP.
   
   (b) Briefly discuss the various methods of measuring national income with reference to the context of Bangladesh.
   
   (c) What are the main causes of inflation? Explain.
   
   (d) Given that
   
   \[ GNP = Tk. 1,02,000 \text{ crore} \]
   \[ \text{Depreciation} = Tk. 9,000 \text{ crore} \]
   \[ \text{Indirect tax} = Tk. 12,000 \text{ crore} \]
   \[ \text{Subsidy is 25% of indirect tax} \]
   
   calculate national income.

4. (a) Discuss Professor Rostow's various stages of economic growth with reference to the context of Bangladesh.
   
   (b) What is meant by the concept of balanced growth?
   
   (c) Briefly discuss the strategy of unbalanced growth with reference to the context of a least developed country like Bangladesh.

Contd .......... P/2
There are FOUR questions in this Section. Answer any THREE.

5. (a) What are the fundamental problems of every economy? (10)
(b) How many kinds of economic systems are there? Discuss all the features of different economic systems. (20)
(c) What is opportunity cost? Explain with example. (5)

6. (a) What is meant by market demand? Explain graphically. (10)
(b) What are the determinants of supply curve? Discuss with example. (20)
(c) Distinguish between the concepts of 'change in demand' and 'change in quantity demanded'. (5)

7. (a) How does disequilibrium situation arise in the market due to price disturbances? Explain with graph. (20)
(b) Define price elasticity of supply. Write down its formula and give suitable example. (5)
(c) Calculate the equilibrium price and the equilibrium quantity of wheat from the following demand and supply functions:

\[ Q_{dx} = 1000 - 20P_x \]  \( \cdots \) (1)
\[ Q_{sx} = 500 + 30P_x \]  \( \cdots \) (2) (10)

8. (a) Describe the Law of diminishing marginal utility. Explain all the conditions under which the Law would be valid. (15)
(b) What are the core values of economic development? (10)
(c) What are the objectives of economic development? (10)
SECTION – A

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

1. (a) Derive Lagrange’s interpolation formula and hence obtain the inverse interpolation formula.

(b) Apply Lagrange’s inverse interpolation formula to find the value of $x$ at $y = 1.285$, by considering the following table:

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<tr>
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<th>0.738</th>
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<td>1.2849085</td>
<td>1.2857159</td>
<td>1.2865247</td>
<td>1.2875348</td>
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</tbody>
</table>

2. (a) Use Newton-Raphson method to find the approximate value for the real root of $x \log_{10} x - 1.2 = 0$, correct to five decimal places.

(b) By the method of iteration, find a real root of $2x - \log_{10} x = 7$, correct to seven decimal places.

3. (a) Find the first and second derivative of the function tabulated below, at the point $x = 3.0$

<table>
<thead>
<tr>
<th>$x$</th>
<th>3.0</th>
<th>3.2</th>
<th>3.4</th>
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<td>-5.296</td>
<td>0.256</td>
<td>6.672</td>
<td>14.000</td>
</tr>
</tbody>
</table>

(b) Find by the method of least squares a formula of the type $y = ab^x$ which fits the following data.

<table>
<thead>
<tr>
<th>$x$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>8</th>
</tr>
</thead>
<tbody>
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<td>3.6</td>
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</table>

4. (a) Find the general quadrature formula for equidistant ordinates and hence obtain the Weddle’s rule.

(b) Evaluate $\int_{0}^{1} \frac{x^3}{e^x + 1} \, dx$, by Weddle’s rule dividing the range of integration into 12 equal parts.
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SECTION – B
There are FOUR questions in this Section. Answer any THREE.

5. Solve the initial value problem \( \frac{dy}{dx} = \frac{x - y}{2} \) subject to the initial condition \( y(0) = 2 \) to find \( y(0.2) \) by
   (i) Euler’s method taking \( h = 0.05 \) and
   (ii) Runge-Kutta method taking \( h = 0.1 \)

6. (a) Define Skewness and Kurtosis with classifications. For a distribution the mean is 10, variance is 16, \( \gamma_1 \) is +1 and \( \beta_2 \) is 4. Find the first four moments about the origin. Represent this distribution graphically for \( \gamma_1 \) and \( \beta_2 \) with proper comments.
   (b) Explain null and alternative hypothesis. The average waiting time in a bank counter to cash a cheque for all customers is 50 minutes. A new service-providing procedure using modern computer facilities being tried. If a random sample of 12 customers had a mean waiting time for service is 42 minutes with a standard deviation of 11.9 minutes under the new system, test the hypothesis that the population mean is now less than 50, using 5% level of significance assuming the waiting time is normally distributed. (see Table 1)

7. (a) Write the concept of regression and correlation analysis. Describe the situations when \( r = -1, 0 \) and \(+1\). Obtain both the regression equations as well as the correlation coefficient from the following data.

<table>
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<tr>
<th>X</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>16</td>
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   (b) Define mutually exclusive events, conditional probability and independent events. A coin is biased so that a head is twice as likely to occur as a tail. If the coin is tossed three times, what is the probability of getting 2 tails and 1 head?

8. (a) Let \( X \) and \( Y \) denote the lengths of life, in years, of two components in an electronic system. If the joint density function of these variables is \( f(x, y) = \begin{cases} e^{-(x+y)}, & x > 0, y > 0 \\ 0, & \text{elsewhere} \end{cases} \)
   find \( P(0 < X < 1 | Y = 2) \).
   (b) Prove that \( \sigma_{XY} = E(XY) - \mu_X \mu_Y \).
   (c) If \( X \) is a binomial random variable with probability distribution \( b(x; n, p) \) and \( n \to \infty, \ p \to 0, \ np \to \lambda \) remains constant then show that \( b(x; n, p) \to p(x; \lambda) \).
   In a certain industrial facility accidents occur infrequently. If it is known that the probability of an accident on any given day is 0.005 and accidents are independent of each other. What is the probability that
   (i) in any given period of 400 days there will be an accident on one day and
   (ii) there are at most three days with an accident.

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APPENDIX VII. The t Distribution

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<td>1.960</td>
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</table>

Table 1 for question 6(b)
SECTION – A

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

1. (a) Give three methods of preparation of chromatic amine. (9)
   (b) How can you prepare p-amino-benzonic acid from p-toludine? Give all the possible steps. (8)
   (c) What products are obtained by reduction of nitrobenzene under different conditions of pH? (9)
   (d) How will you synthesize 1, 3, 5-trinitrobenzene from toluene? (9)

2. (a) Discuss the structure of benzenediazonium chloride. How will you synthesize benzoic acid from benzenediazonium chloride? (4+7)
   (b) Discuss Hofmann-Martius rearrangement reaction. (9)
   (c) How will you distinguish between chlorobenzene and benzyl chloride? (6)
   (d) How can phenylacetic acid be synthesized from toluene? (9)

3. (a) Discuss briefly the directive influence of methyl and nitro groups. (8)
   (b) Show the alkylation reaction of benzene and propyl chloride. (9)
   (c) What are lipids? Give examples of different types of lipids with structure. (9)
   (d) What are essential oils? Give the classification of terpenes. (4)
   (e) Give brief description of pheromones. (5)

4. (a) Describe a mechanism for the SN1 reaction showing transition state, configuration and order of reaction. (12)
   (b) What are the factors affecting the rates of SN1 and SN2 reactions. (11)
   (c) Complete the following equations showing only the major organic product, and predict which reaction mechanism (SN1, SN2, E1, E2) is the most likely: (12)
   
   (i) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{CH}_3\text{OH} \) →
   (ii) \( \text{CH}_3\text{CH}_2\text{CBr} + \text{OH}^- + \text{CH}_3\text{OH} \) →
   (iii) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{CH}_3\text{O}^- \) →

   **Contd ……..** P/2
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SECTION - B

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

5. (a) Give a view of the molecular orbital picture of pyridine. Apply Hückel rule to prove the aromaticity of pyridine. Show the resonance structure of pyridine. (6)

(b) Describe a commercial method for the synthesis of pyridine (3)

(c) Justify with example that pyrrole undergoes electrophilic substitution primarily at C-2 position while pyridine undergoes electrophilic substitution principally at position C - 3. (11)

(d) How can pyridine be converted into the following? (5x3=15)
   (i) Piperidine  (ii) Pyridine-3-sulphonic acid (iii) Pyridine-1-oxide (iv) N-Methyl pyridinium iodide (v) 2-Phenylpyridine

6. (a) Write with a probable mechanism the Skraup synthesis for α,β-benzopyridine and Fischer Indole synthesis for indole. (10)

(b) How furfural undergoes the following reaction: (2x5=10)
   (i) Cannizzaro reaction (ii) Perkin's reaction

(c) Describe a commercial method for the synthesis of fibre nylon 6-6 from tetrahydrofuran (THF). (9)

(d) How will you obtain 4-chlorobutanol and 1,4-dichlorobutane from tetrahydrofuran (THF)? (6)

7. (a) What are alkaloids? Mention some of the important physiological activities of alkaloids. (2+4=6)

(b) Give different methods for the structural elucidation of alkaloids. (11)

(c) Show the preparation of but-2-ene with mechanism using the following reactions (any two): (9)
   (i) Dehydrohalogenation of alkylhalide  (ii) Wittig reaction  (iii) Boord et al synthesis

(d) Give the structures and names of the products expected from the reaction of 2-methyl-but-2-ene with: (3x3=9)
   (i) KMnO₄ (aq), Heat (ii) O₃ followed by Zn with H⁺ (iii) C₆H₅CO₂H.

8. (a) What is conformation? Draw Newman projections for all possible conformations of butane. Give the more and less stable conformers of cyclohexane and methyl cyclohexane. (6+6=12)

(b) Explain, why alkynes are more acidic than alkenes and alkanes. (5)

(c) Show the preparation of Butyne-1, Butyne-2 and Hexyne-3 from acetylene. (9)

(d) Write equations showing the initiation, propagation and termination steps for the chlorination of methane. Why iodination of methane is not feasible? (6+3=9)
1. (a) Consider the flow of fluid in a vertical circular tube of length $L$ and radius $R$.

(i) Derive the Hagen-Poiseuille formula for the volume rate of flow by using shell momentum balance.

(ii) Find the $z$-component of the force of the fluid on the wetted surface of the pipe.

(b) Glycerine at 26.5°C is flowing through a horizontal tube 1 ft long and 0.1 in. inside diameter. For a pressure drop of 40 psi, the flowrate is 0.00398 ft$^3$/min. The density of glycerine at 26.5°C is 1.261 g/cm$^3$. From the flow data, find the viscosity of glycerine in centipoise.

2. In a gas absorption experiment a viscous fluid flows upward through a small circular tube and then downward on the outside as in Fig. for Q. 2. Set up a momentum balance over a shell of thickness $\Delta r$ in the film, as shown in the figure.

(a) Show that the velocity distribution in the falling film is

\[ v_r = \frac{\rho g R^2}{4 \mu} \left[ 1 - \left( \frac{r}{R} \right)^2 + 2a^2 \ln \left( \frac{r}{R} \right) \right] \]

(b) Obtain an expression for the volume rate of flow in the film.

3. (a) Show that for the shock wave where the approaching supersonic flow changes to subsonic flow, the sudden rise in pressure and temperature is given by,

\[ \frac{P_2}{P_1} = \frac{2kM_1^2 - (K - 1)}{K + 1} \]

\[ \frac{V_2}{V_1} = \frac{(K - 1)M_1^2 + 2}{(K + 1)M_1^2} \]

(b) A normal shock wave, occurs in the flow of air where

$P_1 = 70$ N/m$^2$, $T_1 = 5^\circ C$ and $V_1 = 425$ m/s

Find $P_2$, $V_2$ and $T_2$.

(c) What is NPSH and pump priming?

(d) Describe the characteristics curves of a centrifugal pump.
4. (a) Explain the principle of centrifugal pump by the help of a vector diagram.

(b) A horizontal venturi meter having a throat diameter of 20 mm is set to a 75 mm-ID pipeline. Water at 15°C is flowing through the line. A manometer containing mercury under water measure the pressure differential over the instrument. When the manometer reading is 500 mm, what is the flowrate in m³/hr? If 12% of the differential is permanently lost, what is the power consumption of the meter?

(c) It is proposed to pump 10,000 kg/h of toluene at 114°C and 1.1 atm abs pressure from the reboiler of a distribution tower to a second distillation unit without cooling the toluene before it enters the pump. If the frictional loss in the line between the reboiler and pump is 7 kN/m² and the density of toluene is 866 kg/m³, how far above the pump must the liquid level in the reboiler be maintained to give a net positive suction head of 2.5 m?

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

5. (a) Show that the pressure variation within a static fluid is given by

\[ \frac{dp}{dz} = -\gamma \]

(b) On a particular day the atmospheric pressure at sea level is 100 kPa abs, and the temperature is 30°C. Compute the atmospheric pressure at elevation 5000 m. Assume that air temperature decreases linearly with elevation at a rate of 0.0065 °C/m.

(c) In the Figure for Q. No. 5(c), a Newtonian fluid of viscosity \( \mu \) fills the small gap of thickness \( \gamma \). Determine an expression for the torque \( \tau \) required to rotate the truncated cone at constant angular speed \( \omega \). Neglect fluid stress exerted on the circular bottom.

6. (a) Explain Bernoulli’s theorem from the viewpoint of energy conservation. What are the assumptions used here? What modifications do we normally use to apply Bernoulli’s equation in practical situations?

(b) Find the stagnation pressure on the nose of a submarine moving at 30 km/h in seawater (\( \gamma = 10.65 \text{ kN/m}^2 \)) when it is 40 m below the surface.

(c) A pipeline conducts water from a reservoir to a powerhouse, the elevation of which is 250 m lower than that of the reservoir surface. The water is discharged through a nozzle with a jet velocity of 68 m/s and the diameter of the jet is 20 cm. Find the power (kW) of the jet and the kW lost in friction between reservoir and jet.

Contd ……….. P/3
7. (a) Write the physical meanings of Reynolds number, Froud number and Euler number.

(b) A sectional model of a spillway 0.9 m high is placed in a laboratory flume of 25 cm width. Under a head of 10 cm the flow is 20 liter/s. What flow does this represent in the prototype if the model scale is 1: 25 and the spillway is 200 m long?

(c) Use dimensional analysis to derive an expression for the drag on a submerged torpedo. The parameters involved are the size of the torpedo L, the velocity of the torpedo V, the viscosity of water \( \mu \), and the density of water \( \rho \).

8. (a) A smooth pipe consists of 50 m of 20-cm pipe followed by 90 m of 40-cm pipe with an abrupt change of cross section at the junction. It has a re-entrant entrance and a submerged discharge. If it carries water at 15°C (\( \rho = 999.1 \text{ kg/m}^3 \) and \( \mu = 1.139 \times 10^{-3} \text{ N.s/m}^2 \)) in the smaller pipe with a velocity of 5.5 m/s, what is the total head loss?

(b) How large a pipe (relative roughness = 0.002) is required to convey oil (sp. Gr. = 0.9, \( \mu = 0.04 \text{ N.s/m}^2 \)) from one tank to another at a rate of 30 liter/s, if the pipe is 700 m long and the difference in elevation of the free liquid surfaces is 10 m?
Figure for Question 2

Figure for Question 5. (c)
Friction factor for pipes (Moody diagram)
SECTI ON - A

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

1. A 750 mm long hollow column, having circular cross section with 5 mm wall thickness, is made from steel (Yield strength: $\sigma_y = 430$ MPa, Modulus of elasticity: $E = 200$ GPa) and is subjected to an axial load of 60 kN.
   (a) Determine the minimum outside diameter of the column if the column is fixed at both ends. Assume factor of safety 3.0.
   (b) Also determine the load that the designed column can support considering eccentricity ratio $\frac{e}{r}$ of 0.25 and factor of safety 3.5.

2. Determine the dimensions as mentioned in Fig. for Q. No. 2 of a yoke connection to withstand a load of 40 kN. The allowable stress in tension, compression and shear are respectively 200 MPa, 200 MPa and 100 MPa.

3. (a) Draw a typical normal stress and normal strain diagram and locate the following points with definition.
   (i) Proportional limit
   (ii) Elastic limit
   (iii) Yield point
   (b) A 5-m steel shaft rotating at 2 Hz has 70 kW applied at a gear that is 2 m from the left end where 20 kW are removed. At the right end, 30 kW are removed and another 20 kW leaves the shaft at 1.5 m from the right end. (i) Find the uniform shaft diameter so that the shearing stress will not exceed 60 MPa. (ii) If a uniform shaft diameter of 100 mm is specified, determine the angle by which one end of the shaft lags behind the other end. Use $G = 83$ GPa.

4. (a) The rigid platform in Fig. for Q. No. 4(a) has negligible mass and rests on two steel bars, each 250.00 mm long. The center bar is aluminum and 249.90 mm long. Compute the stress in the aluminum bar after the center load $P = 400$ kN has been applied. For each steel bar, the area is 1200 mm$^2$ and $E = 200$ GPa. For the aluminum bar, the area is 2400 mm$^2$ and $E = 70$ GPa.
   (b) A cylindrical steel pressure vessel 400 mm in diameter with a wall thickness of 20 mm, is subjected to an internal pressure of 4.5 MN/m$^2$. (i) Calculate the tangential and longitudinal stresses in the steel. (ii) To what value may the internal pressure be increased if the stress in the steel is limited to 120 MN/m$^2$? (iii) If the internal pressure were increased until the vessel burst, sketch the type of fracture that would occur.

Contd ......... P/2
5. (a) Derive the formula for calculating horizontal shearing stress acting on a beam. From this formula obtain an expression for shear flow. Discuss the physical significance of shear flow.
(b) For the beam loaded as shown in Figure for Q. No. 5(b) write the equations of shear force and bending moment. Also draw the shear force and bending moment diagrams.

6. (a) Derive the relation between horizontal and vertical shearing stresses acting on an element of a beam, and explain.
(b) Consider a cantilever beam of length L subjected to a uniformly distributed load of W over its entire length. Using the double integration method find the equation of the elastic curve for this beam. Hence obtain an expression for the maximum deflection.
(c) What is section modulus? Suppose for a given supporting and loading condition you have the following options to choose a beam cross-section,
   (i) circular (with diameter 'd')
   (ii) square (with one side length 'd')
   which one will you choose and why?

7. (a) For the state of plane stress shown in Figure for Q. No. 7(a), determine
   (i) the principal planes and the principal stresses.
   (ii) the stress components exerted on the element obtained by rotating the given element counter clockwise through 30°.
(b) Determine the maximum tensile and compressive stresses developed in the overhanging beam as shown in Figure for Q. No. 7(b). The cross-section of the beam is an inverted T with the given properties as shown in the figure.

8. (a) What is flexural stress? State the assumptions that are used in deriving the flexural and shearing stresses in beams.
(b) Distinguish between statically determined and indetermined beams.
(c) For the beam loaded as shown in Fig. for Q. No. 8(c), draw the shear force and bending moment diagrams. Also compute the maximum moment.
(d) Briefly discuss the steps to calculate deflection of a beam by using the area-moment method.