BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **IPE 307** (Operations Research)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Let $a$ be a given n-vector, and $A$ be a given n×n symmetric matrix. Compute the gradient and Hessian of $f_1(x) = a^T x$ and $f_2(x) = x^T Ax$. **(13)**

(b) Consider the problem **(13)**

$$\min_{x \in R^2} f(x) = -2x_1 + x_2 \text{ subject to } \begin{cases} (1 - x_1)^3 - x_2 \geq 0 \\ x_2 + 0.25x_1^2 - 1 \geq 0 \end{cases}$$

The optimal solution is $x^* = (0, 1)^T$, where both constraints are active. Does the LICQ hold at this point? Are the KKT conditions satisfied?

(c) Consider the nonlinear problem: **(20⅔)**

min $f(x) = x_1^2 + x_2^2 - 4x_1 + 4$

subject to

$g_1(x) = x_1 - x_2 + 2 \geq 0$

$g_2(x) = -x_1^2 + x_2 - 1 \geq 0$

$g_3(x) = x_1 \geq 0$

$g_4(x) = x_2 \geq 0$

Show that the constraints define a convex set. Also, show that the objective function $f(x)$ is convex.

2. (a) Consider the primal and dual problems in our standard form presented in matrix notation. Use only this definition of the dual problem for a primal problem in this form to prove each of the following results. **(16⅔)**

(i) The weak duality property.

(ii) If the primal problem has an unbounded feasible region that permits increasing Z indefinitely, then the dual problem has no feasible solutions.

(b) For any linear programming problem in our standard form and its dual problem, label each of the following statements as true or false and then justify your answer. **(9)**

(i) The sum of the number of functional constraints and the number of variables (before augmenting) is the same for both the primal and the dual problems.

(ii) At each iteration, the simplex method simultaneously identifies a CPF solution for the primal problem and a CPF solution for the dual problem such that their objective function values are the same.

(iii) If the primal problem has an unbounded objective function, then the optimal value of the objective function for the dual problem must be zero.

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**Contd ... Q. No. 2**

(c) Consider the following problem **(21)**

Maximize $Z = 6x_1 + 8x_2$,

subject to

$5x_1 + 2x_2 \leq 20$

$x_1 + 2x_2 \leq 10$

and

$x_1 \geq 0, x_2 \geq 0$

(i) Construct the dual problem for this primal problem.

(ii) Solve both the primal problem and the dual problem graphically. Identify the CPF solutions and corner-point infeasible solutions for both problems. Calculate the objective function values for all these solutions.

(iii) Use the information obtained in part (ii) to construct a table listing the complementary basic solutions for these problems.

(iv) Work through the simplex method step by step to solve the primal problem. After each iteration (including iteration 0), identify the BF solution for this problem and the complementary basic solution for the dual problem. Also identify the corresponding corner-point solutions.

3. (a) Explain why it is not necessary to add a constraint to the transportation model that the decision variables must have integer values. **(6)**

(b) Two politicians soon will be starting their campaigns against each other for a certain political office. Each must now select the main issue she will emphasize as the theme of her campaign. Each has three advantageous issues from which to choose, but the relative effectiveness of each one would depend upon the issue chosen by the opponent. In particular, the estimated increase in the vote for politician 1 (expressed as a percentage of the total vote) resulting from each combination of issues is as follows: **(20)**

| | | Issue for Politician 2 | | |
|---|---|---|---|---|
| | | **1** | **2** | **3** |
| Issue for Politician 1 | 1 | 7 | −1 | 3 |
| | 2 | 1 | 0 | 2 |
| | 3 | −5 | −3 | −1 |

However, because considerable staff work is required to research and formulate the issue chosen, each politician must make her own choice before learning the opponent's choice. Which issue should she choose?

For each of the situation described here, formulate this problem as a two-person, zero-sum game, and then determine which issue should be chosen by each politician according to the specified criterion.

(i) The current preferences of the voters are very uncertain, so each additional percent of votes won by one of the politicians has the same value to her. Use the minimax criterion.

Contd ..... P/3

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**Contd ... Q. No. 3(b)**

(ii) A reliable poll has found that the percentage of the voters currently preferring politician 1 (before the issues have been raised) lies between 45 and 50 percent. (Assume a uniform distribution over this range.) Use the concept of dominated strategies, beginning with the strategies for politician 1.

(iii) Suppose that the percentage described in part (ii) actually were 45 percent. Should politician 1 use the minimax criterion? Explain. Which issue would you recommend? Why?

(c) The Onenote Co. produces a single product at three plants for four customers. The three plants will produce 60, 80, and 40 units, respectively, during the next time period. The firm has made a commitment to sell 40 units to customer 1, 60 units to customer 2, and at least 20 units to customer 3. Both customers 3 and 4 also want to buy as many of the remaining units as possible. The net profit associated with shipping a unit from plant *i* for sale to customer *j* is given by the following table: **(20⅔)**

| | | Customer | | | |
|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** |
| Plant | 1 | \$800 | \$700 | \$500 | \$200 |
| | 2 | \$500 | \$200 | \$100 | \$300 |
| | 3 | \$600 | \$400 | \$300 | \$500 |

Management wishes to know how many units to sell to customers 3 and 4 and how many units to ship from each of the plants to each of the customers to maximize profit.

(i) Formulate this problem as a transportation problem where the objective function is to be maximized by constructing the appropriate parameter table that gives unit profits. Obtain an optimal solution.

(ii) Now formulate this transportation problem with the usual objective of minimizing total cost by converting the parameter table from part (i) into one that gives unit costs instead of unit profits. Obtain an optimal solution.

(iii) Compare the optimal solutions for the two formulations.

4. (a) Consider a typical barber shop. Demonstrate that it is a queueing system by describing its components. **(6)**

(b) Derive the expressions for the expected number of customers in queueing system for the finite queue variation of the M/M/s model. **(22⅔)**

(c) Consider a birth-and-death process with just three attainable states (0, 1, and 2), for which the steady-state probabilities are $P_0$, $P_1$, and $P_2$, respectively. The birth-and-death rates are summarized in the following table: **(18)**

| State | Birth Rate | Death Rate |
|---|---|---|
| 0 | 1 | --- |
| 1 | 1 | 2 |
| 2 | 0 | 2 |

Contd ..... P/4

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**Contd ... Q. No. 4(c)**

(i) Construct the rate diagram for this birth-and-death process.

(ii) Develop the balance equations.

(iii) Solve these equations to find $P_0$, $P_1$, and $P_2$.

(iv) Use the general formulas for the birth-and-death process to calculate $P_0$, $P_1$, and $P_2$. Also calculate $L$, $L_q$, $W$, and $W_q$.

## SECTION – B

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

5. (a) Discuss the assumptions of Linear Programming. **(15)**

(b) Show that, there is an unbounded solution to the following linear programming problem. **(24⅔)**

Maximize, $Z = 4x_1 + x_2 + 3x_3 + 5x_4$

Subject to,

$$4x_1 - 6x_2 - 5x_3 - 4x_4 \geq -20$$

$$-3x_1 - 2x_2 + 4x_3 + x_4 \leq 10$$

$$-8x_1 - 3x_2 + 3x_3 + 2x_4 \leq 20$$

(c) Define degeneracy and explain when it occurs. **(7)**

6. (a) Differentiate Deterministic and Stochastic models with examples. **(12)**

(b) Briefly describe the steps of mathematical model building procedures. **(24⅔)**

(c) "Post-optimality analysis is an important part of Operations Research study" – explain why? **(10)**

7. (a) Discuss with example in which case a linear programming problem has multiple optimal solutions. **(8)**

(b) A strategic bomber command receives instructions to interrupt the enemy tank production. The enemy has 4 key plants located in separate cities and destruction of any one plant will effectively halt the production of tanks. There is an acute shortage of fuel, which limits the supply to 45,000 litres for this particular mission. Any bomber sent to any particular city must have at least enough fuel for the round trip plus 200 litres. **(24⅔)**

The number of bombers available to the commander and their descriptions are as follows:

| Bomber type | Description | km/litre | Number available |
|---|---|---|---|
| A | Heavy | 2 | 40 |
| B | Medium | 2.5 | 30 |

Information about the location of the plants and their probability of being attacked by a heavy and a medium bomber is given below:

| Plant | Distance from base (km) | Probability of destruction by | |
|---|---|---|---|
| | | Heavy bomber | Medium bomber |
| 1 | 400 | 0.10 | 0.08 |
| 2 | 450 | 0.20 | 0.16 |
| 3 | 500 | 0.15 | 0.12 |
| 4 | 600 | 0.25 | 0.20 |

Contd ..... P/5

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**Contd ... Q. No. 7(b)**

Now, formulate a linear programming model regarding how many of each type of bombers should be dispatched and how should they be allocated among the four targets in order to maximize the probability of success.

(c) There are six cities in kilroy country. The country must determine where to build fire stations. The country wants to build the minimum number of fire stations needed to ensure that at least one fire station is within 15 minutes (driving time) of each city. The times required to drive between the cities in kilroy country are shown in the following table. **(14)**

Table: Time required (in minutes) to travel between cities in Kilroy Country.

| From | To | | | | | |
|---|---|---|---|---|---|---|
| | City 1 | City 2 | City 3 | City 4 | City 5 | City 6 |
| City 1 | 0 | 10 | 20 | 30 | 30 | 20 |
| City 2 | 10 | 0 | 25 | 35 | 20 | 10 |
| City 3 | 20 | 25 | 0 | 15 | 30 | 20 |
| City 4 | 30 | 35 | 15 | 0 | 15 | 25 |
| City 5 | 30 | 20 | 30 | 15 | 0 | 14 |
| City 6 | 20 | 10 | 20 | 25 | 14 | 0 |

Now, formulate an Integer Programming model that will tell kilroy how many fire stations should be built and where they should be located.

8. (a) The Brothers furnitures manufactures tables and chairs. A table requires 1 hr of labor and 9 square board feet of wood, and a chair requires 1 hr of labor and 5 square board feet of wood. Currently, 6 hrs of labor and 45 square board feet of wood are available. Each table contributes \$8 to profit and each chair contributes \$5 to profit. Now solve this problem using Branch-and-Bound technique to maximize the profit. **(26⅔)**

(b) A company has one surplus truck in each of the cities A, B, C, D and E, and one deficit truck in each of the cities 1, 2, 3, 4, 5 and 6. The distance between the cities in kilometers is shown in the table below: **(20)**

| | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| **A** | 12 | 10 | 15 | 22 | 18 | 8 |
| **B** | 10 | 18 | 25 | 15 | 16 | 12 |
| **C** | 11 | 10 | 3 | 8 | 5 | 9 |
| **D** | 6 | 14 | 10 | 13 | 13 | 12 |
| **E** | 8 | 12 | 11 | 7 | 13 | 10 |

Find the assignment of trucks from cities in surplus to cities in deficit so that the total distance covered by the vehicles is minimum.

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L-3/T-1/IPE **Date : 17/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **IPE 301** (Measurement, Instrumentation and Control)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Explain the function of the analog-to-digital (A/D) converter circuit used in analog input modules. Compare bit level and word level addressing. **(10)**

   (b) What is a smart sensor? Describe the configuration of remote I/O PLC systems with appropriate schematic diagram. **(10)**

   (c) Compare the PLC and PC with regard to: **(15)**

   (i) Physical hardware differences
   (ii) Operating environment
   (iii) Method of programming
   (iv) Execution of program

2. (a) Explain the operation of the following input devices, stating the form of the signal being sensed and the output: (i) reed switch, (ii) incremental shaft encoder, (iii) photoelectric transmissive switch. **(12)**

   (b) Explain the "XIC" operation method with necessary sketches. **(10)**

   (c) A potentiometer with a uniform resistance per unit length of track is to have a track length of 100 mm and used with the output being measured with an instrument of resistance 10 kΩ. Determine the resistance required of the potentiometer if the maximum error is not to exceed 1% of the full-scale reading. **(13)**

3. (a) What is the overall transfer function of a closed-loop negative feedback system having a forward path transfer function of 2/(s+1) and a feedback path transfer function of 0.1? **(10)**

   (b) Describe how the I/O modules connect to the processor in a modular-type PLC configuration. **(13)**

   (c) A pump is to be used to fill two storage tanks. The pump is manually started by the operator from a start/stop station. When the first tank is full, the control logic must be able to automatically stop flow to the first tank and direct flow to the second tank through the use of sensors and electric solenoid valves. When the second tank is full the pump must shut down automatically. Indicator lamps are to be included to signal when each tank is full. Prepare a typical PLC program for this control process. **(12)**

Contd ..... P/2

**IPE 301**

4. (a) It is required to have a pilot light come on when all of the following circuit out of three requirements are met: (i) All four circuit pressure switches must be closed. (ii) At least two circuit limit switches must be closed. (iii) The reset switch must not be closed. Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem. **(12)**

(b) Write short notes: **(12)**

(i) Instruction Addressing

(ii) Logical continuity

(iii) Internal Relay Instructions

(c) Compare the method by which the process control operation is changed in a relay-based system to the method used for a PLC-based system. **(11)**

## SECTION – B

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

5. (a) What are the basic principles that should be observed in the design of instruments and gauges? **(8)**

(b) Explain the terms: **(12)**

(i) Bilateral tolerance

(ii) Basic size

(iii) Allowance

(c) Explain with neat sketches the basic hole system and unilateral tolerances. Discuss their suitability in comparison to other systems. **(15)**

6. (a) Explain Taylor's principle. **(13)**

(b) What are the considerations for deciding the limits on the limit gauges? **(12)**

(c) Design the general type go and not-go gauges for component having 25 H7/f8 fit. Being given with usual notations: **(10)**

(i) i (microns) = $0.45\sqrt[3]{D} + 0.001D$ (D in mm)

(ii) the upper deviation for f shaft = $-5.5\ D^{0.41}$

(iii) 25 mm falls in diameter step of 18 and 30

Take wear allowance as 10% of the gauge tolerance. Also determine type of fit and allowance for the fit.

Contd ..... P/3

**IPE 301**

7. (a) Explain the working principles of a profilometer. **(12)**

   (b) Describe various methods of measuring surface texture giving their relative advantages. **(13)**

   (c) Calculate the C.L.A. value of a surface for the following data: the sampling length is 0.8 mm and the graph drawn to a vertical magnification of 15000 and horizontal magnification of 100 and the areas above and below the datum line are 160, 90, 180, 50 $mm^2$ and 95, 65, 170, 150 $mm^2$ respectively. **(10)**

8. (a) Describe the major errors in thread measurement. **(11)**

   (b) What do you understand by drunken thread? How is it caused? **(10)**

   (c) What is a effective diameter of thread? Explain the two-wire method of effective diameter measurement of a thread. **(14)**

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L-3/T-1/IPE Date : 24/05/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **IPE 305** (Manufacturing Process II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Explain different types of laser cutting process. **(14)**

   (b) What are the principle parameters of a grinding wheel? How the grinding zone temperatures can be reduced in grinding operation? Explain briefly. **(13)**

   (c) In a surface grinding operation the wheel diameter = 150 mm and the infeed = 0.07 mm. The wheel speed = 1450 m/min, work speed = 0.25 m/s, and the cross-feed = 5 mm. The number of active grits per area of wheel surface C = 0.75 grits/mm$^2$. Determine (i) average length per chip, (ii) metal removal rate, and (iii) number of chips formed per unit time for the portion of the operation when the wheel is engaged in the work. **(8)**

2. (a) Explain the principle of operation of Ultrasonic Machining with necessary sketches. **(14)**

   (b) What is the difference among water jet cutting, abrasive water jet cutting, and abrasive jet cutting? **(11)**

   (c) The frontal working area of the electrode is 2000 mm$^2$ in a certain ECM operation in which the applied current = 1800 amps and the voltage = 12 volts. The material being cut is nickel (valence = 2), whose specific removal rate C is given ($3.42 \times 10^{-2}$ mm$^3$/A-s). (i) If the process is 90% efficient, determine the rate of metal removal in mm$^3$/min. (ii) If the resistivity of the electrolyte = 140 ohm-mm, determine the working gap. **(10)**

3. (a) Explain the principle of operation of Electron Beam Machining with necessary sketches. **(13)**

   (b) Describe plasma arc cutting method and list its applications. **(12)**

   (c) A drilling operation is to be performed with a 25.4 mm diameter twist drill in a steel workpart. The hole is a blind-hole at a depth = 50 mm, and the point angle = 118°. Cutting conditions are: speed = 25 m/min, feed = 0.25 mm/rev. Determine: (i) the cutting time to complete the drilling operation, and (ii) metal removal rate during the operation, after the drill bit reaches full diameter. **(10)**

4. (a) Write short notes on: **(12)**

   (i) Chemical Blanking

   (ii) Electrochemical Deburring

   (iii) Pocket Milling

   (b) Give two examples of machining operations in which generating and forming are combined to create workpart geometry and explain the steps involved in those operations. **(12)**

   (c) How do you classify photoresist materials on the basis of their chemical properties? Explain their development mechanism with necessary sketches. **(11)**

Contd ..... P/2

**IPE 305**

## SECTION – B

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

5. (a) From the machining performance viewpoint which type of chip is preferred? Explain your answer with suitable justification. Also show the conditions which favor such a chip formation. **(8)**

(b) With the help of Levy-Lode's theorem, show that for pure shear, e = 30°and for pure compression, e = 60°. **(12)**

(c) During turning of a steel rod of diameter 100 mm by a carbide tool of geometry; 0°, –10°, 8°, 7°, 15°, 75°, 0.5 (mm) at speed 625 rpm, feed 0.36 mm/rev and depth of cut 5 mm the followings were observed: **(15)**

Cutting force = 1000 N, Feed force = 200 N, chip thickness = 1 mm.

Determine the expected values of the following parameter for the above mentioned machining operation.

(i) Co-efficient of friction at the chip-tool interface ($\mu$) and the friction angle ($\eta$).

(ii) Shear angle ($\beta$)

(iii) Shear force ($P_s$)

(iv) Compressive force at the shear plane ($P_n$)

(v) Dynamic yield shear strength ($\tau_s$)

6. (a) Describe the general pattern of tool wear of a single point cutting tool. Show the variation of flank wear of cutting tool with machining time and explain its importance from the tool life point of view. **(15)**

(b) With the help of Merchant theory, show that $P_z = \tau_s S_0 t [\cot \beta + \tan (c - \beta)]$, where the notations indicate their usual meaning. **(20)**

7. (a) Demonstrate tool geometry and define tool angles in American Standard Association (ASA) System and Orthogonal Rake System (ORS). **(13)**

(b) Derive the 'Kronenberg equation' for chip reduction coefficient. **(10)**

(c) What are the effects of high cutting temperature on tool and work piece? Describe briefly the basic methods of controlling high cutting temperature. **(12)**

8. (a) Describe the processing sequence in photolithography with necessary sketches. **(15)**

(b) Explain the Czochralski process of silicon crystal growth with a neat sketch. **(8)**

(c) Write short notes on: **(12)**

(i) Thermal Diffusion

(ii) Ion Implantation

(iii) Dry Plasma Etching

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L-3/T-1/IPE Date : 31/05/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **HUM 277** (Fundamentals of Economics)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Explain graphically the concepts of total utility and marginal utility. **(10)**

   (b) Starting with a utility function U = f(A, B), where A and B refer, respectively, to the quantities of commodities A and B and assuming a budget constrained derive the expressions for consumer equilibrium using calculus. **(15)**

   (c) What is meant by market demand for a commodity? Explain graphically. **(10)**

2. (a) Define, write and explain the concept of supply function. **(5)**

   (b) Discuss the factors that affect the supply of a commodity in general. **(12)**

   (c)(i) Calculate the equilibrium price quantity from the following demand and supply functions and show the results in a graph. **(18)**

   $QD_X = 4000 - 400P_x$

   $QS_x = -500 + 500P_x$

   (ii) If a per unit tax of Tk. 0.90 is imposed, how will it affect the equilibrium price and quantity?

   (iii) If government provides a subsidy of Tk. 2 per unit, what will happen to the equilibrium price and quantity?

3. (a) Define income elasticity demand and write down its formula. "A commodity may be luxury at 'low' levels of income, a necessity at intermediate' levels of income and an inferior commodity at 'high' levels of income" – Explain the statement with suitable example. **(10)**

   (b) Discuss any two properties of indifference curve. **(10)**

   (c) Explain Professor Rostow's various stages of economic growth with reference to the context of Bangladesh. **(15)**

4. (a) What is meant by development? Explain. **(10)**

   (b) Mathematically derive the Harrod-Domar growth model of economic development. **(10)**

   (c) Briefly narrate the criteria for making an investment decision. **(15)**

Contd ..... P/2

**HUM 277**

## SECTION – B

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

5. (a) What are the assumptions of a perfectly competitive market? Explain. **(10)**

   (b) Explain the short-run equilibrium of a firm under perfect competition. **(15)**

   (c) From the following revenue and cost functions, calculate the profit maximizing level of output and maximum profit. **(10)**

$$R = 100\,Q - Q^2$$

$$C = \frac{1}{3}\,Q^3 - 7\,Q^2 + 111\,Q + 50$$

6. (a) When does a firm emerge as a monopolist? **(10)**

   (b) Prove that $MR = P\left(1 - \frac{1}{e}\right)$ **(10)**

   where MR = marginal revenue
   P = price
   e = price elasticity of demand

   (c) Why is there no unique supply curve for the monopolist derived from his marginal cost curve? Explain graphically. **(10)**

   (d) What are the two conditions of equilibrium of a firm under monopoly? **(5)**

7. (a) Define fixed cost and variable cost. **(10)**

   (b) How would you derive the long-run average cost curve of a firm from its short-run average cost curves? **(10)**

   (c) A manufacturer has a fixed cost of $ 60,000 and a variable cost of $ 2 per unit made and sold. Selling price is $ 5 per unit. **(15)**

   (i) Find the revenue, cost and profit functions using q for number of units.
   (ii) Compute profit if 2500 units are made.
   (iii) Find the break-even quantity.
   (iv) What is the average cost if 3000 units are made?
   (v) Construct the break-even chart. Label the cost and revenue lines, the fixed cost line and the break-even point.

8. (a) What is meant by the concept of vicious circle of poverty? Explain the demand side and supply side of capital formation of vicious circle of poverty. **(20)**

   (b) Discuss the various steps to break the vicious circle of poverty in the context of a least developed country like Bangladesh. **(15)**

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L-3/T-1/IPE **Date : 10/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **ME 223** (Fluid Mechanics and Machinery)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) What is streamline. Deduce the continuity equation with necessary assumptions. **(18)**

(b) When a liquid jet strikes a flat plate inclined at an angle θ with the horizontal surface (Shown in figure 1(b)), it splits into two streams, one going up the plate with a mass flow rate $m_2$ and the other stream going down the plate with a mass flow rate $m_1$. The force required to hold the plate in position is $F_A$. Determine $F_A$, $\dot{m}_1$, $\dot{m}_2$. Also comment on the limiting cases, $\theta = 0°$, $\theta = 90°$. **(17)**

2. (a) Name different types of motion a fluid particle that can undergo in a flow field. Also derive an equation for translation of a fluid particle in a velocity field. **(15)**

(b) Consider one dimensional, unsteady, incompressible flow through a plane diverging channel shown in figure 2(b). The velocity on the horizontal centerline (x axis) is given by. **(12)**

$$\vec{V} = V_0 \left(1 - e^{-ct}\right)\left(1 - \frac{x}{L}\right)\hat{i}$$

Find the acceleration for a particle moving along that centerline. Also mention what happens when $t \to \infty$.

(c) Explain the working principle of a pitot static tube. **(8)**

3. (a) What is entrance length of flow in a circular pipe. Show, for a laminar flow entrance length is 138 times the diameter of a circular pipe. **(5)**

(b) For a fully developed laminar flow in a circular pipe derive **(15)**

(i) Maximum velocity in terms of average velocity

(ii) Velocity profile in terms of maximum velocity

(iii) Flow rate as a function of pressure drop.

(c) A fire protection system is supplied from a water tower and standpipe 80 ft tall. The longest pipe in the system is 600 ft and made of cast iron about 20 years old. The pipe contains one gate valve. Other minor losses may be neglected. The pipe diameter is 4 in. Determine the maximum rate of flow (gpm) through the pipe. **(15)**

Contd ..... P/2

**ME 223 (IPE)**

4. (a) What is Vena contracta? With a schematic diagram explain the working principle of an orificemeter. **(12)**

(b) Consider a point-source of sound that emits a pulse every $\Delta t$ seconds. Each pulse expands outward from its origination point at the speed of sound C. Discuss the four possibilities of flow situation if the point source itself is moving. **(8)**

(c) The pump in figure 4(c) draws water from a reservoir and delivers it through a 75 mm diameter nozzle to a maximum height of 6 m above the nozzle. What power must be delivered to the water by the pump? **(15)**

## SECTION – B

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

5. (a) What is Newtonian fluid? Give example. **(5)**

(b) An infinite plate is moving over a second plate on a layer of liquid. Assume a linear velocity distribution in the liquid. The viscosity of the liquid is $0.65 \times 10^{-3}$ kg/m-s) and its specific gravity is 0.88. The upper plate is moving at a velocity of 0.3 m/s while the gap between the plates is 0.3 mm as shown in Fig. 5(b). Calculate **(15)**

(i) The kinematic viscosity of the liquid
(ii) The shear stress in lower plate
(iii) Indicate the direction of each shear stress calculated in part (ii).

(c) Determine the force and its position from fluids acting on the door as shown in Fig. 5(c). **(15)**

6. (a) For isothermal fluid, derive the pressure-elevation relation. Also, show graphically how pressure varies with elevation. **(12)**

(b) Two water tubes are connected to each other through a mercury manometer with inclined tubes. The pressure difference between the two tanks is 20 kPa. Determine the parameters a and $\theta$ as shown in Fig. 6(b). The specific gravity of Hg is 13.6 and density of water is 1000 kg/m$^3$. **(10)**

(c) A multi-fluid container is connected to a U-tube. For the given specific gravities and fluid column heights as shown in Fig. 6(c), determine the gage pressure at A and the height of a mercury that would create the same pressure at A. Assume reasonable values if necessary. **(13)**

Contd ..... P/3

## ME 223 (IPE)

7. (a) An irregular shaped crown is weighted in air and then in water with a spring scale [Fig. 7(a)]. Determine whether the crown is made of pure gold or not. Assume density of water 1000 kg/m$^3$ and the density of gold is 19300 kg/m$^3$. **(18)**

   (b) A pump is newly and perfectly installed in your house by a plumber. When it is turned on, the water is not pumped to the overhead tank. Based on your fluid mechanics course, could you identify the possible reason? How would you solve the issue? **(5)**

   (c) Draw typical characteristics curves for a centrifugal pump. Show the relationship among power, head, and efficiency with discharge. **(12)**

8. (a) A centrifugal pump with an impeller of 0.5 m outside diameter rotates at 900 rpm. The constant velocity of flow is 4.5 m/s and the vanes are radial at exit. The impeller is 80 mm wide at the exit. The velocity of water in the delivery pipe is 3 m/s. Neglecting other losses, calculate the height through which water is to be lifted and the output power of the pump. **(15)**

   (b) What are the differences among fan, blower, and compressor? **(6)**

   (c) What are the purposes of a draft tube in a hydraulic turbine? **(9)**

   (d) What turbine does not require a draft tube and why? Explain briefly. **(5)**

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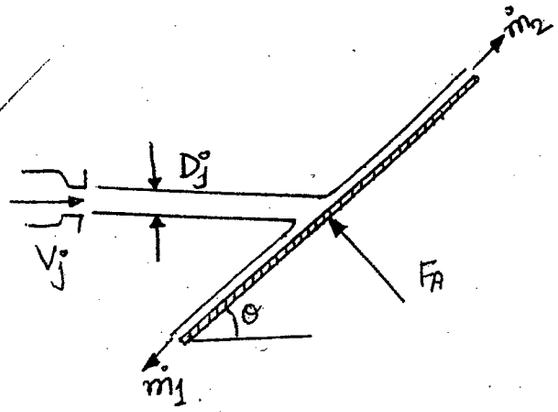


figure 1(b)

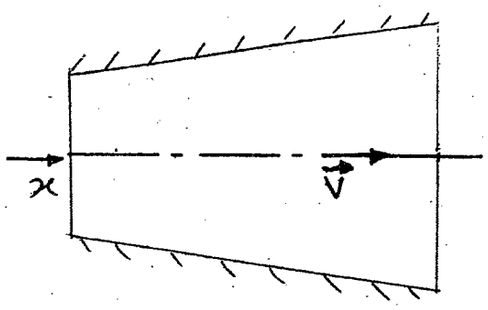


Figure 2(b)

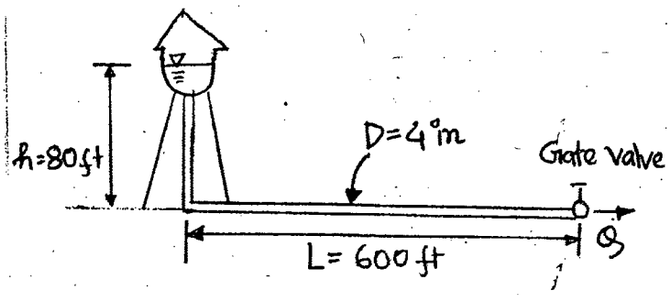


figure 3(c)

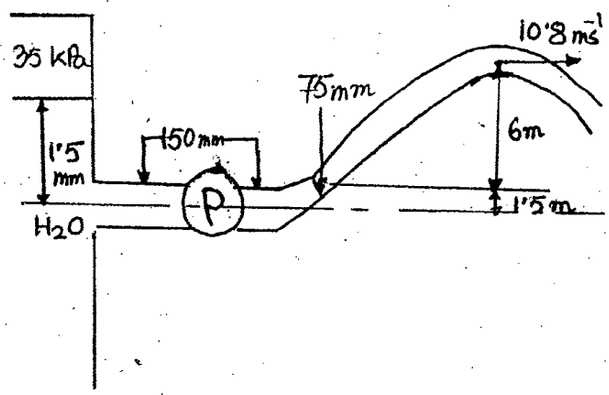


figure 4(c)

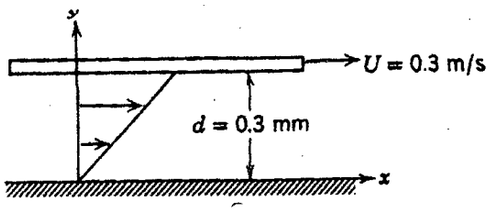


Fig. for Q. 5(b)

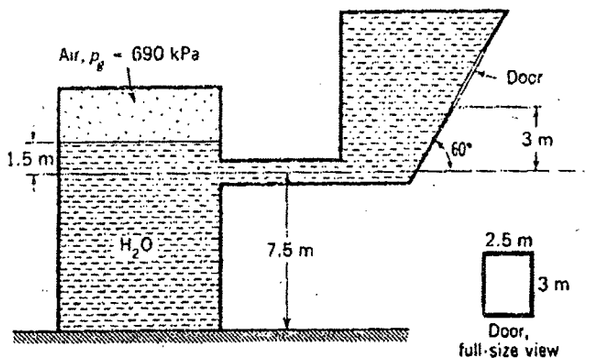


Fig. for Q. 5(c)

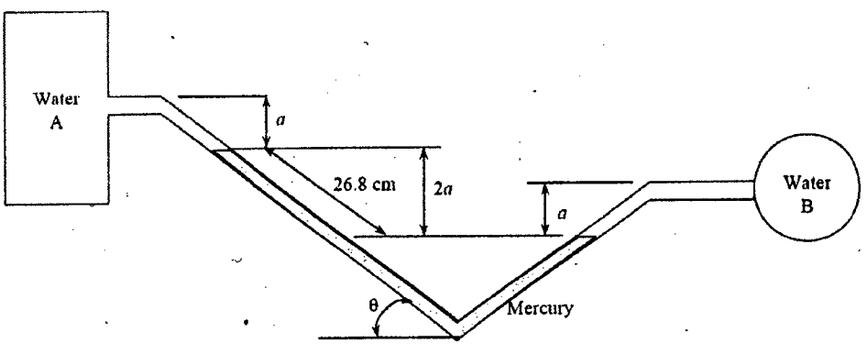


Fig. for Q. 6(b)

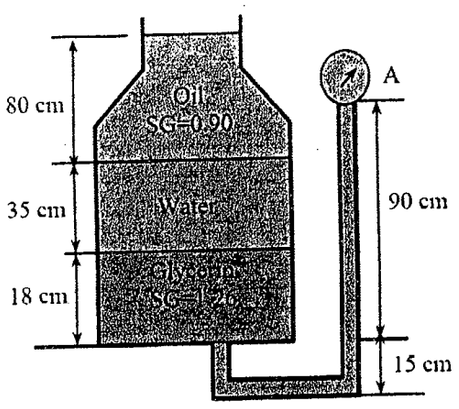


Fig. for Q. 6(c)

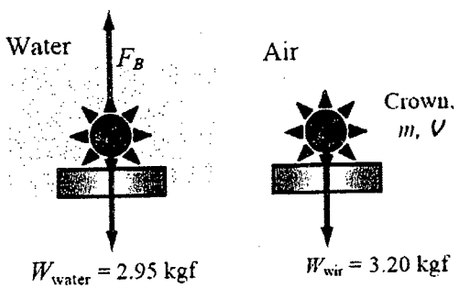


Fig. for Q. 7(a)

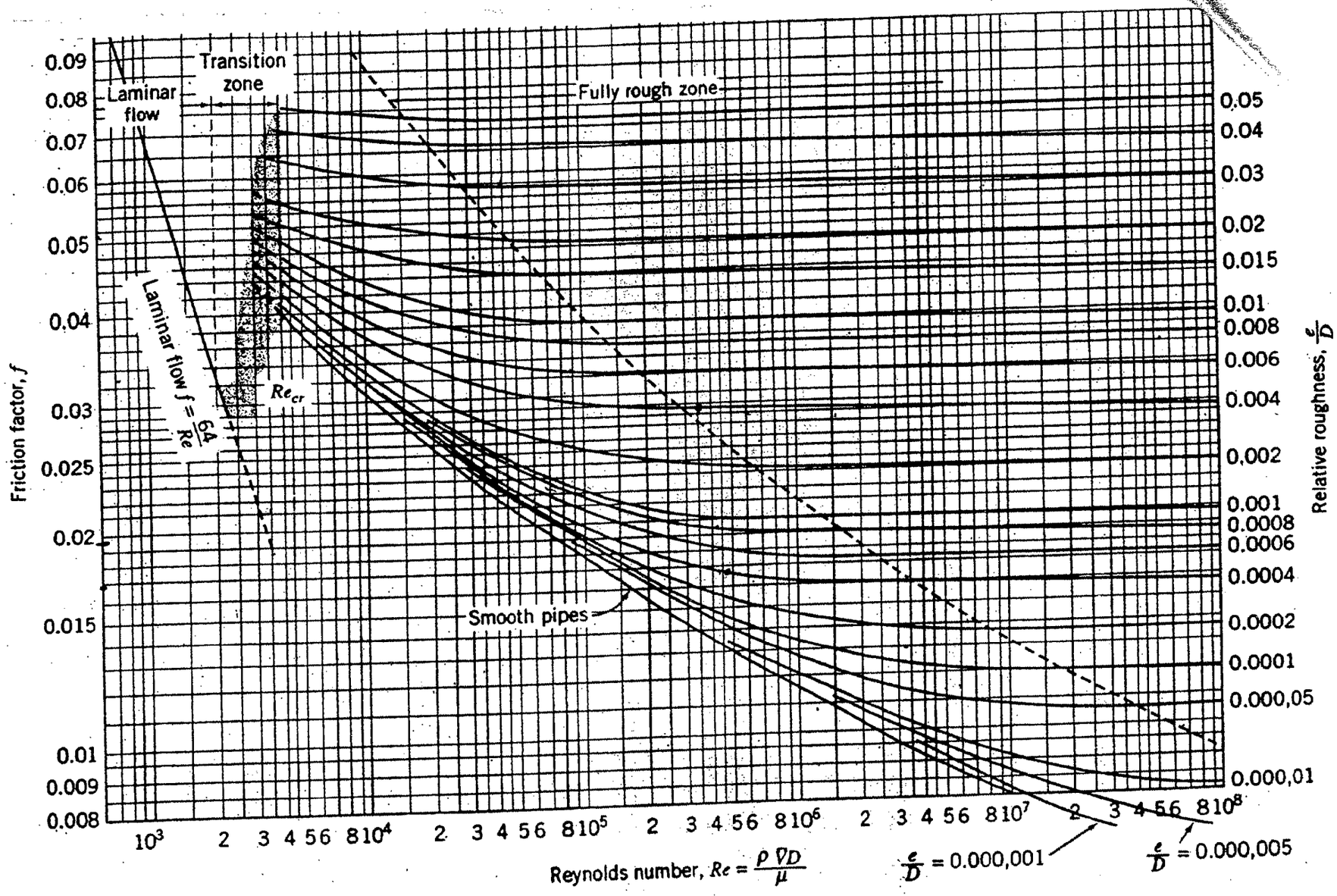


**Fig. 8.13** Friction factor for fully developed flow in circular pipes. (Data from [8], used by permission.)

(Moody diagram)

**Table 8.1** Roughness for Pipes of Common Engineering Materials (Data from [8])

| Pipe | Roughness, $e$ | |
|---|---|---|
| | Feet | Millimeters |
| Riveted Steel | 0.003–0.03 | 0.9–9 |
| Concrete | 0.001–0.01 | 0.3–3 |
| Wood stave | 0.0006–0.003 | 0.2–0.9 |
| Cast iron | 0.00085 | 0.26 |
| Galvanized iron | 0.0005 | 0.15 |
| Asphalted cast iron | 0.0004 | 0.12 |
| Commercial steel or wrought iron | 0.00015 | 0.046 |
| Drawn tubing | 0.000005 | 0.0015 |

**Table 8.4** Representative Dimensionless Equivalent Lengths ($L_e/D$) for Valves and Fittings (Data from [12].)

| Fitting Type | Equivalent Length,[a] $L_e/D$ |
|---|---|
| Valves (fully open) | |
| Gate valve | 8 |
| Globe valve | 340 |
| Angle valve | 150 |
| Ball valve | 3 |
| Lift check valve: globe lift | 600 |
| : angle lift | 55 |
| Foot valve with strainer: poppet disk | 420 |
| : hinged disk | 75 |
| Standard elbow: 90° | 30 |
| : 45° | 16 |
| Return bend, close pattern | 50 |
| Standard tee: flow through run | 20 |
| : flow through branch | 60 |