L-3/T-1/IPE **Date: 07/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

1. (a) What is the effective diameter of a screw thread? Explain the two-wire method. **(15)**

   (b) Is the major diameter of a screw thread larger than the minor diameter for both external and internal thread? Justify your answer with a figure. **(10)**

   (c) Write a short note on the Linear Variable Differential Transformer with necessary figures. **(10)**

2. (a) Write down the salient features of any six different types of thread along with sketches and applications. **(15)**

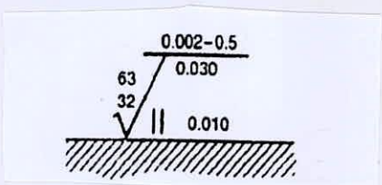
   (b) What do you mean by involute function of gear? Derive a mathematical expression for the involute function. **(10)**

   (c) If base pitch is 8.86 mm and radius of base circle is 33.83 mm, determine the number of teeth of the gear. Why dedendum is larger than addendum for a gear? Explain with necessary figure. **(10)**

3. (a) Discuss different constituent elements of an instrumentation system with examples. Differentiate between sensors and transducers. **(15)**

   (b) Explain the Insertion and Hysteresis errors with diagrams. **(10)**

   (c) Explain different categories of surface irregularities with neat sketches. Identify the symbolic representations of the following figure. **(10)**



4. (a) Describe optical encoders. Differentiate between an absolute and an incremental encoder with relative advantages and neat sketches. How do you measure their resolutions? **(15)**

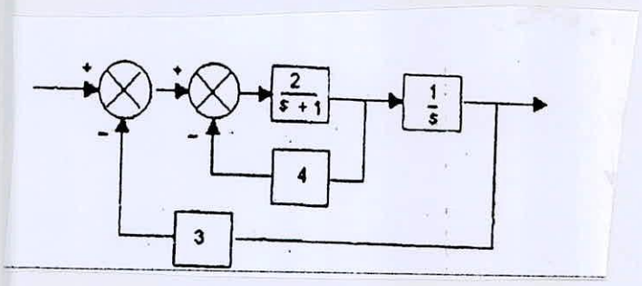
Contd P/2

IPE 301

Contd... Q. No. 4

(b) Illustrate the working principle and mention some real world applications of a Bourdon Tube. **(10)**

(c) What is the overall transfer function for the system shown in the following figure? **(10)**



SECTION – B

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

5. (a) What is "fit"? With necessary sketches, describe three types of fit according to the "Hole Based System". **(10)**

(b) Shafts of 75 ± 0.2 mm diameter are to be checked with the help of go and not-go snap gauge. Determine the go and not-go gauge dimensions in unilateral and bilateral system. Consider normal wear allowance and gauge maker's tolerance. **(10)**

(c) Explain the working principle and application of different temperature sensors with neat sketches. **(15)**

6. (a) Sketch graphs showing how the controller output will vary with time for the error signal shown in Figure 6(a) when the controller is set initially at 50% and operates as **(15)**

(i) just proportional with $K_p = 5$

(ii) Proportional plus derivative with $K_p = 5$ and $K_d = 1.0$ s,

(iii) Proportional plus integral with $K_p = 5$ and $K_i = 0.5\ s^{-1}$,

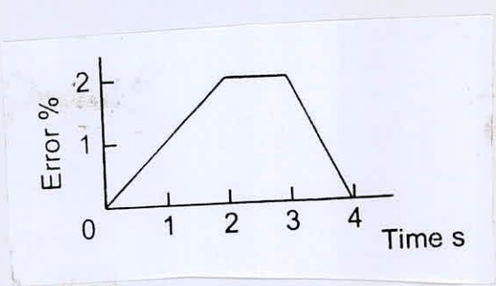


Figure 6(a)

Contd P/3

IPE 301

Contd... Q. No. 6

(b) Draw a block diagram of a domestic central heating system which has the following elements: **(12)**

i. A thermostat has a dial which is set to the required temperature and has an input of the actual temperature in the house. It operates as a switch and gives an output electrical signal which is either on or off.

ii. A solenoid valve which has the input of the electrical signal from the thermostat and controls the flow of oil to the central heating furnace.

iii. A heating furnace where the input is the flow of oil and the output is heat to the rooms via water flowing through radiators in the house.

iv. The rooms in the house where the input is the heat from the radiators and the output is the temperature in the rooms.

(c) Discuss the relative advantages of PD control with suitable diagrams. **(8)**

7. (a) Devise ladder programs for the following system- **(20)**

Count 10 objects passing along a conveyor belt and close a deflecting gate when that number have been deflected into a chute, allowing a time of 5 s between the tenth object being counted and closing the deflector.

(b) State the differences between On-Delay timer and Off-Delay timer of PLC control. **(15)**

8. (a) Devise ladder programs for a system that will carry out the following tasks: Start a machine if switch B is closed with in 0.5 s of switch A being closed; otherwise, the machine is not switched on. **(20)**

(b) Write a short note on the limitations of PID controllers with neat diagram. How can this limitation be overcome? **(15)**

L-3/T-1/IPE **Date : 06/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

SECTION – A

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

1. (a) What do you understand by standard accessories? Explain different standard accessories of Lathe machines with appropriate sketches. **(20)**

   (b) What do you understand by Duplicating Lathe? Explain briefly with its necessity. **(7)**

   (c) "Turning is a micro threading process" – Justify the statement with respect to amount feed. **(8)**

2. (a) Explain the following with necessary sketches. **(4×5=20)**

   (i) Up-milling, (ii) Down-milling, (iii) Face milling, and (iv) Fly cutting.

   (b) Explain the Clapper box mechanism with necessary sketch(es)? Also mention its purpose. **(7)**

   (c) What are the purpose of Body diameter clearance in a twist drill? Also explain how the twist drills are sharpened. **(5+3=8)**

3. (a) Explain briefly the properties of abrasives for grinding wheel and properties of Grinding wheel in grinding operation. **(6+6=12)**

   (b) Explain the Injection molding and Extrusion process of plastic product manufacturing with necessary sketches. **(6+6=12)**

   (c) Discuss the conditions for Continuous chip with Built-up Edge (BUE) and Discontinuous chip. **(5+6=11)**

4. (a) Discuss the features of different types of screw threads with appropriate sketches. **(12)**

   (b) Explain the following gear terminology with necessary sketches: **(3×4=12)**

   (i) Pitch circle, (ii) Pressure angle, (iii) Involute profile, and (iv) Module

   (c) Discuss different methods of gear manufacturing with appropriate diagrams. **(11)**

Contd P/2

IPE 305

SECTION – B

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

Make appropriate assumptions for any missing data.

5. (a) What is tool wear? Explain the mechanisms of tool wear. **(7)**

   (b) Explain the required properties of cutting fluid. **(6)**

   (c) What is chip reduction co-efficient? Derive an expression of chip reduction co-efficient in terms of cutting velocity and chip flow velocity. Provide necessary sketches. **(13)**

   (d) A mild steel rod of 150 mm diameter is turned on a lathe at a speed of 340 rpm, feed of 0.24 mm/rev and 2.5 mm depth of cut by a tool having tool rake angle 20° and principal cutting edge angle 60°. It is found by the dynamometer that the main cutting force 800 N and feed force 400 N. The value of chip reduction coefficient is 3.5. Calculate the coefficient of friction, shear plane angle, and dynamic yield shear strength. **(9)**

6. (a) Write short notes on – **(8)**

   (i) Side cutting edge angle (ii) Synthetic cutting fluid

   (iii) Merchant circle diagram

   (b) Describe the properties of different cutting tool materials. Explain how to position carbide insert in cutting tool. **(8)**

   (c) Compare between orthogonal cutting and oblique cutting. **(7)**

   (d) Derive an expression of shear angle in terms of chip reduction co-efficient and rake angle. **(12)**

7. (a) Describe the classification of modern non-conventional machining processes according to the principle form of energy used for material removal. **(6)**

   (b) Explain the principle of 'Ultrasonic Machining'. What are the advantages, limitations and applications of this machining method? **(10)**

   (c) Prove that the material removal rate (MRR) of abrasive jet machining process is $\left(\frac{\pi d\delta^2}{2}\right)N$ for ductile material and $\frac{2}{3}\pi(d\delta)^{\frac{3}{2}}N$ for brittle material where d = average diameter of the particle, δ = indentation depth and N = number of particles per unit time. **(11)**

   (d) Describe the function of electrolytes in electrochemical machining. What characteristics should the electrolytes process? **(8)**

8. (a) Shade contrast between conventional and modern machining. Explain the use cases where modern non-conventional machining is required. **(7)**

   (b) Write short notes on – **(8)**

   (i) Abrasive Water Jet Machining (ii) Electrochemical Grinding

   (c) What is the working principle of wire EDM? Explain the impact of dielectric fluid in electrical discharge machining. **(12)**

   (d) Describe the impact of standoff distance (SOD) on the accuracy of abrasive jet machining with sketches. **(8)**

L-3/T-1/IPE **Date: 30/03/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

SECTION – A

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

1. (a) You have to design a 3-D block as a water storage (see the figure below). The volume of the block has to be at least 9 cubic meters. The base area of the block is at most 6 square meters, while the height of the block is at least 1 and at most 2 meters. Your task is to design the block that satisfies the above conditions and the difference between the base area and the height of the block is maximal. **(26⅔)**

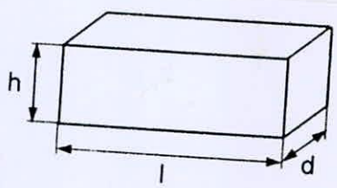


Figure: Q.1(a)

(i) Model the above problem as a constrained non-linear programming (NLP) problem.

(ii) Prove that the height is not 1 at an optimal solution.

(iii) Is this a convex optimization problem? Prove if it is convex; OR give evidence that it is not convex.

(iv) Give the KKT conditions of your NLP formulation.

(v) Check if the height = 1.5 meters, base-area = 6 square meters corresponds to an optimal solution.

(b) Consider the following linearly constrained NLP problem: **(12)**

$$\begin{aligned} min \quad & x_1^2 + (x_2 - 2)^4 \\ s.t. \quad & x_1 + x_2 = 2 \end{aligned}$$

(i) Reduce this problem to an unconstrained optimization problem.

(ii) Make four full Newton steps for the reduced problem. The current point is $x^1 = (2, 0)^T$. Are the solutions converging?

(c) Consider the function: **(8)**

$$f(x) = (x_1 - x_2)^2 + \frac{1}{1 + x_1^2 + x_2^2}$$

(i) Is $f(x)$ a convex function? Justify your answer!

(ii) Let $x^T = (1,-1)$. Is this point a local/global minimum? Justify your answer!

Contd P/2

IPE 307

2. (a) Consider the following LP: **(10)**

$$\begin{aligned} max\ z &= -2x_1 - x_2 + x_3 \\ s.t. \quad & x_1 + x_2 + x_3 \le 3 \\ & x_2 + x_3 \ge 2 \\ & x_1 \quad + x_3 = 1 \\ & x_1, x_2, x_3 \ge 0 \end{aligned}$$

(i) Find the dual of this LP.

(ii) After adding a slack variable s_1, subtracting an excess variable e_2, and adding artificial variables a_2 and a_3, row 0 of the LP's optimal tableau is found to be

$$z + 4x_1 + e_2 + (M-1)a_2 + (M+2)a_3 = 0$$

Find the optimal solution to the dual of this LP.

(b) Radioco manufactures two types of radios. The only scarce resource that is needed to produce radios is labor. The company now has two laborers. Laborer 1 is willing to work up to 40 hours per week and is paid \$5 per hour. Laborer 2 is willing to work up to 50 hours per week and is paid \$6 per hour. The price as well as the resources required to build each type of radio are given in the table below: **(36 2/3)**

Radio 1		Radio 2	
Price (\$)	Resource Required	Price (\$)	Resource Required
25	Laborer 1: 1 hour Laborer 2: 2 hours Raw material cost: \$5	22	Laborer 1: 2 hours Laborer 2: 2 hours Raw material cost: \$4

(i) Letting x_i be the number of type i radios produced each week, show that Radioco should solve the following LP (its optimal tableau is given in the table below):

$$\begin{aligned} max\ z &= 3x_1 + 2x_2 \\ s.t. \quad & x_1 + 2x_2 \le 40 \\ & 2x_1 + x_2 \le 50 \\ & x_1, x_2 \ge 0 \end{aligned}$$

Table: Optimal tableau for Q.2(b)

z	x_1	x_2	s_1	s_2	rhs
1	0	0	$\frac{1}{3}$	$\frac{4}{3}$	80
0	1	0	$-\frac{1}{3}$	$\frac{2}{3}$	20
0	0	1	$\frac{2}{3}$	$-\frac{1}{3}$	10

Contd P/3

IPE 307

Contd...Q. No. 2(b)

(ii) For what values of the price of a Type 1 radio would the current basis remain optimal?

(iii) For what values of the price of a Type 2 radio would the current basis remain optimal?

(iv) If laborer 1 were willing to work only 30 hours per week, would the current basis remain optimal?

(v) If laborer 2 were willing to work as many as 60 hours per week, would the current basis remain optimal?

(vi) If laborer 1 were willing to work an additional hour, what is the most that Radioco should pay?

(vii) If laborer 2 were willing to work only 48 hours, what would Radioco's profits be? Verify your answer by determining the number of radios of each type that would be produced.

(viii) A Type 3 radio is under consideration for production. The specifications of a Type 3 radio are as follows: price, \$30; 2 hours from laborer 1; 2 hours from laborer 2; cost of raw materials, \$3. Should Radioco manufacture any Type 3 radios?

3. (a) Consider a one-server queuing situation in which the arrival and service rates are given by: **(16 2/3)**

$$\lambda_n = 10 - n, n = 0, 1, 2, 3$$
$$\mu_n = \frac{n}{2} + 5, n = 1, 2, 3, 4$$

This situation is equivalent to reducing the arrival rate and increasing the service rate as the number in the system, n, increase.

(i) Set up the transition diagram and determine the balance equation for the system.

(ii) Determine the steady-state probabilities.

(b) Consider a two –person zero-sum game with the reward matrix as shown in the table below. Suppose this game does not have a saddle point. Show that the optimal strategy for the row player is to play the first row a fraction $(d - c)(a + d - b - c)$ of the time and the optimal strategy for the column player is to play the first column a fraction (d– b) $(a + d - b - c)$ of the time. **(10)**

Table: Q.3(b)

a	b
c	d

Contd P/4

IPE 307

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

(c) Consider the following parlor game between two players. It begins when a referee flips a coin, notes whether it comes up heads or tails, and then shows this result to player 1 only. Player 1 may then (1) pass and thereby pay \$5 to player 2 or (2) bet. If player 1 passes, the game is terminated. However, if he bets, the game continues, in which case player 2 may then either (1) pass and thereby pay \$5 to player 1 or (2) call. If player 2 calls, the referee then shows him the coin; if it came up heads, player 2 pays \$10 to player 1. If it came up tails, player 2 recieves \$10 from player 1. **(20)**

(i) Give the pure strategies for each player.

(ii) Develop the payoff table for this game, using expected values for the entries when necessary. Then identify and eliminate any dominated strategies.

(iii) Show that none of the entries in the resulting payoff table are a saddle point. Then explain why any fixed choice of a pure strategy for each of the two players must be an unstable solution, so mixed strategies should be used instead.

(iv) Write an expression for the expected payoff in terms of the probabilities of the two players using their respective pure strategies. Then show what this expression reduces to for the following three cases: (1) Player 2 definitely uses his first strategy, (2) Player 2 definitely uses his second strategy, (3) Player 2 assigns equal probabilities to using his two strategies.

4. (a) Consider an inventory system in which the sequence of events during each period is as follows. (1) We observe the inventory level (call it i) at the beginning of the period. (2) If $i \leq 1$, $4 - i$ units are ordered. If $i \geq 2$, 0 units are ordered. Delivery of all ordered units is immediate. (3) With probability 1, 0 units are demanded during the period; with probability 1/3, 1 unit is demanded during the period; and with probability 1/3, 2 units are demanded during the period. (4) We observe the inventory level at the beginning of the next period.

Define a period's state to be the period's beginning inventory level. Determine the transition matrix that could be used to model this inventory system as a Markov chain. **(10)**

(b) B&K Groceries operates with three checkout counters. The manager uses the following schedule to determine the number of counters in operation, depending on the number of customers in line:

Number of customers in store	Number of counters in operation
1 to 3	1
4 to 6	2
More than 6	3

Customers arrive in the counters area according to a Poisson distribution with a mean rate of 10 customers per hour. The average checkout time per customer is exponential with mean 12 minutes. **(36 2/3)**

(i) Determine the steady-state probability p_n of n customers in the checkout area.

(ii) Determine the probability distribution of the number of open counters.

(iii) Determine the expected number of busy counters.

(iv) Determine the expected number of idle counters.

Contd P/5

IPE 307

Contd...Q. No. 4(b)

(v) Suppose that the interarrival time at the checkout area is exponential with mean 5 minutes and that the checkout time per customer is also exponential with mean 10 minutes. Suppose further that B&K will add a fourth counter and that counter will open based on increments of two customers. Determine the following: the steady-state probabilities, p_n for all n, the probability that a fourth counter will be needed, and the average number of idle counters.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Assume reasonable values for missing data, if any.

5. (a) An increasing number of Americans are moving to a warmer climate when they retire. To take advantage of this trend, Sunny Skies Unlimited is undertaking a major real estate development project. The project is to develop a completely new retirement community (to be called Pilgrim Haven) that will cover several square miles. One of the decisions to be made is where to locate the two fire stations that have been allocated to the community. For planning purposes, Pilgrim Haven has been divided into five tracts, with no more than one fire station to be located in any given tract. Each station is to respond to all the fires that occur in the tract in which it is located as well as in the other tracts that are assigned to this station. Thus, the decisions to be made consist of (i) the tracts to receive a fire station and (ii) the assignment of each of the other tracts to one of the fire stations. The objective is to minimize the overall average of the response times to fires. Table for Q. 5(a) gives the average response time to a fire in each tract (the columns) if that tract is served by a station in a given tract (the rows). The bottom row gives the forecasted average number of fires that will occur in each of the tracts per day. **(23 2/3)**

Table for Q.5(a)

Assigned Station Located in Tract	Response Times (in minutes) Fire in Tract				
	1	2	3	4	5
1	5	12	30	20	15
2	20	4	15	10	25
3	15	20	6	15	12
4	25	15	25	4	10
5	10	25	15	12	5
Average frequency of fires	2 per day	1 per day	3 per day	1 per day	3 per day

Required:
Formulate a binary integer programming (BIP) model for this problem, Identify any constraints that correspond to mutually exclusive alternatives or contingent decisions.

(b) Consider a problem with two decision variables, x_1 and x_2, which represent the levels of activities 1 and 2 respectively. For each variable, the permissible values are 0, 1, and 2, where the feasible combinations of these values for the two variables are determined from a variety of constraints. The objective is to maximize a certain measure of performance denoted by Z. The values of Z for the possible feasible values of (x_1, x_2) are estimated to be those given in Table for Q. 5(b). **(23)**

Contd P/6

IPE 307

Contd...Q. No. 5(b)

Table for Q. 5(b).

x_1	x_2 = 0	x_2 = 1	x_2 = 2
0	0	4	8
1	3	8	13
2	6	12	18

Required:

Based on this information, indicate whether this problem completely satisfies each of the four assumptions of linear programming. Justify your answer.

6. (a) Work through the simplex method step by step to solve the following problem. **(23 2/3)**

Maximize $Z = -x_1 + x_2 + 2x_3$,

subject to

$$x_1 + 2x_2 - x_3 \leq 20$$
$$-2x_1 + 4x_2 + 2x_3 \leq 60$$
$$2x_1 + 3x_2 + x_3 \leq 50$$

and

$$x_1 \geq 0, \quad x_2 \geq 0, \quad x_3 \geq 0.$$

(b) A contractor, Susan Meyer, has to haul gravel to three building sites. She can purchase as much as 18 tons at a gravel pit in the north of the city and 14 tones at one in the south. She needs 10, 5, and 10 tons at sites 1, 2, and 3, respectively. The purchase price per ton at each gravel pit and the hauling cost per ton are given in the table below.

Table for Q. 6(b)

	Hauling Cost per Ton at Site			
Pit	**1**	**2**	**3**	**Price per Ton**
North	\$100	\$190	\$160	\$300
South	\$180	\$110	\$140	\$420

Susan wishes to determine how much to haul from each pit to each site to minimize the total cost for purchasing and hauling gravel. Formulate a linear programming model for this problem. Using the Big M method, construct the initial simplex tableau ready to apply the simplex method (do solve or optimize). **(23)**

7. (a) Consider the transportation problem having the following parameter table: **(30 2/3)**

Table for Q. 7(a)

		Destination 1	2	3	4	5	6	Supply
Source	1	13	10	22	29	18	0	5
	2	14	13	16	21	*M*	0	6
	3	3	0	*M*	11	6	0	7
	4	18	9	19	23	11	0	4
	5	30	24	34	36	28	0	3
Demand		3	5	4	5	6	2	

Contd P/7

IPE 307

Contd…Q. No. 7(a)

Required:

Use each of the following criteria to obtain an initial basic feasible (BF) solution. Compare the values of the objective function for these solutions.

(i) Northwest corner Rule

(ii) Vogel's approximation method

(iii) Russel's approximation method.

(b) Apply the Hungarian algorithm to solve the assignment problem having the following cost table: **(16)**

Table for Q.7(b)

		Task			
		1	2	3	4
Assignee	A	5	8	6	7
	B	9	5	7	8
	C	5	9	8	4
	D	6	3	5	9

8. (a) Consider the following integer programming (IP) problem. **(30 2/3)**

Maximize $Z = -3x_1 + 5x_2$

subject to

$5x_1 - 7x_2 \geq 3$

and

$x_j \leq 3$
$x_j \geq 0$
x_j is integer. for $j = 1, 2$.

Required:

Use the mixed integer programming (MIP) branch-and-bound algorithm to solve this problem. In addition, use the binary representation for integer variables to reformulate this problem as a binary integer programming (BIP) problem.

(b) Consider the following problem: **(16)**

Minimize $Z = 2x_1 + 3x_2 + 2x_3$,

subject to

$x_1 + 4x_2 + 2x_3 \geq 8$
$3x_1 + 2x_2 + 2x_3 \geq 6$

and

$x_1 \geq 0, \quad x_2 \geq 0, \quad x_3 \geq 0.$

Contd P/8

IPE 307

Contd...Q. No. 8

Let x_4 and x_6 be the surplus variables for the first and second constraints, respectively. Let $\bar{x}_5$ and $\bar{x}_7$ be the corresponding artificial variables. After you make the required modifications when using the Big M method, the initial simplex tableau ready to apply the simplex method is a follows:

Basic Variable	Eq.	Coefficient of: Z	x_1	x_2	x_3	x_4	$\bar{x}_5$	x_6	$\bar{x}_7$	Right Side
Z	(0)	-1	$-4M+2$	$-6M+3$	$-2M+2$	M	0	M	0	$-14M$
$\bar{x}_5$	(1)	0	1	4	2	-1	1	0	0	8
$\bar{x}_7$	(2)	0	3	2	0	0	0	-1	1	6

After you apply the simplex method, a portion of the final simplex tableau is as follows:

Basic Variable	Eq.	Coefficient of: Z	x_1	x_2	x_3	x_4	$\bar{x}_5$	x_6	$\bar{x}_7$	Right Side
Z	(0)	-1					$M-0.5$		$M-0.5$	
x_2	(1)	0					0.3		-0.1	
x_1	(2)	0					-0.2		0.4	

Required:

Identify the missing numbers in the above final simplex tableau. Show your calculations.

L-3/T-1/IPE **Date: 02/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

Assume reasonable value for missing data.

1. (a) Define Newtonian and Non-Newtonian Fluid with example. **(05)**

   (b) With suitable diagram, derive the pressure differential equation for a fluid body. Hence, deduce the expression of piezometric head for fluid at rest. **(20)**

   (c) The gage pressure of air in the tank shown in fig. for Q. 1(c) below is measured to be 65 kPa. Determine the differential height *h* of the mercury column. **(10)**

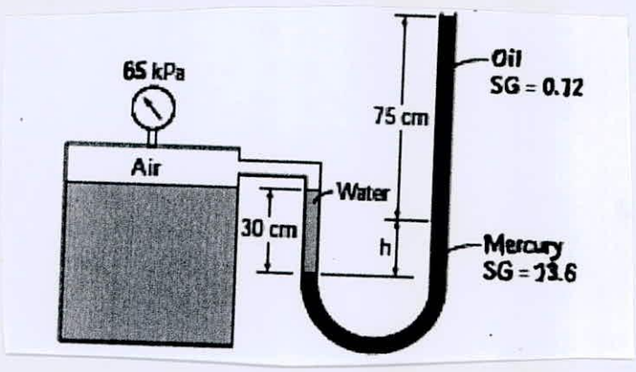


Fig. for Q. 1(c)

2. (a) With necessary assumptions, derive Bernoulli's equation for steady, incompressible flow. Hence, explaining each term, show that Bernoulli equation is the conservation of energy for an inviscid fluid system. **(20)**

   (b) Water Flows in a tapering pipe vertically as shown in fig. for Q. 2 (b). Determine the manometer reading 'h'. The manometer fluid has a specific gravity of 13.6. The flow rate is 100 L/s. **(15)**

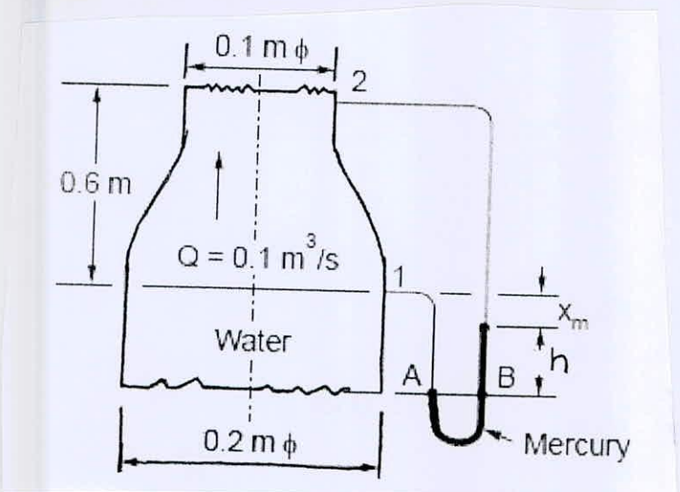


Fig for Q2(b)

Contd P/2

ME 223/IPE

3. (a) With suitable schematic diagram and assumptions, derive the expression of actual flow rate of an orifice meter for an inclined pipe. Define the coefficient of discharge, velocity, and contraction. **(20)**

(b) A garden hose attached with a nozzle is used to fill a **10 Litre bucket**. The inner diameter of the hose is 2 cm, and it reduces to 0.8 cm at the nozzle exit as shown in fig. for Q. 3 (b). If it takes 50s to fill the bucket with water, determine (*a*) the volume and mass flow rates of water through the hose, and (*b*) The average velocity of water at the nozzle exit. **(15)**

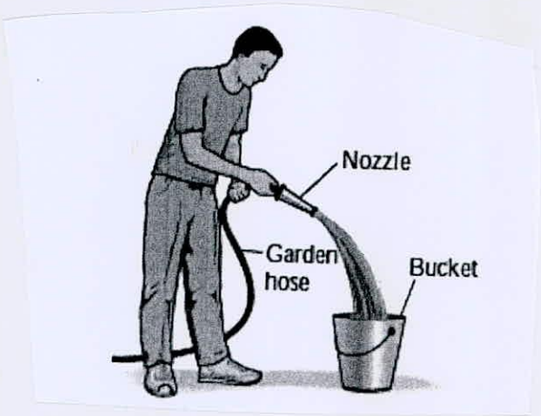


Fig. for Q. 3 (b)

4. (a) Deduce the expression of velocity profile for fully developed laminar flow in a circular pipe, and then prove that, the average velocity of flow is $\frac{1}{2}$ (one-half) of the maximum velocity. **(20)**

(b) An oil with $\rho = 900$ kg/m^3 and v = 0.0002 m^2/s flows upward through an inclined pipe as shown in fig. for Q. 4(b). The pressure and elevation are known at sections 1 and 2, 10m apart. Assuming steady laminar flow, (*a*) verify that the flow is up, (*b*) compute h_f between 1 and 2, and compute (*c*) Q, (*d*) V, and (*e*) Re_d. Is the flow really laminar? **(15)**

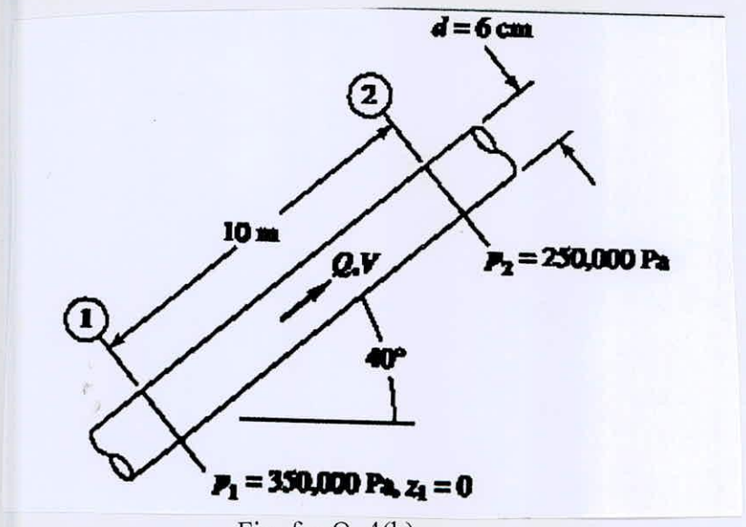


Fig. for Q. 4(b)

Contd P/3

ME 223/IPE

SECTION – B

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

5. (a) A water fountain is to be installed at a remote location by attaching a 25-mm-diameter cast iron pipe directly to a water main through which water is flowing at 20 °C and 450 kPa (abs). The entrance to the pipe is sharp-edged, and the 15-m-long piping system involves three 90° smooth flanged bends, a fully open gate valve, and an angle valve with $k_L = 5$ when fully open. If the elevation difference between the pipe and the fountain is negligible, determine the water flow rate of the piping system. Given, the kinematic viscosity of water at 20°C is 1.004×10^{-6} m^2/s. **(20)**

[Hint: Show a single iteration with initial guess $Q = 2.0$ L/s]

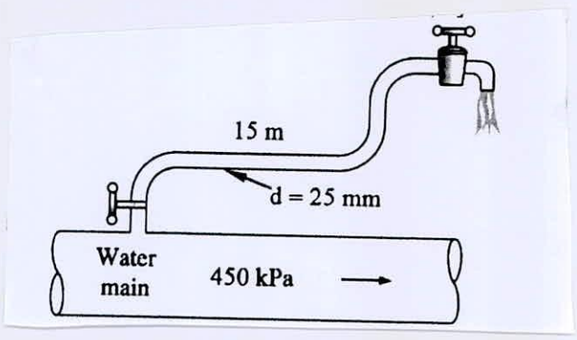


Fig. for Q. 5(a)

(b) With neat sketch, derive an expression for minor loss due to sudden enlargement. Also comment on the value of loss coefficient in case of no area change and discharge into reservoir from the expression. **(15)**

6. (a) Write notes on the following: **(18)**

(i) Priming of centrifugal pump

(ii) Cavitation of centrifugal pump

(iii) Net positive suction head

(b) A centrifugal pump impeller runs at 1300 rpm. Its external and internal diameter are 300 mm and 150 mm respectively. The vanes are set back at an angle of 35° to the outer rim. If the radial velocity of water through the impeller is maintained constant at 3 m/s and water enters at 10 m/s, find the angle of the vanes at inlet, the velocity and direction of water at outlet and the Euler head. **(17)**

7. (a) A jet of water with a velocity of 35 m/s strikes a flat plate inclined at 30° with the axis of jet. If the cross-sectional area of the jet is 25 cm^2, find: **(13)**

(i) the force exerted by the jet on the plate,

Contd P/4

ME 223/IPE
Contd... Q. No. 7(a)

(ii) the components of the force, and

(iii) the ratio in which the discharge gets divided after striking the plate.

(b) A fluid jet strikes at the center of a symmetrical moving smooth curved vane. Find an expression for the efficiency of the vane. What will be the efficiency if the vane is a semicircle and the velocity of the jet is three times the velocity of the vane? **(22)**

8. (a) How can you differentiate between a fan, a blower and a compressor? How do they differ from a pump? **(5)**

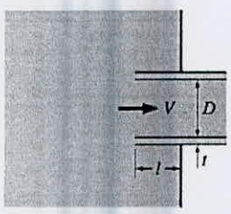
(b) Classify turbine according to hydraulic action and turbine head. **(7)**

(c) What are the reasons behind the double hemispherical shape of Pelton wheel bucket? **(7)**

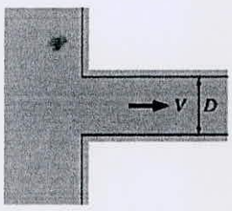
(d) An inward flow reaction turbine is supplied with 100 m^3/s of water under an effective head of 150 m. The diameter at the inlet and outlet are 3.5 m and 2.35 m, respectively. The inlet vane angle is 120° and hydraulic efficiency is 85%. If the discharge is radial with a velocity of 15 m/s, find the rotational speed of the runner. Also find the power developed by the turbine. **(16)**

Loss coefficients K_L of various pipe components for turbulent flow (for use in the relation $h_L = K_L V^2/(2g)$, where V is the average velocity in the pipe that contains the component)*

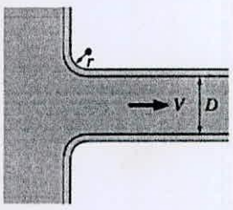
Pipe Inlet
Reentrant: $K_L = 0.80$
($t \ll D$ and $l \approx 0.1D$)



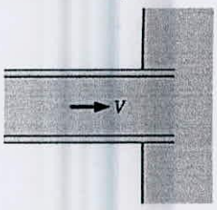
Sharp-edged: $K_L = 0.50$



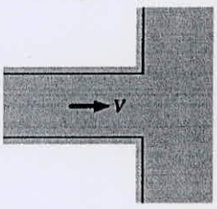
Well-rounded ($r/D > 0.2$): $K_L = 0.03$
Slightly rounded ($r/D = 0.1$): $K_L = 0.12$
(see Fig. 8–36)



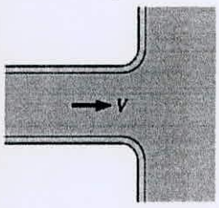
Pipe Exit
Reentrant: $K_L = \alpha$



Sharp-edged: $K_L = \alpha$

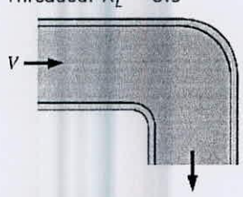


Rounded: $K_L = \alpha$

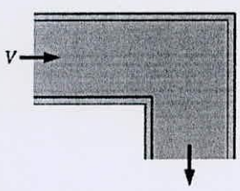


Note: The kinetic energy correction factor is $\alpha = 2$ for fully developed laminar flow, and $\alpha \approx 1$ for fully developed turbulent flow.

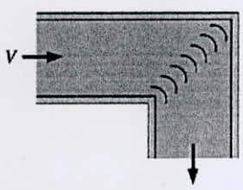
Bends and Branches
90° smooth bend:
Flanged: $K_L = 0.3$
Threaded: $K_L = 0.9$



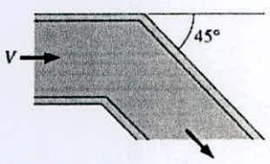
90° miter bend
(without vanes): $K_L = 1.1$



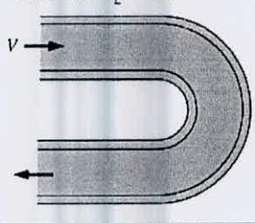
90° miter bend
(with vanes): $K_L = 0.2$



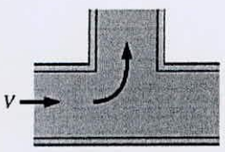
45° threaded elbow:
$K_L = 0.4$



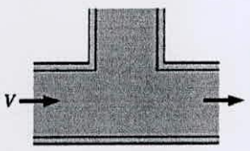
180° return bend:
Flanged: $K_L = 0.2$
Threaded: $K_L = 1.5$



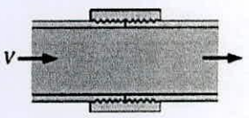
Tee (branch flow):
Flanged: $K_L = 1.0$
Threaded: $K_L = 2.0$



Tee (line flow):
Flanged: $K_L = 0.2$
Threaded: $K_L = 0.9$

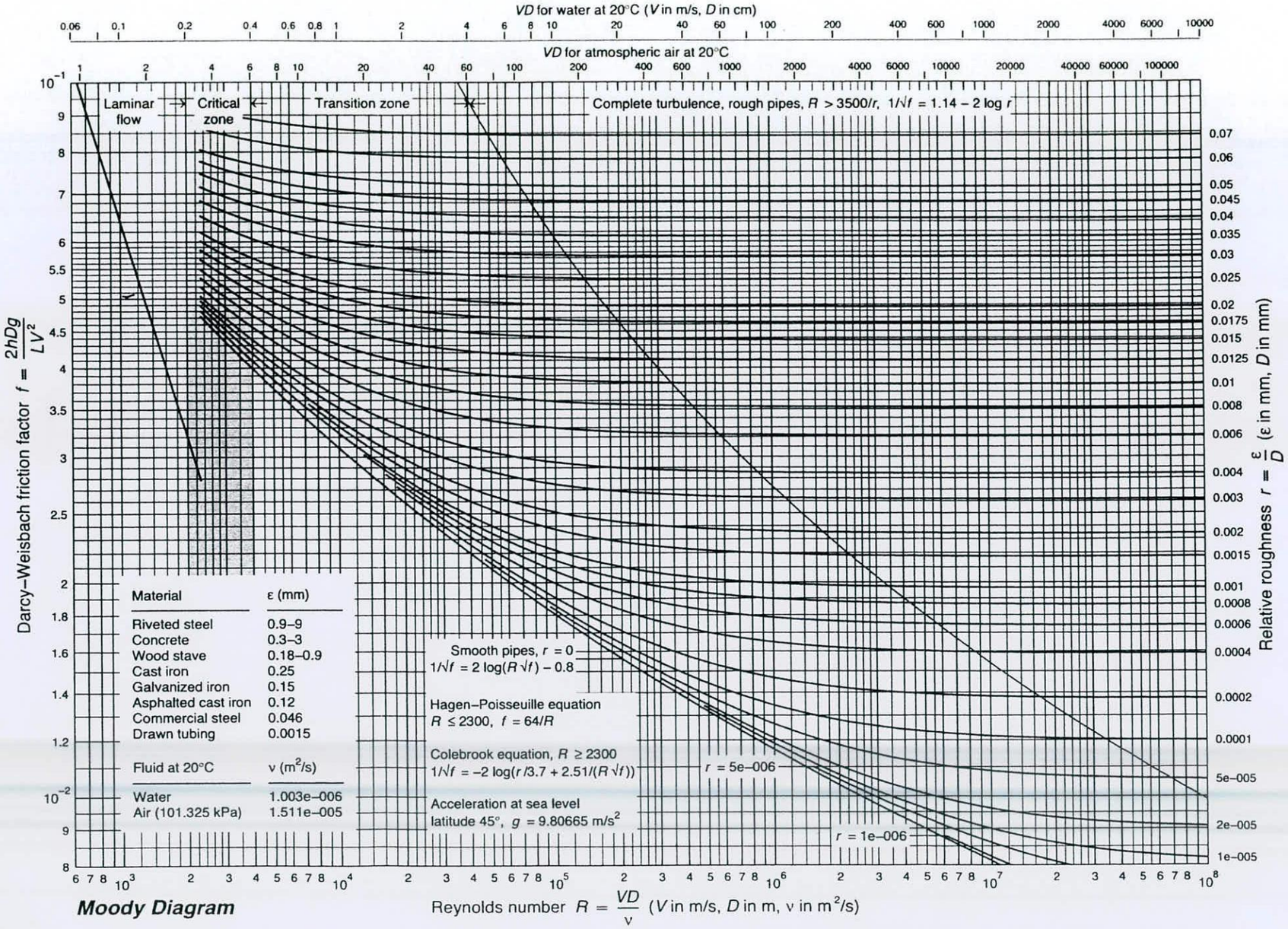


Threaded union:
$K_L = 0.08$



Valves
Globe valve, fully open: $K_L = 10$
Angle valve, fully open: $K_L = 5$
Ball valve, fully open: $K_L = 0.05$
Swing check valve: $K_L = 2$

Gate valve, fully open: $K_L = 0.2$
$\frac{1}{4}$ closed: $K_L = 0.3$
$\frac{1}{2}$ closed: $K_L = 2.1$
$\frac{3}{4}$ closed: $K_L = 17$



Moody Diagram

L-3/T-1/IPE **Date: 13/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2021-2022

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

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

1. (a) Define market demand. How would you draw market demand and market supply curves of a commodity? Explain how the interactions between market demand and market supply curves determine equilibrium price and output of a commodity. **(20)**

   (b) The demand and supply functions of a commodity (say, X) are given respectively **(15)**

   $Q_D = 1550 - 75P_X$ and

   $Q_S = 680 + 25P_X$

   where, P_X is the price of the commodity. Find the equilibrium price and quantity of the commodity X. If the Government provides 25% subsidy on unit price, what would be the new equilibrium price and quantity? What is the proportion of the subsidy that the consumers would actually enjoy?

2. (a) Illustrate the concept of marginal rate of substitution (MRS) when two commodities are consumed. **(10)**

   (b) How would you derive the demand curve for a normal good from a price consumption curve? **(10)**

   (c) Explain the concepts of income effect (IE) and substitution effect (SE) and graphically present them separately for price rise of a normal good. **(15)**

3. (a) Clarify the concepts of 'GNP at factor cost' and 'NNP at market price'. **(10)**

   (b) What are the methods for measuring national income? Explain any two of them. **(10)**

   (c) From the following model, calculate equilibrium level of income and the multiplier. If investment expenditure increases to 300, what will be the new equilibrium level of income? If tax rate is reduced to 15%, what will be the value of the multiplier? **(15)**

   $C = 100 + 0.8\ Y_D$
   $I = 100$
   $G = 200$
   $X = 150$
   $M = 300$
   $T = 0.2Y$
   $TR = 200$

   [The notations best their usual meaning]

Contd P/2

4. Write short notes on any THREE of the following: **(35)**

   i) The main challenges that every economy struggles to overcome

   ii) Law of diminishing marginal utility and derivation of the demand curve.

   iii) Applications of elasticity of demand in trade and business.

   iv) Optimal consumption point of a consumer

SECTION – B

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

5. (a) What do you understand by MRTS? Explain any three characteristics of an isoquant. **(10)**

   (b) Complete the following table and plot the total product (TP), average product (AP) and marginal product (MP) of labour. **(15)**

Number of workers	Total product (TP)	Average Product (AP)	Marginal Product (MP)
1	3		
2	8		
3	12		
4	15		
5	17		
6	17		
7	16		
8	13		

   (c) What is the relation between the AP and MP curves? Use these curves to define three stages of production for labour. **(10)**

6. (a) How would you derive the short run supply curve of a firm under perfect competition? **(10)**

   (b) Explain when a perfectly competitive firm decides to shut-down production? **(10)**

   (c) Graphically explain the long run equilibrium of a firm under perfect competition. **(15)**

Contd …… P/3

HUM 277/IPE

7. (a) Complete the following table and sketch the graph explaining the relations among the various short run cost curves. **(10)**

Quantity of output	Total fixed cost	Total variable cost	Total cost	Average fixed cost	Average variable cost	Average Total cost	Marginal cost
1	70	30					
2	70	40					
3	70	45					
4	70	55					
5	70	75					
6	70	120					

(b) A manufacturer has a fixed cost of $40,000 and a variable cost of $1.60 per unit made and sold. Selling price is $2 per unit. **(15)**

i) Find the revenue, cost and profit functions using q for the number of units.

ii) Compute profit if 150000 units are made and sold.

iii) Find the break-even quantity.

iv) Construct the break-even chart. Label the cost and revenue lines, the fixed cost line, and the break-even point

(c) How would you derive the long run average cost (LCA) curve of a firm from its short run average cost curves? Explain graphically. **(10)**

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

(b) Justify the statement that there is no unique supply curve for the monopolist derived from its marginal cost curve. **(5)**

(c) Prove that the slope of marginal revenue is double than the slope of the demand curve for monopoly. **(10)**

(d) What is the relation among marginal revenue (MR), price (P) and price elasticity of demand(e)? **(10)**
