

**SECTION – A**

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

1. (a) Derive the transformation matrix for 3D reflection with respect to the plane  $x+2y+3z=6$ . You don't need to multiply any matrices. Use homogeneous coordinates. (14)
- (b) For an oblique parallel projection, the projection plane is given by the equation  $y=10$  and the direction of projection is given by the vector  $(6,-2,3)$ . Determine the corresponding transformation matrix. (13)
- (c) Derive the basis matrix of Hermit curve from the basis matrix of Bezier curve. The basis matrix of Bezier curve is given below. (8)
- $$\begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$
2. (a) Outline three different approaches to derive the transformation matrix for 3D rotation by an angle of  $\theta$  around the axis  $\vec{a}$ . Clearly enumerate the steps for each approach. You do not need to prove/derive any properties/equations. Draw appropriate figures when necessary. (6+6+6=18)
- (b) A camera is located at the point  $(1,2,3)$ . Its viewing direction is given by the vector  $(1,1,2)$  and its up direction is given by the vector  $(2,0,-1)$ . Derive the view transformation matrix, such that the camera looks towards the negative Y axis, and the up direction of the camera remains along the positive Z axis. (9)
- (c) Why is the Bezier curve bounded by the convex hull of its control points? The basis matrix of Bezier curve is given in Question 1(c). (8)
3. (a)  $(1,2,3)$  is a point on plane P. The normal vector on P is  $(3,2,1)$ . Determine the equation of P. (8)
- (b) A perspective projection is defined by the position of the camera, C, and the projection plane, P. A set of parallel lines in the 3D space is represented by their

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

direction vector,  $v$ . For the following scenarios, determine the vanishing point for the set of parallel lines along  $v$  under the perspective projection defined by  $C$  and  $P$ . (5+4+8=17)

- (i)  $C:(1,1,1), P: x + y + z = 6, v:(1,1,1)$
- (ii)  $C:(1,2,3), P: x + 2y + 3z = 24, v:(2,2,-2)$
- (iii)  $C:(0,0,0), P: z = 10, v:(1,1,1)$

(c) Explain why 2-degree parametric polynomial curves in 3D can't be non-planar. (10)

4. (a) Solve the following Line-Line intersection and Plane-Plane intersection problems in 3D. (7+7=14)

- (i) Determine the intersection of the lines  $L_1(t) = (1,2,7) + t(1,1,-1)$  and  $L_2(s) = (-3,7,-1) + s(-2,1,-2)$
- (ii) Determine the intersection of the planes  $P_1: x + y + z = 10$  and  $P_2: x - y - z = 10$ .

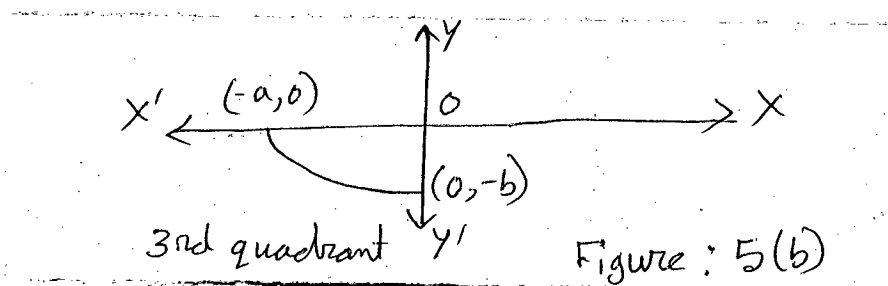
(b) State the differences between perspective and parallel projections. (7)

(c) A Bezier curve segment,  $B$ , is defined by the control points  $P_1 = (1,2,3)$ ,  $P_2 = (1,4,3)$ ,  $P_3 = (3,5,4)$  and  $P_4 = (3,5,7)$ . Determine the point on  $B$  for  $t = \frac{1}{4}$  using two different approaches as follows: (i) using the basis matrix of Bezier curve, and (ii) using subdivision of Bezier curve. The basis matrix of Bezier curve is given in Question 1(c). (7+7=14)

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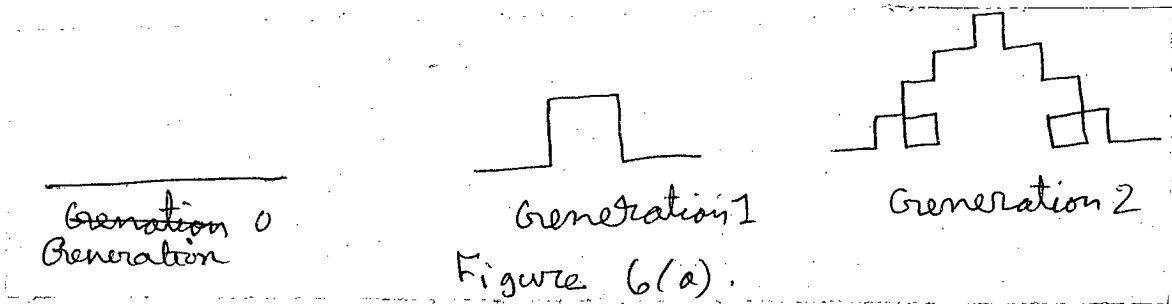
There are **FOUR** questions in this section. Answer any **THREE**.

- 5. (a) Show the calculation of finding area of Koch Snowflake curve for generation  $n$ . (10)
- (b) Suppose we want to draw an arc of ellipse in the 3<sup>rd</sup> quadrant as shown in Figure 5(b). For doing this, describe a procedure where ellipse scan conversion algorithm uses 2<sup>nd</sup> order difference equation. Show the calculations using necessary figures. (25)

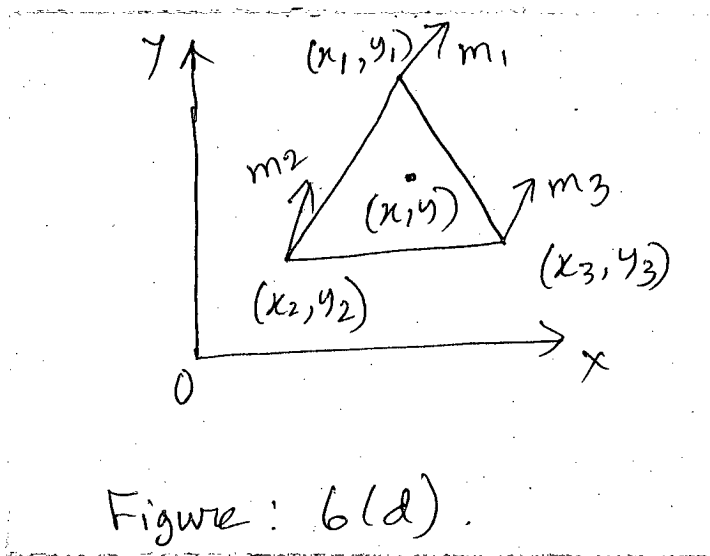


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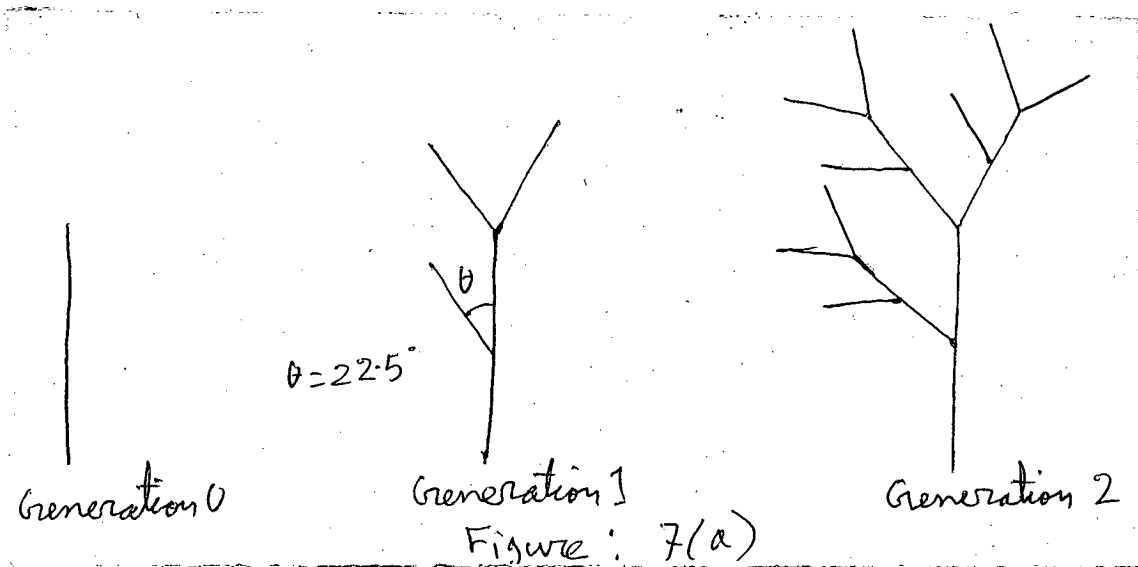
6. (a) Find the fractal dimension for the fractal object shown in Figure 6(a). (5)



- (b) Simulate both Cohen Sutherland and Cyrus-Beck line clipping algorithm to clip line from (-10, -20) to (80,120) where coordinates of the vertices of clipping rectangle are (0,0), (0,50), 50,50), (50,0). (7+10=17)
- (c) "Two polygon may fail all the tests of depth sort algorithm, even though they are already ordered correctly" — explain with an example. (6)
- (d) According to Phong shading derive the formula for finding normal vector at point (x,y) on the triangular surface shown in Figure 6(d). (7)



7. (a) Derive the string production rule to generate the fractal tree shown in Figure 7(a). (10)



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**Contd... Q. No. 7**

- (b) Briefly describe the lists that is kept in scanline algorithm. Then write down the pseudocode for scanline algorithm. (6+10=16)
- (c) Briefly outline the procedure of unweighted and weighted area sampling technique for antialiasing. (4+5=9)
8. (a) Find the refraction vector  $\vec{R}$ , in terms of incident vector  $\vec{I}$  and surface normal  $\vec{N}$ . (6)
- (b) Give one advantage and one disadvantage of backface culling. Give two disadvantages of Z buffer. (4×2=8)
- (c) When does Cohen Sutherland line clipping algorithm perform efficiently? What problem arises in other cases? (5)
- (d) In a scenario a static viewer is at position (1,-2,3) and is looking towards a very tiny object at (7,16,15). There is also a hollow sphere having radius 10, centered at (7,4,5). Determine, if the viewer is able to see the tiny object. If it is possible to view by making some holes in the sphere then calculate the coordinates of the holes. (7)
- (e) Write short note on Blinn and Torrence variation. (4)
- (f) Suppose backface culling is applied in a scenario before applying painters algorithm with BSP tree. The motivation of using backface culling is to reduce the number of polygons to consider in later phases. Will there be any negative impact of backface culling in this case? If yes then state it. (5)
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**SECTION – A**

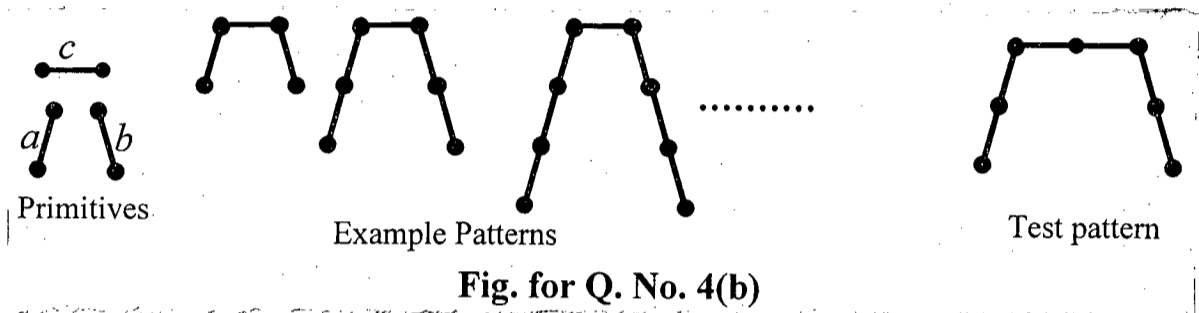
There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) For the motion compensation step in a video coding application, the image frame of size  $I \times J$  is divided into sub-blocks of size  $M \times N$ . For each sub-block the search for its corresponding one, in the current frame, is restricted in an area of size  $[-p, p] [-p, p]$ . Find the required number of operations per second for the computation of the maximum cross-correlation for a full search (basic brute-force method), a two-dimensional logarithmic search, and a hierarchical search of three levels. Typical values for broadcast TV are  $M = N = 16$ ,  $I = 720$ ,  $J = 480$ , and  $p = 15$ . The number of frames transmitted per second is  $f = 30$ . (20)
- (b) Are all training samples equally important in support vector machine? Justify. Why does SVM use 'kernel trick' to classify linearly non-separable training samples? (15)
2. (a) Explain why the cost function of the perceptron algorithm is piecewise linear. Suppose that you are given a set of linearly non-separable patterns to classify them into two classes. Can you learn a single perception to classify them? Justify. (18)
- (b) If you are asked to classify the samples described in Q. No. 2(a) with 100% accuracy using a multilayer perceptron (MLP), design a procedure to find the architecture of the MLP network. Justify that your procedure will find the architecture after a finite number of steps. (17)
3. (a) Suppose that a number of lines intersect each other in a 2D space to form a number of polyhedral regions which can be mapped to different corners of a hypercube. Find the relation between the dimension of the hypercube and the number of lines intersecting each other. Justify your answer. Now with suitable examples, show that a two-layer neural network sometimes fails to classify the polyhedral regions into two classes. If you use a three-layer neural network instead, compute analytically the corresponding synaptic weights. (18)
- (b) The basic perceptron algorithm works for classifying samples into only two classes. Given that samples are linearly separable, can you guarantee that the solution is unique? Justify your answer. Explain how you can use it to classify samples into more than two classes. (17)

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4. (a) Why are the segmented frames of spoken words (speech signals) transformed into frequency domain before matching the test and reference spoken words? What are the significance of local and global constraints in dynamic time warping algorithm for speech recognition? Derive the slopes of Sakoe and Chiba local constraints. (20)

(b) Given the primitives and the set of example patterns shown in the following figure, find a *context free grammar* (CFG) that satisfies the series of example patterns. Convert the CFG to *Chomsky normal form* (CNF). Draw a *Cock-Younger-Kasami* (CYK) table to determine whether the test pattern satisfies the corresponding grammar. (15)



**SECTION – B**

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

5. (a) Consider the data set shown in the following table.

A	B	C	Class
0	0	0	+
0	0	1	-
0	1	1	-
0	1	1	-
0	0	1	+
1	0	1	+
1	0	1	-
1	0	1	-
1	1	1	+
1	0	1	+

(i) Estimate the conditional probabilities for  $P(A|+)$ ,  $P(B|+)$ ,  $P(C|+)$ ,  $P(A|-)$ ,  $P(B|-)$ ,  $P(C|-)$ . (12)

(ii) Use the estimate of conditional probabilities given in the previous question to predict the class label for a test sample ( $A = 0, B = 1, C = 0$ ) using the naïve Bayes approach. (8)

(b) Is naïve Bayes classifier robust to irrelevant attributes? Justify your answer. (10)

(c) How can naïve Bayes classifier handle missing attribute values? (5)

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6. (a) Assume a Bayesian network with 5 boolean random variables, where topology represents that Pneumonia causes Fever, Paleness, Cough, and HighWBCcount. The associated CPT are as follows:

- $P(\text{Pneumonia} = \text{True}) = 0.02$
- $P(\text{Fever} = \text{True} | \text{Pneumonia} = \text{True}) = 0.9$
- $P(\text{Fever} = \text{True} | \text{Pneumonia} = \text{False}) = 0.6$
- $P(\text{Paleness} = \text{True} | \text{Pneumonia} = \text{True}) = 0.7$
- $P(\text{Paleness} = \text{True} | \text{Pneumonia} = \text{False}) = 0.5$
- $P(\text{Cough} = \text{True} | \text{Pneumonia} = \text{True}) = 0.9$
- $P(\text{Cough} = \text{True} | \text{Pneumonia} = \text{False}) = 0.1$
- $P(\text{HighWBCcount} = \text{True} | \text{Pneumonia} = \text{True}) = 0.8$
- $P(\text{HighWBCcount} = \text{True} | \text{Pneumonia} = \text{False}) = 0.5$

Assume that you have the following set of symptoms: Fever and Cough are true; Paleness and HighWBCcount are false. What is the probability  $P(\text{Pneumonia} = \text{T} | \text{Fever} = \text{T}, \text{Paleness} = \text{F}, \text{Cough} = \text{T}, \text{HighWBCcount} = \text{F})$ , that is, the probability that you suffer from Pneumonia, given the symptoms? Simplify the expression as much as possible before plugging in the values.

(15)

(b) A patient goes to the doctor for a medical condition, the doctor suspects three diseases as the cause of the condition. The three diseases are  $D_1, D_2, D_3$  which are marginally independent from each other. There are four symptoms  $S_1, S_2, S_3, S_4$  which the doctor wants to check for presence in order to find the most probable cause of the condition. The symptoms are conditionally dependent to the three diseases as follows:

$S_1$  depends only on  $D_1$ ,  $S_2$  depends on  $D_1$  and  $D_2$ .  $S_3$  depends on  $D_1$  and  $D_3$ , whereas  $S_4$  depends only on  $D_3$ . Assume all random variables are Boolean, they are either 'true' or 'false'.

(20)

- (i) Draw the Bayesian network for this problem.
- (ii) Write down the expression for the joint probability distribution as a product of conditional probabilities.
- (iii) What is the number of independent parameters that is required to describe this joint distribution?
- (iv) Assume there were no conditional independence between the variables, how many independent parameters would be required then?

7. (a) Assume that we have a hidden Markov Model (HMM) observed over  $t$  time steps. If each of the hidden states can take on  $k$  different values and a total of  $m$  different observations are possible (across all states), how many parameters are required to fully define this HMM? Justify your answer.

(15)

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**Contd ... Q. No. 7**

(b) Assume that we have two coins  $C_A$  and  $C_B$  each with two possible observations 'Head' and 'Tail'. **(20)**

'Head' observation probability for  $C_A$  is .2 and for  $C_B$  is .9

Transition probability from  $C_A$  to  $C_A$  is .99 and from  $C_B$  to  $C_B$  is .99

Initial probability of selecting coin  $C_A$  is .99

Calculate the probability of the sequence of observations {'Tail', 'Head', 'Tail'} using both forward and backward algorithm and show that they produce same result.

8. (a) Explain three different kinds of clustering policy. **(9)**

(b) Give three scenarios when you should not use K-means clustering algorithm. **(9)**

(c) What is a core point, noise point and border point with respect to DBSCAN clustering algorithm? When doesn't DBSCAN work well? **(9+8)**

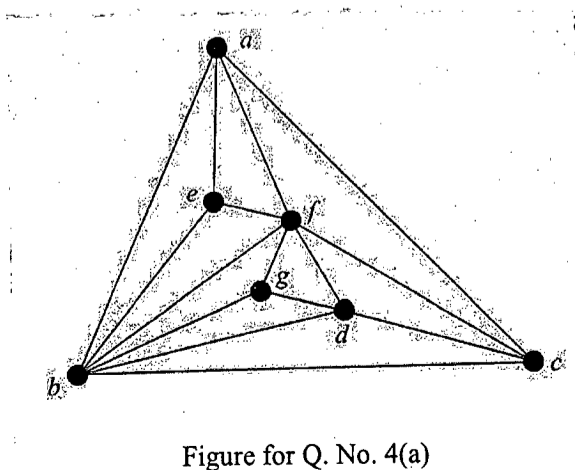
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**SECTION – A**

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

1. (a) Give an algebraic definition of convex hull of a set of points. Prove that, the lower bound of time complexity of convex hull construction in 2D is  $\Omega(n \log n)$ . (2+10=12)  
 (b) Write a linear time algorithm to compute the upper tangent of two non-overlapping convex hulls in 2D. How can you test whether a line segment going through an extreme point of a convex hull is a tangent of the convex hull? (8+5=13)  
 (c) What do you understand by an output sensitive algorithm? Draw two sets of 8 points for which the Chan's algorithm for constructing convex hull in 2D performs best and worst respectively. (2+8=10)
  
2. (a) How can you handle different collinearity in the Graham Scan algorithm for constructing convex hull in 2D? Explain with figures. (12)  
 (b) Consider the plane sweep algorithm to find the intersection points of a set of line segments on a plane where no three line segments are concurrent and no two line segments share common end-point. Write the methods to handle events at the bottom end-points and the intersection points. (6+7=13)  
 (c) Define the Plane-Line Duality with examples. Write three properties of dual transform with illustrative examples. (10)
  
3. (a) What is canonical ordering of a triangulated plane graph. Prove that, every triangulated plane graph has a canonical ordering. (12)  
 (b) Explain the shift algorithm for straight line drawing of a plane graph with necessary figures. (15)  
 (c) Write an algorithm to compute the arrangement of a set of lines in 2D. (8)
  
4. (a) Find schnyder labeling and realize for the plane graph shown in Figure. for Q. No. 4(a). (20)



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**Contd... Q. No. 4**

- (b) Give a data structure to efficiently traverse the faces of the plane graph induced by the vertices  $a, b, c, d$  and  $e$  of the graph shown in Figure for Q. No. 4(a). (10)
- (c) Why do the straight line drawing algorithms usually deal with triangulated plane graphs? (5)

**SECTION – B**

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

5. (a) Prove the followings in sequence for a simple polygon and its triangulation. Use earlier results to prove the next ones: (5×4=20)
- (i) Every simple polygon must have at least one strictly convex vertex.
  - (ii) Every simple polygon with  $n \geq 4$  vertices has a diagonal.
  - (iii) Every triangulation of a simple polygon has  $n-3$  diagonals and  $n-2$  triangles.
  - (iv) The sum of the internal angles of a simple polygon of  $n$  vertices is  $(n-2)\pi$ .
  - (v) Every polygon of  $n \geq 4$  vertices has at least two non-overlapping ears.
- (b) Give an algorithm to construct a 2-dimensional range tree on a set of  $n$  points in the plane. Analyze the construction time of the algorithm and the storage required for the range tree. (15)
6. (a) Analyze the performance of a 2-dimensional kd-tree. Give an example of a 2-dimensional kd-tree consisting of 15 points. (15+5=20)
- (b) Give a recursive algorithm to find the nearest neighbor of a query point  $y$  in a 2-dimensional kd-tree. Explain the behavior of the algorithm using your example of Question No. 6(a). (15)
7. (a) Write down the properties of Voronoi diagrams and argue in favor of them. (10)
- (b) Prove that a minimum spanning tree is a subset of the Delaunay triangulation. (10)
- (c) Deduce the running time of Kruskal's Minimum Spanning tree algorithm, when it is applied on a set of  $n$  points on the plane. How can the result of Question No. 7(b) be used to improve that running time? (15)
8. (a) Describe the triangulation algorithm of a polygon by ear removal and compute its complexity. How many overlapping ears can a polygon of  $n$  vertices have? Give an example. (10+5=15)
- (b) Give an algorithm to triangulate a monotone polygon with  $n$  vertices. Analyze the running time and space requirement of the algorithm. (15)
- (c) Give an algorithm which will find the largest empty cycle whose center is in the convex hull of a set of  $n$  sites. (5)
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**SECTION – A**

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

1. (a) How are the market demand and market supply curves constructed? Graphically explain how the interactions between these two curves determine the equilibrium price and quantity of a commodity in the free market economy. (13 1/3)
- (b) Given respectively the demand and supply functions of Matador ball point pen (13 1/3)

$$Q_D = 1560 - 75 P_m$$

$$Q_S = 770 + 35 P_m$$

Find the equilibrium price and quantity of the commodity. If the Government provides 13% subsidy per unit, what would be the new equilibrium price and quantity? Calculate the amount of the subsidy that the consumers will actually enjoy per unit. (10)
2. (a) What do you understand by price elasticity and cross-price elasticity of demand? Describe the factors that influence the elasticity of demand in general. (13 1/3)
- (b) Given the demand function of a commodity X
 
$$Q_{dx} = 2050 - 25 P_x + 0.005 M + 3.8 P_y - 7 P_z$$

Where price of X ( $P_x$ ) is tk. 90, price of Y ( $P_y$ ) is tk. 140, price of Z ( $P_z$ ) is tk. 110 and the level of income (M) is tk. 65,000. Find the income elasticity and cross-price elasticities of demand for the commodity X. What kind of commodity is X? Define the relationship between X and each of the other two commodities based on the results. (10)
3. (a) What do you know about the optimum consumption point of a consumer? Prove that the equilibrium conditions are identical in the cardinalist approach and in the indifference-curve (ordinalist) approach. (13 1/3)
- (b) Clarify the concepts of diminishing marginal utility (DMU) and marginal rate of substitution (MRS) using graphs. Describe the relationship between these two concepts with numerical examples. (10)
4. Write short notes on any THREE of the following (23 1/3)
  - (i) 'Change in supply' and 'change in quantity supplied'
  - (ii) Fundamental economic problems
  - (iii) 'Substitution effect' and 'income effect' of a price change
  - (iv) Factors affecting demand of commodity in general

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**SECTION – B**

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

5. (a) A manufacturer has a fixed cost of \$60,000 and a variable cost of \$2.60 per unit made and sold. Selling price is \$5 per unit. (10)
- (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) Compute profit if 1000 units are made and sold.  
 (iv) Find the break-event quantity.  
 (v) Construct the break-event chart. Label the total cost and total revenue lines, the fixed cost line, variable cost line and the break-event point.
- (b) Compute the following table and sketch the graph explaining the relations among the various short run average cost curves. (13 1/3)

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

6. (a) From the following revenue and cost functions calculate the profit maximizing level of output and maximum profit. (10)
- $$R = 111Q - 2Q^2$$
- $$C = \frac{1}{3}Q^3 - 8Q^2 + 122Q + 50$$
- (b) Graphically explain the short run equilibrium of a firm under perfect competition. (13 1/3)
7. (a) Define GNP at market price and NNP at factor cost. (10)
- (b) Given that  $C = 100 + 0.8 Y_d$ ,  $I = 100$ ,  $G = 100$ ,  $X = 100$ ,  $M = 150$ ,  $TR = 150$ ,  $T = 0.20Y$ . Calculate (i) Equilibrium level of income and multiplier in this model (ii) If investment is increased to 300, what will be the new equilibrium level of income? (iii) If tax rate is reduced to 15%, what will be the new equilibrium level of income and multiplier? (13 1/3)
8. (a) What do you understand by localization of industries? What are the causes of localization of industries? (10)
- (b) Explain the advantages and disadvantages of localization of industries. (13 1/3)

**SECTION – A**

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

1. (a) What is the approximation ratio of the GREEDY-SET-COVER algorithm? If the approximation ratio is  $\rho(n)$ , prove that the algorithm is a polynomial time  $\rho(n)$ -approximation algorithm for that  $\rho(n)$ . (15)
  - (b) What is the probability that Karger's Min-Cut algorithm fails to find the global min-cut? Prove your answer. (10)
  - (c) Design an exact algorithm for solving the Set Cover Problem using the bit masking DP technique. (10)
  
2. (a) Give a randomized QUICKSORT algorithm for an  $n$ -element array. Prove the expected running time of the randomized algorithm. (5+15=20)
  - (b) What is meant by an approximation algorithm? Discuss performance ratio in context of approximation algorithms. (10)
  - (c) How is the analysis of a randomized algorithm different from the average case analysis of a deterministic algorithm? (5)
  
3. (a) Describe the skip list data structure using an example. What is the expected space required for a skip list with  $n$  elements? Prove your answer. (5+5=10)
  - (b) (i) Suppose you are applying branch-and-bounding technique and multithreading on a problem at the same time. What difficulties may arise for the problem? Explain with an example. (5+5=10)
    - (ii) Discuss the "Spawn Law" and the "Work Law" of multithreaded algorithms.
  - (c) How can you measure the performance of online algorithms? Measure the performance of Moving-To-Front (MTF) algorithm of linear list search. (3+12=15)
  
4. (a) Given a greedy scheduler executes a multithreaded computation on an ideal computer with  $P$  processors. What is the upper bound of execution time for the multithreaded computation? Justify your answer. (15)
  - (b) Consider the following multithreaded algorithm for computing Fibonacci number: (10+5=15)

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

```
Fibonacci (n)
    if n < 2 then return n;
    x = spawn Fibonacci (n - 1);
    y = Fibonacci (n - 2);
    sync;
    return x + y;
```

For the above algorithm answer the following questions:

- (i) Describe the computation for calculating Fibonacci (5) using the directed acyclic graph. Mention different types of edges in the graph.
- (ii) Assume each strand takes unit time. What will be the Work and the Span for the computation?
- (c) Write the optimization version and decision version of Independent Set Problem and Set Packing Problem.

(5)

**SECTION – B**

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

5. (a) Push(St,x)

(8+15=23)

1. if St.size == 0
2. St.mem = allocate\_mem(1)
3. St.size = 1
4. if St.num == St.size
5. newMem = allocate\_mem(2 \* St.size)
6. memcpy(St.mem, newMem, 1)
7. free\_mem(St.mem)
8. St.mem = newMem
9. St.size = 2 \* St.size
10. St.mem[St.num+1] = x
11. St.num = St.num + 1

Suppose you and your partner are working on an offline assignment that asks you to implement a stack system. You have implemented (correctly) the push operation in the form of "Push(St,x)" function shown above as per the requirement of the assignment. In the code snippet above, x is an element that can be pushed into the stack and "St" is an object representing the stack that has the following members:

- mem is a pointer to a memory location where each element of the stack can be stored
- size records the size of the stack

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**Contd... Q. No. 5(a)**

Additionally, the following utility functions have been used:

- `allocate_mem(k)` takes an integer and returns pointer (like `St.mem`) to a memory that can hold  $k$  elements of the stack.
- `free_mem(ptr)` frees the memory pointed to by pointer `ptr`.
- `memcpy(src, dest, k)` copies the elements from the  $k$ th position of the memory pointed to by `src` to the memory pointed to by `dest`.

- (i) Now, after carefully analyzing a sequence of  $n$  Push operations on an initially empty stack, your friend has come up with an argument to prove an upper bound of  $O(n^2)$ . Present that argument.
- (ii) Your genius little brother overheard your discussion with your partner and took the liberty to check your code. Using an amortized analysis he then proves that actually the bound is  $O(n)$ . Your job now is to present that analysis.

(b) What do you know about a Splay tree? Define the splay function. Discuss how a Splay tree uses the splay function to implement other standard operations. (12)

6. (a) Define sorting by reversals, sorting by prefix reversals and sorting by transpositions problems with appropriate examples. (9)

(b) Develop a 4-approximation algorithm for the sorting by reversals problem. You need to discuss relevant concepts to develop your algorithm. You need to prove its correctness. You also need to prove that it is indeed a 4-approximation algorithm. (26)

7. (a) Define local and global alignment. What could be the biological motivation for computing local alignments? (12)

(b) Define the Block Alignment Problem. Present an  $O(n^2)$  Dynamic Programming solution for the Problem. Is there a possibility for a further speedup? How? (23)

8. (a) Your friend has claimed that he can reduce Problem A to Problem B and the reduction is polynomial. Now for the following scenario, deduce what conclusion could be reached from your friend's claim. (10)

- (i) Problem B is NP-Complete
- (ii) Problem A is NP-Complete

(b) Prove: (25)

- (i)  $\text{SUBSET-SUM} \leq_p \text{KNAPSACK}$
  - (ii)  $3\text{-SAT} \leq_p \text{SUBSET-SUM}$
-

**SECTION – A**

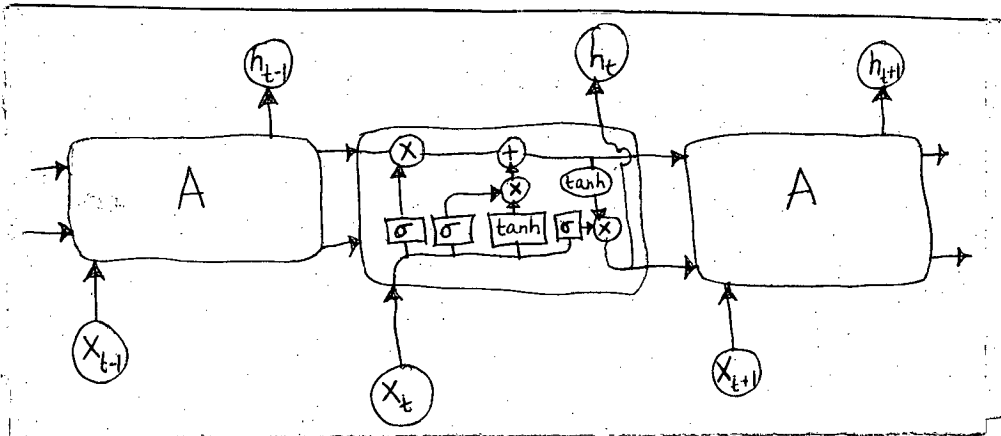
There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Which variant of stochastic gradient descent algorithm with adaptive learning rate does use interim updates? Write its gradient accumulation and velocity update steps with corresponding equation. (5+5+5)
- (b) A 3-node hidden layer word2vec model has been trained over a 5-word unique vocabulary corpus. The weight matrix is given below. (10+10)

$$\begin{bmatrix} 1 & 2 & 3 \\ 2 & 8 & 2 \\ 5 & 6 & 7 \\ 2 & 3 & 4 \\ 6 & 5 & 4 \\ 9 & 9 & 9 \end{bmatrix}$$

What are the one-hot encoding of two most similar words and two most dissimilar words in the corpus?

2. (a) A schematic figure of a recurrent LSTM unit is given below. Redraw the unit which (5+5+5)
  - (i) produces output between 0 to 1
  - (ii) has multiplicative cell state update
  - (iii) uses tanh forget gate



- (b) Here you are given the architecture of a convolutional neural network. Calculate the number of trainable parameters for each layer. The definition of each layer is given below. (20)



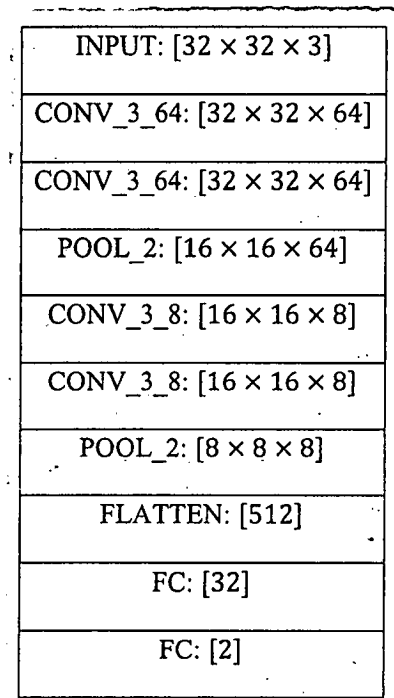
**CSE 471**

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

- (i) INPUT:  $[W \times H \times D]$  = Input layer of dimension  $W \times H \times D$
- (ii) CONV\_L\_D:  $[W \times H \times D]$  = Convolutional layer with total  $D$  filters of dimension  $L \times L$  each producing filtered output of dimension  $W \times H$
- (iii) POOL\_L:  $[W \times H \times D]$  = Pooling layer with window dimension  $L \times L$ , stride  $L$  and output dimension  $W \times H \times D$
- (iv) FLATTEN:  $[WHD]$  = Flatten input dimension  $W \times H \times D$  to output dimension  $1 \times WHD$
- (v) FC:  $[D]$  = Fully connected layer with output dimension  $D$

Architecture:

The network architecture is given below:



- 3. (a) Write the update equations of row latent factor and column latent factor for alternating least square matrix factorization algorithm without any regularization. Define each quantity in your equations. (10+10)
- (b) Consider 3 data points in the 2-d space:  $(-1,-1)$ ,  $(0,0)$ ,  $(1,1)$ . Find the first principal component (write down the actual vector) from their graph plot (no numerical eigen decomposition should be necessary). Calculate its corresponding eigen value. (5+10)

4 Let, a vector  $\mathbf{x}$  with dimension  $D$  can be generated from any one of the  $k$  independent Gaussian distributions with identity co-variance matrix. The probability of selection of Gaussian distribution  $i$  is  $w_i$  where  $\sum_{i=1}^k w_i = 1$  and the probability of generation of sample  $\mathbf{x}_j$  is given as  $P(\mathbf{x}_j | \mu_i, \mathbf{I}) = \frac{1}{\sqrt{(2\pi)^D}} e^{\left(-\frac{1}{2}(\mathbf{x}_j - \mu_i)^T (\mathbf{x}_j - \mu_i)\right)}$

For this particular model answer the following questions

- (a) Write a generative model for above scenario. (5)

**CSE 471**

**Contd... Q. No. 4**

- (b) If  $x_j$  denotes a position vector within 3-dimensional co-ordinate system and there are 4 mixture components, calculate the total number of trainable parameter. (10)
- (c) Write the four steps of the expectation-maximization algorithm to estimate trainable parameters for above model. (20)

**SECTION – B**

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

- 5. (a) Define the least squares linear regression model and ridge regression model. While finding the optimized weight vector  $w$ , what is the problem of these models when the dimension  $D$  is very large? How can we solve this? Explain with necessary mathematical explanations. (13)
- (b) Write short notes on: (12)
  - (i) Locality sensitive hashing
  - (ii) Locally weighted regression
  - (iii) k-d tree
- (c) Explain with example - "Nearest neighbor approaches are sensitive to the curse of dimensionality". Explain two ways to solve this problem. (10)
- 6. (a) Define entropy and information gain. Given the following training examples for calculating risk of loan credit, find a decision tree using information gain heuristics. (18)

No.	History	Debt	Collateral	Income	Risk
1	bad	High	none	\$0-15K	high
2	unknown	High	none	\$15-35K	high
3	unknown	Low	none	\$15-35K	mod
4	unknown	Low	none	\$0-15K	high
5	unknown	Low	none	over \$35K	low
6	unknown	Low	adequate	over \$35K	low
7	unknown	Low	none	\$0 to 15K	high
8	bad	Low	adequate	over \$35K	mod
9	good	Low	none	over \$35K	low
10	good	High	adequate	over \$35K	low
11	good	High	none	\$0 to \$15K	high
12	good	High	none	\$15 to \$35K	mod
13	good	High	none	over \$35K	low
14	bad	High	none	\$15 to \$35K	high

**CSE 471**

**Contd... Q. No. 6**

(b) Consider the following plot of performance of a decision tree in Figure 6(b). (10)

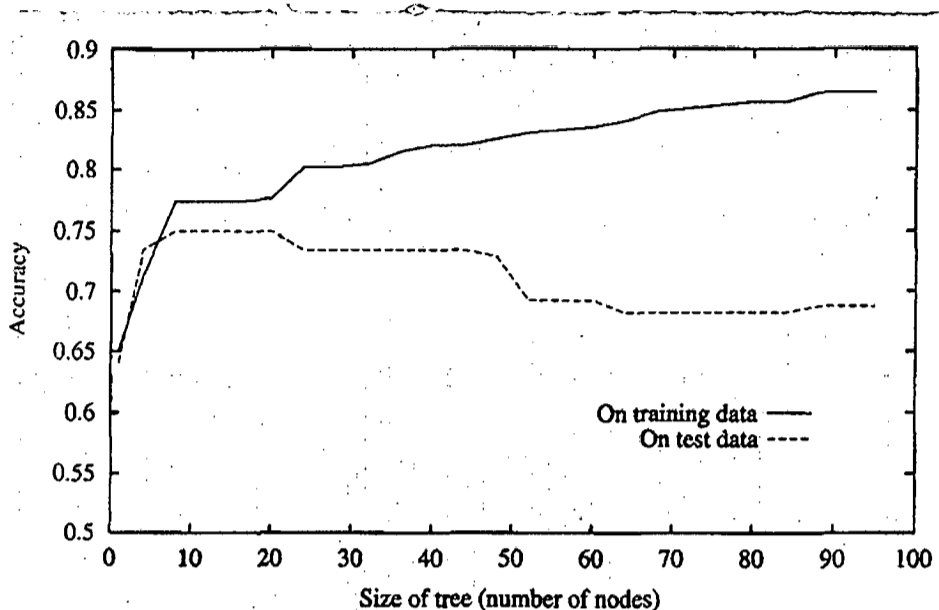


Figure 6(b)

The horizontal axis of this plot indicates the total number of nodes in the decision tree, as the tree is being constructed. The vertical axis indicates the accuracy of predictions made by the tree. The solid line shows the accuracy of the decision tree over the training examples, whereas the broken line shows accuracy measured over an independent set of test example (not included in the training set).

- (i) Why did the decision tree behave in this way?
- (ii) How can one get rid of this behavior?

(c) What is underfitting of data? How can this be avoided? (7)

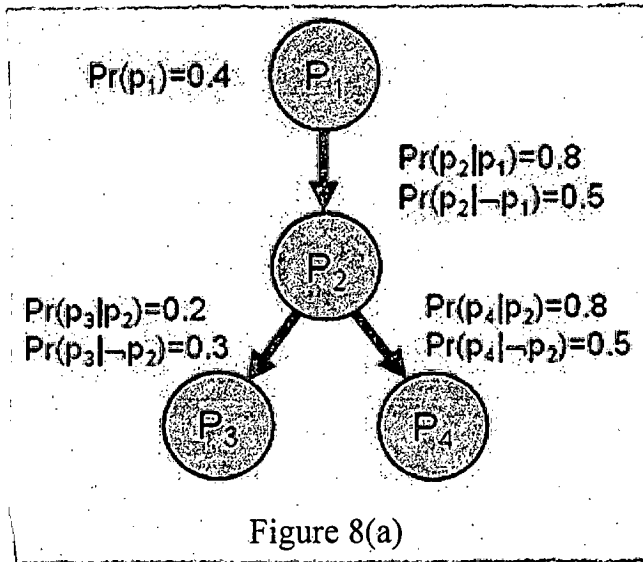
7. (a) Define weak and strong classifiers. How does AdaBoost algorithm assign weights to different classifiers so that combined classification error is minimized? Does AdaBoost algorithm cause overfitting of data? Justify your answer. (5+9+5)

(b) What is the significance of generalization in the context of machine learning algorithms? Differentiate between supervised learning and semi supervised learning. (4+4)

(c) Explain bagging and stacking in context of ensemble learning. (8)

**CSE 471**

8. (a) Consider the following Bayesian Network in Figure 8(a): (20)



Calculate marginal and conditional probabilities  $\Pr(\neg p_3)$ ,  $\Pr(p_2|\neg p_3)$  and  $\Pr(p_1|p_2, \neg p_3)$  using the method of **inference by enumeration**.

(b) Consider you have to develop a model which identifies Nobel laureates from average people. In the given dataset, there are 80 million people and of them 193 (confirmed) were Nobel laureates. Now, you decided not to do any work and simply label "Not Nobel laureate" to every people. You feel happy about your model "accuracy" which is 99.9998%!! (12)

What is wrong with "accuracy" for this scenario? Describe three metrics which can be helpful for pointing out the pitfalls in this type of scenario. Explain with example.

(c) Define **peeking** in context of supervised learning. (3)

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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2016-2017

Sub: **HUM 371** (Financial and Managerial Accounting)

Full Marks: 140

Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION – A**

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

1. (a) The degree of operating leverage for X company is 5 times whereas 7 times for Z company. What does it imply? (5 1/3)

- (b) Quality Gazettes makes high quality calculators. The following information are available for the last year: (18)

Sales (in units)	2800
Selling price per unit	Tk. 265
Contribution margin ratio	60%
Annual fixed expense	111,300

**Required:**

- (i) Compute company's break-even points in units and Tk.
  - (ii) Refer to the original data. The sales manager decided the following changes– a 15% reduction in the selling price combined with a Tk. 60,000 increase in advertising cost would cause annual sales in units to increase by 40%. Would you recommend that the company should do as the sales manager decided?
  - (iii) Compute income or loss when 50,000 units are sold if variable cost increases by Tk. 3 per unit. (Other information remaining the same as original data)
  - (iv) The company estimates that sales will increase by Tk. 500,000 next year due to increased demand. By how much should net operating income increases (Use CM ratio to calculate your answer).
  - (v) Refer to the original data. Assume that next year management wants the company to earn a profit of Tk. 182,850. How many units will have to be sold to meet this target profit?
  - (vi) Refer to the original data. Compute degree of operating leverage and margin of safety.
2. (a) Why is manufacturing overhead considered as an indirect cost of a unit of product? (5 1/3)
- (b) Nokia Mobile Company makes cell phone. The following details are available for the year ended 31<sup>st</sup> December, 2017. (18)

**HUM 371**

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

**Nokia Mobile Company**

	Amount (Tk.)
<b><u>Opening stocks:</u></b>	
Direct material	19,000
Work-in-process	32,000
Finishing goods	80,000
Driver salary, delivery van	17,000
Direct material purchased	350,000
Direct labor	43,000
Indirect labor	40,000
Administrative expenses	160,000
Depreciation on factory equipment	70,000
Selling expenses	67,000
Factory power, heat and light	20,000
Building rent (production uses 50% of the spaces, administration and sales uses the rest)	75,000
Maintenance cost, factory	17,500
Oil and fuel cost	14,000
Sales person commission	20,000
Sales	1,475,000
Audit expense (administration)	15,000
Utility, factory	22,000
<b><u>Closing stock:</u></b>	
Direct material	49,000
Work-in-process	31,500
Finished goods	55,000

**Required:**

- (i) Prepare a cost of goods sold statement.
  - (ii) Assume that the company produced the equivalent of 15,000 units of product during that year, then what was the unit cost for direct material?
3. (a) PQR Company has two supports departments- Administrative services (AS) and Information Systems (IS) and two operating departments- Government Consulting (GOVT) and Corporate Consulting (CORP). For the first quarter of 2018, the following records are available-

(23 1/3)

**HUM 371**

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

**PQR Company**  
For the first quarter, 2018

Budgeted overhead before allocation	Support Dept.		Operating Dept.		Total
	AS	IS	GOVT	CORP	
	600,000	24,00,000	87,56,000	124,52,000	
Support work supplied by AS	—	25%	40%	35%	100%
Support work supplied by IS	10%	—	30%	60%	100%

**Required:** Allocate two supports departments cost to the two operating departments by using:-

- (i) Direct method.
- (ii) Step-down method.
- (iii) Reciprocal method.

4. (a) In what situation, absorption costing will result higher net income than variable costing. Why? (5 1/3)

(b) Chuck wagon grills manufacturing company makes a single product. Information for the last operating year were as follows- (18)

Particulars	Amounts (Tk.)
<b>Cost Data:</b>	
Direct materials	50
Direct labor	80
Variable manufacturing overhead	20
Variable selling and administrative overhead	10
<b>Fixed cost:</b>	
Fixed manufacturing overhead	700,000
Fixed selling and administrative expenses	285,000
<b>Production and Sales:</b>	
Beginning inventory	Nil
Units produced	20,000
Units sold	19,000
Selling price per unit	Tk. 210

**Required:**

- (i) Calculate the product cost per unit under absorption costing system and variable costing system.
- (ii) Draw income statement and calculate net income or net loss using under and variable costing system.
- (iii) Reconcile the amount of income under two costing systems.

**HUM 371**

**SECTION – B**

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

5. Rayhans Computers Solution Ltd is a software and hardware selling firm started their business operation in Bangladesh on 1st January 2018. During the first month of its operation following events and transactions occurred.

(23 1/3)

January 1	Owner invested Tk. 200,000 cash in the business.
January 2	Hired an office Manager at a salary of Tk. 20,000 per month.
January 3	Purchased Tk. 25,000 of Office Furniture on account from Autobi Furniture Ltd.
January 7	Paid office rent of Tk. 9,000 cash for the month.
January 11	Completed a customized software and billed client Tk. 60,000.
January 12	Received Tk. 40,000 advanced on a consulting service engagement.
January 17	Received cash of Tk. 12,000 for services completed for KBC Co Ltd.
January 31	Paid Office Manager Tk. 20,000 salary for the month.
January 31	Paid 60% of balance due Autobi Company Ltd.

Rayhans Computers Solution Ltd uses the following accounts: Cash, Accounts Receivable, Accounts Payable, Unearned Service Revenue, Owner's Capital, Service Revenue, Salaries Wages Expense, Rent Expense. Supplies, and Office Furniture.

**Requirements:**

- (a) Journalize the transactions.
  - (b) Post to the Ledger Accounts.
  - (c) Prepare a Trial Balance on January 31, 2018.
6. (a) Explain four basic assumption of Accounting with proper examples. (8)
- (b) Joan Robinson opens her own law office on July 1, 2017. During the first month of operations, the following transactions occurred. (15 1/3)

- (i) Joan invested Tk. 11,000 in cash in the law practice.
- (ii) Paid Tk. 800 for July rent on office space.
- (iii) Purchased office equipment on account Tk. 3,000.
- (iv) Provided legal services to clients for cash Tk. 1,500.
- (v) Borrowed Tk. 700 cash from a Sonali Bank Ltd.
- (vi) Performed legal services for client on account Tk. 2,000.
- (vii) Paid monthly expenses: salaries and wages Tk. 500, utilities Tk. 300, and supplied Tk. 100.
- (viii) Joan withdraws Tk. 1,000 cash for personal use.

**Requirements:**

Show the effect of above transaction on Accounting Equation, and prepare the Income Statement on July 31 for Joan Robinson, Attorney.



**HUM 371**

7. Mr. Denli started his own consulting firm, Denli Company, on June 1, 2018. The trial balance at June 30 is shown below:

(23 1/3)

**DENLI COMPANY**

Trial Balance

June 30, 2018

Accounts	Debit (Tk.)	Credit (Tk.)
Cash	1000	
Accounts Receivable	6000	
Supplies	2000	
Prepaid Insurance	3000	
Equipment	15000	
Accounts Payable		4500
Unearned Service Revenue		4000
Owner's Capital		24600
Service Revenue		7900
Salaries and Wages Expense	4000	
Rent Expense	1000	
Total	<u>41000</u>	<u>41000</u>

In addition to those accounts listed on the trial balance, the chart of accounts for Mr. Denli Company also contains the following accounts and account:

Salaries and Wages Payable, Supplies Expense, Insurance Expense, Utilities Expense, and Utility Payable.

**Other adjustments related data:**

- (i) Supplies on hand at June 30 are Tk. 500.
- (ii) A utility bill for Tk. 2500 has not been recorded and will not be paid until next month.
- (iii) The insurance policy is for a year.
- (iv) Tk. 3,800 of unearned service revenue has been earned at the end of the month.
- (v) Salaries of Tk. 3000 are accrued at June 30.
- (vi) Invoices representing Tk. 1,200 of services performed during the month have not been recorded as of June 30.

**Requirements:**

- (a) Prepare the adjusting entries for the month of June.
- (b) Prepare an adjusted trial balance at June 30, 2018.

**HUM 371**

8. The Trial Balance of Greenbury Company Ltd for the year ended on 31<sup>st</sup> December 2017 is as follows:

(23  $\frac{1}{3}$ )**Greenbury Company Ltd.****Trial Balance****31<sup>st</sup> December, 2017**

<b>Accounts Name</b>	<b>Debit (Tk.)</b>	<b>Credit (Tk.)</b>
Cash	50,000	
Accounts Receivable	20,500	
Accounts Payable		21,000
Owners' Equity		100,800
Office Equipment	25,000	
Service Revenue		30,000
Salary Expense	12,000	
Prepaid Rent	4,000	
Miscellaneous Expense	1,000	
Commission Expense	3,000	
Supplies	700	
Notes Payable		6,400
Drawings	2,000	
Goodwill	20,000	
Building	150,000	
Long term Investment	50,000	
Bond Payable		155,000
Interest Payable		<u>25,000</u>
Total	<u>3,38,200</u>	<u>3,38,200</u>

**Adjustments: Year-end adjusting data are as follows**

- (i) Salary were unpaid Tk. 8000 during the year 2017
- (ii) Annual Depreciation rate on Equipment is 20%
- (iii) Supplies on hand on 31<sup>st</sup> December is Tk. 300
- (iv) Prepaid Rent were expired Tk. 3000.

**Requirements:**

- (a) Prepare Income Statements/Profit and Loss Statement
- (b) Prepare an Owners Equity Statements
- (c) Prepare a Classified Balance Sheet/Statement of Financial Position at 31<sup>st</sup> December 2017.

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