

Indian Institute of Information Technology,  
Allahabad  
IML

C1 Paper  
90 Min

15 marks.

---

Answer all the following questions

Question 1:

We would like to use the following regression function:  $y = w^2x + wx$  where  $x$  is a single value variable. Given a set of training data points  $(x_i, y_i)$ , derive a solution for  $w$ . Simplify as much as you can. (5 marks)

Question 2:

We would like to compare the above regression model (given in question 1, (Model 1)) to the regression model  $y = wx$  (Model 2). Given limited training data, which model (1 or 2) would fit the training data better. Give explanation. (2 marks)

Question 3:

The following dataset consists of eight rows.  $x, y$  are input features. Status is the output target variable. (4 marks)

$x$	$y$	<i>status</i>
2	4	great
5	5	normal
6	4	less
3	6	less
2	2	normal
4	6	great
5	2	less
6	5	great

Classify the following tuple using k-nn algorithm.

- (3.5, 4)

Hyperparameters to be used for k-nn algorithm are  $k = 1, 2, 3$  and distance metric has to Minkowski distance for  $p = 1, 2, 3$ .

Question 4:

Why we need different kind of error functions for regression and classification? Provide rational behind this. Why we need regularization? Explain with examples. How it affects learning of the models? (4 marks)

**C2- Review**  
**Introduction to Machine Learning**  
**Time: 1hr Date: 7-11-2023**

1. Explain what effect will the following operations have on the bias and variance of your model. Fill in one of 'increases', 'decreases' or 'no change' in each of the cells: Explain your choice in one to two sentences [5 Marks]

	Bias	Variance
Regularizing the weights in a linear/logistic regression model		
Increasing k in k-nearest neighbor models		
Pruning a decision tree (to a certain depth for example)		
Increasing the number of hidden units in an artificial neural network		
Removing all the non-support vectors in SVM		

2. We have 1000 fruits which are 1) banana 2) apple and 3) other. Each fruit is characterized by three (Long, Sweet, Yellow) binary (0 and 1) features. We want to build a naïve bayes classifier to predict if a given fruit is a 'Banana' or an 'Apple' or 'Other' when the three features (long, sweet and yellow) are known. The training dataset is as below: [5 Marks]

Type	Long	Not Long	Sweet	Not sweet	Yellow	Not Yellow	Total
Banana	400	100	350	150	450	50	500
Apple	0	300	150	150	300	0	300
Other	100	100	150	50	50	150	200
Total	500	500	650	350	800	200	1000

**Question:** Given that a fruit that is long, sweet and yellow, predict which fruit it is.

# Introduction to Machine Learning

## C3 Review Test

Duration: 2 hrs

Maximum Marks: 50

1. Specify whether TRUE/FALSE along with a short answer. Correct answer with a no explanation or a wrong explanation will carry negative (-1) marks. [2x5=10]
  - a) We can get multiple local optimum solutions if we solve a linear regression problem by minimizing the sum of squared errors using gradient descent.
  - b) When a decision tree is grown to full depth, it is more likely to fit the noise in the data.
  - c) When the hypothesis space is richer or feature space is larger, overfitting is more likely.
  - d) When working with large datasets, held-out validation is cheaper to execute as compared to k-fold cross-validation.
  - e) The Power method can be used to solve the PCA problem but it cannot be used to solve the kernel PCA problem.
2. Draw a fully connected Neural Network with the following specifications [5]
  - 4 Inputs  $x_1, x_2, x_3, x_4$
  - 2 Hidden Layers
  - Hidden Layer 1 is made up of  $a_j = \sum_i^4 W_{i,j} x_i + \beta_j^1$  and  $b_j = \sigma(a_j)$ .
  - Hidden Layer 2 is made up of  $c_k = \sum_j^4 W_{j,k} b_j + \beta_k^2$  and  $d_k = \sigma(c_k)$ .
  - The output layer is made up of  $e = \sum_k^3 W_k^3 d_k + \beta^3$  and  $o = \sigma(e)$ .
  - Include the bias terms in all layers marking them as  $\beta^m$  with  $m$  as their layer number. Make sure you label your drawings.

What can we say about this Neural Network if we replace the activation functions with  $b_j = a_j$ ,  $d_k = c_k$  and  $o = e$ . Specifically, what other ML methods can this be compared to? Explain your answer in one short sentence.

3. Explain the difference between stochastic gradient descent and mini-batch gradient descent. Describe the scenario where each one is a better option than the other. Derive an expression of gradient term for backpropagation in ANN where the neuron is an output neuron and the loss function is MSE. [5]
4. Explain the boosting algorithm, while explaining its merit and demerits by performing Adaboost over Random Forest to create one stump from the following data. Provide sample weight data for creation of second stump [10].

Temperature (F)	Humidity	Rain_Past	Rain_Future
65	80%	Yes	No
79	10%	No	No
70	50%	No	Yes
60	100%	Yes	Yes

5. We have a dataset in which  $x_i \in R^2$ . The data is  $X = \{(0,0), (2, 1), (3, 5), (4, 3), (5, 6), (6, 7)\}$ . Compute the second principal component using PCA. [10]



**भारतीय सूचना प्रौद्योगिकी संस्थान इलाहाबाद**  
**Indian Institute of Information Technology Allahabad**  
An Institute of National Importance by Act of Parliament  
Deoghat Jhalwa, Allahabad-211015 (U.P.) INDIA

**Department of Information Technology**  
**Image and Video Processing, C1 Review Test**  
**B.Tech. IT and IT-BI (V semester)**

**Duration: 90 min.**

**Maximum Marks: 20**

**Note:** All questions are compulsory. All the subparts of a question are to be attempted together.

- Q1.** An 8-bit digital image of size  $12 \times 10$  has a histogram where the gray levels are equally distributed in the range from 161 to 220 (uniform distribution). Sketch the histogram. Describe the produced effect on the image contrast and brightness in the following cases:
- Calculation of the image negative. [1]
  - Addition of 50 to all pixel gray levels. [1]
  - Application of thresholding function where the threshold is selected as gray level 128. [1]

- Q2.** For the matrix given below, consider the two highlighted pixels and find

4	5	6	5	4	4
3	3	5	1	4	4
3	2	1	6	8	3
4	5	3	5	3	3
6	3	7	4	6	1
3	6	3	4	5	4

- Euclidean distance [1]
- City-block distance [1]
- Chessboard distance [1]

- Q3.** Answer the following.

- What type of noise is shown in the image below? [1]

25	43	35	255	69	0
78	0	56	0	255	98
255	65	0	76	255	0
45	0	255	89	90	255

- What filter is most suitable for removing such noise? [1]
- Explain how it achieves this function. [2]
- Given such a filter of dimension  $3 \times 3$  and the below image, what will be the output of the center pixel? [1]

25	43	35
78	0	56
255	65	0

- Q4.** Consider the following two  $8 \times 8$  images. Perform histogram matching for the image on the left using the reference image on the right. [5]

0	5	7	7	5	8	7	8
7	2	6	2	6	5	6	8
6	9	7	7	0	7	2	7
6	6	1	7	6	7	7	5
9	6	0	7	8	2	6	7
2	8	8	2	7	6	7	8
7	3	2	6	1	7	5	8
9	9	5	6	7	7	7	7

Original Image

2	6	7	8	5	0	6	8
7	2	6	2	6	2	6	7
6	8	9	2	0	7	3	7
7	6	1	4	6	0	5	9
9	7	0	9	8	4	6	7
9	8	9	4	7	1	7	8
7	3	5	5	1	3	5	7
5	8	8	4	6	2	7	6

Reference Image

- Q5.** Answer the following.

- a. Consider a 1-D function  $f$  and a filter  $w$  given below:

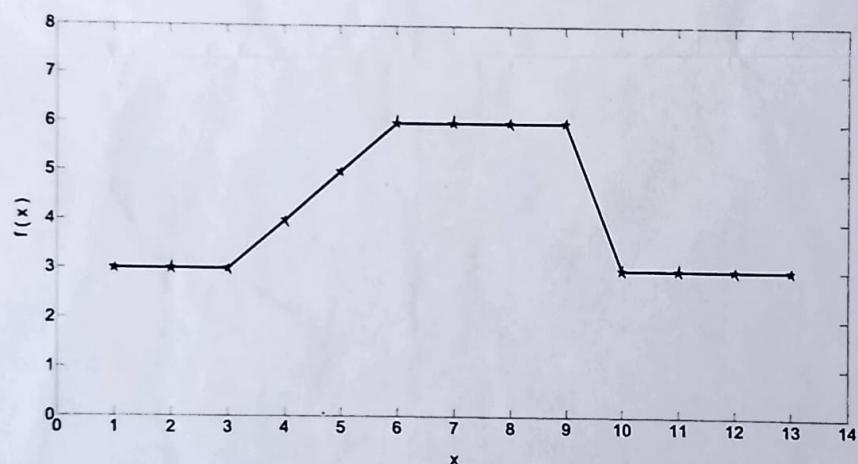
$f$								
1	2	3	4	5	6	7	8	9

and

$w$				
1	2	3	2	1

Show the result of the enhanced signal after applying the convolution operator. Use zero padding, if required. [1]

- b. Compute the first-order and second-order derivatives of the 1-D signal shown below. [2]



- c. State TRUE or FALSE with proper justification: A small-sized box filter does more smoothing than a large-sized box filter. [1]



भारतीय सूचना प्रौद्योगिकी संस्थान इलाहाबाद  
Indian Institute of Information Technology Allahabad

1172021134

An Institute of National Importance by Act of Parliament  
Deoghat Jhalwa, Allahabad-211015 (U.P.) INDIA

Department of Information Technology  
Image and Video Processing, C2 Review Test  
B.Tech. IT and IT-BI (V semester Section B)

**Duration:** 90 min. **Maximum Marks:** 20 **Note:** All questions are compulsory. All the subparts of a question are to be attempted together.

- Q1.** What is the region growing ? Apply region growing on the following image with initial point at (2,2) and threshold value as 2. Use 4 connectivity and assume the index of the image starts with zero. [3 marks]

0	1	2	0
2	5	6	1
1	4	7	3
0	2	5	1

**Q2.**

- a. Bella, a passionate web designer, was working on a new website project. She knew that the site's load speed could significantly impact user experience, and heavy images could slow it down. Bella was keen on optimizing her images, but she was torn between JPEG and PNG. If you were Bella, which one would you choose, and why?  
b. On the other side of Technopolis, Carlos, an innovative digital artist, was preparing to share his latest artwork online. His creations were typically filled with intricate patterns and transparent backgrounds, requiring a compression format that could handle these elements without losing detail. Carlos pondered, would JPEG or PNG be best for his artwork? Why ?

**Q3.**

Explain each of the following in 3 to 4 sentences

[3 marks]

- a) Watershed algorithm
- b) Hough Transform
- c) Thinning
- d) Pruning
- e) Convex hull
- f) Lossy and lossless compression

**Q4**

[3+1.5= 4.5 Marks]

- a) Consider a Source with 7 messages having probability 0.25 , 0.25, 0.125, 0.125, 0.125, 0.0625, 0.0625. Find the average code length , entropy and efficiency using huffman coding.  
b) Given the following binary bit stream:  
11110000000011111110011111000011111111  
Provide the run-length encoded representation of the bit stream.

**Q5.** You are working on a medical imaging project where it is critical to preserve the exact original data due to legal and professional requirements. Which type of image compression would you use and why? [1.5 marks]

- A. You are developing a mobile application that involves sending and receiving images over the network. The application should work smoothly even on slow network connections. However, perfect fidelity in the images is not necessary. Which type of image compression would you recommend and why?
- B. You are creating a website and you need to use a background image. However, you want to ensure the website loads quickly. Would you use lossy or lossless compression for the background image and why?
- C. You're working on a project where you need to archive and retrieve high-quality photographs. The storage space is not an issue, but the quality of the photographs is of utmost importance. What type of image compression would you use and why?

**Q6.** What is Boundary Extraction ? Which morphological operation among opening, closing , erosion and dilation is required as the primary step in boundary extraction of objects from an image? Perform boundary extraction on image A with help of structuring element B [3 marks]

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	1	1	1	0	0
0	1	1	1	1	1	0	0
0	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0

A

0	1	0
1	1	1
0	1	0

B

**Q7. A)** Apply opening in image A using structural element B [3 marks]

1	1	1	0	1	1	1
1	1	1	1	1	1	1
1	1	1	0	1	1	1

A

1	1	1
1	1	1
1	1	1

B

**B) Apply closing on Image A using structural element B (Use structuring element from Part A)**

1	1	1	1	1	1	1	1
1	1	1	0	1	1	1	1
1	1	1	0	1	1	1	1

A



**भारतीय सूचना प्रौद्योगिकी संस्थान इलाहाबाद**  
**Indian Institute of Information Technology Allahabad**  
An Institute of National Importance by Act of Parliament  
Deoghat Jhalwa, Allahabad-211015 (U.P.) INDIA

**Department of Information Technology**  
**Image and Video Processing, C3 Review Test**  
**B.Tech. IT and IT-BI (V semester)**

**Duration: 2 hrs.**

**Maximum Marks: 40**

**Note:** All questions are compulsory. All the subparts of a question are to be attempted together.

**Q1.** Apply histogram equalization on the input image of  $8 \times 8$  below. Let the input and output gray levels be in the range of [0,7].

[6]

1	1	5	5	0	0	1	0
1	1	2	2	0	1	0	1
1	7	6	6	5	5	0	0
0	7	6	7	5	5	5	5
4	7	6	7	3	5	7	0
1	1	4	1	6	5	6	1
2	2	4	1	1	5	1	1
1	2	2	0	0	0	0	5

**Q2.** Apply contrast stretching on the 3-bit grey level image of size  $4 \times 4$ .

[4]

2	1	2	1
4	5	5	6
3	2	1	4
6	2	1	6

**Q3.** A set of images is to be compressed by a lossless method. Each pixel of each image has a value in the range (0-3) i.e. 2 bits/pixel. An image from this set is given below. In this image, the occurrence of pixels of different values is typical of the set of images as a whole. What is the degree of compression achievable using Huffman coding of the pixel values?

[6]

3	3	3	2
2	3	3	3
3	2	2	2
2	1	1	0

**Q4.** You are given the following spatial-domain filter

[6]

0.15	0.35	0	-0.35	-0.15
------	------	---	-------	-------

- Compute the spectrum and phase of this filter.
- What do you think the effect of applying this filter to an image will be? In other terms, what type of filter do you think it is? Justify your answer.
- How would you modify the filter to achieve exactly the opposite effect? Provide the steps you would follow. You do not need to find the actual filter that will achieve this effect.

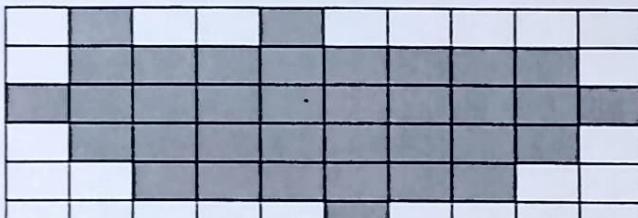
Q5. Show the validity of the following expressions.

[6]

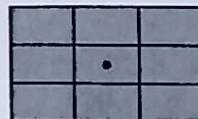
- A is a subset of A•B
- If C is the subset of D, then C•B is the subset of D•B
- $(A \cdot B) \cdot B = A \cdot B$

Q6. Consider the image and the two structuring elements given below. Note that the shade gray represents 1 while white represents 0. Boundary extraction is to be performed.

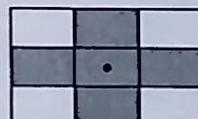
[4]



Image



A



B

- What will be the output of using structuring element A on the given image?
- What will be the output of using structuring element B?

Q7. Apply k-means clustering over the following image and divide the image into 2 segments. Every grid represents a pixel of an image with its intensity written inside the bracket. Consider the pixel 1 and pixel 11 as the seed pixels. Show the results after two iterations.

[6]

1 (227,38,208)	2 (50,90,234)	3 (97,135,145)	4 (41,42,176)
5 (245,66,62)	6 (64,212,73)	7 (145,199,120)	8 (203,154,191)
9 (140,214,237)	10 (157,149,193)	11 (19,238,3)	12 (79,67,115)
13 (35,65,89)	14 (121,140,192)	15 (14,33,86)	16 (135,167,21)

Q8. In respect to high pass filtering, fill in the missing value (x and y):

[2]

0	1	0
1	x	1
0	1	0

(a)

1	1	1
1	y	1
1	1	1

(b)

**Indian Institute of Information Technology, Allahabad**

**C1 Review Test, September 2023**

**Network Security - 5th Semester B.Tech (IT)**

**Maximum Marks: 50**

**Time: 90 Minutes**

**1(a)** Security of all public key cryptographic schemes is based on some one-way function. State the one-way function associated with the:-

- a. Discrete Log Problem(DLP)
- b. Integer factorization problem

**1(b)** "Any cryptographic scheme can be broken by Brute force Attack" - justify. Then, how do we claim a cryptographic scheme secure?

**1(c)** Compare between symmetric and asymmetric cryptography. Name two symmetric encryption algorithms.

$$2 + 2 + 2 + 1.5 + 2 = 9.5$$

**2(a)** Which of the following basic security objectives can be achieved by MD5: Confidentiality, Authenticity, Integrity, Non-repudiability?

**2(b)** State the 2nd pre-image resistance and the collision resistance properties of a secure hash function.

$$0.5 + 1 + 1 = 2.5$$

**3(a)** Which of the following basic security objectives can be achieved by RSA encryption: Confidentiality, Authenticity, Integrity, Non-repudiability?

**3(b)** State the RSA encryption scheme. Establish its correctness proof.

**3(c)** Which of the following statements is/are true? Justify your answer:

"RSA is secure as long as integer factorization is hard."

"RSA is secure because integer factorization is hard."

**3(d)** The soundness of the RSA encryption scheme is established based on Euler's Theorem. State the 1st and 2nd versions of the Euler's Theorem.

$$0.5 + 3 + 1 + 3 + 2 + 1 = 10.5$$

**4(a)** Which of the following basic security objectives can be achieved by RSA Digital signature scheme: Confidentiality, Authenticity, Integrity, Non-repudiability?

**4(b)** State the RSA digital signature scheme. Establish its correctness proof.

$$0.5 + 1 + 1 = 2.5$$

5. Wireshark is a tool that we use to sniff the network packets. Is it possible to capture the HTTPS packet flowing between two users and read the message? Justify your answer. 2

6. Let us consider, you will PING our Institute network proxy and guess the type of its operating system through the TTL. If there are three intermediate nodes between your machine and the proxy then what will be the TTL value of PING reply that gets displayed in your machine. You may consider the TTL at the proxy is 64 or 128. Justify your answer. 5

7. How a receiver can ensure the non-repudiation while receiving the message from the semi-trusted sender. 3

8. List any three Active attacks and its impact in the network 6

9. Your password is of 5 characters and possible combinations are lower case alphabets and numbers (0..9). In this case, what is the security lifetime of your password? You can use any actually possible method and number of instructions per second in the machine to show the lifetime. 6

10. As we know, we have two general types of attackers: insider and outsider. What advantages does an inside attacker have over an outside attacker? 3

**Indian Institute of Information Technology, Allahabad**  
**C3 Assessment, November 2023**  
**Network Security - 5th Semester B.Tech (IT)**

**Maximum Marks: 55**

**Time: 120 Minutes**

- 1 (a) How does the PKI protocol work?**
- 1 (b) Show the format of an X.509 certificate.**
- 1 (c) Show the format of a X.509 CRL.**
- 1 (d) How do the HTTPS and SFTP protocols work?**

$$1 + 1 + 1 + 1 = 4 \text{ Marks}$$

- 2 (a) Show the steps of the Kerberos authentication protocol.**
- 2 (b) What is a Kerberos realm?**

$$2.5 + 0.5 = 3 \text{ Marks}$$

- 3 (a) What are the four main protocols of SSL?**
- 3 (b) State the purpose of each of these four protocols.**
- 3 (c) Show the main steps of the SSL handshaking protocol.**
- 3 (d) In SSL, why random numbers are exchanged between client and server?**
- 3 (e) What is the relationship between SSL and TLS?**

$$0.5 + 1 + 2 + 1 + 0.5 = 5 \text{ Marks}$$

- 4 (a) What is the purpose of Difie-Hellman protocol?**
- 4 (b) State the Diffie-Hellman Protocol.**
- 4 (c) Show its correctness proof.**
- 4 (d) What is the Diffie-Hellman Problem and what is Diffie-Hellman Assumption?**

$$0.5 + 1.5 + 1 + 1 = 4 \text{ Marks}$$

- 5 (a) Which of the fundamental security objectives are achieved in PGP based secure e-mail communication?**
- 5 (b) How are those objectives ensured?**
- 5 (c) What is the main difference between PGP and DKIM protocol?**

$$1 + 2 + 1 = 4 \text{ Marks}$$

- 6. How is the Host based Intrusion Detection System different from the Anti-Virus? [2 marks]**
- 7. What is the advantage(s) an organization is going to get from the Honeypot? [3 marks]**
- 8. What is the advantage of IPSec when compared with the SSL/TLS? [3 marks]**
- 9. What is the use of the Security Parameter Index in IPSec? [3 marks]**
- 10. How the heartbleed exploits the heartbeat feature of the OpenSSL [3 marks]**
- 11. ARP poisoning allows man in the middle to collect all packets including the sensitive packets flowing between victims. How can the DHCP snooping or its methodology help in preventing the ARP poisoning attack? [3 marks]**
- 12. What are the possible privacy issues that arise in the DNS over TLS? [3 marks]**

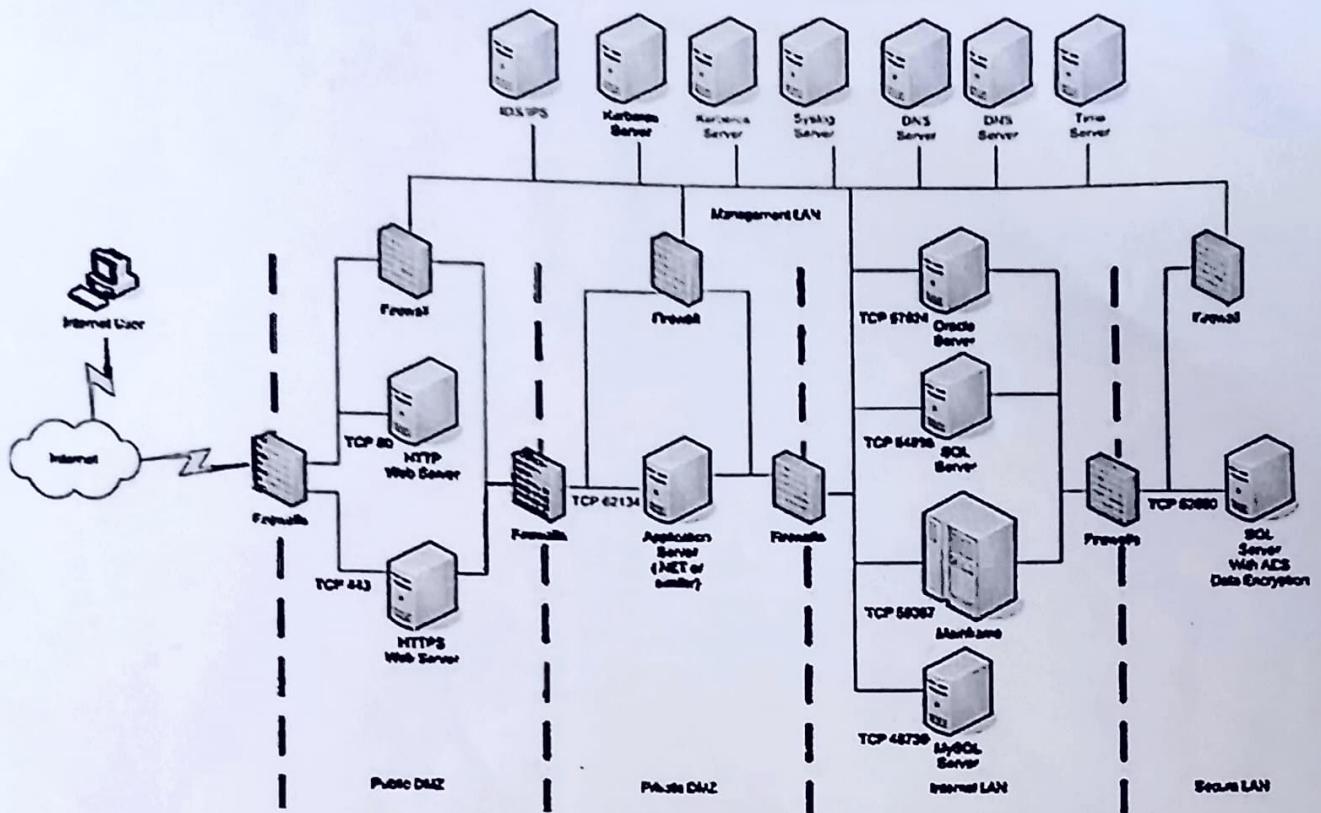


Figure 1: Topology of Ultra Secure Network.

13. Use Figure 1 to answer the questions: [2\*5 marks]

- What kind of secure design is adopted in the topology and is there any scope to adopt alternative design without any change in the topology?
- Why two http servers are placed in one location and what if we may have one http server instead of two?
- How insider threat and authorized access does is granted?
- How does the “SQL Server” being restricted with only access to back-up scheduling?
- How would the traces of the event being recorded and handled in the Ultra secure Network Topology?

14. What are the necessary steps involved in testing the Web application security? Create a DFD indicating all the steps involved? [1\*2 marks]

15. Write syntax for the following: [1\*3 marks]

- Host discovery.
- To scan port for http.
- TCP Syn Scan

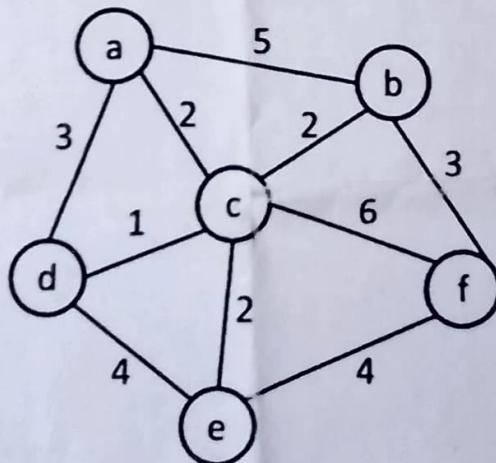
**Indian Institute of Information Technology- Allahabad**  
**C1 Review Test (Artificial Intelligence)**  
**B.Tech. IT/BIN 5th Sem.**

**Time: 2:00 Hrs**

**Max. Marks: 30**

1. Write the percept sequence for the following agent: [5 Marks]  
 Agent "A" can move in a rectangular grid one step at a time in "up", "down", "left" or "right" directions. It is placed at the (0,0) position of the grid of size  $2 \times 3$  and moves around. If an edge is observed, the agent moves accordingly.
2. Why is the space complexity lesser than the time complexity of DFS which are the same in BFS in a state space tree of branching factor 'b' with depth of the goal node as 'd'. Write the values for each using appropriate asymptotic notation and compare. [2+4 Marks]
3. Discuss the completeness of depth limited/bounded search algorithm with reference to the state space search. If simple hill climbing algorithm is used in place of depth limited search, what can you say about the completeness? [3+2 Marks]
4. Solve 4-queen's problem using Iterative Deepening algorithm. Write down the intermediate steps by clearly mentioning the initial state. Does the algorithm face any problem associated with memory allocation or missing a solution even if it exists? If so, illustrate these with suggestions to overcome them. [4+2 Marks]
5. Apply A\* algorithm on the following graph to find the shortest path from start state (node a) to goal state (node f). Here the cost is given as the weight of an edge and heuristics is defined as the estimate of distance between the goal state and any other state represented by the following tabular data. Discuss why a simple greedy algorithm will not work. [6+2 Marks]

a	b	c	d	e	f
6	2	5	6	4	0



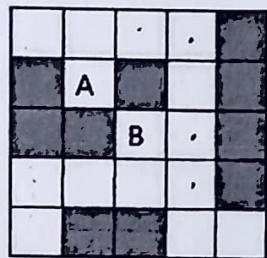
(End of the Paper)

**Indian Institute of Information Technology- Allahabad**  
**C3 Review Test (Artificial Intelligence)**  
**B.Tech. IT/BIN 5th Sem.**

**Time: 2:00 Hrs**

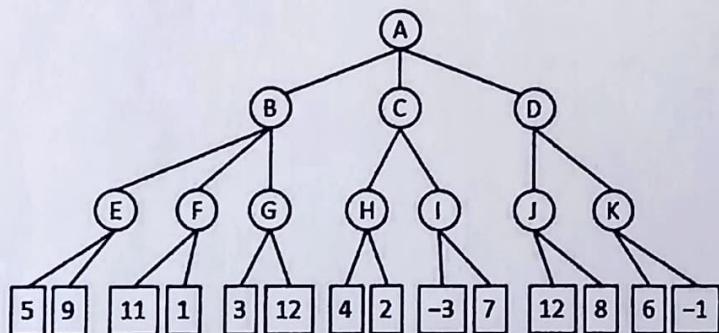
**Max. Marks: 25**

1. Let us define an intelligent agent which can move through the following grid. It can move one step at a time in any of the four directions- left, right, up or down. Write down the percept sequence to reach from point A to point B. The dark cells of the grid represent obstacles. [3 Marks]



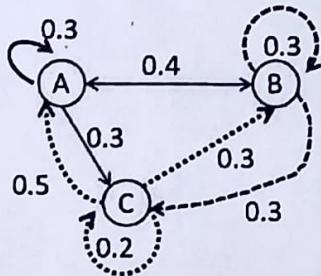
2. Compare the time complexity of minimax algorithm and  $\alpha$ - $\beta$  pruning. Apply  $\alpha$ - $\beta$  pruning on the following tree to identify the nodes which are pruned and mention the reason for pruning (Write down all the steps to show the results).

[2+ 3 + 1 Marks]

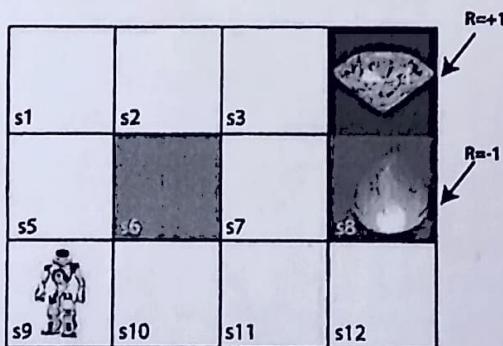


3. Write down the algorithm for evaluating a decision network. Implement it with one simple decision making problem. Highlight the role of a utility node in a decision network. [2 + 2 + 1 Marks]

4. The following transition diagram represents a system of 3 states. Let the present state be represented by the probability vector  $\{0.1, 0.6, 0.3\}$ . Find the next few states for the given system and check if it converges (Truncate the decimal digits for brevity of calculations). If it doesn't converge, what may be the reason for it (Write in 1 sentence only)? **[4 + 2 Marks]**



5. In the following figure, the agent is at  $s_9$  block of the maze which consists of:  
 $s_6$  block: a wall  
 $s_8$  block: a fire pit, and  
 $s_4$  block: a diamond block.  
The agent can take four actions: move up, move down, move left, and move right. However, it cannot cross the  $s_6$  block which is a solid wall. If the agent reaches  $s_4$  block, it gets  $+1$  reward point and if it reaches the fire pit, it gets  $-1$  reward point. Show all the steps using the reward function. **[5 Marks]**



(End of the Paper)

# INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, ALLAHABAD

C1 Assessment, 15 September 2023.

Graphics & Visual Computing IGVC-5211

B.Tech - IT: V - Semester

Full Marks - 20 Which will be Scaled to 10.

Time – 2.0 hrs.

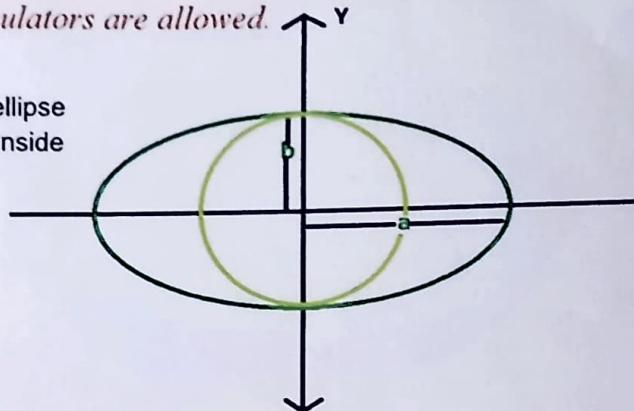
Answers should be brief and to the point. Marks will be deducted for unnecessary writing.

Calculators are allowed.

1. Write the midpoint line drawing algorithm of ellipse and draw the following figure where circle is inside

Consider the radius of the circle as

6 i.e.  $b$  and  $a$  is 8.



[5]

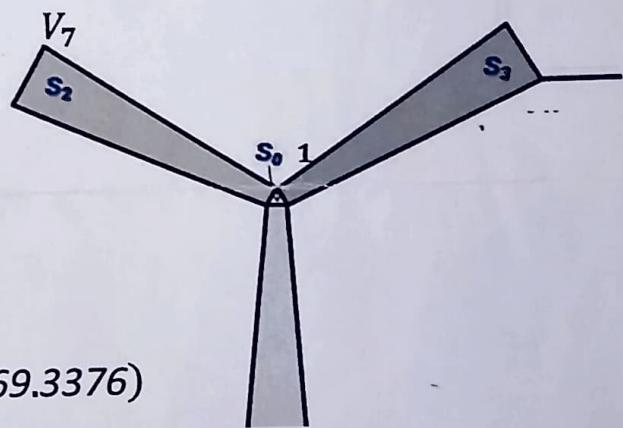
2. A Helicopter Propeller needs to be designed using 3 equal isosceles trapezoids as shown in the figure. The dimensions of each trapezoid are **height=100** and the **bases** are **10** and **30**.

A vector  $\vec{R}$  formed from the vertex

$$(x_a = 20.0, y_a = 30.0, z_a = 25.0) \text{ and}$$

$$(x_b = 164.3376, y_b = 174.3376, z_b = 169.3376)$$

is the axis of rotation of the propeller. The centre of the propeller is placed at  $(x_b, y_b, z_b)$ . The propeller is rotated by an angle



$V_4$

$\omega t$  around  $\vec{R}$ .

- a) Describe and generate all the vertices of the propeller and then make the data structure of the vertices, the edges and the surfaces  $S_0(V_1, V_2, V_3)$ ,  $S_1(V_2, V_3, V_5, V_4)$ ,  $S_2(V_1, V_2, V_6, V_7)$  and  $S_3(V_1, V_3, V_8, V_9)$  and in a hierarchical manner. Where  $V_i[x_i, y_i, z_i]$ . Assume  $z_i = 0.0$  in the **Object Frame**. Compute and Tabulate the coordinates of the vertex  $V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9$ . The Origin of the **Object Frame** is the center of  $S_0$ .

- b) Derive the transformations to rotate the propeller. Define the Transformation matrix and then use short notation only. (Hint: It is easier to represent this transformation as a product of multiple transformations). If  $\omega = \frac{2\pi}{3}$  Radiane/second, and if the animation frames are buffered at every  $t = 1$  second, then what is observed and why? What is the technical word for the observation?
- c) The Camera is located at  $(x_c = 1463.3758, y_c = 1473.3758, z_c = 1468.3758)$  The **Lookat point** is the **center** of surface  $S_0(V_1, V_2, V_3)$  and the **UP Vector** is towards the vertex  $V_1$  from the **Lookat point**. Compute and Tabulate the coordinates of the vertex  $V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9$  in the **Camera Frame**.
- d) If the Focal length of the camera  $f = 1000$ , Compute and Tabulate the coordinates of the vertex  $V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9$  in the **Perspective Projection**.
- e) In the case of a monitor with an industry-standard Full HD 1080p resolution, this display has a resolution of  $1920 \times 1080$ . This means that the screen will have a width of 1,920 pixels while the height of the screen will be 1,080 pixels. The **ScalingFactor = 10.0**. find the pixel coordinates of the vertex  $V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9$ . Please Note: the **Lookat point** is the **center of the Screen**.
- f) To colour the polygons/ surfaces  $S_1(V_2, V_3, V_4, V_5)$ ,  $S_2(V_1, V_2, V_6, V_7)$ ,  $S_3(V_1, V_3, V_8, V_9)$  and  $S_0(V_1, V_2, V_3)$  using **Boundary-Fill / Flood-Fill Algorithm A** point within each polygons/ surfaces is needed. Compute and Tabulate:

POLIGONE	$x_{in(pixel)}$	$y_{in(pixel)}$
$S_0(V_1, V_2, V_3)$		
$S_1(V_2, V_3, V_4, V_5)$		
$S_2(V_1, V_2, V_6, V_7)$		
$S_3(V_1, V_3, V_8, V_9)$		

$$[(1+2)+(2+2)+2+2+2=15]$$

## Questions on GVC Lectures (Finite Time Assessment)

Lectures: 12 to 24

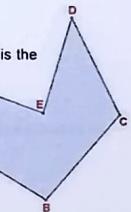
Date November 09, 2023 5:00PM to 6:00PM / 6:00PM to 7:00PM (1 Hour)

[Marks: 80X1=80 Max].

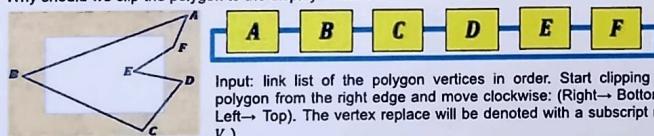
The answer should be at least 75% correct to obtain 1 otherwise the marking will be 0. If a student has gone through the lectures and read the book they will surely be able to answer; while the student who has not done any effort will find it difficult to reply within the time frame. NO EXTRA ANSWER BOOK WILL BE PROVIDED

- What is a convex polygon? Concave polygon? Intersecting polygons? Polygon with a hole? Draw.
- How is a Polygon determined as convex (Methode 1)?
- How is a Polygon determined as convex (Methode 2 different form 1)?
- Why are polygons used for surface representation?
- What is the need of "two vertices consideration" in the Scan Line algorithm? What is the major challenge of the "two vertices consideration" and how to tackle it?
- Show that  $x_k = x_0 + (k/m)$  in the Scan Line algorithm where  $x_0$  and  $x_k$  represent the initial and  $k^{\text{th}}$  intersection points of the scan line and  $m$  is the slope.

- Show the data structure of this polygon corresponding to the Scan line algorithm for the figure:



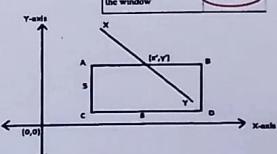
- Explain 4 point and 8 point algorithms with appropriate examples.
- When does the 4 point algorithm fail and you will require an 8 point algorithm?
- What is the difference between Boundary Fill and Flood Fill Algorithms?
- Draw the bi-level bitmap pattern of character 'Z'.
- What are the possible outcomes when you clip a triangle?
- Give an example of Sutherland-Hodgman Polygon clipping algorithm returning "no output".
- Explain "point-to-plane" test.
- What is the Sutherland-Hodgman Polygon clipping algorithm?
- Why should we clip the polygon to the display window?



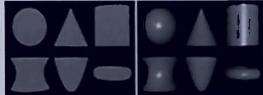
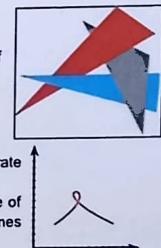
Input: link list of the polygon vertices in order. Start clipping the polygon from the right edge and move clockwise: (Right  $\rightarrow$  Bottom  $\rightarrow$  Left  $\rightarrow$  Top). The vertex replace will be denoted with a subscript no ( $V_n$ ).  
 If the vertex is modified again in future iteration it will have 2 subscript no ( $V_{nn}$ ).  
 $V = (A, B, C, D, E, F)$ . Show the clipped figure with the new vertices and show how the link-list is modified with each edge clipping leading to the final clipped polygon.

- Examine the end-points of each line to see if they are in the window or not. If both end-points are within the window then: "Don't Clip". One end-point inside, one outside: "Must Clip" Then why if both end-points are outside the window, the solution is "Don't Know!"
- How is the position of the vertices remembered in Cohen - Sutherland Line Clipping Algorithm?
- How does the clipping algorithm know when a line segment should be accepted or summarily rejected in Cohen-Sutherland Line Clipping Algorithm?

- How is partitioning different in Nicholl-Lee-Nicholl (or NLN) Line Clipping algorithm to Cohen-Sutherland Line Clipping Algorithm? And why is it considered faster in 2D clipping?
- Find the point of intersection ( $x', y'$ ) if the coordinate of C is (4,1), X is (5,10) and Y is (11,5,2). See Figure:



- How is the front/back surface determined using the normal to the surface?
- What are the 3 reasons that scene primitives can be invisible?
- Describe the implementation of Z-buffering.
- What is Z-buffering in contrast to Ray casting?
- How is BSP Tree partitioning of space made into front and back nodes?
- What are the 4 steps of Warnock's Algorithm: (An Elegant hybrid of Object-space and Image-space)?
- Describe the Painter's Algorithm:
- Which Triangle is on TOP? How can Painter's algorithm be implemented in such a situation of interlaced triangles as shown in the figure?
- The Curve shown in the figure is self intersecting. To mathematically generate such curves should we use Explicit, Implicit or Parametric? Explain why?
- Write the Explicit, Implicit and Parametric equation for a circle. Modify one of the equations (Explicit, Implicit or Parametric) of the circle so that it becomes a self intersecting curve as shown in the figure of previous question.
- What are  $C_0, C_1, C_2, \dots, C_n$ ? On Continuity of a line passing through multiple vertices?
- In Hermite Spline what are the geometric constraints for fitting a cubical spline (A Cubical Polynomial)?
- For obtaining a line with  $C_0, C_1$  and  $C_2$  continuity what are the geometric constraints required and what will be the order of the spline polynomial?
- Spline fits a smooth curve between vertices (1 & 2) and (2 & 3) .... ( $k-1$  &  $k$ ) and ( $k$  &  $k+1$ ). How is the  $C_1$  continuity conserved at the vertices 2, 3, ...,  $k-1$ ,  $k$ ?
- In the equation  $x(u) = U \cdot M_{\text{spline}} \cdot M_{\text{geom}}$  What is  $M_{\text{geom}}$ ? How do we obtain the blending functions from this equation?
- What is the significance of having just 4 Blending functions Hermite or Bézier.
- Bézier Spline Matrix is derived from Hermite Spline Matrix by multiplying Hermite Spline Matrix by:  
 — Explain in short how you get this matrix.
- What is the effect of tension parameter  $t$  and the bias parameter  $b$  in the other specialized splines?
- Why was B-Spline preferred while making the movie Terminator-II to other splines?
- What are the differences between the left and right images? Though both are in grayscale, which one of the looks realistic and desirable while displaying any graphics?
- Illumination models fall into two categories:  
 i) Empirical: ii) Physically based. What are these two categories?
- When is an object, is visible by the observer/camera?  
 i) Does all light from the source reach the observer?
- How is the Ray tracing algorithm made efficient?
- The figure shows a light source (sun). The light from this source reflects from different objects to reach the observer. i) How many rays are shown to be single scattering? ii) Do all rays reach the observer? How is it depicted in the figure?
- Which object exhibits a refraction? ii) If an object refracts, what can you say about the scattered/reflected "ray intensity" that reaches the observer? iii) What can you tell about the object where the refracted ray reaches the observer?
- To achieve the visual effects that match reality, an empirical model of illumination is constructed. Why are two components of the illumination model (light sources and surface properties) considered?
- Can the Source of "Ambient illumination" be determined and a direction of illumination be fixed?
- The model illumination is conceptualized as \_\_\_\_\_.



**Full Marks -  $12+20+5+3+10+10 = 60$  Which will be Scaled to 25.**

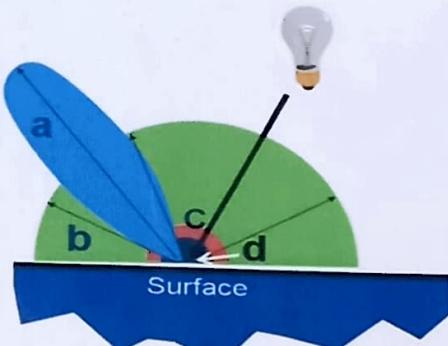
**Time – 2.0 hrs.**

*Answers should be brief and to the point. Marks will be deducted for unnecessary writing. Calculators are allowed.*

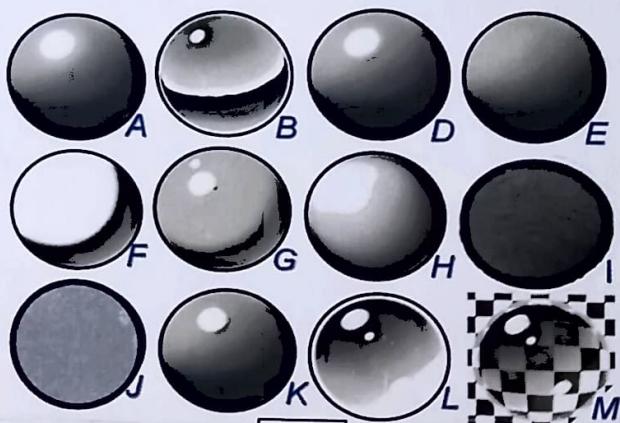
1. a) Write the generalized empirical formula for illumination for multiple light sources. Explain each term of the equation and graphically show the angular dependence of the intensity of each term.

Identify the terms of the equation with "a", "b", "c" and "d" in Fig. 1 and determine which of them is i) "diffuse reflection", ii) "specular reflection", iii) "ambient" and iv) "emission".

- b) Is the above derived generalized empirical formula applicable if the object/surface is transparent? If not what are the modifications. If  $I_{background}$  is the illumination of a background object, Will that have an effect?



**Fig. 1**



**Fig. 2**

- c) Discuss the illumination of the spheres (A, .. to .., M) shown in Fig. 2 with respect to the generalized illumination equation derived in (a) and (b). **[4+2+12X0.5=12]**

2. Assume that you will have to design a well-polished sphere of radius  $R=10$ . This sphere is illuminated from the top ( $y$ -axis) in the world frame by sunlight. The camera capturing the image of the sphere is placed at  $x_c=30, y_c=50, z_c=40$ ,  $(30, 50, 40)$  with respect to the center of the sphere. The camera is looking at the center of the sphere and the up vector of the camera is  $(0, 1, 0)$ .

- a) Draw neatly a diagram showing the sphere with respect to the camera in the world frame. Mark the coordinates and the angles properly. Indicate the camera Look-at vector and the up vector. Indicate the direction of light  $\bar{L}$  at 3 points on the sphere. Make a projection diagram choosing appropriate coordinates which illustrates the above points the best (Indicate the projection axis on the above diagram). If the light source was not the sun but a point source place at  $(0, 20, 0)$  in the world space, then what deference would it make.
- b) Write the equation (Cartesian coordinates  $[x, y, z]$ ) of the sphere in the **Camera Space** (Origin at the camera). Redraw the diagram in **Camera Space**. In the same camera space, write the vector  $\hat{L}$  (Direction of Sunlight),  $\hat{V}$  (Viewing Vector),  $\hat{N}$  (Normal to the surface) for the point  $(x, y, z)$  on the sphere. [Note that the vectors are normalized. Derive the vector  $\bar{R}$  (Reflected light) with the help of **snell's law**.]
- c) Relate the illumination equation derived above to this example. Eliminate the terms which are not required in the above example with proper justification.
- d) From symmetry we can say that the specular lighting maximum will be at  $x_{cam} = 0$ . How will you determine  $y$  of the specular lighting maximum even if  $\bar{R}$  is not normalized?

$$[(2+2+1) + (1+1+1+1+4) + (2) + (5) = 20]$$

3. The illumination equation does not show the effect of shadow. Knowing the position of all the Light sources  $L_i(x_i^l, y_i^l, z_i^l)$  and using the ray-tracing method explain with a pseudo code how one could determine if the particular point on the object is the shadow or not. What will you change in the illumination equation if the particular point is in the shadow?

[5]

4.



The pyramid prism shown in the figure has 5 facets **A, B, C, D** and **E**. If the prism was not transparent which are the facets which will be visible? Each facet **A, B, D** and **E** make an angle of  $45^\circ$  w.r.t to the Base **C**. Looking at the shading of the prism in the figure can you guess the direction of the light source knowing that surface **C** looks the darkest? Compare the angles  $\theta_A, \theta_B, \theta_C, \theta_D$  and  $\theta_E$ ; that the direction of illumination  $\vec{L}$  makes with the normal of each facet ( $\vec{n}_A, \vec{n}_B, \vec{n}_C, \vec{n}_D$  and  $\vec{n}_E$ ). [3]

5. a) Derive and formulate the **Hermite Cubical Spline**. Determine all the terms of the equation

$$p(u) = U \bullet M_{\text{spline}} \bullet M_{\text{geom}}$$

After formulating the constraints of **Bézier spline**, derive it from the **Hermite Spline**. Determine the 4 **Hermite**  $H_i(u)$  and **Bézier**  $B_i(u)$  blending functions and roughly plot and compare them.

$$H_i(u) \rightarrow B_i(u) \rightarrow U \cdot M_{\text{spline}}$$

- b) Assume an equilateral triangle **ABC** of a side **AB=a=10**. The coordinates of the vertex **A** is **(5,3)**. The slope of the segment **AB** is  $(1/\sqrt{3})$ . If the coordinate of **B** and **C** are  $(x_B, y_B)$  and  $(x_C, y_C)$ , then  $(y_B > y_C)$

This triangle controls a smooth curve. This smooth curve is tangent at 2 vertices on the segments **AB** and **AC** at  $1/4a$  from **B** and **C**. Draw the figure properly and mark and determine the coordinates of the 2 knots (**B'** and **C'**) and 2 control points (**B** and **C**) of the spline and determine the equations for the smooth spline curve using **Bézier** blending functions.

- c) Assume the triangle **ABC** described in (b) in 3-dimensions. The **Z** coordinates for each point is zero (**Z=0**) to start with. This triangle is rotated by an angle  $\theta$  about the axis formed by the median of the triangle emanating from the vertex **A**. Determine the required transformations to rotate the triangle. What changes will there be in the spline equation when  $\theta = 3\pi/2$ .

$[(3 + 2) + (2+1) + 2 = 10]$

6. Write a pseudo code for Cohen-Sutherland Line Clipping algorithm. Assume a rectangular window having the delimiters  $[x_{\min}, x_{\max}; y_{\min}, y_{\max}]$ .

- a) To help with the code, first make the diagram with the region codes and mark the delimiters.
- b) Write the pseudo code to code the vertices.
- c) Write the pseudo code trivial accept, trivial reject, Clip against one side, Computations of new vertices and assigning of code ....

{Assume  $\text{Clip}(V_i, V_j)$  is given which clips against one side  $[x_{\min}, x_{\max}; y_{\min}, y_{\max}]$  (where code  $V_k$  is non-zero) and assign new code to  $V_i$  or  $V_j$  based on the side clipped}

$[2 + 3 + 5 = 10]$