Strathmore
UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
BACHELOR OF COMPUTER NETWORKS AND CYBER SECURITY
END OF SEMESTER EXAMINATION

CNS 2204: COMPUTATIONAL MODELLING

Final Exam

DATE: 6th December, 2023 **Time: 08:00-10:00 Hours**

Instructions
1. This examination consists of **FIVE** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

QUESTION ONE **(Total:30 Marks)**

a. Use an example to describe how probability concepts can be applied in cyber security. (2 Marks)

b. Discuss the following graph theory concepts. (*use illustrations with explanation*) (8 Marks)
   i. Vertices vs Degrees
   ii. Spanning Tree
   iii. Isomorphism
   iv. Traversability

c. During a study on the security of a network, it was observed that the DDOS attack packets hits the server at the rate of 90 packets per second between 2300 hrs and 0000 hrs. The random variable X is the number of DDOS attack packets to the server between 2321 hrs and 0032 hrs. State the values of λ and t for this Poisson process and explain what they mean. (3 Marks)

d. A given network load balancing system uses two servers to balance the traffic load in that network. The system has been structured in a way that the default setting load capacity of server A is 80% of the total load while server B handles the remaining 20%. An algorithm has been developed that allows load balancing (one round) based on the probabilities in table 1.

Table 1

	Server B	Server B
Server A	0.75	0.25
Server A	0.55	0.45

   i. What will be the probability of the load in server A & B after another two rounds of balancing the load? *Show all the steps* (4 Marks)

ii. Assuming that in the long-run, the load balancing system reaches an equilibrium $[x_1, x_2]$ where $[x_1, x_2] = [x_2, x_1]P$ and $x_1 + x_2 = 1$, determine the optimal balanced load probabilities for server A & B. (5 Marks)

e. The probability that audio packets are delivered in a network is 70% while the rest are video packets. What is the probability of delivering 2 audio packets through the next 3 nodes? *Use probability tree and show all the steps.* (3 Marks)

f. In game theory, mixed strategies is when a pure strategy is not available for the players and thus there's no saddle point. The matrix below shows two players with their playing strategies. By letting p be the proportion of time A plays row a_1 and $(1 - p)$ being the proportion of time that he plays a_2, determine the best strategy for player A. (3 Marks)

		Player B	
		b_1	B_2
Player A	a_1	1	0
	a_2	- 4	3

g. Figure 1 shows the line configuration strategies used in queuing. Describe the type of the line configuration for A,B, C,and D in the figure. (2 Marks)

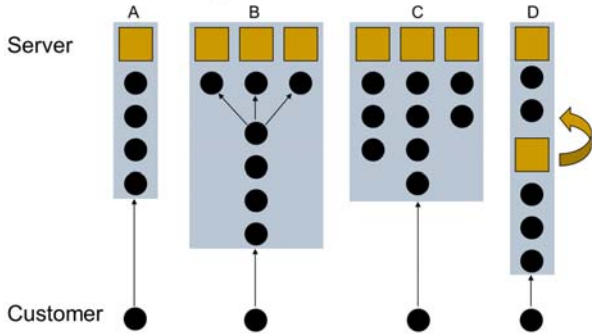

Figure 1

QUESTION TWO **(Total: 15 Marks)**

a. Given a transition matrix, S={1,2,3,4}, draw its state transition diagram. (2 Marks)

$$\begin{pmatrix} \frac{1}{3} & \frac{2}{3} & 0 & 0 \\ \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ \frac{1}{4} & 0 & \frac{1}{4} & \frac{1}{4} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

b. Determine the state transition matrix of a Markov chain transition diagram in figure 2 below. (3 Marks)

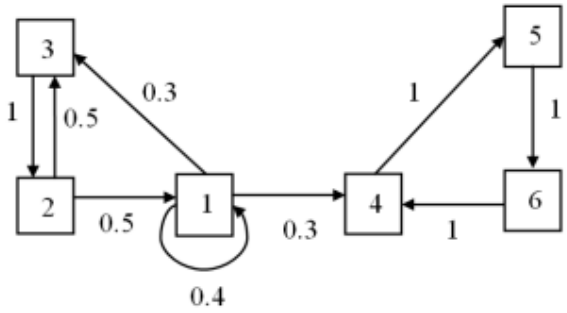

Figure 2

c. Differentiate between incidence and adjacently matrix as used in graph theory. (2 Marks)

d. Consider a modified form of " network load balancing " problem. In this scenario, there are two servers which are designed in a way that they can balance the load to avoid congestion in the network based on Minmax-Maxmin game theory principle. If load is fully balanced between the two servers, (server A & B), then server A gets 8 units of value while server a gets 1 unit, otherwise, server B gets 3 units of value over server A. Determine the optimum strategies for these "players" (serves) and the value of the game. *(hint: construct the pay off matrix and determine whether it is a fair game and calculating their optimal mixed strategies)* (8 Marks)

QUESTION THREE **(Total: 15 Marks)**

a. Consider a local area network with ten stations. Assume that, at a given moment, each node can be active with probability $p = 0.1$.
   i. Using binomial distribution, determine the probability of a number of stations being active as per table 2 below; *show all the steps* (5 Marks)

Table 2

Stations Active	1	2	3	4	5	6	7	8	9	10
Probability										

   ii. Show the binomial distribution from table 2 above using bar chart (2 Marks)

b. Suppose that measurements show that the average length of a phone call is 3 minutes. Assuming that the length of a call is an exponential random variable, what is the probability that a call lasts more than 6 minutes based on Exponential Distribution? (3 Marks)

c. Suppose that a switch has two parallel links to another switch and that packets can be routed on either link. Consider a packet A that arrives when both links are already in service. Therefore, the packet will be sent on the first link that becomes free. Suppose that this is link 1. Now, assuming that link service times are exponentially distributed, which packet is likely to finish transmission first: packet A on link 1 or the packet continuing service on link 2? (2 Marks)

d. A (time-homogeneous) Markov chain built on states A and B is depicted in the figure 3 below. By using transition matrix, determine the probability that a process beginning on B will be on B after 3 moves? (3 Marks)

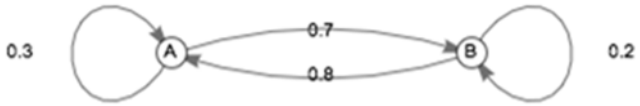

Figure 3

QUESTION FOUR **(Total: 15 Marks)**

a. Compare Hierarchical Clustering and k-Means Clustering in terms of Scalability and flexibility. *(explain your answer)* (4 Marks)

b. Describe the technique used in measuring similarity between two objects. (3 Marks)

c. Explain three fundamental elements of clustering (3 Marks)

d. How do you determine k using the Elbow Method? (2 Marks)

e. Figure 4 shows a network (*undirected graph*) consisting of 5 nodes with their associated path costs. Develop a spanning tree with the node D as the root based on the shortest path. *Show all the steps, i.e. hops and cost metric)* (3 Marks)

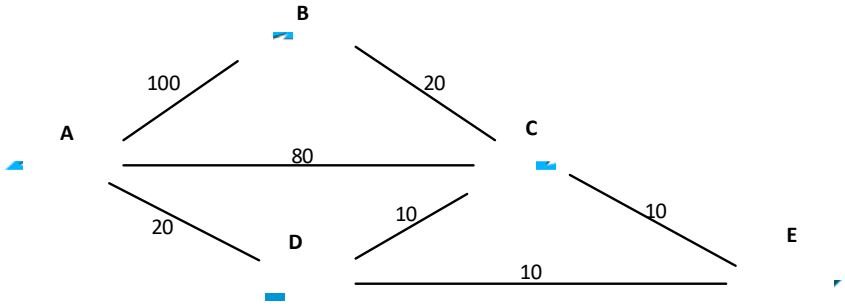

Figure 4

QUESTION FIVE **(Total: 15 Marks)**

a. Discuss the following terms as used in queuing theory. (5 Marks)
   i. Tandem queue
   ii. Balking
   iii. Reneging
   iv. Jockeying
   v. Steady state period

b. Figure 5 below shows a Python code used to draw a simple graph.
   i. Give the result of line 13 in this code. (2 Marks)
   ii. Write the complete code in line 26 that allows this code to be executed successfully. (2 Marks)
   iii. Draw the resulting graph when the complete code in b(ii) is executed. (3 Marks)
   iv. On executing the complete code of figure 5, an error was encountered and could not complete successfully. Identify all errors in this code and correct the error. (3 Marks)

```
import networkx as nx
import matplotlib,pyplot as plt

G = nx.Graph()

G.add_edge(1, 2)
G.add_edge(1, 3)
G.add_edge(1, 5)
G.add_edge(2, 3)
G.add_edge(3, 4)
G.add_edge(4, 5)

print(graph)

pos = {1: (0, 0), 2: (-1, 0.3), 3: (2, 0.17), 4: (4, 0.255), 5; (5, 0.03)}

options = {
 "font_size": 36.
 "node_size": 3000,
 "node_color": "white",
 "edgecolors": "black",
 "linewidths": 5,
 "width": 5,
}

nx.draw_networkx(_____)

ax = plt.gca()
ax.margins(0.20)
plt.axis("off")
plt.show()
```

Figure 5