ARTIFICIAL INTELLIGENCE
(CSEN 3111)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Which of the following is not a valid constraint for a 4-queens problem on a 4x4 chess board, where Q_i stands for the column number of the queen positioned in the i^{th}row?

(a) $|Q_3 - Q_4| \neq 1$ (b) $Q_1 - Q_4 \neq 3$
(c) $|Q_1 - Q_3| \neq 3$ (d) $Q_2 - Q_4 \neq -2$

(ii) A heuristic h_1 is said to dominate heuristic h_2, if at any node n

(a) $h_1(n) > h_2(n)$ (b) $h_1(n) < h_2(n)$
(c) $h_1(n) \geq h_2(n)$ (d) $h_1(n) \leq h_2(n)$

(iii) In genetic algorithm, mutating a string is:

(a) Changing all the genes in the strain
(b) Removing one gene in the strain
(c) Randomly changing one gene in the strain
(d) Removing the strain from the population.

(iv) Height of a normal fuzzy set is -

(a) 0 (b) 1
(c) any value in the open interval between 0 and 1 (d) None of these.

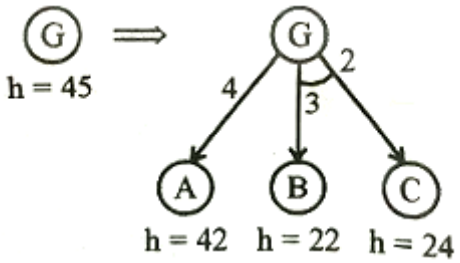
(v) If h1 and h2 are admissible, which of the following are also guaranteed to be admissible?

(i) h1 + h2
(ii) h1 * h2
(iii) max(h1 , h2)
(iv) min(h1 , h2)
(v) $(\alpha)h1+(1-\alpha)h2$ for any value α between 0 and 1

(a) (i), (ii), (iii) (b) (iii), (iv), (v)
(c) (v) only (d) All of the above.

(vi) If a model predicts 120 examples as belonging to the minority class, 90 of which are correct, and 30 of which are incorrect, then the precision for this model is
(a) 0.9 (b) 0.43 (c) 0.75 (d) None of these.

(vii) Consider the following AO graph. Which is the best node to expand next by AO* algorithm?



(a) B (b) C (c) A (d) B and C

(viii) Decision tree reaches its decision by using
(a) Single test (b) Two test
(c) Sequence of tests (d) No test.

(ix) Consider the following probabilities:
P(i|<s>) = 0.25, P(want|i) = 0.23, P(english|want) = 0.0011, P(food|english) = 0.34, P(</s>|food) = 0.68
What is the probability of the sentence: "I want English food"
(a) 0.000031 (b) 0.000026 (c) 0.000014 (d) None of these

(x) Suppose a computer program for recognizing cats in photographs identifies 9 cats in a picture containing 13 cats and some dogs. Of the 9 cats identified, 6 actually are cats, while the rest are dogs. Which of the following is the precision for the given situation?
(a) 6/9 (b) 6/13 (c) 9/13 (d) None of these.

Group – B

2. (a) Consider the following set of propositional sentences:
(i) $p \vee q$ (ii) $p \rightarrow r$ (iii) $q \rightarrow r$
Apply resolution theorem to prove the goal 'r'.
[(CSEN3111.1) (CSEN3111.4)(Apply/IOCQ)]

(b) Justify each of the following statements:
(i) BFS is a special case of Uniform-Cost search
(ii) Uniform Cost method never expands a node more than once.
[(CSEN3111.1) (Remember, Understand/LOCQ)]

(c) Prove that for a branching factor of b, depth of goal node d, the ratio of the number of nodes expanded by iterative-deepening search w.r.t. breadth first search is given by: b/(b – 1). [(CSEN3111.4)(Apply/IOCQ)]

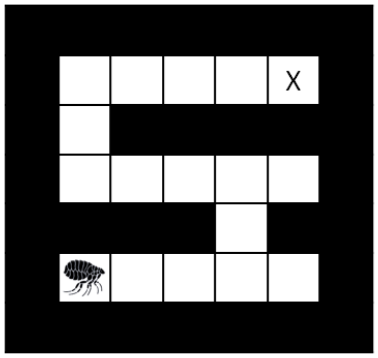
3 + (2 + 2) + 5 = 12

3. (a) Suppose you are controlling a single mite as shown in the maze below, which must reach a designated target location X. However, in addition to moving along the maze as usual, your mite can jump on top of the walls (coloured in black).

When on a wall, the mite can walk along the top of the wall as it would when in the maze. It can also jump down of the wall, back into the maze. Jumping onto the wall has a cost of 2, while all other actions (including jumping back into the maze) have a cost of 1. Note that the mite can only jump onto walls that are in adjacent squares (either north, south, west, or east of the flea).

(i) Represent this problem as a state space search problem, by mentioning initial state, goal state, allowed set of operators and pre-condition of those operators. [(CSEN3111.4, CSEN3111.6)(Create/HOCQ)]

(ii) Show that your state space representation will work on the given instance (as shown in figure) by finding one solution of the problem. [(CSEN3111.4, CSEN3111.6)(Analyse/IOCQ)]



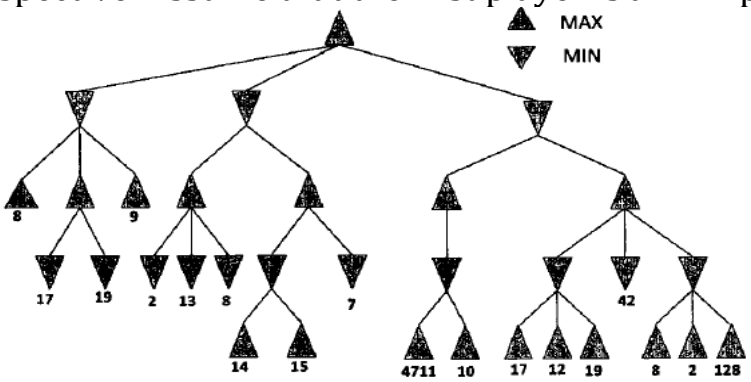
(b) Convert the following propositional sentence into CNF clauses:
¬[(XV¬Y)→Z)→(XVZ)] [(CSEN3111.2)(Understand/LOCQ)]

(c) If the parameter m (maximum depth of the state space) is infinite, which search method among BFS, DFS, Uniform-cost search and Depth limited search should not be used at all? Justify your answer. [(CSEN3111.1)(Analyse/IOCQ)]

(4 + 2) + 4 + 2 = 12

Group – C

4. Consider the following game tree where the evaluation scores at the leaf nodes are from the first player's perspective. Assume that the first player is a MAX player.



(i) What is the minimax value for the root node? Indicate which action the first player would choose assuming a fully rational opponent. [(CSEN3111.1) (Understand/LOCQ)]

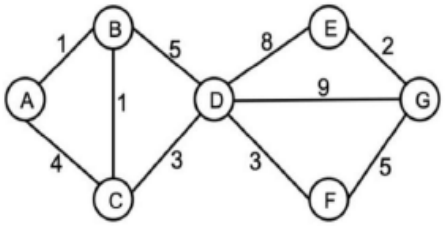
(ii) Show which branches (if any) would be pruned by alpha – beta cut-off assuming that the nodes are evaluated in left-to-right order. Also mention the type of cut-off in each case. [(CSEN3111.1) (Understand/LOCQ)]

(iii) Suppose the 2nd player chooses moves uniform randomly and the 1st player is aware of it. In this case what will be the propagated value at the root? Which move will the 1st player choose in this case? [(CSEN3111.4) (Evaluate/HOCQ)]

(iv) Suppose that in some game tree, the search tree is cut off at the depth D, and in the second game tree at the depth D + 1. Why do you expect that you will have a better strategy in the second case? [(CSEN3111.4)(CSEN3111.6)(Evaluate/HOCQ)]

(2 + 4 + 4 + 2) = 12

5. (a) Consider the state space graph shown below. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions. Note that the heuristic h_1 is monotonic but the heuristic h_2 is not monotonic.



Node	h_1	h_2
A	9.5	10
B	9	12
C	8	10
D	7	8
E	1.5	1
F	4	4.5
G	0	0

For each of the following graph search strategies, examine which, if any, of the listed paths it could return. Write Yes / No in the table accordingly. Note that for some search strategies the specific path returned might depend on tie-breaking behaviour. In any such cases, make sure to write Yes in all the boxes corresponding to paths that could be returned under some tie-breaking scheme. Show the detailed steps in each case.
[(CSEN3111.4)(CSEN3111.6)(Apply/IOCQ)]

Search Algorithm	A-B-D-G	A-C-D-G	A-B-C-D-F-G
A* search with heuristic h_1			
A* search with heuristic h_2			

(b) For each of the following agent environments, decide if it is fully or partially observable, deterministic or stochastic, static or dynamic, and discrete or continuous:
(i) Robot soccer player.
(ii) Autonomous Mars rover.
(iii) Playing tic-tac-toe. [(CSEN3111.1)(Understand/LOCQ)]

8 + 4 = 12

Group – D

6. (a) Consider the following set of English sentences:
A. Tom owns a kindle.
B. Every kindle owner loves books.
C. No book lover burns books.
D. Either Tom or Austin burned the book called Origin.
E. Every kindle is a book.
Now, answer the following questions:
(i) Encode the above sentences into First Order Predicate Logic (FOPL) using the following predicates:

owns(x, y):	x owns y
bookLover(x):	x is a book lover
burns(x, y):	x burns y
book(x):	x is a book
kindle(x):	x is a kindle

[(CSEN3111.1)(CSEN3111.2)(CSEN3111.3)(Remember, Understand/LOCQ)]
(ii) Convert those FOPL sentences into their equivalent CNF sentences.
[(CSEN3111.1)(CSEN3111.2)(CSEN3111.3)(Remember, Understand/LOCQ)]

(iii) Apply resolution-refutation method on those CNF sentences to answer the query: "Did Austin burn the Origin"?
[(CSEN3111.1)(CSEN3111.2)(CSEN3111.3)(Apply/IOCQ)]

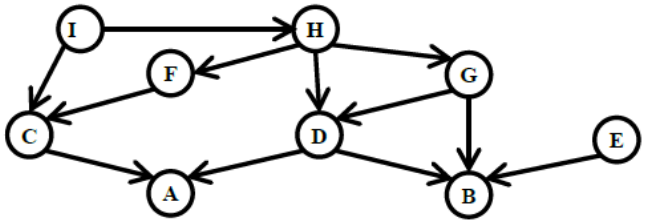
(b) Write a Prolog program which splits a list into 2 sub lists, one of them contains all the positive elements (including 0) in the original list, and the second one contains the negative elements. [(CSEN3111.5)(Create/HOCQ)]

(2.5 + 2.5 + 3) + 4 = 12

7. (a) Complete the following sentences:
(i) A formula is said to be valid if _____
(ii) In FOPL, _____ and _____cannot be quantified by for-all and there-exist operators.
(iii) A formula is said to be satisfiable if _____
(iv) A predicate logic formula of n variables, k predicate symbols (including propositions), and w function symbols (including constants) can have _____ number of interpretations.
[(CSEN3111.1)(Remember, Understand/LOCQ)]

(b) Draw the Bayesian networks (of four variables) that correspond to each of the following factorization of the joint probability distribution P (A, B, C, D).
(i) P(B|A, C)P(A)P(C|D)P(D)
(ii) P(D|C)P(C|B)P(B|A)P(A) [(CSEN3111.3)(Apply/IOCQ)]

(c) Write down the factored conditional probability expression that corresponds to the graphical Bayesian Network shown. [(CSEN3111.3) (Understand/LOCQ)]



4 + 4 + 4 = 12

Group – E

8. (a) Consider the following training dataset:

Age	Income	Married	Health	Class
Young	High	No	Fair	No
young	High	No	Good	No
Middle	High	No	Fair	Yes
Old	Medium	No	Fair	Yes
Old	Low	Yes	Fair	Yes
Old	Low	Yes	Good	No
Middle	Low	Yes	Good	Yes
Young	Medium	No	Fair	No
Young	Low	Yes	Fair	Yes
Old	Medium	Yes	Fair	Yes
Young	Medium	Yes	Good	Yes
Middle	Medium	No	Good	Yes
Middle	High	Yes	Fair	Yes
Old	Medium	No	Good	No

Apply Naïve-Bayes classifier on the above training dataset to predict the class label of a test record X = (Age = Young, Income = Medium, Married = Yes, Health = Fair)[(CSEN3111.2)(CSEN3111.3)(CSEN3111.4)(CSEN3111.6)((Apply/IOCQ)]

(b) Consider the following example:

Training data:

⟨s⟩I am Sam⟨/s⟩
⟨s⟩Sam I am ⟨/s⟩
⟨s⟩Sam I like ⟨/s⟩
⟨s⟩Sam I do like⟨/s⟩
⟨s⟩do I like Sam ⟨/s⟩

Assume that we use a bigram language model based on the above training data. What is the most probable next word predicted by the model for the following word sequences?

(i) ⟨s⟩ Sam . . . (ii) ⟨s⟩do I like . . . [(CSEN3111.6)(Evaluate/HOCQ)]

8 + 4 = 12

9. (a) Differentiate between partial and total ordered planning with suitable examples. [(CSEN3111.1)(Remember, Understand/LOCQ)]

(b) Differentiate between Stemming and Lemmatization with suitable example. [(CSEN3111.3)(Remember/LOCQ)]

(c) Differentiate between supervised and unsupervised learning methods. Explain with suitable example. [(CSEN3111.3)(Remember/LOCQ, Understand/LOCQ)]

(d) Why the logical XOR function can't be implemented by using a single perceptron? [(CSEN3111.1) (Remember, Understand/LOCQ)]

3 + 3 + 3 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.6%	39.6%	20.8%

Course Outcome (CO):

After the completion of the course students will be able to

CSEN3111.1. Remember and understand the basic principles of state-space representation of any given problem, various searching and learning algorithms, game playing techniques, logic theorem proving etc.

CSEN3111.2. Comprehend the importance of knowledge as far as intelligence is concerned and the fundamentals of knowledge representation and inference techniques in both certain and uncertain environment.

CSEN3111.3. Apply this knowledge so that it can be used to infer new knowledge in both certain and uncertain environment

CSEN3111.4. Apply various AI searching algorithms, like state-space search algorithm, adversarial search algorithm, constraint satisfaction search algorithm as and when required.

CSEN3111.5. Understand the working knowledge of Prolog/ Lisp in order to write simple Prolog/ Lisp programs and explore more sophisticated Prolog/ Lisp code in their own.

CSEN3111.6. Design and evaluate the performance of a heuristic applied to a real-world situation.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission Link
CSE - A	https://classroom.google.com/c/NDAzNTEzOTcyNDc0/a/NDYzOTUwMDIyMTI5/details
CSE - B	https://classroom.google.com/c/NDA1MzEwMDUyMjcx/a/NDY0MzIzMzEzMTIz/details
CSE - C	https://classroom.google.com/c/NDAwODkxNDY5NTI4/a/NDY0MzU0ODM3MDA4/details