**SECTION A TOTAL 10 MARKS**

***Circle TRUE or FALSE for the following and state the reason for each of your answer. Each question carries 2 marks.***

1. Among goals of AI is to act humanly which is acting as typified by the Turing test.

**TRUE**

The Turing test is a test of a computer’s ability to exhibit intelligent behavior, equivalent to or indistinguishable from, that of an actual human.

1. Search and knowledge discovery are the most important concepts in artificial intelligence.

**FALSE**

Because it is actually search and knowledge **representation** that are the most important concepts in artificial intelligence.

1. In conjunction elimination, such as in the expression IsFemale(Sarah) ^IsaTeacher(Sarah), we can break the expression into two separate facts:

(i)IsFemale(Sarah) (ii)IsaTeacher(Sarah)

**TRUE**

In conjunction elimination, we can break the expression into two separate facts.

1. eats (Ahmad, \_ ). is a valid fact in PROLOG programming.

**TRUE**

Underscore can be used as variable in PROLOG.

1. In a data-driven search, the direction of reasoning to obtain the solution to a problem is done in a backward chaining manner.

**FALSE**

Data-driven search is done in a forward-chaining direction moving towards the goal.

**SECTION B TOTAL 10 MARKS**

***Short Explanation (theory) Questions:Answer each question in the space provided. Each question carries 2 marks.***

1. The use of fuzzy logic in home appliances is one example of AI application. Give an example of intelligent home appliances and what is the feature in this kind of home appliances that is associated with AI applications.

Example: Washing machine.

Features: Controlling the washing time and have sensors for input (level or quantity of clothes and water)

* *As far as student can give a logic operation that they understand it is intelligent*

1. What is the difference between refutation and unification in resolution?

Refutation : To resolve, add the negation of the this we want to prove to the fact fase

Unification: To resolve, just substitute the variable with suitable constant according to the facts.

1. **Describe two**(out of three) of the main categories in PROLOG programming and give an example for each of them.

Facts :Those are true statements that form the basis for the knowledge base. Ex.**likes (X, Y).**

Rules: Similar to functions in procedural programming (C++, Java…) and has the form of if/then.Ex. **likes (ali,aminah) :- beautiful(aminah), happy(aminah).**

Query : Questions that are passed to the interpreter to access the knowledge base and start the program.Ex. **?- likes (ali, X).**

1. If the forward chaining algorithm is applied to TSP (the travelling salesman problem) for a salesman who has to visit five cities, how do you determine the desired series of visits? Assume that he cannot visit a city more than once.

Since the direction of search is in a forward manner, the desired series of visits will be the path from the starting city (ex. A), then visiting other cities at least once and end by returning back to the city that it started from (i.e. A). Since cities cannot be revisited, the solution path should avoid and cannot include visits of a city which has already been visited i.e. avoid visiting the same city again.

1. What is the difference between a state space graph and a search tree?

A state space graph is a model representing the solution framework of the problem whereas a search tree represents the paths to be searched to find solution path(s) of the problem from the start state to any possible goal configurations, and also taking into account of dead ends.

**SECTION C TOTAL 80 MARKS**

***Structured Questions:Answer questions in the space provided. Use extra paper if necessary. Each question carries a total of 20 marks.***

1. (a) Propositional Logic has a number of limitations in representing knowledge. Give at least two of these. *(2 marks)*

* *No quantifiers are available (e.g for all, existential)*
* *Cannot analyze the internal structure of the sentence*

1. (b) Consider the knowledge base given as in **Figure 1** below. For this question, answer parts (i) – (vi). The marks for each part is stated at the end of the sub-question.

|  |
| --- |
| male(ahmed)  female(nadia)  father(ahmed, belal)  brother(ahmed, chalil)  owns(belal, car)  hates(ahmed, chalil) |
| ∃Y female(Y)  ∀X,∀Y,∀Z (male(X) ∧ male(Y) ∧ male(Z) ∧ father(Z, Y) ∧ father(Z, X))⇒ brother(X, Y) |

**Figure 1**

1. What are the predicates used in **Figure 1** above. *(2 marks)*

**male**

**female**

**father**

**brother**

**owns**

**hates**

1. What are the constants used in **Figure 1** above. *(2 marks)*

**ahmed**

**nadia**

**belal**

**chalil**

**car**

1. What are the quantifiers used in **Figure 1** above. *(1 mark)*

**∃**- existential quantifier

**∀**- universal quantifier

1. Referring to (iii), what does each quantifier stand for? *(1 mark)*

**∃**- existential quantifier**meaning to include several possibilities or at least one.**

**∀**- universal quantifier**meaning to include each and every one or all possibilities.**

1. List down **2 facts** used in **Figure 1** above.**(any two from below)** *(1 mark)*

**male(ahmed)**

**female(nadia)**

**father(ahmed, belal)**

**brother(ahmed, chalil)**

**owns(belal, car)**

**hates(ahmed, chalil)**

1. Give a rule which utilizes an implication connective in **Figure 1** above. *(1 mark)*

**∀X,∀Y,∀Z (male(X) ∧ male(Y) ∧ male(Z) ∧ father(Z, Y) ∧ father(Z, X)) ⇒ brother(X, Y)**

1. (c) Convert the English sentences in parts (i) – (v) into standard predicate logic sentences using the predicates indicated.

swimming\_pool, steamy, large, unpleasant, noisy, in\_class, swim, use\_internet

## All large swimming pools are noisy and steamy places. *(2 marks)*

**∀x (swimming\_pool(x) ∧large(x) → noisy(x) ∧ steamy(x)**

## All noisy and steamy places are unpleasant. *(2 marks)*

**∀x noisy(x) ∧ steamy(x) → unpleasant(x)**

## All noisy and steamy places except swimming pools are unpleasant. *(2 marks)*

**∀x noisy(x)x ∧ steamy (x) ∧ ¬ swimming\_pool (x) → unpleasant (x)**

## Somebody in this class enjoys swimming. *(2 marks)*

**∃xInClass(x) ∧ Swim(x)**

## Someone in this class has never used the Internet.  *(2 marks)*

**∃x InClass(x) ∧¬UseInternet(x)**

2. (a) Why is unification important in a resolution process?*(2 marks)*

*It is important because the substitutions made for variables in a clause with constants of another clause enable the two clauses to be resolved with each other to infer a new clause.*

2. (b) Identify whether the pair of PROLOG clauses given below can be unified or fails to do so. If unification is possible, give the unifier(s). Otherwise, say why it fails.

*(4 marks)*

|  |  |  |
| --- | --- | --- |
| Clause 1 | Clause 2 | Unifier |
| drinks(kadir, syrup)**.**  fav\_CD(45, maherzain, mama)**.**  take\_exam(X, AI)**.**  ancestor(X,Y)**.** | drinks(Who, What)**.**  fav\_CD(X, Y, forgiveme)**.**  take\_exam(sumayyah, subject)**.**  ancestor(bill, father(bill))**.** | **{ Who / kadir, What / syrup }**  **FAILS, X / 45, Y / maherzain, but forgiveme cannot substitute with mama**  **{ X / sumayyah , AI / subject }**  **{ X / bill, Y / father(bill) }** |

2. (c) Convert the following predicate logic formulas into clause form.

(i) ∀x (pass(x, exam) ∧ win(x, game)) → happy(x) *(1 mark)*

**¬pass(x, exam) ∨¬win(x, game) ∨ happy(x)**

(ii) ∀x∀y (study(x) ∨ lucky(x)) → pass(x, y) *(1 mark)*

**(¬study(x) ∧¬lucky(x)) ∨ pass(x, y)**

**Jadi: ¬(study(x) ∨ lucky(x)) ∨ pass(x, y)**

**ATAU: (¬study(x) ∧¬lucky(x)) ∨ pass(x, y)**

**Jadi (¬(study(x) ∨ pass(x, y)) ∧ (¬lucky(x) ∨ pass(x, y))**

**Pecah (eliminate conjunction/and) to get**

(ii) a. **¬(study(x) ∨ pass(x, y)**

(ii) b. **¬lucky(x) ∨ pass(x, y)**

(iii) ¬(study(Johan) ∧ lucky(Johan)) *(0.5 mark)*

**¬study(Johan) ∨¬lucky(Johan))**

(iv) ¬∃x ¬(¬likes(x, ice\_cream) → likes(x, carrot)) *(2 marks)*

**∀x ¬**¬ (¬likes(x, ice\_cream) → likes(x, carrot))

Drop ∀x, eliminate double negation and then expand

(¬likes(x, ice\_cream) → likes(x, carrot))

After expansion:

(¬¬likes(x, ice\_cream) ∨ likes(x, carrot))

Eliminate double negation again:

**likes(x, ice\_cream) ∨ likes(x, carrot)** *new answer*

(v) likes(Rina, ice\_cream) *(0.5 mark)*

**likes(Rina, ice\_cream)because it is already in clause form**

2. (d) Given the following simplified predicate logic sentences.

a.(boy(x) ∨ girl(x)) → child(x)

b.child(y) → (gets(y, doll) ∨ gets(y, train) ∨ gets(y, coal))

c.boy(w) →¬gets(w, doll)

d.(child(z) ∧ good(z)) →¬gets(z, coal)

e.boy(Jack)

Using the above five sentencesconstruct a proof by ***refutation resolution*** of the sentence

¬gets(Jack, train) →¬good(Jack) *(9 marks)*

*[NOTE: You may have to convert to clause form before resolution begins.]*

**To prove by *refutation resolution,* negate the conclusion, put as part of clause set. Resolve as usual to get a NIL clause. Boleh juga guna TREE method selain LINEAR method.**

[SOLUTION for Question 2(d).]

Sentences in clause form (the final set of clauses in bold):

1. ¬ (boy(x) ∨ girl(x)) ∨ child(x)

(¬boy(x) ∧¬girl(x)) ∨ child(x)

(¬boy(x) ∨ child(x))∧(¬girl(x) ∨ child(x))using distributivity rule of ∨ over ∧, we get:

1. (a) **(¬boy(x) ∨ child(x))** *0.5 markah*

1. (b) **(¬girl(x) ∨ child(x))**

1. **¬child(y) ∨ gets(y, doll) ∨ gets(y, train) ∨ gets(y, coal)** *0.5 markah*
2. **¬ boy(w) ∨¬gets(w,doll)** *0.5 markah*
3. ¬ (child(z) ∧ good(z)) ∨¬gets(z,coal)

**¬child(z) ∨¬good(z) ∨¬gets(z,coal)** *0.5 markah*

1. **boy(Jack)** *no marks already given*

6. **¬ (¬gets(Jack,train) →¬good(Jack)) negated conclusion** *must mention this!*

¬(gets(Jack,train) ∨¬good(Jack))

¬gets(Jack,train)∧good(Jack)

That is:

6. (a) **¬gets(Jack,train)** *0.5 markah*

6. (b) **good(Jack)**

Proof of resolution after refuting / negating the goal and include in the set of clauses.

Resolve 2 & 6a: {y/Jack} *1/8 markah*

7: **¬child(Jack) ∨ gets(Jack, doll) ∨ gets(Jack, coal)** *1 markah*

Resolve 7&4: { z /Jack} *1/8 markah*

8: **¬child(Jack) ∨ gets(Jack, doll) ∨¬good(Jack)** *1 markah*

Resolve 8&3: { w /Jack} *1/8 markah*

9: **¬child(Jack) ∨¬good(Jack)∨¬ boy(Jack)** *1 markah*

Resolve 9&1a: { x /Jack} *1/8 markah*

10: **¬good(Jack)∨¬ boy(Jack)** *1 markah*

Resolve 10&5:

11: **¬good(Jack)** *1 markah*

Resolve 11&6b:

12: **NIL** *1 markah*

3. Consider the following scenario about friends and their relations or properties.

Bob, Chong and Vijay are males. Aishah, Mariam, Jamilah and Anne are females. Chong and Vijay have dark hair. Bob, Mariam and Jamilah have blonde hair.On the other hand, Aishah and Anne have brown hair. Anne owns a house and Bob owns a car. Persons like Chong and Mariamare rich because theyowngold. Males like only females and vice-versa. Bob likes either rich or blonde-haired persons. Vijay likesonly rich persons. Chong likes persons with brown hair. Both Aishah and Mariam like dark-haired persons. At the same time Mariam likes rich persons too.

Based on the above relations:

1. Write a PROLOGprogram to exhibit its knowledge base which consists of both facts and rules. *(15 marks)*

/\* facts \*/

male(bob).

male(chong).

male(vijay).

female(aishah).

female(mariam).

female(jamilah).

female(anne).

owns(chong,gold).

owns(anne,car).

owns(bob,car).

owns(mariam,gold).

blonde(mariam).

blonde(jamilah).

blonde(bob).

brown(aishah).

brown(anne).

dark(chong).

dark(vijay).

/\* Rules: \*/

likes(bob,Person) :- female(Person), blonde(Person), rich(Person).

likes(chong,Person) :- female(Person), brown(Person).

likes(vijay,Person) :- female(Person),rich(Person).

likes(aishah,Person):-male(Person),dark(Person).

likes(mariam,Person):-male(Person), dark(Person).

rich(Person).

rich(Person):-owns(Person,gold).

1. Code queries in PROLOG to answer or validate the following questions. Provide a response by the compiler based on your code answered from 3(a). *(5 marks)*
2. Who is a male?

? - male(X).

1. Who does Bob like?

? - likes(bob,X).

1. Who likes Aishah?

? - likes(aishah,Y).

1. Does Mariam like anyone?

? - likes(mariam,Z).

1. Is there a couple (male and female) who likes each other?

? - likes(X,Y), likes(Y,X).

4. (a) What is backtracking? *(1 mark)*

*Backtracking is a technique for systematically trying all paths through a state space.*

4. (b) How is backtracking implemented in a search tree? *(3 marks)*

*Backtracking search begins at the start state and follows a path until it reaches either a goal or a “dead-end”. If it finds a goal, it quits and returns the solution path. If it reaches a dead end, it “backtracks” to the most recent node on the path having unexamined siblings and continues down one of these branches.*

4. (c) (i) Consider a search problem where the search tree is represented as in **Figure 2**:

















**Figure 2**

Each node has an alphabetic label. A is the initial state, whereas J and M are goal states. By applying the backtracking concept, draw arrows on the tree in **Figure 2**to show the movement of the searched paths (mark with bold arrows ) and backtracked paths (mark with broken arrows ) to reach the first goal either J or M. *(5 marks)*

4. (c) (ii) List the solution path generated by this search. *(1 mark)*

**A, B, E, J**

1. (d) Search may be executed in either of two directions: data-driven or goal-driven.

i. Explain how data-driven search is implemented. *(1 mark)*

*Data-driven search is implemented in a forward-chaining manner. Search will begin from the initial position and proceed to the next state(s) checking for any goal positions. If a goal is found the search will be terminated or else search fails.*

ii. Explain how goal-driven search is implemented. *(1 mark)*

*Goal-driven search is implemented in a backward-chaining manner. Search will begin from either one of the goal position(s) and backtracks to ancestor state(s) checking for any initial / start positions. If a start state is found the search will be terminated or else search fails.*

1. (e) You are given two jugs (one can hold 4 liters and the other 3 liters of water). Assume that you are given no external measuring device. You can fill up a jug from a pump any time you need, and you can pour water out of a jug or from one into the other. The problem is for you to begin from astart state [0, 0] i.e. both jugs are empty, and to get to a goal state[2, 0]i.e. the 4-liter jug has 2 liters of water and the 3-liter jug is empty. Show the transition made between states by a sequence of legal moves (apply the rules given below).

The list of rules that you may apply to show the possible in solving this problem:

R1: If the 4-liter jug is empty, fill up the 4-liter jug until the 4-liter jug is full.

R2: If the 3-liter jug is empty, fill up the 3-liter jug until the 3-liter jug is full.

R3: Pour out water from the 4-liter jug until the 4-liter jug is empty.

R4: Pour out water from the 3-liter jug until the 3-liter jug is empty.

R5: Pour water from the 4-liter jug into the 3-liter jug until the 3-liter jug is full.

R6: Pour water from the 3-liter jug into the 4-liter jug until the 4-liter jug is full.

R7: Pour water from the 4-liter jug into the 3-liter jug until the 4-liter jug is empty.

R8: Pour water from the 3-liter jug into the 4-liter jug until the 3-liter jug is empty.

In this configuration [L, R], L represents the status of the 4-liter jug and R represents the status of the 3-liter jug.Draw the fullsearch treelisting all possible moves to get from the start state [0, 0] until a goal configuration [2, 0] is found. Avoid cycles (dead ends) by not generating children of states already explored. *(8 marks)*

[SOLUTION for Question 4(e).]

