CS_345
Artificial Intelligence Applications

(Attempt 2 questions out of 3)

1   a) Outline the main features of Genetic Programming (GP) and Genetic Algorithms (GA), distinguishing clearly between the two methods. You should indicate the various parameters on which the two methods depend.   **[6 marks]**

The values of a function `f(x)` are given at all intervals of 0.1 in the range 0 to 10. It is required to use the method of Genetic Algorithms to obtain a cubic fit function `g(x) = ax³ + bx² + cx + d`, where the co-efficients are 16-bit natural numbers. Indicate a suitable coding of the problem for solution using GAs and also provide two possible fitness functions which could be employed.   **[4 marks]**

Show how GP can be used to solve the same problem but produce a general polynomial with real co-efficients as a solution. You should give a basic set of functions and terminals.   **[4 marks]**

b) Default logic is an example of a non-montonic logic, what does this mean? Illustrate your answer using the following example:

    Default rule: $\forall$X(republican(X) -> hawk(X))
    Specialised rule: $\forall$X(republican(X)$\wedge$ quaker(X) -> not hawk(X))

    We are initially told `republican(nixon)` then later `quaker(nixon)`.

     [4 marks]

c) The following set of rules are part of an expert system for selecting houses for consideration for possible purchase. Show, by constructing a full and/or tree, how a backward chaining inference engine would solve the goal `consider(H)`. You should indicate when the user would be asked to provide answers and when answers can be obtained from the working memory. (Assume there is only one instantiation for any of the variables.)

Rules:

```
1. IF house(H) AND house_in(H,A) AND good_area(A)
THEN consider(H)

2. IF house(H) AND in_catchment(H,S) AND
good_school(S)
THEN consider(H)

3. IF high_in_league_tables(S) AND teach_science(S)
THEN good_school(S)

4. IF high_in_league_tables(S) AND has_six_form(S)
THEN good_school(S)
```

```
5. IF in_country(A) AND
(has_public_swimming_pool(A) OR has_park(A))
THEN  good_area(A)

6. IF in_country(A) AND on_bus_route_to(A,C)
AND big_city(C)
THEN  good_area(A)
```

[7 marks]

2   a) Explain how a knowledge engineer might assign certainty factors (CFs) to rules and facts. How is inexact reasoning in MYCIN performed using CFs (the main formulas used in the calculation of CFs should be presented)?   **[5 marks]**

b) A set of rules from a knowledge base, with associated certainty factors, is given below:

```
IF jill beats jane in the race
   OR joe is not at the restaurant
THEN jane is unhappy                              0.7


IF robbie doesn't have a number one hit
THEN jane is unhappy                              0.9


IF joe has no money
   AND bill is not at the restaurant
THEN joe is not at the restaurant                 0.8


IF john is at the restaurant
THEN joe is not at the restaurant                 0.6


IF jill is good runner
THEN jill beats jane in the race                  0.9
```

The certainty factors for facts are given as:
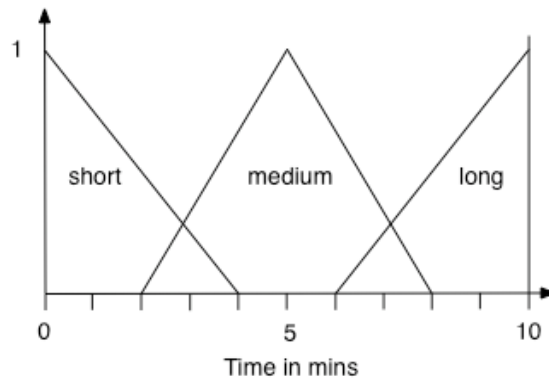
```
CF(jill is good runner) =                    1.0
CF(bill is not at the restaurant) =          0.7
CF(robbie doesn't have a number one hit) = 0.5
CF(joe has no money) =                       0.6
CF(john is at the restaurant) =              0.8
```

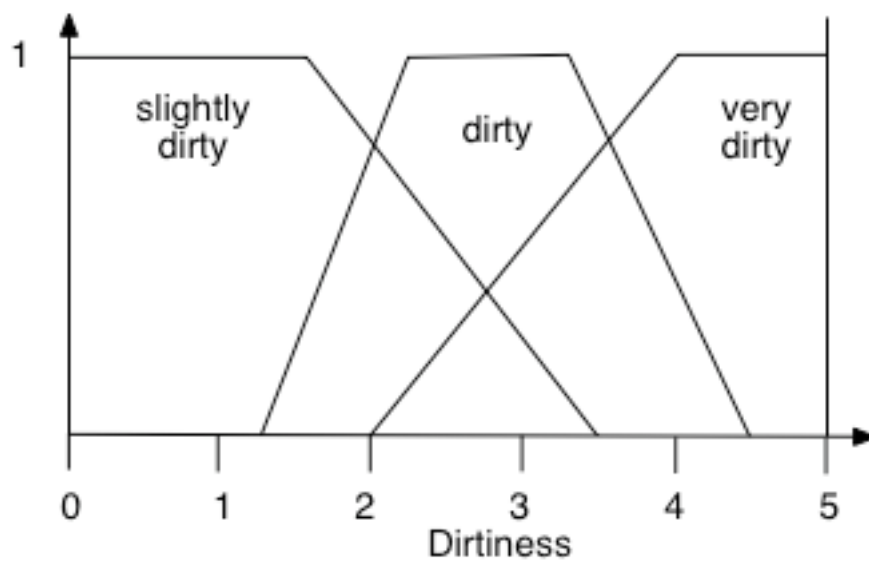Calculate the CF of the fact `jane is unhappy`. Indicate all your reasoning.

[6 marks]

c) Explain in detail how inference is performed in a fuzzy controller based on a set of fuzzy rules. What is the advantage of using fuzzy sets with straight line segment graphs in the fuzzy controller?   **[6 marks]**
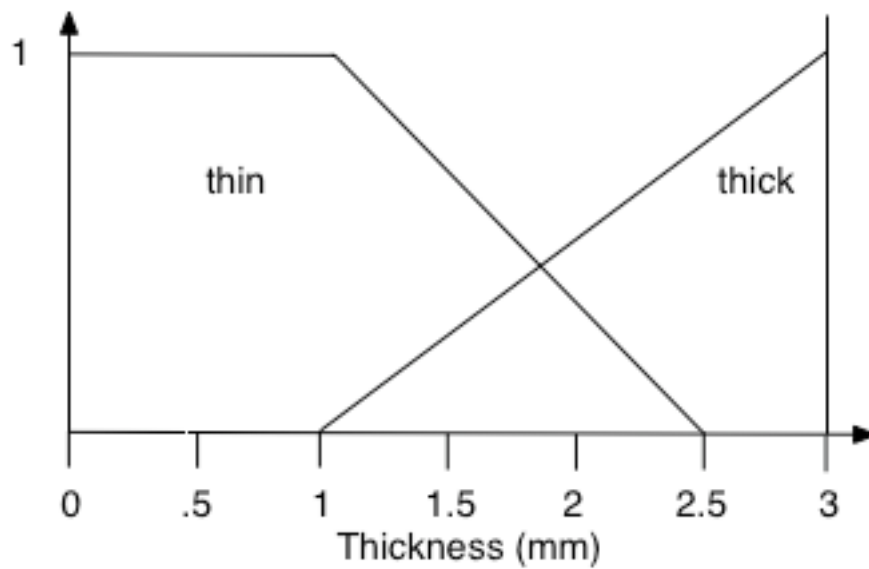
A fuzzy controller in a washer for drinking glasses depends on the thickness of the glasses and the their dirtiness. The length of time of the wash, measured in minutes, is described by the fuzzy values `short`, `medium` and `long` and indicated in the figure below.

Time in mins

The dirtiness of the glasses is described as `slightly dirty`, `dirty` and `very dirty` and measured on a scale 0 to 5, with graphs given below:

Dirtiness

The thickness is described as `thin` or `thick` with graphs:

Thickness (mm)

The rules for the controller are:

```
IF glass thin AND (slightly dirty OR dirty)
THEN time is short
IF glass thin AND very dirty
THEN time is medium
IF glass thick AND slightly dirty
THEN time is medium
IF glass thick AND (dirty OR very dirty)
THEN time is long
```

If the glasses are 2mm thick and have a dirtiness value of 3, determine the running time of the washer. Indicate all your working with appropriate diagrams.   [**8 marks**]

3   a) An airline MLK, provides a frequent flyer card service. There are four levels of cards: blue plus; silver elite; gold elite and platinum elite, which offer increasing levels of benefit. A MLK passenger accumulates, in each year, level miles points and the number of one way flights. An upgrade to a level is dependent on the value of these two numbers. The rules are as follows:

A blue plus card holder with at least 25,000 level miles or at least 20 one way flights can upgrade to silver elite.

A silver elite card holder with at least 50,000 level miles or at least 40 one way flights can upgrade to gold elite.

A gold elite card holder with at least 75,000 level miles or at least 60 one way flights can upgrade to platinum elite.

Indicate suitable CLIPS representations to record information of the form:
the card status of a passenger;

the number of level miles the passenger has accumulated;
the number of one way flights the passenger has made;
the number of miles the passenger has just flown in the current flight and whether it was club or economy (this is not yet included in the level miles).   [**2 marks**]

Write a `deffacts` which will assert the following information: bill is a blue plus card holder; he has 53,000 level miles, 21 one-way flights and has just flown 7,400 miles in club class on 1 one way flight.   [**3 marks**]

Using your representation, write `defrules` in CLIPS to implement the rules for upgrading card levels.   [**4 marks**]

The number of air miles points allocated to card holders for a particular flight are determined as follows:

A bonus is first added based on the original mileage — for silver elite 50% extra; gold elite 100% extra and platinum elite 125% extra. If the passenger is travelling club, then additional miles are added equivalent to the original mileage.

Write a CLIPS function (using `switch`) to calculate the allocated miles for a given flight. Give a rule which will update the level miles using this function and increment the

number of one way flights. Attach a salience to the rule to ensure that any card upgrades which might be necessary are performed *before* the new allocation of miles is calculated (though there might be further upgrades performed after this calculation).   [**5 marks**]

Show the change in the facts agenda (working memory) when your rules are run with the given `deffacts` (after a `reset`).   [**3 marks**]

b) Describe the basis of Ant Colony Optimisation (ACO) algorithms. Outline how this technique may be used to solve the symmetric Travelling Salesman Problem. In an evaluative study, how did the ACO algorithm compare with other nature inspired algorithms for solving the TSP?   [**8 marks**]