Q1) Suppose that you have the following natural language sentences:

- I feel that you can solve these questions.
- You must think before answering question.

1. Built a suitable Context Free Grammar (CFG) and Case Grammar for the above sentences.  
   *(3 marks)*

2. Write a prolog program to achieve the syntax and semantic (thematic) analysis for the given sentences by using the grammars that you built in step 1.  
   *(7 marks)*

Q2) Design an expert system to classify computers (three types only) by using backward chaining according to the following properties: (processor speed, memory capacity, mother board type, and video card quality).
   *(10 marks)*

Q3) Consider the inference network below and then give the results of the following items:

1. Find the certainty factor for the node C4 (the implication value of each node is equal to 0.5).  
   *(6 marks)*

2. Show the contents of WHY stack when the system asks the user about the certainty value of node e2.  
   *(2 marks)*

3. Describe the HOW explanation mechanism when the user asks H C2. What is the system response?  
   *(2 marks)*
Q4) What is the main goal of use the following adaptive parameters? (Choose five only)

(Fitness function, Reproduction, Momentum Term, Bias, Mutation, Activation Function, genetic Programming).

(10 marks, 2 marks for each)

Q5) Choose one branch to solve:

A) A BAM artificial neural network is trained using the following input and output patterns:

A1 = (1 1 0 0), B1 = (0 0 1)
A2 = (1 0 1 0), B2 = (0 1 1)
A3 = (1 0 0 1), B3 = (0 1 0)

then,

1. Build the weight matrix. (4 marks)

2. Apply an input vector A3 = (1 0 0 1) to test the net to remember A3 (In one iteration only). (6 marks)

B) Consider the following samples that are stored in a Hopfield artificial neural network:

(1 1 0 0), (1 0 1 0), (1 0 0 1), then,

1. Calculate the thresholds for all units of the input pattern. (5 marks)

2. Build the weight matrix. (5 marks)

Q6) In two iterations only, by using genetic algorithm approach and operators (crossover, mutation, and reproduction), try to solve the 8-puzzle problem with any initial population that you suggest.

(10 marks)
The Solution of the Questions

Q1) Solution

1. Context Free Grammar

\[ S \rightarrow Np, Vp, Pp \]
\[ Np \rightarrow \text{Pro-noun} / Np, Vp, Np/\text{det} \text{noun} / \text{noun}, \text{noun}. \]
\[ Vp \rightarrow \text{verb} / \text{helping verb} \]
\[ Pp \rightarrow \text{preposition}, \text{Np} \]

2. Case Grammar

Sentence 1

agent case
verb case
object case

Sentence 2

agent case
verb case
time case

2.

run:- readln(S), str_to_list(S, L), parse(L), case(L, L0).
parse(L):- append(A1, A2, A3, L),
           np(A1),
           vp(A2),
           pp(A3).

np(X):- append(Y1, Y2, _, X),
       det(Y1),
       noun(Y2).
np(X):- append(Y1, Y2, _, X),
       noun(Y1),
       noun(Y2).
np(X):- append(Y1, Y2, Y3, X),
       np(Y1),
       vp(Y2),
       pp(Y3).
np(X):- pro_noun(X).

vp(Z):- append(Y1, Y2, _, X),
       h.verb(Y1),
       verb(Y2).
vp(Z):- verb(Z).
pp(M):- append(W1, W2, _, M),
        preposition(W1),
        np(W2).

/* set of Facts */
det([“these”]).
pro_noun([“I”]).       pro_noun([“you”]).
noun([“questions”]).   noun([“question”]).   noun([“answering”]).
verb([“solve”]).       verb([“think”]).       verb([“feel”]).
h.verb([“can”]).       h.verb([“must”]).
preposition([“that”]).  preposition([“before”]).

\[ \text{case}(S,S0): - \text{agent}(S,S1), \text{backparta}(S1, S0). \]
\[ \text{backparta}(S,S0): - \text{verb}(S,S1), \text{object}(S1,S0). \]

\[ \text{case}(S,S0): - \text{agent}(S,S1), \text{backpartb}(S1, S0). \]
\[ \text{backpartb}(S,S0): - \text{verb}(S,S1), \text{time}(S1,S0). \]

**Q2) Solution**

database
db_confirm(symbol, symbol)
db_denied(symbol, symbol)

clauses
guess_computer :- identify(X), write(“Your computer is a(n) ”,X),!.

\[ \text{identify(type1)}: - \]
\[ \text{it_is}(\text{video card quality}), \]
\[ \text{not} (\text{confirm(has, old mother board)}), \]
\[ \text{confirm(has, big RAM capacity)}, \]
\[ \text{it_is}(\text{processor version}),! . \]

\[ \text{identify(type2)}: - \]
\[ \text{it_is}(\text{processor version}), \]
\[ \text{confirm(has, normal RAM capacity)}, \]
\[ \text{confirm(has, normal RAM capacity)}, \]
confirm(has, a compatible mother board),

it_is(video card quality)!.  

identify(type3) :-

   it_is(video card quality),
   it_is(processor version),
   confirm(has, small RAM capacity),
   confirm(has, old mother board),!.

it_is(video card quality):-

   confirm(has, high video card quality),!.

it_is(video card quality):-

   confirm(has, normal video card quality),!.

it_is(processor version):-

   confirm(has, new version processor),!.

it_is(processor version):-

   confirm(has, modern version processor),!.

confirm(X,Y):- db_confirm(X,Y),!.
confirm(X,Y):- not(denied(X,Y)),!, check(X,Y).

denied(X,Y):- db-denied(X,Y),!.

Check(X,Y):- write(X, " it ", Y, "n"), readln(Reply), remember(X, Y, Reply).

remember(X, Y, yes):- asserta(db_confirm(X, Y)).
remember(X, y, no):- asserta(db_denied(X, Y)), fail.
Q3) Solution

1-
\[ C_t(C_1) = 0.2 \times 0.5 \]
\[ = 0.1 \]
\[ C_t(C_2) = -0.2 \times 0.5 \]
\[ = -0.15 \]
\[ C_t(C_1) = (0.1 - 0.15) / (1 - 0.1) \]
\[ = -0.05 \]
\[ C_t(C_2) = -0.3 \times 0.5 \]
\[ = -0.15 \]
\[ C_t(C_3) = 0.8 \times 0.5 \]
\[ = 0.4 \]
\[ C_t(C_4) = -0.05 \times 0.5 \]
\[ = -0.025 \]
\[ C_t(C_4) = -0.4 \times 0.5 \]
\[ = -0.2 \]
\[ C_t(C_1) = (-0.025 - 0.2) + (-0.025 \times -0.2) \]
\[ = -0.22 \]

2-
The contents of why stack about \( W e_2 \)

\[ \text{db_imp(imp(a, r, C_1, pos, e_1, pos, e_2, o.5))} \]
\[ \text{db_imp(imp(o, r, C_4, neg, C_1, neg, C_2, o.5))} \]

3-
The system response of How facility about \( H C_2 \)

How describer of the system
S: type h(how) node name, or c to continue
U: h \( C_2 \)

S: Concluded \( C_2 \) with certainty of -0.15 from \( e_3 \) and \( e_4 \rightarrow C_2 \)
the rule is reversible
certainty of \( e_3 \) is -0.3
certainty of \( e_4 \) is 0.7
certainty of the implication is 0.5
Q4) Solution

1. Fitness Function
A function that can give a decision to choose the best individuals in the next population through the genetic algorithm learning.

2. Reproduction
To add new genetic information to the population of the chromosomes by combining strong parents with strong children, the hope is to obtain new more fit children.

3. Momentum Term
To increase the learning rate without leading to oscillations is to modify the GDR (Generalized Delta Rule) to include momentum term.

4. Bias
It is a constant value that is added to the input of the neural network so to enhance the learning process.

5. Mutation
A way to introduce new information is by changing the content of some genes. Mutation can be applied to:

1- Chromosomes selected from the MP.
2- Chromosomes that have already subject to crossover.

6. Activation Function
A function that used in neural network to give the final output of each neuron, it is two types Linear functions and non-Linear functions according to the application.

7. Genetic Programming
It is one of the central goals of computer science namely automatic programming. The goal of automatic programming is to create, in an automated way, a computer program that enables a computer to solve a problem.

Q5) Solution

A) BAM ANN

1. \((A_i) Vectors\ Transpose \times (B_i) = \text{Weight\ Matrix\ (W)}\)

\[
\begin{pmatrix}
1 & 1 & 1 \\
1 & -1 & -1 \\
-1 & -1 & 1
\end{pmatrix}
\times
\begin{pmatrix}
-1 & -1 & 1 \\
1 & 1 & -1 \\
1 & -1 & 1
\end{pmatrix}
= \begin{pmatrix}
-3 & 1 & 1 \\
1 & -3 & 1 \\
1 & 1 & 1
\end{pmatrix}
\]
2-
Forward Phase
\[ A_3 \ast W = \begin{pmatrix} -3 & 1 & 1 \\ 1 & -1 & -1 \\ 1 & 1 & 1 \end{pmatrix} \ast \begin{pmatrix} 1 & -3 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & -3 \end{pmatrix} = (\begin{pmatrix} -4 & 4 & -4 \end{pmatrix}) = B_3(0 \ 1 \ 0) \]

Backward Phase
\[ B_3 \ast W^T = \begin{pmatrix} -3 & 1 & 1 & 1 \\ -1 & 1 & -1 \end{pmatrix} \ast \begin{pmatrix} 1 & -3 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} = (\begin{pmatrix} 3 & -5 & -1 & 3 \end{pmatrix}) = A_3(1 \ 0 \ 0 \ 1) \]

The BAM ANN able to remember each vector in each pair.

B) The Hopfield ANN
1- The Thresholds for all units of input pattern

The vectors
\[(1 \ 1 \ -1 \ -1) \ (1 \ -1 \ 1 \ -1) \ (1 \ -1 \ -1 \ 1)\]

The matrix
\[1 \ 1 \ -1 \ -1 \]
\[1 \ -1 \ 1 \ -1 \]
\[1 \ -1 \ -1 \ 1 \]

The transpose of matrix
\[1 \ 1 \ 1 \ 1 \]
\[1 \ -1 \ -1 \ * \ 1 \ = \ -1 \ = \ \ W_0 \]
\[-1 \ 1 \ -1 \ 1 \]
\[-1 \ -1 \ 1 \ -1 \]

\[-3 \ (T_1) \]
\[T_1 = -W_0 = \]
\[1 \ (T_2) \]
\[1 \ (T_3) \]
\[1 \ (T_4) \]

2- The weight matrix
The vectors
\[(1 \ 1 \ -1 \ -1) \ (1 \ -1 \ 1 \ -1) \ (1 \ -1 \ -1 \ 1)\]

After applying the Heb rule, the weight matrix is
\[0 \ -1 \ -1 \ -1 \]
\[-1 \ 0 \ -1 \ -1 \]
\[-1 \ -1 \ 0 \ -1 \]
\[-1 \ -1 \ -1 \ 0 \]
Q6) Solution
Suppose the following initial population of 80Puzzle problem

**Initial Population**

\[ \begin{align*}
X_1 &= [2 \ 3 \ 1 \ 0 \ 4 \ 6 \ 5 \ 7 \ 8] & X_2 &= [4 \ 3 \ 2 \ 1 \ 0 \ 5 \ 6 \ 7 \ 8] \\
X_3 &= [0 \ 8 \ 7 \ 6 \ 4 \ 3 \ 2 \ 1 \ 5] & X_4 &= [8 \ 7 \ 6 \ 5 \ 3 \ 4 \ 1 \ 0 \ 2] \\
\end{align*} \]

**The Target Goal**

\[ [1 \ 2 \ 3 \ 4 \ 0 \ 5 \ 6 \ 7 \ 8] \]

The initial population with fitness value for each chromosome (number of tiles in place according to the target goal chromosome)

By using ordered crossover let \( K_1 = 3 \) and \( K_2 = 6 \)

\[ \begin{align*}
[2 \ 3 \ 1 \ 0 \ 4 \ 6 \ 5 \ 7 \ 8] & \quad \text{....2} \\
[4 \ 3 \ 2 \ 1 \ 0 \ 5 \ 6 \ 7 \ 8] & \quad \text{....4} \\
[0 \ 8 \ 7 \ 6 \ 4 \ 3 \ 2 \ 1 \ 5] & \quad \text{....0} \\
[8 \ 7 \ 6 \ 5 \ 3 \ 4 \ 1 \ 0 \ 2] & \quad \text{....0} \\
\end{align*} \]

Now we apply crossover operator between chromosomes 1 & 2 and chromosomes 3 & 4

\[
\begin{align*}
&2 \ 3 \ 1 \ 0 \ 4 \ 6 \ 5 \ 7 \ 8 \\
&4 \ 3 \ 2 \ 1 \ 0 \ 5 \ 6 \ 7 \ 8 \\
\end{align*}
\]

Forms new two chromosomes

\[
\begin{align*}
&3 \ 4 \ 6 \ 1 \ 0 \ 5 \ 7 \ 8 \ 2 \\
&2 \ 1 \ 5 \ 0 \ 4 \ 6 \ 7 \ 8 \ 3 \\
\end{align*}
\]

\[
\begin{align*}
&0 \ 8 \ 7 \ 6 \ 4 \ 3 \ 2 \ 1 \ 5 \\
&8 \ 7 \ 6 \ 5 \ 3 \ 4 \ 1 \ 0 \ 2 \\
\end{align*}
\]

Forms new two chromosomes

\[
\begin{align*}
&8 \ 7 \ 6 \ 5 \ 3 \ 4 \ 2 \ 1 \ 0 \\
&8 \ 7 \ 5 \ 6 \ 4 \ 3 \ 1 \ 0 \ 2 \\
\end{align*}
\]

The new population is

\[
\begin{align*}
[3 \ 4 \ 6 \ 1 \ 0 \ 5 \ 7 \ 8 \ 2] & \quad \text{....2} \\
[2 \ 1 \ 5 \ 0 \ 4 \ 6 \ 7 \ 8 \ 3] & \quad \text{....0} \\
[8 \ 7 \ 6 \ 5 \ 3 \ 4 \ 2 \ 1 \ 0] & \quad \text{....0} \\
[8 \ 7 \ 5 \ 6 \ 4 \ 3 \ 1 \ 0 \ 2] & \quad \text{....0} \\
\end{align*}
\]
Now we do mutation in the 4th chromosome by swapping the 1st gen with 7th gen

\[
\begin{array}{ccccccccc}
3 & 4 & 6 & 1 & 0 & 5 & 7 & 8 & 2 \\
2 & 1 & 5 & 0 & 4 & 6 & 7 & 8 & 3 \\
8 & 7 & 6 & 5 & 3 & 4 & 2 & 1 & 0 \\
1 & 7 & 5 & 6 & 4 & 3 & 8 & 0 & 2
\end{array}
\]  

…..2 

Now we apply the reproduction operator between initial population and new population to choose the best chromosomes.

After reproduction we obtain the following chromosomes

\[
\begin{array}{ccccccccc}
4 & 3 & 2 & 1 & 0 & 5 & 6 & 7 & 8 \\
2 & 3 & 1 & 0 & 4 & 6 & 5 & 7 & 8 \\
3 & 4 & 6 & 1 & 0 & 5 & 7 & 8 & 2 \\
1 & 7 & 5 & 6 & 4 & 3 & 8 & 0 & 2
\end{array}
\]  

…..4 

…..2 

…..2 

…..1 

Now we apply crossover operator again between chromosomes 1 & 2 and chromosomes 3 & 4

\[
\begin{array}{ccccccccc}
4 & 3 & 2 & 1 & 0 & 5 & 6 & 7 & 8 \\
2 & 3 & 1 & 0 & 4 & 6 & 5 & 7 & 8
\end{array}
\]

Forms new two chromosomes

\[
\begin{array}{ccccccccc}
2 & 1 & 5 & 0 & 4 & 6 & 7 & 8 & 3 \\
3 & 4 & 6 & 1 & 0 & 5 & 7 & 8 & 2
\end{array}
\]

\[
\begin{array}{ccccccccc}
3 & 4 & 6 & 1 & 0 & 5 & 7 & 8 & 2 \\
1 & 7 & 5 & 6 & 4 & 3 & 8 & 0 & 2
\end{array}
\]

Forms new two chromosomes

\[
\begin{array}{ccccccccc}
1 & 0 & 5 & 6 & 4 & 3 & 7 & 8 & 2 \\
6 & 4 & 3 & 1 & 0 & 5 & 8 & 2 & 7
\end{array}
\]

The new population is

\[
\begin{array}{ccccccccc}
2 & 1 & 5 & 0 & 4 & 6 & 7 & 8 & 3 \\
3 & 4 & 6 & 1 & 0 & 5 & 7 & 8 & 2 \\
1 & 0 & 5 & 6 & 4 & 3 & 7 & 8 & 2 \\
6 & 4 & 3 & 1 & 0 & 5 & 8 & 2 & 7
\end{array}
\]  

…..0 

…..2 

…..1 

…..3 

We obtain new chromosome with better fitness value (3) which is not found before, and the process is continue until we obtain a chromosome with (9) fitness value.