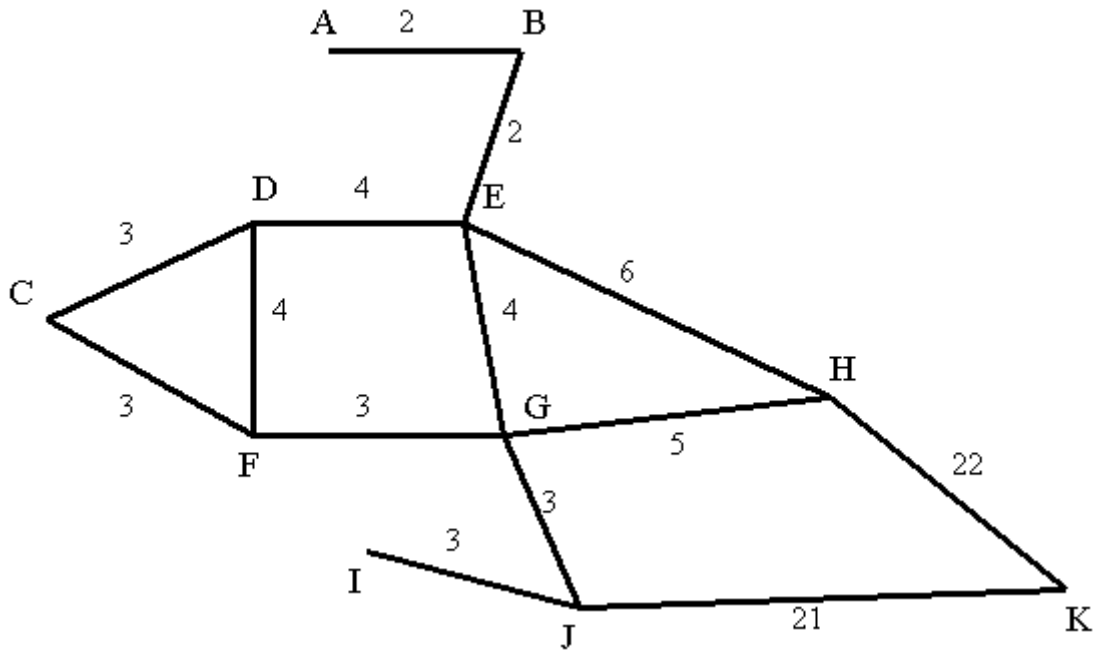
Question 1 Search (8+6+6+5 = 25 marks)

Consider the map below (not drawn to scale) with distance between cities shown on the arcs:



Straightline heuristic values for the distance from each city to city **A** are given in the following table:

h(A) = 0	h(B) = 2	h(E) = 3	h(D) = 3	h(C) = 5	h(F) = 6
h(G) = 7	h(H) = 8	h(I) = 8	h(J) = 9	h(K) = 29	

(a) Using the straightline distance heuristic, show the operation of the A* search algorithm in finding the shortest path from city **C** to city **A**. You should construct a heuristic search tree with the nodes annotated on the side, showing the following:

1. the order of expansion of the nodes (e.g., a circled number 3 marked beside a node indicates the node is the 3rd to be expanded). **(8 marks)**

2. at each step of the expansion, the nodes in the OPEN and CLOSED lists, until a solution is found. **(6 marks)**

3. the evaluation function *f*-value of each node in the search graph. **(6 marks)**

(b) Would you expect the A* search using the straightline distance heuristic to be better than a Breadth-First Search (BFS)? Explain why briefly. **(5 marks)**

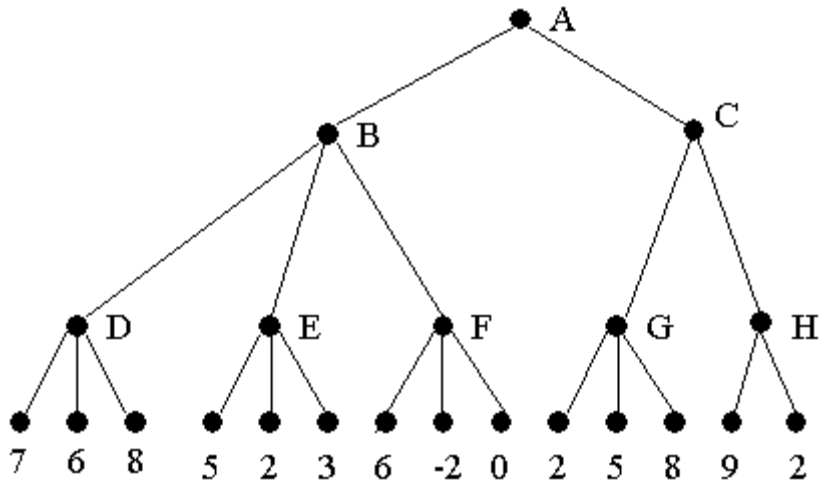
Question 2 Search and game playing (3+3+4+5 = 15 marks)

(a) Define the concept of "admissibility" of a heuristic. Describe how admissibility relates to the A* algorithm. **(3 marks)**.

(b) Describe a search space in which Iterative Deepening Search (ITS) performs much worse than Depth-First Search (DFS). **(3 marks)**

(c) Assuming MAX is about to move in the game tree below, which move will be chosen if minimax search is used? **(4 marks)**

(d) Redraw the game tree below showing ONLY the nodes expanded by an alpha-beta search and showing clearly the ORDER of evaluation of the nodes. **(5 marks)**



Question 3 Logic (3+5+3+4 = 15 marks)

(a) Using truth tables, show that $P \Rightarrow Q$ is logically equivalent to $\neg P \vee Q$. **(3 marks)**

(b) Consider the following story:

"All people that are not poor and are smart are happy. Those people that read are smart. John is wealthy. Helen can read and is wealthy. Happy people have exciting lives. Wealthy people are not poor."

1. Translate the story into first order logic expressions. **(5 marks)**

2. Determine who has an exciting life using rules of inference in first order logic. **(3 marks)**

3. Show the solution process with the AND/OR graph. **(4 marks)**

Question 4 Planning (6+3 +4 +2 = 15 marks)

A kitchen cleaning robot plans how to clean a kitchen. There is a fridge in the kitchen. The kitchen is considered cleaned if the fridge and the floor are all cleaned, and the kitchen has no garbage. The robot is smart enough that it only cleans or washes things when they are dirty, and only takes out garbage when there is garbage. The constraints for cleaning the kitchen are as follows:

- Cleaning the fridge will get the floor dirty.
- Cleaning the fridge generates garbage.
- Before the floor can be wasted, it must be swept.
- Before the floor can be swept, the garbage must be taken out.

There are 4 actions that the kitchen cleaning robot can take:

- *clean(fridge)*
- *wash(floor)*
- *sweep(floor)*
- *takeout(garbage)*

The vocabulary of predicates you should use is:

- *clean(X)* – where X is cleaned. X can be either fridge or floor.
- *dirty(X)* – where X is dirty. X can be either fridge or floor.
- *swept(floor)* – where floor has been swept.
- *hasGarbage(kitchen)* – indicates whether the kitchen has garbage.

The corresponding STRIPS definition of the *wash(floor)* action is:

	P: *dirty(floor)* $\wedge$ *swept(floor)*
wash(floor)	A: *cleaned(floor)*
	D: *dirty(floor)* $\wedge$ *swept(floor)*

(a) Write the STRIPS operators for the other three actions, **using only the predicates given above**. **(6 marks)**
(b) The goal for the robot is to clean the kitchen, and the initial state of the kitchen is: the fridge is dirty, the floor is cleaned, and there is no garbage in the kitchen. Using only the predicates given above, write down descriptions of the initial state and the goal state. **(3 marks)**
(c) Show how a plan can be generated to solve the problem described in (b). **(4 marks)**
(d) Given your plan, in what order will the actions be executed by the robot? **(2 marks)**

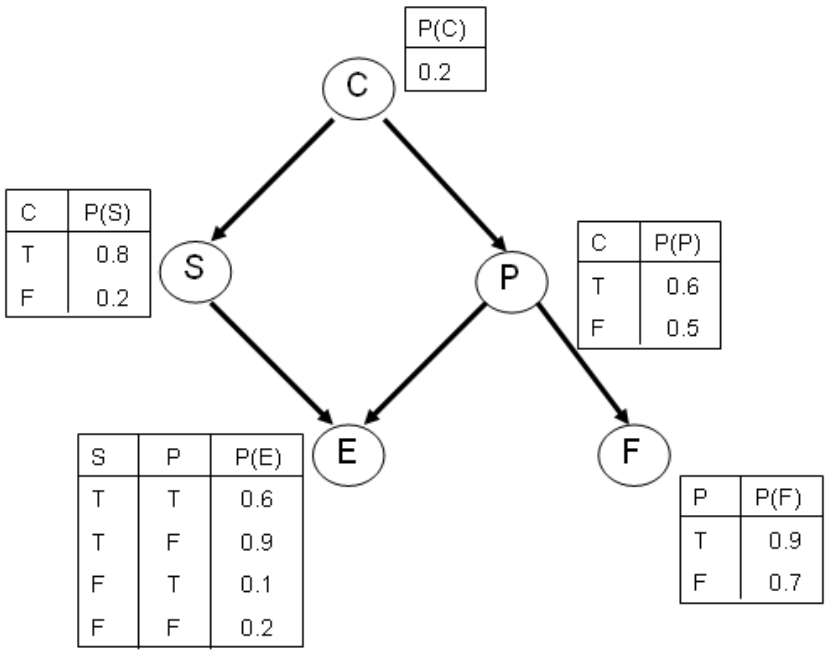
Question 5 Probability and Bayesian Networks (5+5+6+6 = 22 marks)

(a) David is a professional poker player. At the moment, he wants very much to draw two diamonds in a row. As he sits at the table looking at his hand and at the upturned cards on the table, David sees 11 cards. Of these, 4 are diamonds. The full deck contains 13 diamonds among its 52 cards, so 9 of the 41 unseen cards are diamonds. Because the deck was carefully shuffled, each card that David draws is equally likely to be any of the cards that he has not seen. What is David's probability of drawing two diamonds? **(5 marks)**

(b) A laboratory blood test is 99% effective in detecting a certain disease when it is, in fact, present. However, the test also yields a "false positive" result for 1% of the healthy persons tested (that is, if a healthy person is tested, then, with probability 0.01, the test result will imply he has the disease). If 0.5% of the population actually has the disease, what is the probability a person has the disease given that his test result is positive? **(5 marks)**

(c) The following figure shows a simple Bayesian Network, with each node representing the following statements:

C = that you will go to college
S = that you will study
P = that you will party
E = that you will be successful in your exams
F = that you will have fun



Given the CPT for each node, complete the following:

(d) Calculate the probability that you will go to college and that you will study and be successful in your exams, but will not party or have fun. **(6 marks)**

(e) What is the probability that you will have success in your exams if you have fun and study at college, but don't party? **(6 marks)**

Question 6 Genetic algorithms (4+4 = 8 marks)

(a) Write the pseudo-code for a standard genetic algorithm. **(4 marks)**
(b) Identify and briefly discuss at least three similarities and differences between genetic algorithms and genetic programming. **(4 marks)**

End of exam paper