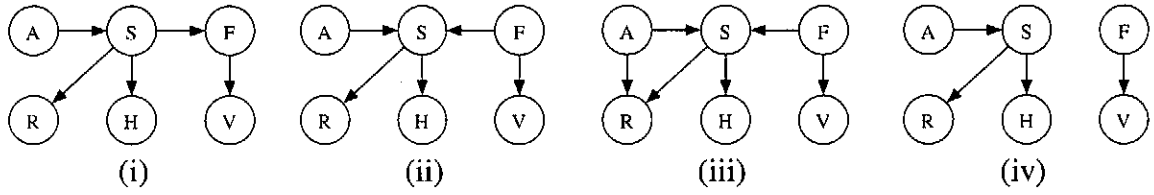
C1 Artificial Intelligence (25 points)

Uncertainty. (13 points) Assume there are two types of conditions: (S)inus congestion and (F)lu. Sinus congestion is is caused by (A)llergy or the flu. There are three observed symptoms for these conditions: (H)eadache, (R)unny nose, and fe(V)er. Runny nose and headaches are directly caused by sinus congestion (only), while fever comes from having the flu (only). For example, allergies only cause runny noses indirectly. Assume each variable is boolean.

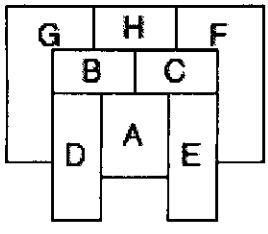


(i) (ii) (iii) (iv)

(a) (8 points) For each network, if it models the domain exactly as above, write *"correct."* If it has too many conditional or unconditional independence properties, write *"extra independence,"* and state one that it has but should not have (that is, *"X should not be independent of Y given Z"*, or *"X should not be independent of Y"*. If it has too few conditional or unconditional independence properties, write "missing independence," and state one that it should have but does not have (that is, *"X should be independent of Y;* or *X should be independent of Y given Z"*).

(b) (5 points) Assume we wanted to remove the Sinus congestion (S) node. Draw the minimal Bayes Net over the remaining variables which can encode the original model's marginal distribution over the remaining variables.

Search. (12 points)



You are asked to provide a 3-coloring of the map above. Suppose your first attempt starts by coloring region B with color 1.

a. (4 points) Use forward checking to determine the values remaining in the domains of the other regions.
b. (3 points) Using the minimum remaining values (MRV) and degree heuristics, which node would you select next?
c. (5 points) Suppose regions A, B, and C are given colors 3, 1, and 2, respectively. Use arc consistency to show that a solution cannot be found from this point.

C2 Artificial Intelligence (25 points)

Planning. (15 points) Consider how you may adapt the POP/POCL partial order planning algorithm for conditional effects. A conditional effect has the form Conditional effects are effects of the form When <antecedent> then <consequent>

To implement this, we modify the standard causal link planner in two ways:
(1) When selecting an action to satisfy a goal, we also consider unifying the goal with a consquent of a conditional effect. If they do unify, the consequent's antecedent is put into the agenda of propositions to be satisfied.
(2) If the consequent threatens another action, there is an additional alternative for resolution (besides promotion and demotion), called *confrontation*: add the negation of the antecedent to the agenda.

Assume the following STRIPS-style action schemas:

put-in-briefcase(?X) PRE: (at ?X ?loc) (at briefcase ?loc) ADD: (in ?X briefcase)	**take-out-briefcase**(?X) PRE: (in ?X briefcase) DEL: (in ?X briefcase)	**move-briefcase**(?new) PRE: (at briefcase ?old) ADD: (at briefcase ?new) WHEN (in keys briefcase) ADD (at keys ?new) WHEN (in pchk briefcase) ADD (at pchk ?new) DEL: (at briefcase ?old) WHEN (in keys briefcase) DEL (at keys ?old) WHEN (in pchk briefcase) DEL (at pchk ?old)

Consider that we start with the briefcase, keys, and paycheck at home, and the keys and paycheck in the briefcase. Consider that our goal is that the paycheck is at home and the keys are at work.

(a) [8 points] give an example of modification (1), that is, the selection of an action with conditional effects that unifies with a goal. Describe the action schema unification, and the agenda before and after the action is added to the plan.

(b) [7 points] give an example of modification (2), that is, confrontation.

Search. (10 points)
Prove the following. Carefully define all variables you use in your proofs.

a. (5 points) The time and space complexity of breadth-first search is exponential in the depth of the solution.
b. (5 points) The time complexity of depth-first search is exponential in the depth of a solution, but the space complexity is linear.

C3 Artificial Intelligence (25 points)

Learning. (7 points)

Explain briefly (2 or 3 sentences) the use of a training set and a test set in evaluating learning programs.

Planning. (18 points) Assume you are planning to cook a 2-egg omelet with cheese filling. There are 4 objects: a pan, the cheese, and two eggs E1 and E2. You need to model 3 kinds of actions: heating the pan, adding an egg, and adding the cheese. Initially the pan is empty and cold. You must add the cheese after both eggs. You must heat the pan before adding anything.

(a) (8 points) Construct a set of operator descriptions for this domain ***suitable for creating a planning graph.***

(b) (10 points) Show the first five layers (proposition, action, proposition, action, proposition) of the planning graph.

C4 Artificial Intelligence (25 points)

Learning. (10 points) Construct a decision tree using the notion of information gain (as was covered in the text) for the set of training instances below. **Consider only X1 and X2 as possible split values.** Thus, you should ignore X3 in the decision tree induction process.
Show the equations you would use to determine which of X1 or X2 should be the root of the tree. (You do not actually have to do the calculation – just show the equations.)

Draw the entire tree (which will involve only X1 and X2) and show how the examples D1,...D10 are sorted down the tree and how they are classified by the tree.

No.	X1	X2	X3	Classification
D1	0	0	1	+
D2	0	0	2	+
D3	0	0	3	+
D4	0	0	4	+
D5	0	1	1	-
D6	0	1	2	-
D7	0	1	3	-
D8	0	1	4	-
D9	1	1	2	+
D10	1	0	3	+

Search. (15 points) Suppose you are writing a program to find the shortest sequence of links someone would need to click to get from one Wikipedia page to another. Your application must crawl pages and process them individually; you cannot use graph algorithms like Floyd-Warshall. Thus you decide to use a search technique.

a. (2 points) Between naïve breadth-first and depth-first strategies, which do you prefer and why?
b. (4 points) Is a bidirectional strategy appropriate for this problem? Why or why not? What information would you need to implement bidirectional seach?
c. (9 points) Say whether each of the following heuristics is admissible. If admissible, prove it. If not, provide a counterexample.
    a. Heuristic 1: h(n) = the number of outgoing links on page n.
    b. Heuristic 2: h(n) = the number of clicks needed to go from page n to Wikipedia's full A-Z index to the goal page G. (You do not need to know how many clicks this is to answer this question.)
    c. Heuristic 3: Suppose you are given $d_c(m)$, the number of links needed to go from any page m to a particular, pre-determined "central" page c. The "level difference" heuristic is $h(n) = |d_c(n) - d_c(G)|$.