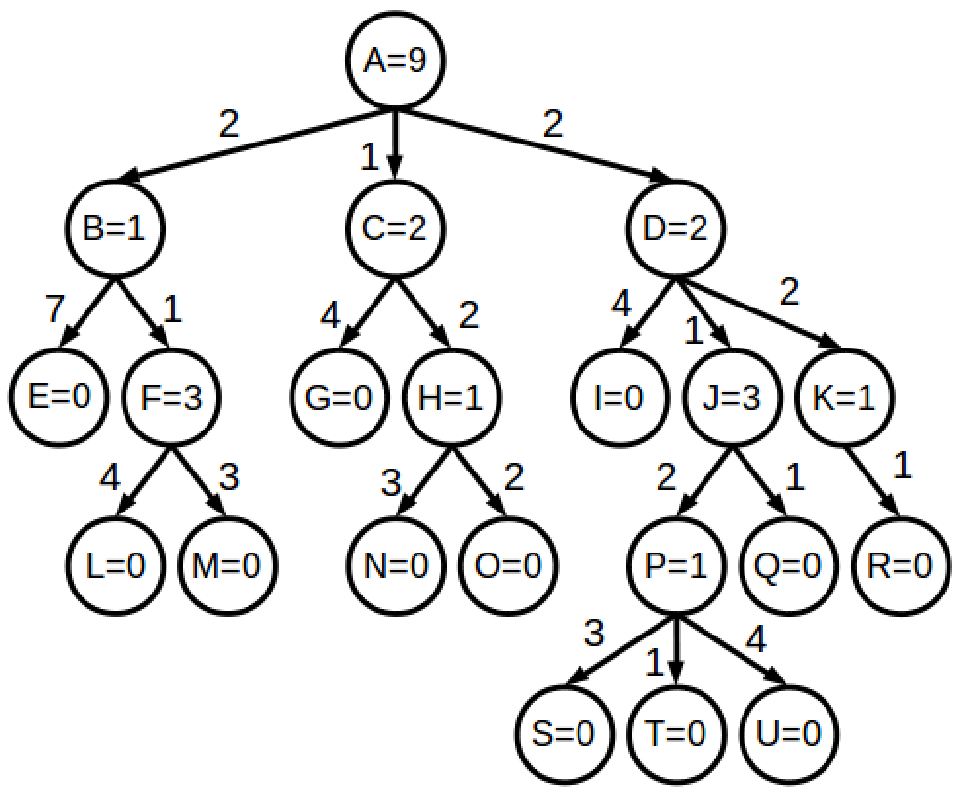
# CSci 4511
# Final

Name: ____________________________________________

Student ID: ______________________________

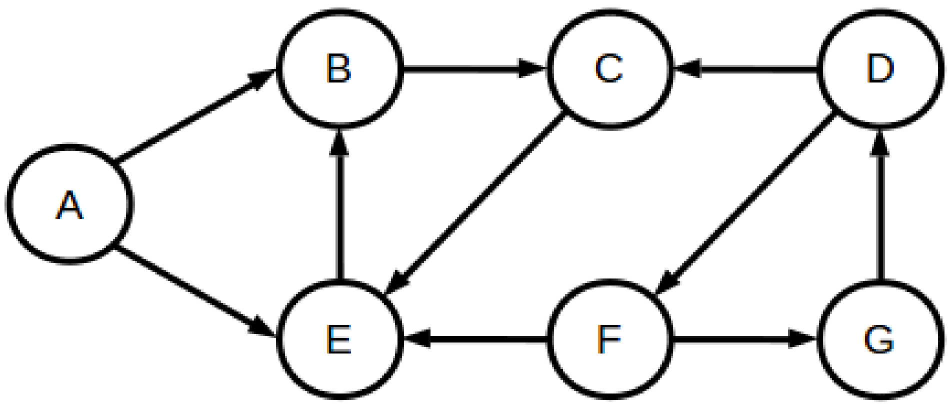
*Instructions*: The time limit is 120 minutes. Please write your answers in the space below. If you need more space, write on the back of the paper. The exam is open book and notes. You may not use the internet or any other outside resources. Usage of phones during the test is not allowed. For all questions you must **show work** to receive full credit.

**Problem (1)** [15 points]
Run A* search on the following tree where the state/node "A" is the initial/start and any leaf (i.e. has no children and the heuristic is zero) are the goals. The heuristics for each state are shown inside the node, so for example the heuristic at state "A" is 9. The numbers next to edges/actions are the cost of that action (goal is to minimize total path cost from start to goal, which is normal A* setup). Show the queue at every step of the way.



**Problem (2)** [20 points]
(Part 1) Is it possible for a Nash equilbirum point to be "better" than a Pareto optimal point when playing a two-player zero-sum game? Here "better" means that both players would want to change to the Nash from the Pareto.
(Part 2) When doing k-consistency in a Constratint Satisfaction Problem, as soon as we reduce the domain of a variable down to just one possible value, we assign the variable that value and eliminate it from future computations. In other words, if at some point we found the the only possible value for x was the value 1, we'd just replace x with 1 in all the constraints and continue solving. Is this a good way of reducing the problem? Explain your reasoning.

**Problem (3)** [25 points]
Suppose we had a directed graph which represented road connections (see figure below), and we wanted to figure out if there was a path between two nodes in the graph.
(1) Describe how you would prepresent this graph using **propositional logic**. (Note: your representation needs to be general, not just for the specific example below. You can, however, use the figure below as an example in your description.) Explain your representation.
(2) How would you use propositional logic to check if there is a path between two a specific start and end node?



**Problem (4)** [15 points]
Convert the following propositional statement to CNF form:
$(X) \wedge (Y) \wedge (Z) \wedge (Y \iff Z) \wedge \neg(X \Rightarrow Y)$

**Problem (5)** [15 points]
Use resolution to find if $KB \models \alpha$, where $\alpha = \forall x \exists y,\ A(x) \Rightarrow B(x, y)$.

KB is:
$A(Sam)$
$\forall x\ B(Jill, x)$
$\exists x\ C(Sam, x)$
$\forall x, y\ [B(x, y) \iff C(y, x)]$

**Problem (6)** [10 points]
Convert each of the following logic statments into a "normal sounding" English statement (i.e. do not just say "for all x where x is a student and..."). The sentences deal with taking classes with the following relationships:

- Student(x) = x is a student.
- Class(x) = x is a class/course.
- Takes(x,y) = x is takes (is enrolled) in y.
- Pass(x,y) = x gets a passing grade (i.e. does not fail) in y.

(1) $Student(Marie) \wedge Class(CSci) \wedge Takes(Marie, CSci)$
(2) $\forall x \exists y\ [Student(x) \Rightarrow (Class(y) \wedge Takes(x, y))]$
(3) $\exists x, y\ [Student(x) \wedge Class(y) \wedge \neg Pass(x, y)]$
(4) $\forall x \exists y, z\ [Class(x) \wedge Student(y) \wedge Student(z) \wedge Takes(y, x) \wedge Takes(z, x) \wedge y \neq z]$
(5) $\forall x, y, z\ [Student(x) \wedge Class(y) \wedge Class(z) \wedge Pass(x, y) \wedge Pass(x, z) \Rightarrow y = z]$

**Problem (7)** [20 points]
Suppose you had the following actions:

| Actions: | $A()$ | $B()$ | $C()$ |
|---|---|---|---|
| Preconditions: | | $x \wedge z$ | $\neg y \wedge \neg z$ |
| Effects: | $x \wedge z$ | $\neg y$ | $x \wedge y$ |

Your goal state is: $(x \wedge \neg y)$. If you are doing a backwards-search from this state, what are the possible resultant states for a single "backwards" action (i.e. only do search for depth=1)? (Note: Do **not** assume anything un-said is false. If it is unsaid, the value is unknown or not important for that part. For example, both $(x \wedge \neg y \wedge z)$ and $(x \wedge \neg y \wedge \neg z)$ are valid goal states.)