Name: _____

CptS 440/540 – Artificial Intelligence

Sample Exam II

No solution will be provided.

Duration: 75 minutes

Instructions: Clearly write your name at the top of this exam. Complete all problems on this exam. Write all your work on this exam. The exam is closed book, closed notes, and closed neighbor. No electronic devices are allowed, except your own calculator. Failure to turn in your exam at the end of 75 minutes will result in deduction of points. Anyone cheating on the exam will receive a zero.

Problem	Points Possible	Your Score
1	10	
2	10	
3	10	
4	10	
5	10	
6	10	
7	5	
8	10	
Total	75	

1. (10 points) Translate the following sentences into first-order logic using the predicates: Color(*s,c,t*), Shining(*s,t*), DayTime(*t*), NightTime(*t*), where *s* is a variable representing the Sun, Moon, Sky or Sea; *c* is a variable representing a color, and *t* is a variable representing a time of day.

    a. (3 points) At any time, it is either daytime or nighttime, or both.

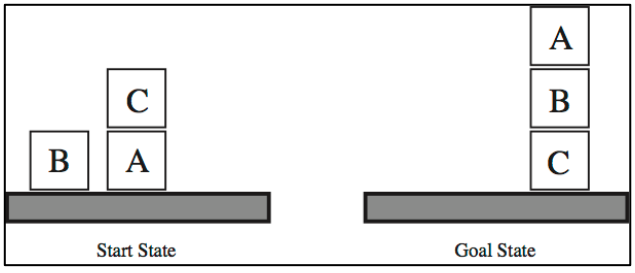
    b. (3 points) There is a time when everything is blue.

    c. (4 points) If something is shining at some time during the nighttime, then its color is gray.

2. (10 points) Below is a PDDL domain for the blocks world and the PDDL for the problem depicted in the figure.

```
(define (domain BLOCKS)
  (:predicates (on ?x ?y) (ontable ?x) (clear ?x)
               (handempty) (holding ?x))

  (:action pick-up
    :parameters (?x)
    :precondition (and (clear ?x) (ontable ?x) (handempty))
    :effect (and (not (ontable ?x)) (not (clear ?x))
                 (not (handempty)) (holding ?x)))

  (:action put-down
    :parameters (?x)
    :precondition (holding ?x)
    :effect (and (not (holding ?x)) (clear ?x)
                 (handempty) (ontable ?x)))

  (:action stack
    :parameters (?x ?y)
    :precondition _____________________________________
    :effect (and (not (holding ?x)) (not (clear ?y))
                 (clear ?x) (handempty) (on ?x ?y)))

  (:action unstack
    :parameters (?x ?y)
    :precondition (and (on ?x ?y) (clear ?x) (handempty))
    :effect (and (holding ?x) (clear ?y) (not (clear ?x))
                 (not (handempty)) (not (on ?x ?y))))
)
```

```
(define (problem stack)
  (:domain BLOCKS)
  (:objects A B C )
  (:init (ONTABLE A) (ONTABLE B) (ON C A)
         (CLEAR B) (CLEAR C) (HANDEMPTY))
  (:goal (AND (ON A B) (ON B C)))
)
```



a. (4 points) The stack action in the domain file is missing a precondition. Fill in the blank with the correct precondition.

b. (6 points) Show the plan that a planner would produce to solve the given problem. For each instance of an action, show the values for the parameter variables.

3. (10 points) Using the following first-order logic knowledge base, show a resolution proof by refutation that "$\exists s,t$ Shining(s,t)" is true.

   i. $\forall t$ DayTime(t) $\Rightarrow \exists s$ Shining(s,t)
   ii. $\forall t \neg$ NightTime(t) $\Rightarrow$ DayTime(t)
   iii. $\neg$ NightTime(Noon)

   a. (5 points) Convert the knowledge base and negated query to CNF. Give each clause a number.

   b. (5 points) Show each resolution step by indicating the two clause numbers being resolved, the resulting clause (give it a new number), and any necessary substitutions. Be sure to standardize variables.

4. (10 points) The table below shows the full joint probability distribution over three random variables: Sea ∈ {blue, gray}, Sun ∈ {true, false}, and Sky ∈ {clear, cloudy, overcast}. Based on this distribution, compute the following probabilities. Show your work.

Sea		blue		gray	
Sun		true	false	true	false
Sky	clear	0.12	0.07	0.06	0.08
	cloudy	0.07	0.10	0.07	0.09
	overcast	0.05	0.09	0.08	0.12

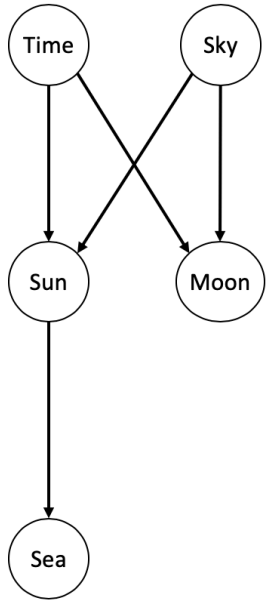
a. (2 points) P(Sky=cloudy)

b. (2 points) P(Sea=gray, Sky=cloudy)

c. (3 points) P(Sea=gray | Sky=cloudy)

d. (3 points) P(Sea=gray | Sky=cloudy ∨ Sky=overcast)

5. (10 points) Using the Bayesian network below, answer the following questions.



P(Time)	
day	night
0.5	0.5

P(Sky)		
clear	cloudy	overcast
0.5	0.3	0.2

Time	Sky	P(Sun | Time, Sky)	
		true	false
day	clear	0.9	0.1
	cloudy	0.6	0.4
	overcast	0.2	0.8
night	clear	0.0	1.0
	cloudy	0.0	1.0
	overcast	0.0	1.0

Time	Sky	P(Moon | Time, Sky)	
		true	false
day	clear	0.2	0.8
	cloudy	0.1	0.9
	overcast	0.0	1.0
night	clear	0.9	0.1
	cloudy	0.5	0.5
	overcast	0.1	0.9

Sun	P(Sea | Sun)	
	blue	gray
true	0.8	0.2
false	0.3	0.7

a. (2 points) Compute P(Time=night, Sky=cloudy, Sun=false, Moon=true, Sea=gray). Show your work.

b. (8 points) Compute P(Time=night | Sun=false, Moon=true). Show your work.

6. (10 points) Draw a Bayesian network depicting the relationship between random variables $Breeze_{3,3}$, $Pit_{3,2}$, $Pit_{2,3}$, $Pit_{3,4}$ and $Pit_{4,3}$, in a 4x4 Wumpus world, where $P(Pit_{x,y})=0.2$. Be sure to show all causal links and conditional probability tables.

7. (5 points) Suppose there are two random variables: Grade $\in$ {A, B, C, D, F} and Study $\in$ {true, false}. Given the following probabilities, compute P(Study=true | Grade=A). Show your work.
    - P(Grade=A | Study=true)=0.8
    - P(Grade=A | Study=false)=0.1
    - P(Study=true)=0.6

8. (10 points) Suppose your agent is playing a 3x3 Wumpus world game. In the (1,1) location, the agent does not sense a breeze. The agent moves to location (2,1) and senses a breeze. The agent then moves to location (1,2) and senses a breeze. Then, the agent moves to location (1,3) and dies. Our brave agent will attempt the same world again, but first wants to compute the probability that there is a pit in location (3,1). Based on what we know about pits (*known*) and breezes (*breeze*), compute $P(Pit_{3,1}=true \mid known, breeze)$.