Introduction to AI (Spring 2012) Final Exam 6/21/2012 Name:_______________ ID: ____________

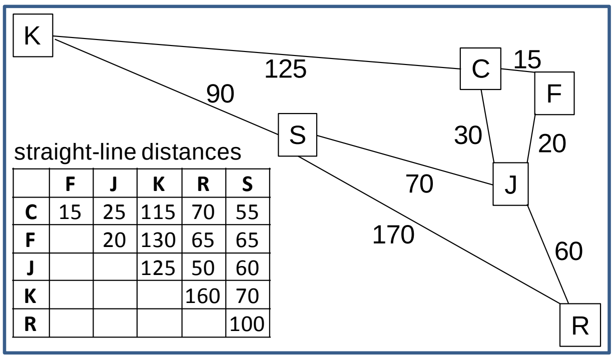
Prob#	A	B1	B2	**Total**
Score				

PART A [60%]: Multiple Choices (one answer per question)

List your answers here:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
11.	12.	13.	14.	15.	16.	17.	18.	19.	20.

1. Which of the following is true about "complete" searching algorithms?
(A) It always finds a path with minimal cost.
(B) It always finds a path that is shortest.
(C) It always finds a path if one exists.
(D) It always finds a path that has the fewest steps.



	F	J	K	R	S
C	15	25	115	70	55
F		20	130	65	65
J			125	50	60
K				160	70
R					100

Questions 2-4: Consider the map to the right.

2. For finding a path from R to C using uniform-cost search, which of the following node is not expanded before C?
(A) S (B) R (C) F (D) J

3. To find a path from F to S, which of the following is false?
(A) It is possible for depth-first search to find a path that has 3 steps.
(B) J is expanded before C when using greedy best-first search.
(C) Uniform-cost search and A* search give the same solution.
(D) Uniform-cost search will expand R before S.

4. To go from S to R, which of the following algorithms will find the path with minimum cost?
(A) uniform-cost (B) breadth-first (C) greedy best-first (D) IDS

Questions 5-7: This is a CSP problem. The variables a, b, c, d, and e are single-digit integers that satisfy the following constraints: a is even, b>a, c>7, d=2b, e=c-3, e≠a, |d-e|=1

5. How many binary constraints do we have?
(A) 2 (B) 7 (C) 4 (D) 5

6. After applying only the unary constraints, which variable should we assign first according to the minimum-remaining-value heuristic?
(A) b (B) e (C) a (D) c

7. If the first assigned variable is d=2, this will lead to no solution. What method can we use to detect this failure before any other variable is assigned?
(A) maintaining-arc-consistency algorithm (B) degree heuristic (C) local search (D) forward checking

8. Which of the following propositional logic sentences is valid?
(A) $p \lor q$ (B) $p \Rightarrow p$ (C) $p \land \neg p$ (D) $p \land p$

Questions 9-11: The variables are in domain of people. Use the following predicates and functions.
Parent(x,y): x is a parent of y   Loves(x,y): x loves y   Happy(x): x is happy

9. Which of the following English sentence best matches the FOL sentence $\forall x\ \exists y$ Loves(y,x)?
(A) Everyone is loved by someone.
(B) Someone loves everyone.
(C) Everyone loves someone.
(D) Someone is loved by everyone.

10. Which of the following FOL sentence best matches the English statement "Everyone who loves both his/her parents is happy."

(A) $\forall x\ \exists y\ Loves(x,y) \wedge Parent(y,x) \wedge Happy(x)$

(B) $\forall x\ [\forall y\ Parent(y,x) \Rightarrow Loves(x,y)] \Rightarrow Happy(x)$

(C) $\forall x\ Loves(x, Parent(x)) \Rightarrow Happy(x)$

(D) $\forall x\ [\forall y\ Loves(x,y) \wedge Parent(y,x)] \Rightarrow Happy(x)$

11. Some relations are reflective, i.e., if x is A of y, then y is A of x, too. Examples include Sibling, Classmate, etc. Which FOL sentences below define the reflectivity of a relation A?

(A) $\forall x,y\ [y=A(x)] \wedge [x=A(y)]$

(B) $\forall x,y\ [y=A(x)] \Leftrightarrow [x=A(y)]$

(C) $\forall x,y\ A(x,y) \wedge A(y,x)$

(D) $\forall x,y\ A(x,y) \Leftrightarrow A(y,x)$

12. Inference by forward-chaining involves repeated application of which inference rule?

(A) resolution (B) modus ponens (C) and-elimination (D) standardizing-apart

13. Which of the following unifies the terms Loves(John, x) and Loves(y, Father(John))?

(A) {x/John, y/Father(John)} (B) {x/ Father(John), y/John}

(C) {x/y, Father(John)/John} (D) {x/John, y/John}

14. Which of the following logical operands does not appear in conjunctive normal form?

(A) $\wedge$ (B) $\vee$ (C) $\neg$ (D) $\Rightarrow$

15. Given the sentence "$\forall x,y$ Friend(x,y) $\Rightarrow$ Likes(x,y)", we can infer " Friend (Mary,Amy) $\Rightarrow$ Likes(Mary,Amy)". What is the name of this rule?

(A) generalized resolution (B) existential instantiation

(C) universal instantiation (D) generalized modus ponens

16. Given the sentences "$\forall x,y$ Friend (x,y) $\Rightarrow$ Likes(x,y)" and " Friend (Mary,Amy)", we can infer "Likes(Mary,Amy)". What is the name of this rule?

(A) generalized resolution (B) existential instantiation

(C) universal instantiation (D) generalized modus ponens

17. Which of the following is false regarding the statement "entailment of FOL sentences is semidecidable"?

(A) If no function is involved, entailment in FOL is decidable.

(B) If a given sentence is entailed by a FOL KB, we can prove this in finite steps.

(C) If a given sentence is not entailed by a FOL KB, we can prove this in finite steps.

(D) There are complete and sound inference rules for FOL.

18. Which of the following can cause uncertainty?

(A) Incomplete information (partial observability of the world).

(B) The world is too complex.

(C) The available information is not accurate enough.

(D) All of the above.

19. An agent is given the desired actions for a set of scenarios, and it is to learn from this information. This type of learning is

(A) reinforcement (B) direct (C) supervised (D) unsupervised

20. What is the meaning of "Ockham's razor"?

(A) Using the simplest model to explain the data.

(B) Using the fewest necessary data to build the model.

(C) Attempting to adjust the model to fit the data as well as possible.

(D) First identifying which data are useful before learning.

PART B: There are two problems. Provide all the details

1. [20%] A propositional KB contains two sentences:

P_1: (Food $\Rightarrow$ Party) $\vee$ (Drinks $\Rightarrow$ Party)

P_2: Food $\wedge$ Drinks $\Rightarrow$ Party

(a) Convert P_1 and P_2 into conjunctive normal form.

(b) Use resolution to prove $P_1 \Rightarrow P_2$.

(a) P_1: $(\neg F \vee P) \vee (\neg D \vee P)$ $\rightarrow$ $\neg F \vee \neg D \vee P$

P_2: $\neg(F \wedge D) \vee P$ $\rightarrow$ $\neg F \vee \neg D \vee P$

(b) To prove that P1 entails P2, start with P1 as given and P2 as the query.

$P1 \wedge \neg P2$ $\rightarrow$ $(\neg F \vee \neg D \vee P) \wedge \neg(\neg F \vee \neg D \vee P)$

$\rightarrow$ $(\neg F \vee \neg D \vee P) \wedge F \wedge D \wedge \neg P$

$\rightarrow$ $(\neg D \vee P) \wedge D \wedge \neg P$

$\rightarrow$ $P \wedge \neg P$

$\rightarrow$ false (empty clause)

Note: There are more than one possible ways to do this. However, it is required that resolution is used in order to get full credit here.

2. [20%] For the following 5 training samples with 3 binary inputs and one output, build a decision tree. Use information gain to choose the attributes to split the nodes. You can use $\log_2 3 \approx 1.6$.

A	B	C	Output
1	0	0	0
1	0	1	0
0	1	0	0
1	1	1	1
1	1	0	1

To select the first attribute, we compute the remaining entropies when the 5 samples are split by A, B, or C.

Split by A: 4 samples (2 zeros, 2 ones) for A=1, 1 sample (1 zero) for A=0

Remainder(A): $\frac{4}{5}\left[-\frac{2}{4}\log_2\frac{2}{4}-\frac{2}{4}\log_2\frac{2}{4}\right]+\frac{1}{5}\left[-\frac{1}{1}\log_2\frac{1}{1}-\frac{0}{1}\log_2\frac{0}{1}\right]=0.8$

Split by B: 3 samples (1 zeros, 2 ones) for B=1, 2 sample (2 zeros) for B=0

Remainder(B): $\frac{3}{5}\left[-\frac{1}{3}\log_2\frac{1}{3}-\frac{2}{3}\log_2\frac{2}{3}\right]+\frac{2}{5}\left[-\frac{2}{2}\log_2\frac{2}{2}-\frac{0}{2}\log_2\frac{0}{2}\right]\approx\frac{3}{5}\left[\frac{1.6}{3}+\frac{2\times 0.6}{3}\right]+\frac{2}{5}\times 0=0.56$

Split by C: 2 samples (1 zero, 1 one) for C=1, 3 samples (2 zeros, 1 one) for C=0

Remainder(C): $\frac{2}{5}\left[-\frac{1}{2}\log_2\frac{1}{2}-\frac{1}{2}\log_2\frac{1}{2}\right]+\frac{3}{5}\left[-\frac{2}{3}\log_2\frac{2}{3}-\frac{1}{3}\log_2\frac{1}{3}\right]\approx\frac{2}{5}\times 1+\frac{3}{5}\left[\frac{2\times 0.6}{3}+\frac{1.6}{3}\right]=0.96$

Remainder(B) is the smallest. So the first attribute is B.

Now we need to choose the second attribute.

For the subtree of B=1:

Split by A: 2 samples (2 ones) for A=1, 1 sample (1 zero) for A=0

Remainder(A) = 0

Split by C: 1 samples (1 one) for C=1, 2 sample2 (1 one, 1 zero) for C=0

Remainder(C) > 0

So we split by A. The subtree terminates here as there is no need to go any further.

For the subtree of B=0:

Both samples are zeros, so there is no need to go any further.

The resulting tree is shown to the right.