COS30019 – Final Assessment

Answering Instructions:

Please do not use a red pen/type in red.

There are 6 problems.

Total marks on paper: 90 + 5 bonus marks
The maximum mark you can get for the final assessment is 90 (100%). However, if you lose marks in some questions and you get the bonus marks, the bonus marks will be added to your total of the final assessment.

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Problem 1 – Propositional Logic (4x3 = 12 marks)

About Mr James Bond (JB), we know the following:

- *IF* JB *does not get enough physical activity AND* JB *has an unhealthy diet THEN* JB *has heart disease.*
- *IF* JB *has an unhealthy diet THEN* JB *does not get enough physical activity.*
- JB *does not get enough physical activity.*

1. Represent the above knowledge base KB1 in propositional logic using the following vocabulary:
   JA for JB *gets enough physical activity*,
   JU for JB *has an unhealthy diet*,
   JH for JB *has heart disease*,

(3 marks)

ANSWER:

JA	**JU**	**JH**	**~JA**	**(~JA & JU) => JH**	**JU => ~JA**
T	T	T	F	T	T
T	T	F	F	T	T
T	F	T	F	T	T
T	F	F	F	T	T
F	T	T	T	T	T
F	T	F	T	F	T
F	F	T	T	T	T
F	F	F	T	T	T

Using a truth table for KB1, please answer the following multiple-choice questions:

2. How many models does the knowledge base KB1 have?

(3 marks)

   a. 1 model
   b. 2 models
   c. 3 models
   d. 4 models
   e. 6 models

ANSWER: c. 3 models

3. JB has an unhealthy diet.

(3 marks)

   a. True.
   b. False.
   c. Don't know.

ANSWER: c. Don't know.

4. JB has heart disease.

(3 marks)

   a. True.

b. False.
c. Don't know.

ANSWER: c. Don't know.

Problem 2 – Propositional Logic (4x3 = 12 marks)

About Mr Harry Potter (HP), we know the following:

- *IF* HP *does not get enough physical activity AND* HP *has an unhealthy diet THEN* HP *has heart disease.*
- *IF* HP *has an unhealthy diet THEN* HP *does not get enough physical activity*.
- HP *gets enough physical activity.*

1. Represent the above knowledge base KB2 in propositional logic using the following vocabulary:
   HA for HP *gets enough physical activity*,
   HU for HP *has an unhealthy diet*,
   HH for HP *has heart disease*,

(3 marks)

ANSWER:

HH	HU	HA	(~HA&HU) =>HH	HU =>~HA
T	T	T	T	F
T	T	F	T	T
T	F	T	T	T
T	F	F	T	T
F	T	T	T	F
F	T	F	F	T
F	F	T	T	T
F	F	F	T	T

Using a truth table for KB2, please answer the following multiple-choice questions:

2. How many models does the knowledge base KB2 have?

(3 marks)

a. 1 model
b. 2 models
c. 3 models
d. 4 models
e. 6 models

ANSWER: b. 2 models

3. HP has an unhealthy diet.

(3 marks)

a. True.
b. False.
c. Don't know.

ANSWER: **b. False**

4. HP has heart disease.

(3 marks)

   a. True.
   b. False.
   c. Don't know.

ANSWER: c. Don't know.

Problem 3 – Propositional Logic (4x3 = 12 marks)

Decide whether each of the following sentences is **valid**, **unsatisfiable**, or **neither**.

A	B	(~A||B) &(A&~B)	(A&~B) =>A	A ||(B=>B)	(A=>~A) & B
T	T	F	T	T	F
T	F	F	T	T	F
F	T	F	T	T	T
F	F	F	T	T	F

1. $(\neg A \vee B) \wedge (A \wedge \neg B)$

(3 marks)

   a. Valid
   b. Unsatisfiable
   c. Neither

ANSWER: False in all models => b. Unsatisfiable

2. $(A \wedge \neg B) \Rightarrow A$

(3 marks)

   a. Valid
   b. Unsatisfiable
   c. Neither

ANSWER: True in all models => a. Valid

3. $A \vee (B \Rightarrow B)$

(3 marks)

   a. Valid
   b. Unsatisfiable
   c. Neither

ANSWER: True in all models => a. Valid

4. $(A \Rightarrow \neg A) \wedge B$

(3 marks)

   a. Valid
   b. Unsatisfiable
   c. Neither

ANSWER: True in some models and False in some models = > c. Neither

Problem 4 – First-Order Logic (4x5 = 20 marks)

Represent the following statements in first-order logic (FOL), using the following vocabulary:

Student(x) : x **is a student**
Phone(y) : y **is a phone**
Game(z) : z **is a game**
Year(t) : t **is a year**
Has_In(u, v, y) : u **has** v **in the year** y
Plays(u,v) : u **plays** v
Year_2024 : the constant represents the year 2024

Select ALL correct options for the FOL representations of the following English statements:

1. Every student has some phones in the year 2024.

(5 marks)

a. $\forall x.Student(x) \wedge (\exists p.Phone(p) \Rightarrow Has\_In(x, p, Year\_2024))$
b. $\forall x.Student(x) \wedge (\exists p.Phone(p) \wedge Has\_In(x, p, Year\_2024))$
c. $\forall x.Student(x) \Rightarrow (\exists p.Phone(p) \wedge Has\_In(x, p, Year\_2024))$
d. $\forall x.Student(x) \Rightarrow (\exists p.Phone(p) \Rightarrow Has\_In(x, p, Year\_2024))$
e. $\forall x.Student(x) \Rightarrow (\forall p.Phone(p) \Rightarrow Has\_In(x, p, Year\_2024))$

ANSWER: c

2. Every student has all the games in at least one year.

(5 marks)

a. $\forall x.Student(x) \Rightarrow (\exists y.Year(y) \Rightarrow (\forall g.Game(g) \Rightarrow Has\_In(x, g, y)))$
b. $\forall x.Student(x) \Rightarrow (\exists y.Year(y) \Rightarrow (\forall g.Game(g) \wedge Has\_In(x, g, y)))$
c. $\forall x.Student(x) \Rightarrow (\exists y.Year(y) \wedge (\forall g.Game(g) \Rightarrow Has\_In(x, g, y)))$
d. $\forall x.Student(x) \Rightarrow (\forall g.Game(g) \wedge (\exists y.Year(y) \Rightarrow Has\_In(x, g, y)))$
e. $\forall x.Student(x) \Rightarrow (\forall g.Game(g) \Rightarrow (\exists y.Year(y) \wedge Has\_In(x, g, y)))$
f. $\forall x.Student(x) \wedge (\forall g.Game(g) \wedge (\exists y.Year(y) \wedge Has\_In(x, g, y)))$

ANSWER: c

3. There is a student who has a phone in a year but does not play all games.

(5 marks)

a. $\exists x.Student(x) \wedge (\exists p.Phone(p) \wedge ((\exists y.Year(y) \wedge Has\_In(x, p, y))) \wedge \neg(\forall g.Game(g) \Rightarrow Plays(x,g))$
b. $\exists x.Student(x) \wedge (\exists y.Year(y) \wedge ((\exists p.Phone(p) \wedge Has\_In(x, p, y))) \wedge \neg(\forall g.Game(g) \Rightarrow Plays(x,g))$
c. $\exists x.Student(x) \wedge (\exists y.Year(y) \wedge ((\exists p.Phone(p) \wedge Has\_In(x, p, y))) \wedge (\exists g.Game(g) \wedge \neg Plays(x,g))$
d. $\exists x.Student(x) \wedge (\exists y.Year(y) \wedge ((\exists p.Phone(p) \wedge Has\_In(x, p, y))) \wedge \neg(\exists g.Game(g) \wedge Plays(x,g))$
e. $\exists x.Student(x) \wedge (\exists y.Year(y) \wedge ((\exists p.Phone(p) \wedge Has\_In(x, p, y))) \wedge \neg(\forall g.Game(g) \wedge Plays(x,g))$
f. $\exists x.Student(x) \wedge (\exists p.Phone(p) \wedge ((\exists y.Year(y) \wedge Has\_In(x, p, y))) \wedge (\forall g.Game(g) \Rightarrow \neg Plays(x,g))$

ANSWER: b, c

I feel like **c** can also express the same meaning.
(not play all games (**b**) = there is at least a game that the student does not play (**c**))

4. There is a student who plays exactly one game.

(5 marks)

a. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge \neg(\exists h.Game(h) \wedge Plays(x,h) \wedge \neg(h = g)))$
b. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge (\forall h.(Game(h) \wedge Plays(x,h)) \Rightarrow (h = g)))$
c. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge (\forall h.(Game(h) \wedge (h = g)) \Rightarrow Plays(x,h)))$

d. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge (\forall h.(Game(h) \wedge \neg(h = g)) \Rightarrow \neg Plays(x,h)))$
e. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge (\forall h.(Game(h) \wedge \neg Plays(x,h)) \Rightarrow \neg(h = g)))$
f. $\exists x.Student(x) \wedge (\exists g.Game(g) \wedge Plays(x,g) \wedge (\exists h.Game(h) \wedge Plays(x,h) \wedge (h = g)))$

ANSWER: a, b, d

Problem 5 – AI Planning (5 + 12 = 17 marks)

Our agent is a robot with two hands: *Hand1* and *Hand2*. The robot's task is to tidy up the room by putting rubbish into the *Bin* and putting things at their right places. Initially, the robot is at the *Door*, the *Rubbish* and the *Toy* are at the *Table* and both hands of the robot are free. The right place for the *Toy* is at the *Shelf*. The actions available to the robot include *Go* from one place to another, and *Grasp* or *Ungrasp* an object. Grasping results in holding the object using a free hand if the robot and object are at the same place. One effect of grasping is that the free hand that the robot uses to grasp the object will no longer be free after grasping the object.

1. Complete the description of the initial state and the agent's goals.

(5 marks)

ANSWER:

Init(RobotAt(Door) ∧ At(Rubbish, Table) ∧ At(Toy, Table) ∧ HandFree(Hand1) ∧ HandFree(Hand2))

Goal(At(Rubbish, Bin) ∧ At(Toy, Shelf))

2. Write down STRIPS-style definitions of the three actions.

(12 marks)

ANSWER:

Action (Go(from, to)):
PRECONDS: RobotAt(from)
EFFECTS: ~RobotAt(from) ∧ RobotAt(to)

Action(Grasp(object, hand)):
PRECONDS: RobotAt(loc) ∧ At(object, loc) ∧ HandFree(hand)
EFFECTS: ~HandFree(hand) ∧ Holding(object, hand) ∧ ~At(object, loc)

Action(Ungrasp(object, hand)):
PRECONDS: Holding(object, hand) ∧ RobotAt(loc)
EFFECTS: HandFree(hand) ∧ ~Holding(object, hand) ∧ At(object, loc)

Problem 5 – Uncertain reasoning (17 marks + 5 bonus marks)

Mr James Bond takes his car to the mechanic for regular servicing. The mechanic runs a test on the car transmission. The test would return one of two values: **1** (Test finds Fault) or **0** (test finds No Fault). The accuracy of the test is as follows: The probability of the test returning **1** when the car transmission is actually faulty is 0.99, and the probability of the test returning **0** when the car transmission is NOT faulty is 0.97. After running the test on Mr James Bond's car, the test returns **1**. According to the manufacturer of Mr James Bond's car, at the age of his car, only 1 in 500 cars would have a faulty transmission.

Please use the following vocabulary when answering the following questions **using Bayes' rules**: (*Your answer will need to include the working out of how you derive the answer.*)
F – The car transmission is actually faulty;
T1 – The test returns the value **1**.

1. What is the probability that Mr James Bond's car transmission is faulty?

(15 marks)

ANSWER:
P(F) = 1/500 = 0.002
=> P(~F) = 1 - P(F) = 1 - 0.002 = 0.998

P(T1|F) = 0.99
=> P(T1|~F) = 1 - 0.97 = 0.03

Using Baye's rules, we have:
P(F|T1) = (P(T1|F) * P(F)) / (P(T1|F)* P(F) + P(T1|~F)* P(~F))

=> P(F|T1) = (0.99* 0.002) / ((0.99* 0.002) + (0.03* 0.998)) = 0.062

=> The probability that Mr James Bond's car transmission is faulty is 6.2%

2. After further investigation, we also know that Mr James Bond has a very aggressive driving style that is really damaging to the car transmission and the car manufacturer informs that with Mr James Bond's driving style, 1 in 10 cars would have a faulty transmission. The mechanic then informs that the cost of replacing the transmission is $4,000. If the car transmission is in fact faulty and it is not replaced, then it will soon break during driving causing the entire engine to be broken which will cost $12,000 to repair. If Mr James Bond does not replace the transmission of his car now, what is the ***expected cost*** for him? If Mr James Bond is rational, would he replace the car transmission now?

(2 marks + 5 bonus marks)

ANSWER:
P(F) = 1/10 = 0.1
P(~F) = 1 - P(F) = 1 - 0.1 = 0.9

Using Baye's rules, we have:
P(F|T1) = (P(T1|F) * P(F)) / (P(T1|F) * P(F) + P(T1|~F) * P(~F))
=> P(F|T1) = (0.99 * 0.1) / ((0.99 * 0.1) + (0.03 * 0.9)) = 0.7857 = 0.786

=> Mr James Bond's car transmission faulty with his driving style given a T1 test result is 78.6%

Cost of replacing the transmission is $4,000
If the car transmission is in fact faulty and it is not replaced, then it will soon break during driving causing the entire engine to be broken which will cost $12,000 to repair.
And cost if the car has no faulty and no need to repair is $0.

So, the expected cost will be:
12000* (0.99* 0.1) / ((0.99 * 0.1) + (0.03*0.9)) + (1 - (0.99 * 0.1) / ((0.99 0.1) + (0.03*0.9)))* 0
= 9428.571

Since $9428.571 is more expensive than $4000
=> Mr. James Bond should choose to replace the car transmission now.