COS30019 – Final Exam

Answering Instructions:

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

There are 5 problems.

Total marks on paper: 90 + 8 bonus marks
The maximum mark you can get for the final exam 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 exam.

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Problem 1 – Propositional Logic (18 marks)

About the credit card application the intelligent agent is assessing, the agent knows the following:

- *IF the applicant has high income OR the applicant does NOT overspend, THEN the applicant is creditworthy.*
- *The applicant does NOT have high income OR the applicant overspends.*
- *The applicant does NOT overspend.*

Represent the above sentences in propositional logic using the following vocabulary:
HI for The applicant has high income,
OS for The applicant overspends,
CW for The applicant is creditworthy.

Using a truth table, can you determine the answers to the following questions:

a. Is the applicant creditworthy?
b. Does the applicant have high income?

Your answer has to be **Yes** or **No** or **Don't know**. For instance, if you answer **Yes** to question **1.a.**, you'll have to demonstrate that the knowledge base entails '*The applicant is creditworthy*'; if you answer **No** to question **1.a.**, you'll have to demonstrate that the knowledge base entails '*The applicant is NOT creditworthy*.' Clearly indicate which **rows** of the truth table support your answer.

Ans-

Row	CW	HI	OS	(HI ∨ ¬OS)	¬OS ***(3)***	(¬HI ∨ OS) ***(2)***	((HI ∨ ¬OS) → CW) ***(1)***
1	F	F	F	T	T	T	F
2	F	F	T	F	F	T	T
3	F	T	F	T	T	F	F
4	F	T	T	T	F	T	F
5	T	F	F	T	T	T	T

6	T	F	T	F	F	T	T
7	T	T	F	T	T	F	T
8	T	T	T	T	F	T	T

a)
We do not know. In 5th row, there are 5 instances where KB finds applicant is CW. But in 1st row, there are not CW for some. So, it is uncertain.

b)
Applicant does not have high income as in row 1 and 5 when applicant doesn't OS and doesn't HI or does OS, applicant does not have HI.

Problem 2 – Propositional Logic (16 marks)

Decide whether each of the following sentences is **valid**, **unsatisfiable**, or **neither**. Verify your decisions using truth table. Clearly indicate which **rows** of the table support your answer.

a. $\neg A \Rightarrow \neg B$
b. $(A \wedge B) \Rightarrow A$
c. $\neg A \Rightarrow (A \vee B)$
d. $(A \Rightarrow A) \vee B$

Hint: You can use just one truth table for all four sentences.

(4x4=16 marks)

a)

A	B	$(\neg A \rightarrow \neg B)$
F	F	T
F	T	F
T	F	T
T	T	T

In row 1, $(\neg A \rightarrow \neg B)$ is T, so it is not unsatisfiable, and row 2 has F, so it is not valid. Hence, it is neither.

b)

A	**B**	**$((A \wedge B) \rightarrow A)$**
F	F	**T**
F	T	**T**
T	F	**T**
T	T	**T**

In all the rows, it is True, so it is valid.

c)

A	**B**	**$(\neg A \rightarrow (A \vee B))$**
F	F	**F**
F	T	**T**
T	F	**T**
T	T	**T**

On the first row, it is False, so not valid, but row 2 has True, so it is not unsatisfiable. Hence, neither.

d)

A	**B**	**((A → A) ∨ B)**
F	F	**T**
F	T	**T**
T	F	**T**
T	T	**T**

All the rows have True, so it is valid.

Problem 3 – First-Order Logic (16 marks)

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

Person(x): x **is a person**
IsAVegetable(y): y **is a vegetable**
IsAFruit(z): z **is a fruit**
Likes(u,v): u **likes** v

1. Every person likes some vegetable.
2. There is a person who likes all vegetables or likes some fruit.
3. Every person likes all fruits but does not like some vegetable.
4. There is a person who likes exactly one vegetable.

(4+4+4+4 = 16 marks)

Ans-
1)

$\forall x \exists y (Person(x) \land IsVegtable(y) \rightarrow Likes(x,y))$

2)

$\exists x\ Person(x) \land \forall y\ IsaVegtable(y) \rightarrow Like(x,y) \land$
$\exists z\ IsaFruit(z) \rightarrow Likes(x,z)$

3)

$\forall x\ Person(x) \rightarrow \forall z\ Isafruit(z) \land$
$Likes(x,z) \land \exists y\ IsaVeg(y) \land \neg Likes(x,y)$

4)

$\exists x\ Person(x) \land \exists y\ IsaVeg(y) \land Likes(x,y)$
$\land \forall p\ Person(p) \land \exists y\ IsaVeg(y) \rightarrow x = p$

Problem 4 – AI Planning (25 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. Write down the initial state description and the agent's goals. (7 marks)
2. Write down STRIPS-style definitions of the three actions. (9 marks)
3. Write down a consistent partial-order plan (POP) with no open preconditions for this problem. (9 marks)

(*Hint*: You may consider using the following template for question 3 of this problem:
Actions={ Start, Go(Door, Table), …}
Orderings={ Start < Go(Door, Table), …}
Links={
Start - RobotAt(Door)-> Go(Door, Table), … }

Open preconditions={…}

And complete it with your answer.

You may also want to include a hand-drawn diagram showing the partial-order plan POP if you wish.)

Problem 5 – Uncertain reasoning (15 marks + 8 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: **TF** or **NF**. If the test returns **TF**, it indicates that the transmission has a major issue and needs to be replaced. If the test returns **NF**, it indicates that the tests finds no issues and the transmission does not need to be replaced. The accuracy of the test is as follows: The probability of the test returning **TF** when the car transmission is actually faulty is 0.99, and the probability of the test returning **NF** when the car transmission is NOT faulty is 0.97. After running the test on Mr James Bond's car, the mechanic told him that the test returns **TF**. 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 that needs replacement.

Please use the following vocabulary when answering the following questions **using Bayes' rules**:
F – The car transmission is actually faulty
TF – The test returns the value **TF** indicating that the transmission has major issues

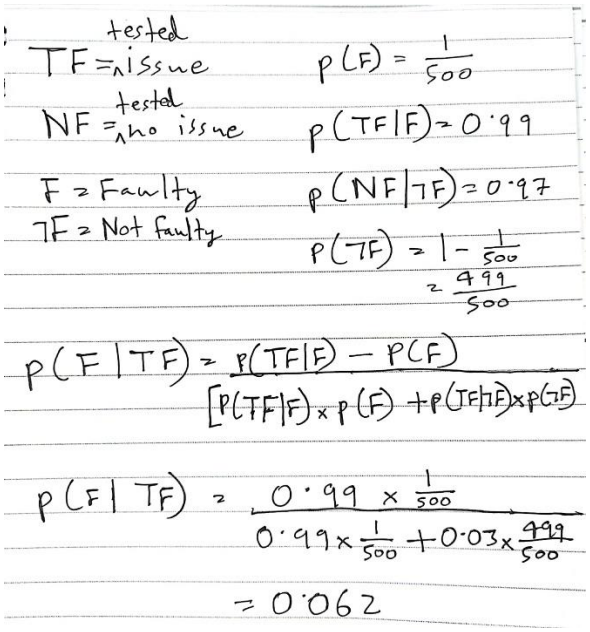
1. What is the probability that Mr James Bond's car transmission is faulty?

(15 marks)

2. **(Bonus question)** 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 that needs replacement. The mechanic then informs that the cost of replacing the transmission is $4,000. If the car transmission does have a major issue and it is not replaced then it will break during driving causing the entire engine to be broken which will cost $12,000. 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?

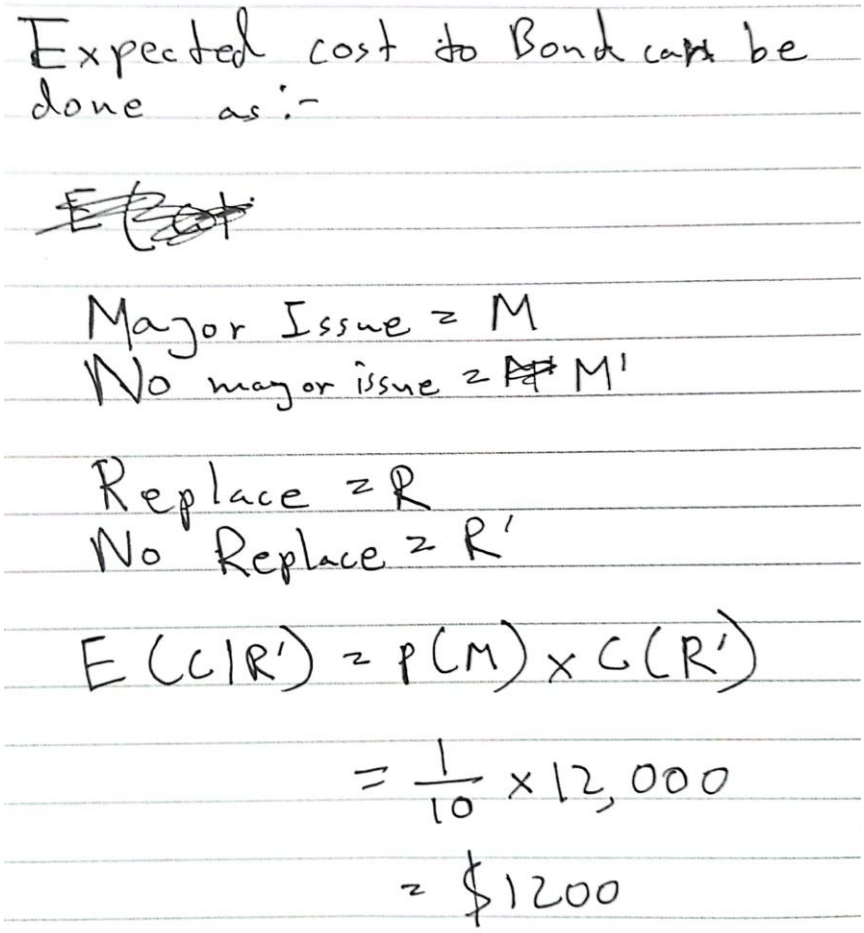
(8 bonus marks)

Ans-
1)



The probability of Bonds car being faulty given it is tested TF is 0.062.

2)



Expected cost is 1200$, given transmission isn't replaced. Cost of replacement is 4000$. Hence, if Bond is smart, he wont replace the transmission now.