Name:

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(Choose and provide one applicable)

Institute of Systems Science
National University of Singapore

GRADUATE CERTIFICATE
INTELLIGENT REASONING SYSTEMS

Assessment

Subject: *Machine Reasoning*

SECTION A

Question	Marks
1	/1.0
TOTAL	/1.0

Instructions for Paper

Duration: Five minutes reading
Duration: Fifteen minutes exam

This is an *OPEN BOOK* examination. This examination paper consists of *one* Section and *one* Question. You are to answer *ALL* questions. There are a total of *1.0 Mark* for this paper.

1. The first **5** minutes are for reading and understanding the questions in this examination paper. You must **NOT** answer any questions using any writing instrument during this time.

2. Read **ALL** instructions before answering any of the examination questions.

3. Write your Student ID number on the **front page** of this examination paper in the box provided.

4. This is an **Open Book** examination. If you wish, you may use reference materials to answer a question. Reference materials can be *books, manuals, handouts* or *notes*.

5. Answers are to be written **only** in this **examination paper** and any **attachments** provided and will be considered for credit. Answers written in any appendices will **NOT** be marked.

6. Use a pen for writing your answers. Pencil may only be used for drawing diagrams and writing program code.

7. Non-programmable calculators may be used if required. **However, computers of any form (laptops, tablets, smart watches etc.) are not permitted to be brought into the examination hall.**

8. State clearly any assumptions you make in answering any question where you feel the requirement is not sufficiently clear.

9. At the end of the examination:

   a) Hand-in the examination paper for **each** section **separately**, any appendices and attachments.

   b) You are **not** allowed to remove the examination paper, appendices or attachments from the examination hall.

REMEMBER:

- *This is an OPEN BOOK exam.*
- *There are a total of 1.0 Mark for this paper.*
- *You are required to answer ALL questions.*
- *State clearly any assumptions you make in answering any question where you feel the requirement is not sufficiently clear.*

SECTION A

Question 1　　　　　　　　　　　　　　　　　　　　　　　*(Total: 1.0 Mark)*

With the current low interest rate for loans, **ABC Bank** is receiving many housing loan applications every day. The following regulations have been used by the Bank for housing loan approval since 2008:

(1)　　The loan will be rejected if the applicant currently has another housing loan with more than 50% of the loan amount unpaid.

(2)　　The loan will be rejected if the applicant has a bad credit history within the last three years.

(3)　　The loan will be approved if the applicant currently does not have an unpaid housing loan and does not have a bad credit history within the last three years.

(4)　　The loan will be partially approved if the applicant currently has another housing loan with less than 25% of the loan amount unpaid, and does not have a bad credit history within the last three years.

Based on these regulations, for $x \in X$, where X is the group of applicants to be assessed, the following **binary (true or false)** predicates have been defined:

unpaid_big(x)　　　　the person x has a loan with $> 50\%$ unpaid amount.

unpaid_small(x)　　　the person x has a loan with $< 25\%$ unpaid amount.

bad_credit(x)　　　　the person x has a bad credit history within the last three years.

no_loan(x)　　　　　the person x does not have an unpaid housing loan at the moment.

reject(x)　　　　　　the housing loan application from person x is rejected.

approval(x)　　　　　the housing loan application from person x is approved.

partial(x)　　　　　　the housing loan application from person x is partially approved.

　　(**Note**:　　For all these predicates, no details of the loan amount are needed.)

Answer the following questions:

1.1 Translate the regulations into WHEN/THEN rules.
    For example: WHEN unpaid_big(x) THEN reject(x)

                                          (0.5 Mark)

[Answer]

    (1) WHEN unpaid_big(x) THEN reject(x)
    (2) WHEN bad_credit(x) THEN reject(x)
    (3) WHEN no_loan(x) AND ¬bad_credit(x) THEN approval(x)
    (4) WHEN unpaid_small(x) AND ¬bad_credit(x) THEN partial(x)

1.2 Mr A is currently applying for a housing loan with ABC Bank. Given that *Mr A has a current loan with 20% of the loan amount unpaid, and had a bad credit history ten years ago*, prove that *the housing loan application for Mr A will be partially approved* is **true**. Show your reasoning steps: rule firing sequences based on matching conditions.

(0.5 Mark)

[Answer]

Hypothesis: Housing loan application for Mr A will be partially approved.

1) **Forward Chaining**

Fact1: 20% of loan amount unpaid → unpaid_small(Mr A)
Fact2: Bad credit history ten years ago → bad_credit(Mr A) is false → ¬ bad_credit(Mr A)

Pattern Matching: unpaid_small(MrA) and ¬ bad_credit(Mr A) → partial (Mr A)

The above facts will fire rule 4 and the loan for Mr A will be partially approved.

Hypothesis is TRUE.

2) **Backward Chaining**

Facts:

(a) unpaid_small(Mr A) – since Mr A has loan of <25% unpaid amount
(b) ¬bad_credit(Mr A)

Rules:

(1) WHEN unpaid_big(x) THEN reject(x)
(2) WHEN bad_credit(x) THEN reject(x)
(3) WHEN no_loan(x) AND ¬bad_credit(x) THEN approval(x)
(4) WHEN unpaid_small(x) AND ¬bad_credit(x) THEN partial(x)

Based on matching conditions of facts (a) and (b), only conditions for rule (4) matches. Hence resulting in partial(Mr A) => housing loan application from person Mr A is partially approved.

Rules:

(1) unpaid_big(x) -> reject(x)
(2) bad_credit(x) -> reject(x)
(3) no_loan(x) ∧ ¬bad_credit(x) -> approval(x)
(4) unpaid_small(x) ∧ ¬bad_credit(x) -> partial(x)

Converted rules:

(1) ¬unpaid_big(x) ∨ reject(x)
(2) ¬bad_credit(x) ∨ reject(x)
(3) ¬(no_loan(x) ∧ ¬bad_credit(x)) ∨ approval(x) => ¬no_loan(x) ∨ bad_credit(x) ∨ approval(x)
(4) ¬(unpaid_small(x) ∧ ¬bad_credit(x)) ∨ partial(x) => ¬unpaid_small(x) ∨ bad_credit(x) ∨ partial(x)

Prove hypothesis a: partial(Mr A)

Prove refutation ¬ a: ¬ partial(Mr A)

KB ^ ¬ a:

- (1) ¬unpaid_big(Mr A) ∨ reject(Mr A)
- (2) ¬bad_credit(Mr A) ∨ reject(Mr A)
- (3) ¬no_loan(Mr A) ∨ bad_credit(Mr A) ∨ approval(Mr A)
- (4) ¬unpaid_small(Mr A) ∨ bad_credit(Mr A) ∨ ~~partial(Mr A)~~ ∧ ~~¬partial(Mr A)~~

- (1) ¬unpaid_big(Mr A) ∨ reject(Mr A)
- (2) ¬bad_credit(Mr A) ∨ reject(Mr A)
- (3) ¬no_loan(Mr A) ∨ bad_credit(Mr A) ∨ approval(Mr A)
- ~~(4)~~ ¬unpaid_small(Mr A) ∨ ~~bad_credit(Mr A)~~ ∧ ~~¬bad_credit(Mr A)~~

- (1) ¬unpaid_big(Mr A) ∨ reject(Mr A)
- (2) ¬bad_credit(Mr A) ∨ reject(Mr A)
- (3) ¬no_loan(Mr A) ∨ bad_credit(Mr A) ∨ approval(Mr A)
- ~~(4)~~ ~~¬unpaid_small(Mr A)~~ ∧ ~~unpaid_small(Mr A)~~

- (1) ¬unpaid_big(Mr A) ∨ reject(Mr A)
- (2) ¬bad_credit(Mr A) ∨ reject(Mr A)
- (3) ¬no_loan(Mr A) ∨ bad_credit(Mr A) ∨ approval(Mr A)
- (4) {}

Refutation is unsatisfiable

Proof that hypothesis is true

- **Partial(Mr A)**

END OF ASSESSMENT PAPER