

This exam contains 5 pages (including this cover page) and 5 problems.

Check to see if any pages are missing.

Do not detach any question pages from the booklet.

Enter **all** requested information on the top of this page before you start the exam, and put your **initials** on the top of every page, in case the pages become separated.

Attempt **all** questions. Answer each question in the boxed space provided.

The following rules apply:

- **NO QUESTIONS DURING THE EXAM.**
- **If a question is ambiguous or unclear, then please write your assumptions and proceed to answer the question.**
- Only writings within the designated answer boxes will be graded. Plan your answers on the sketch paper provided.
- **Write in valid Rodin ASCII syntax** wherever required.
- Where descriptive answers are requested, use complete sentences and paragraphs. Be precise and concise.
- In writing a sequent proof, only one inference rule can be applied at a time.
- Whenever the **ARI** inference rule is used, justify in writing its use.
- **Organize your work**, in a reasonably neat and coherent way, in the space provided. Work scattered all over the page without a clear ordering will receive very little credit.
- **Mysterious or unsupported answers will not receive credit.** A correct answer, unsupported by calculations or explanation will receive no credit; an incorrect answer supported by substantially correct calculations and explanations might still receive partial credit.
- All answers must appear in the boxed areas in this booklet.

Do not write in this table which contains your raw mark scores.

Problem	Points	Score
1	10	
2	10	
3	10	
4	10	
5	20	
Total:	60	

1. Given a model (with static and dynamic parts), what are the factors determining the number sequents generated for invariant preservation?

[of 10 marks]

2. Justify whether or not the following statement is true:

A partial function is always a total function.

[of 10 marks]

3. Can the left sequent below be transformed to the two right sequents via OR-L?

$a + 1 > 5 \vee a + 1 = 5$ \vdash $a > 0$??	$a > 0$ \vdash $a + 1 > 5$
		$a > 0$ \vdash $a + 1 = 5$

[of 10 marks]

4. Consider the following action which intends to update the balance function $b \in ACCOUNT \rightarrow \mathbb{Z}$:

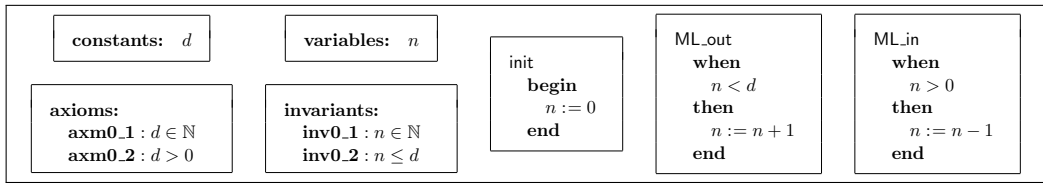
$$b(a) := b(a) + v$$

In valid Rodin ASCII syntax, rewrite the right-hand side of “becomes” operator using set and/or relational operators.

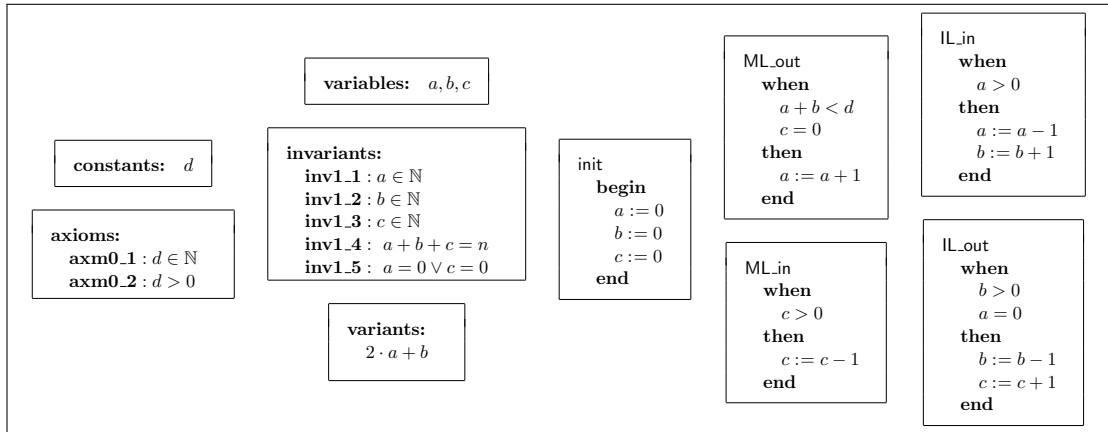
[of 10 marks]

5. Consider the following models of the bridge controller system:

m0: Initial Model



m1: First Refinement



Formulate and prove **ML_in/GRD**.

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