Problem Set 1: Inference and Soundness

Submit your responses as a single PDF file to gradescope before **8:29pm** on **Thursday, 23 January**.

You are strongly encouraged to start early and take advantage of the scheduled office hours for this course.

Collaboration and Resources Policy - Read Carefully
Remember to follow the course pledge you read and signed at the beginning of the semester.

For this assignment, you may discuss the problems and work on solutions with anyone you want (including other students in this class), but you must write your own solutions and understand and be able to explain all work you submit on your own.

To confirm your own understanding, after discussing the problems with others, you should attempt to write your solutions on your own without consulting any notes from group work sessions. If you get stuck, you may visit notes from the group work sessions, but should make sure you understand things well enough to produce it on your own. You may also use any external resources you want, with the exception of solutions and comments from last year's offering of this course.

Since the staff and students benefit from being able to both reuse problems from previous years, and from being able to provide detailed solutions to students, it is important that students do not abuse these materials even if it is easy to find them. Using solutions from last year's course would be detrimental to your learning in this course, and is considered an honor violation.

If you use resources other than the class materials, lectures, and course staff, you should document this and mention it clearly on your submission. For everyone other than the course staff you work with, you should credit them clearly on your assignment. If you use any AI tools like ChatGPT or Claude, you should explain how you used them and include a URL that links to a transcript of your interactions.

Preparation

This problem set focuses on Chapter 1 of the *MCS book* (but only covers material up to section 1.3), and Classes 1–3.

Directions

1. Follow the steps as in Problem Set 0 to create your own copy of the template in https://www.overleaf.com/read/vfmzgfghbsbh#023fd0.
2. Solve all the problems and put your responses in the clearly marked answer boxes. For full credit, your answers should be correct, clear, well-written, and convincing.
3. Before submitting, make sure to list your collaborators and resources by replacing the TODO in `\collaborators{TODO: replace ...}` with your collaborators and resources. Check the policy in the pink box on the front page to make sure you understand what you need to document here.
4. Replace the second line in ps0.tex, `\usepackage{dmt}` with `\usepackage[response]{dmt}` so the directions do not appear in your final PDF.
5. Download your complete ps1.pdf file, and submit it using gradescope.

Proofs and Certification

The introduction for the MCS book states:

> "Proofs also play a growing role in computer science; they are used to certify that software and hardware will *always* behave correctly, something that no amount of testing can do."

Problem 1 *Testing Software*

The statement suggests "no amount of testing can certify software will always behave correctly." Is this claim valid or invalid? Support your answer with a short justification.

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Problem 2 *Proofs and Guarantees*

The statement suggests “proofs can certify that software will always behave correctly.” Argue that this is not a correct statement.

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Problem 3 *Mysterious Boolean Operators*

Consider the three-input, one-output Boolean operation BIZ described by the truth table below:

P	Q	R	BIZ(P, Q, R)
true	**true**	**true**	**true**
true	**false**	**true**	**false**
true	**true**	**false**	**true**
true	**false**	**false**	**false**
false	**true**	**true**	**true**
false	**false**	**true**	**true**
false	**true**	**false**	**false**
false	**false**	**false**	**false**

(a) For any values for Q and R, what is the value of BIZ$(\mathbf{true}, Q, R)$?

(b) What would be a good name for the BIZ operator as defined above?

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Problem 4 *Useful Boolean Operators*

Use truth tables to show that for any propositions P, Q: $\text{NOT}(\text{OR}(P, Q)) = \text{AND}(\text{NOT}(P), \text{NOT}(Q))$.

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Problem 5 *Inference Rules*

For each candidate rule below, indicate whether or not the rule is sound. Support your answer with a convincing argument. The variables P, Q, and R are Boolean propositions (either true or false).

(a)
$$\frac{P, NOT(P)}{\text{Taylor Swift sings high notes like a pterodactyl with a head cold.}}$$

- ◯ Sound
- ◯ Not Sound
- ◯ Cannot be determined if it is sound or not sound

(b)
$$\frac{P \implies Q, Q \implies R}{R}$$

- ◯ Sound
- ◯ Not Sound
- ◯ Cannot be determined if it is sound or not sound

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(c) $\dfrac{\neg(\neg(P))}{P}$

- ◯ Sound
- ◯ Not Sound
- ◯ Cannot be determined if it is sound or not sound

(d) $\dfrac{P \implies \neg(P)}{Q \implies \neg(P)}$

- ◯ Sound
- ◯ Not Sound
- ◯ Cannot be determined if it is sound or not sound

End of Problem Set 1!
Remember to follow the instructions to prepare and submit your PDF.

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