

CS 511  
Formal Methods for High-Assurance Software Engineering  
*Homework Assignment 01*

Out: 4 September 2020  
Due: Friday, 11 September 2020, by 11:59 pm

A few administrative issues, before you start working on this assignment:

- You first need to open a Gradescope account, after which you need to add yourself to the CS511 roster for this semester. The entry code for CS511 Fall 2020 is: **9N6E68**.

If you want to read more on adding yourself to the CS511 roster, go to [Adding a Course](#) .

- Typeset your solutions with Latex and prepare a single ‘.pdf’ file containing all your solutions. Do not submit hand-written solutions. It is the ‘.pdf’ file that you will submit in Gradescope. You do not need to use any particular format in naming your ‘.pdf’ file, because Gradescope will keep track of who is submitting it. Nonetheless, it is nice to use suggestive names in case of a mishap and we need to recover your file. So, here is a possible naming:

`<your last name>_<your first name>.hw01.pdf`

For example, for myself, I would call my file ‘`kfoury_assaf.hw01.pdf`’.

- For full credit in the homework, you need to complete 4 out of 6 problems in this assignment. Each is worth 4 points. Of course, you may want to try all 6 problems. You will get credit for all extra exercises you do (correctly!).

**Problem 1** The Boolean majority function over three variables  $\{x, y, z\}$  returns *true* if at least two of the three variables are assigned *true*, and returns *false* otherwise.

1. Write a DNF (Disjunctive Normal Form)  $\varphi$  of the majority function over three variables  $\{x, y, z\}$ .
2. Write a CNF (Conjunctive Normal Form)  $\psi$  of the majority function over three variables  $\{x, y, z\}$ .
3. Write a script to certify with Z3 that  $\varphi$  and  $\psi$  define the same function, *i.e.*, the wff  $\varphi \leftrightarrow \psi$  is a tautology. Your script should use the three variables  $\{x, y, z\}$  and start with the declarations:

```
(declare-const x Bool)
(declare-const y Bool)
(declare-const z Bool)
```

4. Write a script to certify with Z3Py that  $\varphi$  and  $\psi$  define the same function. Your script should use the three variables  $\{x, y, z\}$  and start with the declarations:

```
x, y, z = Booleans ('x y z')
```

**Remark 1:** You will easily find the answers for **Problem 1** by searching the Web. It is perfectly acceptable if you search for the answers, but make sure the answers you find are correct (they are often wrong on the Web!).

**Remark 2:** In parts 3 and 4, we ask you to write the scripts only, we do not ask you to execute the scripts. But of course, if you wish, you may decide to also execute them to make sure they are bug-free, before inserting them in your Latex source file. In the Latex source file, you should insert each of your scripts inside a `verbatim` environment, *i.e.*, insert them between `\begin{verbatim}` and `\end{verbatim}`.

**Problem 2** [LCS, page 80]: Exercise 1.2.5, parts (a), (c), and (d), only – omit part (b).

*Hint:* You have to formally deduce the propositional formulas in each of (a), (c), and (d), using the rules of natural deduction. The examples worked out in Lecture Slides 02 may help you.

**Problem 3** [LCS, page 81]: Exercise 1.2.8.

**Problem 4** [LCS, page 86]: Exercise 1.4.9.

**Problem 5** [LCS, page 87]: Exercise 1.5.3.

**Problem 6** [LCS, page 87]: Exercise 1.5.4.