CS 511
Formal Methods for High-Assurance Software Engineering
Homework Assignment 12

Out: 22 November 2024
Due: Thursday, 5 December 2024, by 11:59 pm

Repeated below are administrative issues already mentioned in the handout of Assignment 01:

- You 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 2023, is `WWX2NW`.

  If you want to read more on adding yourself to the CS511 roster, go to Adding a Course .

- You also need to create a *GitHub repository* where you store your solutions for *coding exercises with* Lean_4.

  To create a GitHub repository, you need to open a GitHub account. Instructions for how to do this are at the following webpages: Set Up a GitHub Account and Create a GitHub Repository.

- Typically, each weekly assignment consists of two parts:

  1. One part includes ***hand exercises***, *i.e.* ***pencil-and-paper exercises***, and
  2. One part includes ***coding exercises*** in Lean_4.

  And each of the two parts will consist of:

  - **2 easy exercises**, and
  - **1 demanding exercise**, which we will call a **problem**,

  for a total of **4 easy exercises** and **2 problems** in each weekly assignment.

- Typeset your solutions with Latex to produce a single '`.pdf`' file containing:

  1. All your solutions for the ***hand exercises***, and
  2. Links to your ***coding exercises***, which are stored in your GitHub repository. (You should insert the links as active, *i.e.* clickable, *hyperlinks* in your '`.pdf`' file.)

  It is the '`.pdf`' file produced with Latex 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`'.

This homework assignment is a little longer than usual because you have two weeks to complete it.

1 By Hand

The three exercises are from **Lecture Slides 32**, "Second-Order Logic".

Exercise 1 Do the exercise on page 42. □

Exercise 2 Do **both parts** of the exercise on page 47. □

Exercise 3 Do **part 1 only** of the exercise on page 50. □

PROBLEM 1 Open **[LCS, page 165]**: Do parts (a), (b), and (c) only in Exercise 2.6.5.

Hint: Part (c) is already done in **Lecture Slides 32**, pp 20-24. You may want to do it differently! □

2 With Lean_4

Exercise 4 From Macbeth's book:

1. Exercise 6.4.3.1 . □

Exercise 5 From Macbeth's book:

1. Exercise 9.1.10.1 ,
2. Exercise 9.1.10.2 ,
3. Exercise 9.1.10.3 . □

Exercise 6 From Macbeth's book:

1. Exercise 9.1.10.6 ,
2. Exercise 9.1.10.7 ,
3. Exercise 9.2.8.5 . □

PROBLEM 2 From Macbeth's book:

1. Exercise 9.2.8.6 ,
2. Exercise 9.3.6.1 . □