CS 511
Formal Methods for High-Assurance Software Engineering
Homework Assignment 10

Out: 8 November 2024
Due: Thursday, 14 November 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`'.

1 By Hand

Exercise 1 Open **Lecture Slides 24**, "Deductive Closure and First-Order Theories", page 7: Carefully answer the question highlighted in green.

Hint: An appropriate answer should take no more than 4-5 lines. You will find it helpful to read the preceding pages in the same set of slides. □

Exercise 2 Open **EML.Chapter_6.pdf**: Do Exercise 109 on page 65.

Hint: There is some reading to do in this exercise, but the answers are straightforward. Correct answers for parts 1, 2, and 3, are each no more than a single line. An appropriate answer for part 4 invokes Compactness and can be written in three or four lines. □

PROBLEM 1 Open **EML.Chapter_6.pdf**: Do part 1 and part 2 only of Exercise 108 on page 64. You do not need to do part 3 of that exercise. □

2 With Lean_4

Exercise 3 From Macbeth's book:

1. Exercise 8.1.13.2 ,
2. Exercise 8.1.13.3 ,
3. Exercise 8.1.13.5 . □

Exercise 4 From Macbeth's book:

1. Exercise 8.1.13.8 ,
2. Exercise 8.1.13.9 ,
3. Exercise 8.1.13.11 . □

PROBLEM 2 From Macbeth's book:

1. Exercise 8.1.13.13 ,
2. Exercise 8.1.13.14 ,
3. Exercise 8.1.13.16 . □

We will post an appropriate Lean 4 template for this homework on Piazza by the end of Friday, November 1 (today). □