Homework 0

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Reading

1. (Required) Mitchell, Chapters 1–2.

2. (Recommended) "Why Undergraduates Should Learn the Principles of Programming Languages", 2011.

   An overview of why PL is worth studying and what the course objectives are. Draft Available on the course web page.

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Homework Submission Instructions

You submitted homeworks should:

- include your ID number at the top,
- be turned at the beginning of class on the due date,
- be clearly written or typed,
- include source code print outs for questions involving programming (in later weeks),
- list any students with whom you discussed the problems (see Honor Code below), and
- be stapled, with your answers clearly marked and in the same order as the questions.

Homework not satisfying these requirements will be penalized. I will not accept homework by email.

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Problems

Q1. (5 points) ..................................................... Anonymous Grading ID

Each of you will be given a unique ID number so that we can grading can be done anonymously. You should use this number in place of your name on all submitted work. Your number is:

(The above space will include a number on the paper copies handed out in class.)

Please register your id number with me using the following GoogleDocs form, which is also reachable via the class web page:

https://goo.gl/forms/tHXDLm61KPCIXG9h1
Q2. (10 points) ................................. Partial and Total Functions

For each of the following function definitions, give the graph of the function. Say whether this is a partial function or a total function on the integers. If the function is partial, say where the function is defined and undefined.

For example, the graph of \( f(x) = \text{if } x > 0 \text{ then } x + 2 \text{ else } x/0 \) is the set of ordered pairs \( \{(x, x + 2) \mid x > 0\} \). This is a partial function. It is defined on all integers greater than 0 and undefined on integers less than or equal to 0.

Functions:

(a) \( f(x) = \text{if } x + 2 > 3 \text{ then } x \times 5 \text{ else } x/0 \)
(b) \( f(x) = \text{if } x < 0 \text{ then } 1 \text{ else } f(x - 2) \)
(c) \( f(x) = \text{if } x = 0 \text{ then } 1 \text{ else } f(x - 2) \)

Q3. (10 points) ................................. Deciding Simple Properties of Programs

Suppose you are given the code for a function \( Halt_\emptyset \) that can determine whether a program \( P \) requiring no input halts. Can you solve the halting problem using \( Halt_\emptyset \)?

To be more precise, suppose I give you a Java function

\[
\text{boolean Halt}_\emptyset(\text{string program})
\]

where calling the function with the source code for program \( P \) has the following behavior:

- \( Halt_\emptyset(P) \) returns true if program \( P \) will halt without reading any input when executed.
- \( Halt_\emptyset(P) \) returns false if program \( P \) will not halt when executed.

You should not make any assumptions about the behavior of \( Halt_\emptyset \) on arguments that do not consist of a syntactically correct program.

Can you write a Java program \( \text{Halt} \) that reads a program text \( P \) as input, reads an integer \( n \) as input, and then decides whether \( P \) halts when it reads \( n \) as input? Such a \( \text{Halt} \) program would have the following form, and it would print “yes” if \( P \) halts when it runs and reads input \( n \) and “no” if \( P \) does not halt when it runs and reads input \( n \):

\[
\text{void Halt}() 
\{
\quad P = \text{readString}();
\quad n = \text{readInteger}();
\quad \ldots
\}
\]

You may assume that any program \( P \) read by your program begins with a statement that reads a single integer from standard input, and then performs operations \( Q \). That is, all \( P \) read at the start of your \( \text{Halt} \) function will have the form

\[
\text{x = readInteger(); } Q
\]

where \( Q \) is the rest of the program text, and \( Q \) does not perform any input.

If you believe that the halting problem can be solved if you are given \( Halt_\emptyset \), then explain your answer by describing how a program solving the halting problem would work. To do this, just describe what replaces \( \ldots \) in the \( \text{Halt} \) program definition above. If you believe that the halting problem cannot be solved using \( Halt_\emptyset \), then explain briefly why you think not.