Homework 0

Reading

1. **(Required)** Mitchell, Chapters 1–2.


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

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.

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/tHxDLM6lKPCiXG9h1](https://goo.gl/forms/tHxDLM6lKPCiXG9h1)
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 \( f(x) = \begin{cases} x + 2 & \text{if } x > 0 \\ x/0 & \text{else} \end{cases} \) is the set of ordered pairs \( \{ (x, x + 2) | x > 0 \} \). 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) \( f(x) = \begin{cases} x + 2 & \text{if } x > 3 \\ x \times 5 & \text{else} \end{cases} \)
(b) \( f(x) = \begin{cases} x & \text{if } x < 0 \\ 1 & \text{else} \end{cases} f(x - 2) \)
(c) \( f(x) = \begin{cases} 1 & \text{if } x = 0 \\ 1 & \text{else} \end{cases} f(x - 2) \)

Q3. (10 points) Deciding Simple Properties of Programs

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

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

```java
boolean Halt\_\emptyset(String program)
```

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

\( \text{Halt}_\emptyset(P) \) returns true if program \( P \) will halt without reading any input when executed.
\( \text{Halt}_\emptyset(P) \) returns false if program \( P \) will not halt when executed.

You should not make any assumptions about the behavior of \( \text{Halt}_\emptyset \) 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 \( n \):

```java
void Halt() {
    String P = readString();
    int n = readInteger();
    ....
}
```

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

```java
int x = readInteger(); \quad 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 \( \text{Halt}_\emptyset \), then explain your answer by describing how a program solving the halting problem would work. To do this, just describe what replaces \( .... \) in the \( \text{Halt} \) program definition above. If you believe that the halting problem cannot be solved using \( \text{Halt}_\emptyset \), then explain briefly why you think not.