

Homework 1

Due Friday, 9/12/08

Please turn in your homework solutions at the beginning of class.

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

2. (20 points) **Deciding Simple Properties of Programs**

Suppose you are given the code for a function Halt_\emptyset that can determine whether a program P that requires no input halts. To be more precise, assume that you are writing a C or Java program that reads in another program P as a string. Your program is allowed to call Halt_\emptyset with the string P as an argument. A call to $\text{Halt}_\emptyset(P)$ 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 Halt_\emptyset on arguments that do not consist of a syntactically correct program.

Can you solve the halting problem using Halt_\emptyset ? More specifically, can you write a program 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 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 ?

```
P = readString();
n = readInteger();
...
```

You may assume that any program P you are given begins with a read statement that reads a single integer from standard input. Thus P has the form

```
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_θ , then explain your answer by describing how a program solving the halting problem would work. To do this, just describe what replaces ... in the Halt program definition above – there is no need to write the program out fully. If you believe that the halting problem cannot be solved using Halt_θ , then explain briefly why you think not.

3. (10 points) **Background**

Consider the programming language that you have used the most. Answer the following questions about it:

- (a) Describe two programming errors that the compiler identifies and reports while compiling a program in that language.
- (b) Describe two programming errors that can cause your program to halt with an error message or crash after you compile and start to run it.
- (c) What do you find to be the most difficult aspect of writing and debugging programs in that language?
- (d) Does the language have any features that you rarely or never use? If so, why do you not use them?