CSI 30 LECTURE NOTES (Ojakian)

Topic 8: Algorithms

OUTLINE
(References: 3.1)

1. Algorithms/programs

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1. Algorithms

   (a) An algorithm is a finite set of precise instructions for performing a computation.

   (b) Example: multiplication, division, etc.

   (c) Example (dumb): Given any input positive integer, repeatedly subtract 1 till the value is zero, then stop and return the current value (i.e. zero ...)

2. Basic Programming Constructs

   (a) Use pseudo code or actual code.

   (b) Assignment statements

   (c) Basic data structure: Lists

   (d) Conditional statements

   (e) For Loops

   (f) While Loops

   (g) Functions with return statement

3. Algorithms

   PROBLEM 1. *Supposing x and y are set to integers. Set z to the larger of x or y.*

   PROBLEM 2. *Write the definition of a function which takes an integer n as input and returns n if n is negative, 0 if n is zero, and $-n$ if n is positive (do with with a conditional statement, and without). Graph it.*

   PROBLEM 3. *Write the definition of a function which takes two arguments, the first a negative integer s and the second a positive integer t. The function returns the sum of the even integers inbetween s and t (including s and t).*

   PROBLEM 4. *Do one of the above for-loop questions with a while loop.*

4. Programs Instead of Proofs?

   (a)

   PROBLEM 5. *What do you think the sum of consecutive integers should be? Write a program to test your hypothesis.*

   PROBLEM 6. *Write program to test the claim: The sum of evens is even (test all pairs of evens up to 100)*

   (b) Do our programs prove the claim? What are the issues?

5. Harder Questions...

   (a) Are there infinitely many prime numbers?
   (b) Are there infinitely many twin primes?
   (c) Test your hypothesis with a program.

6. Proofs on program correctness

   (a) One kind of question: Does the program always terminate?
   (b) Second kind of question: Given some initial assertion, verify some final assertion.

   PROBLEM 7. *Consider the following program:*

```
y = 5
if y <= 5:
    z = x + 2*y
else:
    z = x - 2*y
```

   Suppose the initial assertion is that $x = 3$. Then prove the final assertion that $z = 13$.

   PROBLEM 8. *Consider the following program:*

```
x = 0
for k in range(1, n+1):
    x = x + 2*k
```

   Suppose the initial assertion is that $n = 100$. Then prove the final assertion that $x = 10100$.

   PROBLEM 9. *Consider the following program:*

```
while x < 10000:
    if x % 7 == 0:
        x = x + 1
    else:
        x = x + 3
```

   Prove that whatever integer the initial value of x is, the program terminates.

7. Classic Issues

   (a) Linear search versus binary search
   (b) Sorting: Bubble Sort and Insertion Sort

8. Exercises

   Section 3.1: 3, 4*, 13, 14, 16*, 19, 23, 24*

   (where * means maybe hard ..)