CPSC-354 Report

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Abstract

Placeholder

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Placeholder

2 Homework

2.1 Week 1

```python
def numInput():
    while True:
        numStr = input("Enter a number: ")
        try:
            num = int(numStr)
            if num > 0:
                return num
            else:
                print("The number must be greater than 0.")
                continue
        except:
            print("Invalid input.")

def gcd(numA, numB):
    if (numA > numB):
        result = gcd(numA-numB, numB)
    elif (numA < numB):
        result = gcd(numA, numB-numA)
    else:
        result = numA
    return result

# Main
numA = numInput()
print("First number acquired.")
numB = numInput()
print("Second number acquired.")

result = gcd(numA, numB)
print("The GCD of " + str(numA) + " and " + str(numB) + " is: " + str(result) + ".")
```

I chose to write my GCD program in Python.

The numInput function first gets inputs from the user and makes sure that they are valid inputs to perform the gcd function on. The while loop traps the user until they input a valid non-zero integer. This repeats twice to obtain two numbers.

After that, the two numbers are put into the gcd function. If number A is greater than number B, it recursively calls on the function again to find the GCD between the difference of A and B and number B. If number B is greater than number A, it recursively calls on the function again to find the GCD between number A and the difference of B and A. This repeats until the two numbers being compared are equal, after which the function returns the equal number. This equal number is the GCD of the two given numbers. This recursive function works because the method of subtraction will repeatedly lower the numbers until they inevitably equal out to yield a result.

2.2 Week 2

```haskell
select_evens [] = []
select_evens (x:xs) | length (x:xs) >= 2 = (head xs) : (select_evens (tail xs))
                    | length (x:xs) == 1 = []
                    | otherwise = x:xs

select_odds [] = []
select_odds (x:xs) | length (x:xs) >= 1 = x : (select_odds (tail xs))
```

```
                | otherwise = x:xs

member i [] = False
member i (x:xs) | i == x = True
                | otherwise = member i xs

append [] [] = []
append xs [] = xs
append [] ys = ys
append xs ys = head xs : (append (tail xs) ys)

revert [] = []
revert xs = append (revert (tail xs)) (head xs : [])

less_equal [] [] = True
less_equal xs [] = False
less_equal [] ys = True
less_equal xs ys | head xs <= head ys = less_equal (tail xs) (tail ys)
                 | otherwise = False
```

For my select evens function, I set the base case to return an empty list. The recursive function has 3 cases. In the first case, provided the given list has a length of 2 or greater, the head of the list xs is taken as the first element of the list. This is the second element of the given list because x is the head of list x:xs. After that the tail of the list xs is put back into select evens, which removes the first two elements from the list x:xs. In the second case, if the length of the list is 1, it also returns an empty list. Otherwise, it just returns the given list.

```
select_evens [1,2,3,4,5] =
   2 : (select_evens [3,4,5]) =
   2 : 4 : (select_evens [5]) =
   2 : 4 : [] =
   [2,4]
```

My select odds function is similar to my select evens function, with a base case of an empty list. If the length of the given list is greater than or equal to 1, the head of list x:xs, which is the value x, is taken as the first element of the list. The tail is then passed back into select odds for the same reasons as the select evens function. If the length is too short, it returns the given list.

```
select_odds [1,2,3,4,5] =
   1 : (select_odds [3,4,5]) =
   1 : 3 : (select_odds [5]) =
   1 : 3 : 5 : [] =
   [1,3,5]
```

The member function returns a base case of False given any input with an empty list. When given a list, as long as the list is greater than or equal to 1, it checks to see if the given input value matches the head of the given list. If it matches, it returns true, otherwise, it passes the tail of the list back into the member function.

```
member 3 [1,2,3,4,5] =
   member 3 [2,3,4,5] =
   member 3 [3,4,5] =
   True
```

When given an empty set of lists, the append function returns an empty list. If only one of the given lists is

empty, it returns the non-empty list. When given two non-empty lists, the head of the first list is taken as the first element of the list. It is attached to the resulting list from appending the tail of the first list with the whole of the second list. Eventually, this empties out the first list, which will cause the entirety of the second list to be appended onto the elements of the first list.

```
append [1,2,3] [4,5,6] =
   1 : (append [2,3] [4,5,6]) =
   1 : 2 : (append [3] [4,5,6]) =
   1 : 2 : 3 : (append [] [4,5,6]) =
   1 : 2 : 3 : [4,5,6] =
   [1,2,3,4,5,6]
```

The base case of the revert function returns an empty list when given an empty list. When given a non-empty list, the revert function uses the previous append function to create a new list where the head of the given list is placed at the back. The remaining list elements are passed back into the revert function, which will result in a list where the elements are in reversed order.

```
revert [1,2,3,4,5] =
   (append (revert [2,3,4,5])) : 1 : [] =
   (append (revert [2,3,4,5])) : [1] =
   (append (revert [3,4,5])) : 2 : [] : [1] =
   (append (revert [3,4,5])) : [2] : [1] =
   (append (revert [4,5])) : 3 : [] : [2] : [1] =
   (append (revert [4,5])) : [3] : [2] : [1] =
   (append (revert [5])) : 4 : [] : [3] : [2] : [1] =
   (append (revert [5])) : [4] : [3] : [2] : [1] =
   (append (revert [])) : 5 : [] : [4] : [3] : [2] : [1] =
   (append (revert [])) : [5] : [4] : [3] : [2] : [1] =
   [] : [5] : [4] : [3] : [2] : [1] =
   [5,4,3,2,1]
```

When the two lists given to the less equal function are both empty, the function returns a true. If the first list is non-empty but the second list is, the function returns false. If the second list is non-empty but the first one is, the function returns true. If both lists are non-empty lists, the head of both lists is compared to one another. If the head of the first list is less than or equal to the second list, the function continues by passing on the tails of both lists back into itself. Otherwise, if the head of the first list is greater than the head of the second list, the function stops and returns a false.

```
less_equal [1,1,4] [1,2,3] =
   less_equal [1,4] [2,3] =
   less_equal [4] [3] =
   False
```

2.3 Week 3

```
hanoi 5 0 2
   hanoi 4 0 1
      hanoi 3 0 2
         hanoi 2 0 1
            hanoi 1 0 2 = move 0 2
            move 0 1
            hanoi 1 2 1 = move 2 1
         move 0 2
```

```
      hanoi 2 1 2
         hanoi 1 1 0 = move 1 0
         move 1 2
         hanoi 1 0 2 = move 0 2
   move 0 1
   hanoi 3 2 1
      hanoi 2 2 0
         hanoi 1 2 1 = move 2 1
         move 2 0
         hanoi 1 1 0 = move 1 0
      move 2 1
      hanoi 2 0 1
         hanoi 1 0 2 = move 0 2
         move 0 1
         hanoi 1 2 1 = move 2 1
move 0 2
hanoi 4 1 2
   hanoi 3 1 0
      hanoi 2 1 2
         hanoi 1 1 0 = move 1 0
         move 1 2
         hanoi 1 0 2 = move 0 2
      move 1 0
      hanoi 2 2 0
         hanoi 1 2 1 = move 2 1
         move 2 0
         hanoi 1 1 0 = move 1 0
   move 1 2
   hanoi 3 0 2
      hanoi 2 0 1
         hanoi 1 0 2 = move 0 2
         move 0 1
         hanoi 1 2 1 = move 2 1
      move 0 2
      hanoi 2 1 2
         hanoi 1 1 0 = move 1 0
         move 1 2
         hanoi 1 0 2 = move 0 2
```

These instructions count the leftmost pole as the Pole 1, the middle pole as Pole 2, and the rightmost pole as Pole 3.

Move the top disk from Pole 1 to Pole 3. Next, move the next top disk from Pole 1 to Pole 2. Take the top disk from Pole 3 and move it to Pole 2. Then, move the top disk from Pole 1 to Pole 3. Follow by moving the top from Pole 2 to Pole 1. Then, move the top disk from Pole 2 to Pole 3. Afterwards, move the top disk from Pole 1 to Pole 3. Move the next top disk from Pole 1 to Pole 2. Next, take the top disk from Pole 3 and move it to Pole 2. Take the next top disk from Pole 3 and move it to Pole 1. Then, take the top disk from Pole 2 and move it to Pole 1. Follow by moving the top disk from Pole 3 to Pole 2. Next, move the top disk from Pole 1 to Pole 3. Then, move the next top disk from Pole 1 to Pole 2. Return to the top disk of Pole 3 and move it to Pole 2. Now, take the top disk of Pole 1 and move it to Pole 3. Next, take the top disk from Pole 2 and move it to Pole 1. Then, take the top disk from Pole 2 and move it to Pole 3. Follow by taking the top disk from Pole 1 and moving it to Pole 3. Return to Pole 2 and move its top disk to Pole 1. Now, take the top disk from Pole 3 and move it to Pole 2. Next, take the top disk from Pole 3 and move it to Pole 1. Then, take the top disk from Pole 2 and move it to Pole 1. Take the next top disk from Pole 2 and move it to Pole 3. Now, take the top disk from Pole 1 and move it to Pole 3. Return to the next top

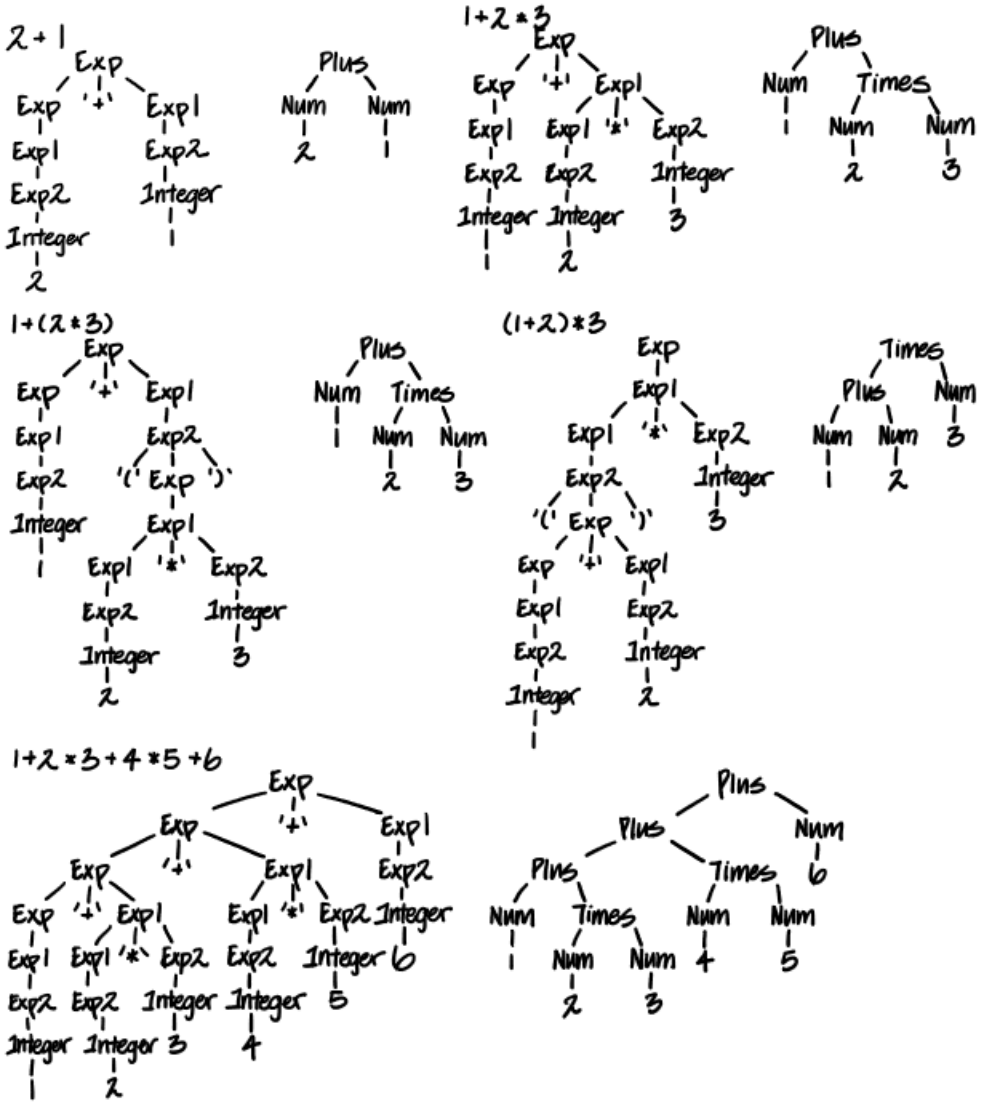
disk from Pole 1 and move it to Pole 2. Then, take the top disk from Pole 3 and move it to Pole 2. Next, take the top disk from Pole 1 and move it to Pole 3. Then, take the top disk from Pole 2 and move it to Pole 1. Move the next top disk from Pole 2 to Pole 3. Then, take the top disk from Pole 1 and move it to Pole 3. A 5-disk Tower of Hanoi has now been successfully moved from Pole 1 to Pole 3.

The word hanoi appears 31 times in the computation.

$$\text{hanoi}(1)(x)(y) = \text{move}(x)(y)$$

$$\begin{aligned}\text{hanoi}(n+1)(x)(y) &= \text{hanoi}(n)(x)(\text{other}(x)(y)) \\ &= \text{move}(x)(y) \\ &= \text{hanoi}(n)(\text{other}(x)(y))(y)\end{aligned}$$

2.4 Week 4



2.5 Week 5

Placeholder

2.6 Week 6

```
(\exp . \two . \three . exp two three)
(\m.\n. m n)
(\f.\x. f (f x))
(\f.\x. f (f (f x)))
=
((\m.\n. m n) (\f.\x. f (f x)) (\f2.\x2. f2 (f2 (f2 x2))))
=
((\n. (\f.\x. f (f x)) n) (\f2.\x2. f2 (f2 (f2 x2))))
=
(((\f.\x. f (f x)) (\f2.\x2. f2 (f2 (f2 x2)))))
=
(((\x. (\f2.\x2. f2 (f2 (f2 x2))) ((\f2.\x2. f2 (f2 (f2 x2))) x))))
=
(((\x. (\x2. ((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2
    x2))) x) x2))))))
=
(((\x. (\x2. ((\x2. x (x (x x2)))) (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x)
    x2))))))
=
(((\x. (\x2. (\x2. x (x (x x2))) (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x)
    x2))))))
=
(((\x. (\x2. (x (x (x (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))))))
=
(((\x. (\x2. (x (x (x (((\x2. x (x (x x2)))) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))))))
=
(((\x. (\x2. (x (x (x ((\x2. x (x (x x2))) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))))))
=
(((\x. (\x2. (x (x (x ((x (x (x (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))))))))
=
(((\x. (\x2. (x (x (x ((x (x (x (((\x2. x (x (x x2))) x) x2)))))))))))
=
(((\x. (\x2. (x (x (x ((x (x (x (((x (x (x x)))) x2)))))))))))
=
((\x. (\x2. (x (x (x (x (x (x ((x (x (x x))) x2)))))))))
```

2.7 Week 7

In lines 5-7 the variables e1 and e2 are bound by evalCBN with the scope being the body of the evalCBN function. The variables i and e3 are free. In lines 18-22 the variables id1, e1, and s are bound by subst with the scope being body of the subst function. The variables f and e2 are free.

```
evalCBN (\x.x)((\y.y)a) = line 6
evalCBN ((\y.y)a) = line 7
evalCBN (a) = line 8
a
```

```
evalCBN (\x.\y.x) y z = line 6
evalCBN (\y.y) z = line 7
evalCBN (z) = line 8
z
```

Placeholder [Re-add trees later]

2.8 Week 8

This ARS does not terminate because the rules ba -¿ ab and ab -¿ ba will loop with each other infinitely.

The normal forms of this ARS are a and b because those two cannot be reduced any further than their current form.

No, because adding unique normal forms would break the looping equivalency relations caused by the rules ba -¿ ab and ab -¿ ba.

The existint normal forms of a and b reduce duplicates into into singular forms. The ARS as a whole is a reversing function that will reverse a given string while reducing its duplicates.

2.9 Week 9

For my project, the two major parts will be the list generating functions and the list arithmetic functions. I will give myself the deadline of November 13th to complete the 4 list generating functions (triangle, cube, square, and fibonacci). Then, I will give myself the deadline of December 4th to complete the list artihmetic functions, but at this point they will only work with lists of the same length. I suspect that my method of augmenting lists in order to perform arithmetic between lists of different lengths will need time. Therefore, I will give myself until December 11th to figure out how to make lists of different lengths compatible in my arithmetic functions. This will give me all of finals week to do any finishing touches and complete the report details.

The ruleset is nonterminating because the first half of the rules can be used to form an infinite loop. It is non-confluent because diverging paths taken will not meet back up, there is no way to form compatible peaks and valleys. It does not have unique normal forms because while everything does have reducible forms, there are multiple ways to reduce to b or an empty list, making them non-unique.

The invariants are:

length

number of a's

number of b's

number of c's

number of a's = number of b's = number of c's

number of a's + number of c's = number of b's

I feel like there's more after this but I'm stumped.

2.10 Week 10

Placeholder

2.11 Week 11

Questions and answers to questions surrounding this paper:

https://www.cs.tufts.edu/ nr/cs257/archive/simon-peyton-jones/contracts.pdf

Q (From myself): How would this handle contracts with multiple conditions that would affect one another and, in turn, affect the outcome of the contract? Often contracts come with many overlapping conditions that are difficult for an ordinary, non-lawyer person to parse. In such scenarios, how would one teach a computer to interpret such conditions? Would it be possible to establish something like a universal default PEMDAS hierarchy for your conditions, in which case how flexible should the language be in allowing the user to alter the hierarchy when making their contract?

Q (From Marc Domingo): Do the benefits of designing/creating a Domain Specific Language specifically for financial contracts outweigh representing financial contracts by abstracting and extending them through a template class containing values and functions in a high-level programming language?

A: Having a language specifically tailored for this purpose could help with being able to provide a more specialized tool to construct contracts with. For example, you could technically build a database using high level programming languages, but it would be better to use a specialized language for it, e.g., SQL, because of how it is already built to handle databases. Similarly, even though you could build a method of handling contracts through a high-level programming language, it could be more helpful to have a specialized language for it that is already built to handle a lot of the common cases that you will encounter in your work.

Q (From Cole Matsueda): How do Combinator Libraries and DSL's take into account for human behavior/-constraints? (Late payments, partial payments)

A: Human factors would definitely muddy the waters, particularly in cases where the factors at play are very vague and much more difficult to enforce. Late or partial payments would be a problem that could be solved with good default cases like Cecilia mentioned as well as integrating a more complex web of how conditions in a contract can work. However, in cases such as an NDA, it would be very difficult to encode that into a language on account of how difficult it would be for a computer to understand whether or not the concept protected by the NDA has been leaked or not.

3 Project

Placeholder

3.1 Specification

I want to make a program involving infinite lists in Haskell in order to generate lists of variable size and manipulate them. There are a variety of sequences in math similar to the Fibonacci sequence, and I will implement them as separate functions. The sequences being implemented will be arithmetic, geometric, triangular, square, cube, and Fibonacci.

Triangle, cube, square, and Fibonacci will work by taking in 1 integer number and generating a list of the sequence with the length of the given integer. For example, (fib 5) would generate a list containing the first 5 Fibonacci numbers. Arithmetic and geometric will take in 3 integer numbers. The first integer works the same as the other sequences, where it dictates the list's length. The 2nd number will be the first entry of the list and the 3rd number will be the number added to each entry. For example, (arit 3 1 6) will produce the list [1, 7, 13]. In geometric, the 2nd number works the same but 3rd number will be the number multiplied against the given value to continue the list. For example, (geo 3 1 6) will produce the list [1, 6, 36].

These lists can have mathematical operations performed between them, which will result in a new list. The available operations will be addition, subtraction, multiplication, and integer division. When performing mathematical operations between lists of different lengths, the resulting list will be the length of the longer

list. The shorter list will be extended with 0 values to fill it out to match the length of the longer list. For example, adding the lists [2, 4, 8, 16] and the list [1, 2, 3] will be the same as adding the lists [2, 4, 8, 16] and [1, 2, 3, 0], resulting in the list [3, 6, 11, 16].

3.2 Prototype

Placeholder

3.3 Documentation

Placeholder

3.4 Critical Appraisal

Placeholder

4 Conclusions

Placeholder

References

[PL] Programming Languages 2022, Chapman University, 2022.