

# Homework 3

Due Sunday, October 2 by 10:00pm

Handout 8  
CSCI 334: Fall 2022

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## Turn-In Instructions

Each question in this assignment must be written using  $\LaTeX$ . I provide a  $\LaTeX$  template in your repository for you to use to get started.

It is likely that you have not used  $\LaTeX$  before. Treat it like you would when learning any other programming language: make small changes and compile frequently. The template I provide should compile successfully without modification. Please note that for full credit, you must submit both your `.tex` source file as well as the rendered `.pdf` file. (5 points) Your source file should be called `lab-3.tex` and your PDF should be called `lab-3.pdf`. (5 points)

Note that your submission must be completed entirely using  $\LaTeX$ . To draw trees, please use the `forest` package. The supplied  $\LaTeX$  template includes an example for you to start with and modify.

Turn in your work using the Gitlab repository assigned to you. The name of the Github repository will have the form `https://evolene.cs.williams.edu/cs334-f22/<YOUR_USERNAME>/lab02.git`. For example, if your CS username is `22abc1`, the repository would be `https://evolene.cs.williams.edu/cs334-f22/22abc1/lab02.git`.

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## Honor Code

This is a solo lab. You may study with another classmate if you wish, however you are not permitted to share solutions. Your work must be exclusively your own. Please refer to the section “single author programming assignments” in the honor code handout for additional information. You are always welcome to ask me for clarification.

This assignment is due on Sunday, October 2 by 10:00pm.

**Sanity Check:** Students sometimes submit incomplete assignments, accidentally forgetting to run `git add` for all of their files. Fortunately, there is an easy way to make sure that this does not happen to you. Before you are done, `git clone` your repository to a new folder and then try building/running everything. It only takes a couple minutes and can spare you from headaches later on.

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## Reading

1. (Required) “Introduction to the Lambda Calculus, Part 1”
2. (Required) “Grammars and Parse Trees”
3. (Required) “Introduction to  $\LaTeX$ ”

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## Problems

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**Q1.** (30 points) ..... Parse Tree

Draw the parse tree for the derivation of the expression “ $1 - 5 + 24$ ”. Is there another derivation for “ $1 - 5 + 24$ ”? If so, draw the other parse tree. Refer to the grammar on the bottom of the first page of the reading “Grammars and Parse Trees.”

**Q2.** (30 points) ..... Parsing and Precedence

Draw parse trees for the following expressions, assuming the grammar and precedence described in Example 4.2 of the reading “Grammars and Parse Trees”:

(a)  $1 + 1 * 1$

(b)  $1 + 1 - 1$

(c)  $1 - 1 + 1 - 1 * 1$ , if + is given higher precedence than -.

**Q3.** (30 points) ..... Parsing Lambda Expressions

Given the following grammar for the lambda calculus,

```
<expression> ::= <variable>
               | <abstraction>
               | <application>
               | <parens>

<variable>    ::= x | y
<abstraction> ::=  $\lambda$ <variable>.<expression>
<application> ::= <expression><expression>
<parens>      ::= (<expression>)
```

draw parse trees for the following expressions.

(a)  $\lambda x.xy$

(b)  $\lambda x.x\lambda y.xx$

(c)  $(\lambda x.\lambda y.xy)(\lambda x.xy)$

**Q4.** ( $\frac{1}{10}$ <sup>th</sup> bonus point) ..... Optional: Feedback

I always appreciate hearing back about how easy or difficult an assignment is.

For  $\frac{1}{10}$ <sup>th</sup> of a bonus to your final grade, please fill out the following Google Form.