Introduction to Lab #2

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General Intro to 229 Labs

- In 229, a “lab” is a programming assignment:
  - A lab requires many more hours of work than the time allocated for lab sessions.
  - Lab sessions are “consulting hours” when TAs are available to answer questions and to help.
  - Reading/work prior to the lab date/time is essential.
  - The lab assignments will be progressively more difficult, and will require more time as the term advances.

- A CMPUT 229 lab is not a “lab” in the sense of a chemistry lab.

The `calculator` Program

Write a RISC-V assembly program that acts as a calculator for reverse Polish notation/postfix expressions.

Infix notation:

```
(1 + 2) * 3 = 9
```

Postfix notation:

```
1 2 + 3 *  = 9
```

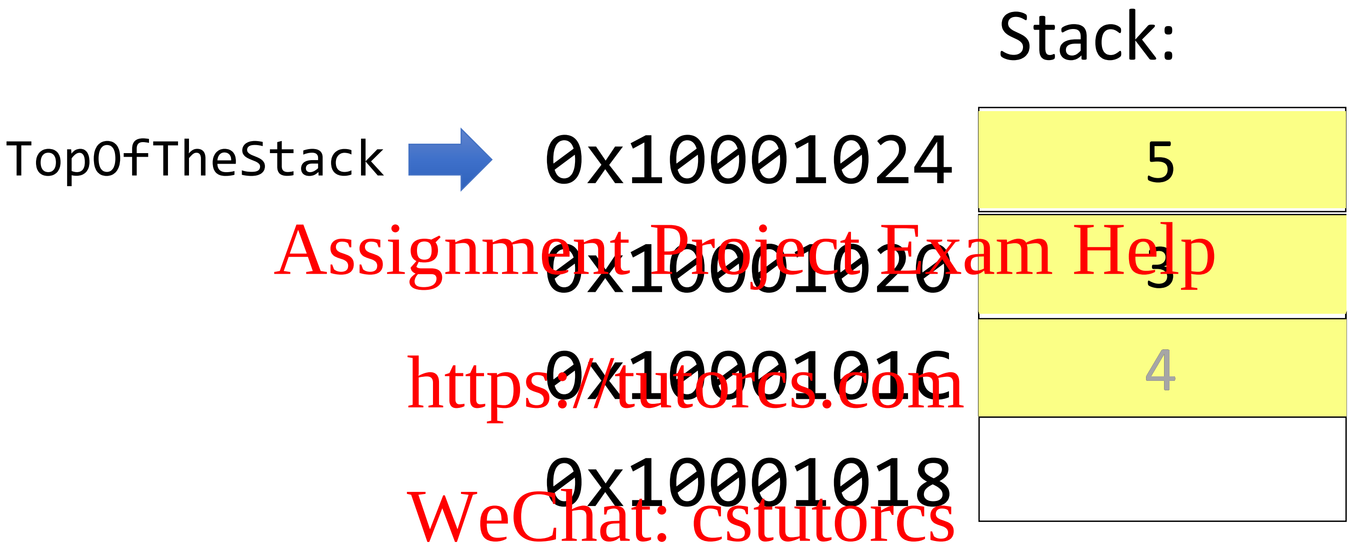
Types of input tokens for `calculator`

Token Type	**Value**
OPERAND	non-negative integer
PLUS	-1
MINUS	-2
TERMINATION	-3

Operation of the `calculator`

- read a token from the input list
- if token == OPERAND (a non-negative value)
  - push value into the stack
- if token == PLUS or token == MINUS
  - pop two topmost values from the stack
  - perform operation
  - push result into the stack
- if token == TERMINATION
  - print out the value that is on top of the stack
  - terminate the program

How does the stack grow?



Stack:

TopOfTheStack	0x10001024	5
	0x10001020	3
	0x1000101C	4
	0x10001018	

Initial State: Stack only contains value 5

Action: Push 1 on top of stack

Action: Push 4 on top of stack

Action: Pop 4 from top of stack

Action: Pop 1 from top of stack

Action: Push 3 on top of stack

Input Token List:

0x1000100C	-3
0x10001008	-2
0x10001004	1
0x10001000	5

Stack:

0x10001024	4
0x10001020	1
0x1000101C	
0x10001018	

Token Type: TERMINATION

```
4
```

Pop 1 and 5 from stack, execute the operation 5-1
and push result into the stack

Pop 4 from stack and write it to output

Formatting and Style

- Check the provided `example.s` file
- Check the lab grading marksheet

Assembler Syntax

comments begin with a sharp sign (#) and run to the end of the line.

identifiers are alphanumeric sequences, underbars (_), and dots (.) that do not begin with a number.

labels are identifiers placed at the beginning of a line, and followed by a colon.

```
          .data
item:
          .word 1

          .text
          .globl  main
main:
          lw      s3, item
Loop:
          add     t1, s3, s3      # t1 <- 2 * i
          add     t1, t1, t1      # t1 <- 4 * i
          add     t1, t1, s6      # t1 <- Addr(save[i])
          lw      t0, 0(t1)       # t0 <- MEM[save[i]]
          bne     t0, s5, Exit    # if save[I] != k goto Exit
          add     s3, s3, s4      # i <- i + j
          jal     zero, Loop      # goto Loop
Exit:
```

Assembler Directives

`.data` identifies the beginning of the data segment (in this example this segment contains a single word).

`.word 1` stores the decimal number 1 in 32-bits (4 bytes)

`.text` identifies the beginning of the text segment (where the instructions of the program are stored).

`.globl main` declares the label main global (so that it can be accessed from other files).

```
         .data
item:
         .word 1

         .text
         .globl   main
main:
         lw       s3, item
Loop:
         add      t1, s3, s3        # t1 <- 2 * i
         add      t1, t1, t1        # t1 <- 4 * i
         add      t1, t1, s6        # t1 <- Addr(save[i])
         lw       t0, 0(t1)         # t0 <- MEM[save[i]]
         bne      t0, s5, Exit      # if save[I] != k goto Exit
         add      s3, s3, s4        # i <- i + j
         jal      zero, Loop        # goto Loop
Exit:
```

Pseudo Instructions

pseudo instruction that loads the immediate value in the register

pseudo instruction that loads the address of specified label into register

```
# What's going on here ?
         .data
val:
         .word 12, 34, 56, 78, 90
outputMsg:
         .asciz "\n Result = "
newln:
         .asciz "\n\n"

         .text
main:
         li    a1, 5
         la    t0, val
         xor   t1, t1, t1
         xor   t2, t2, t2

loop:
         sub   t3, a1, t2
         blez  t3, exit
         lw    t4, 0(t0)
         add   t1, t1, t4
         add   t2, t2, 1
         addu  t0, t0, 4
         jal   zero, loop
```

```
exit:
         div   t5, $t1, $a1
         li    a7, 4
         la    a0, outputMsg
         ecall

         li    a7, 1
         add   a0, 0, t5
         ecall

         li    a7, 4
         la    a0, newln
         ecall

         li    a7, 10
         ecall
```

OS-style call to obtain services from RARS:
a0-a2: arguments
a7: system call code
a7: return value

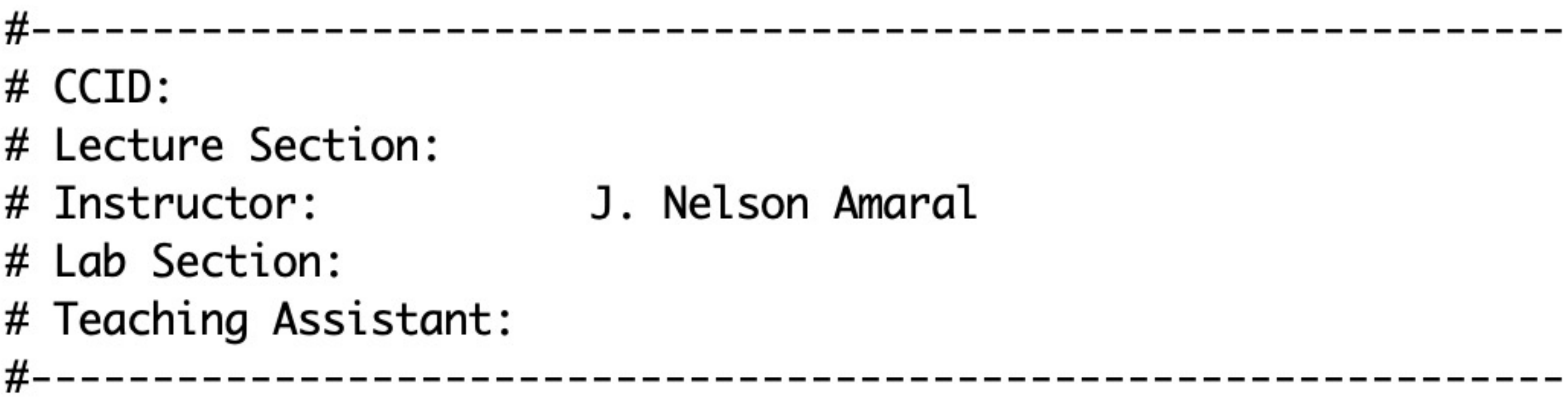
Using GitHub

- While you can either type directly or copy and paste into an editor provided by github, this is not recommended.
- Learn to use basic command-line commands for git such as:
  - `clone`
  - `pull`
  - `commit`
  - `push`

- When you initially clone the repository provided, you will see a `Code` folder.
- In this folder there will be a `calculator.s` file.
  - Your solution goes at the bottom of this file.
  - Your code must start under the label ‘calculator’.

CMPUT 229 Student Submission License

- Carefully read the text of the CMPUT 229 Student Submission License to understand what you are allowed to do with your code before and after submission.
- After reading the license, complete the following information, in the `calculator.s` file, to acknowledge that you have read and understood the license:



```
#-----------------------------------------------------------
# CCID:
# Lecture Section:
# Instructor:              J. Nelson Amaral
# Lab Section:
# Teaching Assistant:
#-----------------------------------------------------------
```

`common.s`

- Every lab will have a `common.s` file that performs some actions and then calls the function written by the student.
- Read carefully and try to understand the `common.s` file as a way to learn.