CSE12 Lab 4: Simple CSV File Analysis

Due at 11:59 PM on the marked due date

Objective

This lab takes as input a CSV (comma separated values) file (.csv extension) that is used for generating tabular data in spreadsheets. ***Specifically, for this assignment, you will NEED to assume this CSV file was generated in Windows*** (the reason will be explained shortly). Consider the *data.csv* file below as it appears when you open it in Excel as an example.

	A	B
1	Kruger Industrial Smoothing	365
2	Kramerica	0
3	Vandelay Industries	500
4	Pendant Publishing	100
5	J. Peterman Catalog	42
6		

Figure 1 data.csv file in Excel

This file shows the stock returns from an investment portfolio over a year. "A" column contains the stock name and "B" column indicates the returns in USD (***We will assume that there is no negative stock return in all our CSV files***). You will run the *lab4_testbench_rev##.asm* file in RARS which takes *data.csv* as an input CSV file. Doing so will yield the following analysis, based on the calculations made by thes assembly files that you will be submitting):

1. Find the total file size in bytes (excluding any metadata generated by your OS) (length_of_file.asm)
2. List the dollar amount of all the input records. (input_from_record.asm)
3. Provides the name of the stock that gives the maximum income. (maxIncome.asm)
4. Provides the name of the stock that gives the minimum income. (
5. Calculate the total income generated from all stocks

When we run (the completed) *lab4_testbench_rev##.asm* in RARS, we get the output console as shown below:

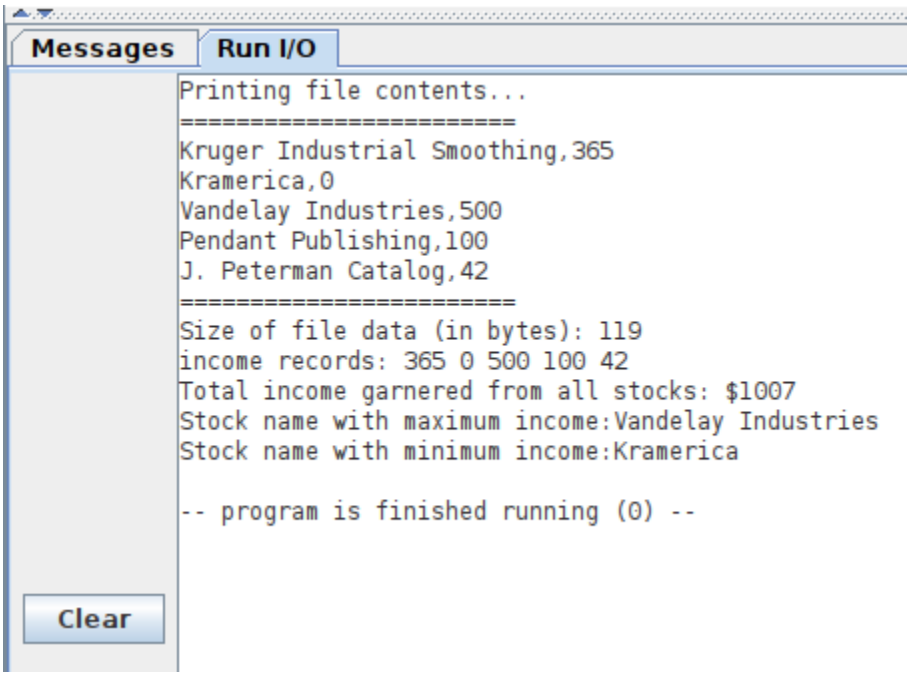


Figure 2 After running the lab4_testbench_rev##.asm file with the Lab4 assignment fully completed

About the Windows CSV file format

To distinguish between each entry/row/record in the spreadsheet format of the CSV file, the following convention is adopted depending on the OS :

Windows - Lines end with both a <CR> followed by a <LF> character
Linux - Lines end with only a <LF> character
Macintosh (Mac OSX) - Lines end with only a <LF> character
Macintosh (old) - Lines end with only a <CR> character

where <CR> is the carriage return ('\r') character and <LF> is the line feed/newline ('\n') character.

If you open the provided *data.csv* file in Notepad++ on Windows with "Show all Characters" enabled, then you should get the following view showing the placement of the carriage return and line feed characters. .

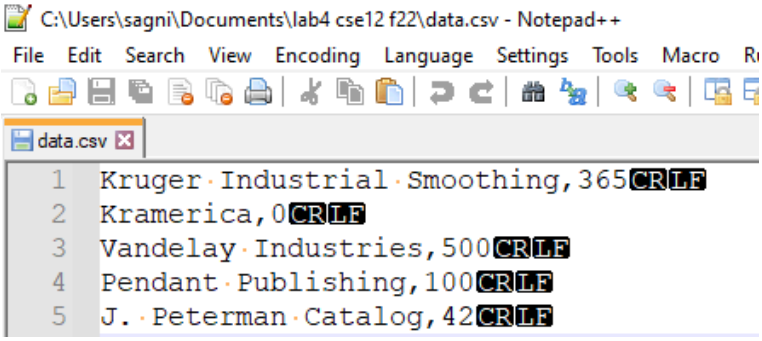


Figure 3 data.csv on Notepad++ on Windows

So, for example, if I were to express record 2 from *data.csv* as a string of characters in RARS, I would write: "Kramerica,0\r\n". If you are using an OS that is NOT Windows, it is likely that *data.csv* would not open correctly due to the encoding differences. If you have a text editor like Notepad++ that allows you to see all characters, make sure that the "\r\n" appears for each record in the file as shown in Figure 3. It is the case for the data.csv that we include in the directory.

Another assumption that we will state at this point is that we expect that in each record, the name of the stock is followed by the "," and then immediately by the stock price expressed as an unsigned integer in base 10. So, with record 2 as an example, we will never have a situation where it is written as "Kramerica, . . 0\r\n" where the 2 red dots indicate two blank spaces. This assumption will make the CSV file analysis by RARS a bit easier to code.

Resources

Much like how a high-level program has a specific file extension (.c for C, .py for python) RARS based RISC-V programs have an .asm extension.

In the Lab4 folder in the course Google Slide, you will see 9 assembly files. They are meant to read *(and understood)* **in sequence**:

1. *add_function.asm* – This program accepts two integers as user inputs and prints their addition result. The actual addition is done through calling a function, sum. Sum accepts two arguments in the a0, a1 registers and returns a0+a1 in a0 register

2. *multiply_function.asm* – This program accepts two integers as user inputs and prints their multiplication result. The actual multiplication is done through calling a function, multiply. Multiply accepts two arguments in the a0, a1 registers and returns a0*a1 in a0 register. This function in turn calls the function sum, described previously, to do a particular addition. Thus, multiply function is an example of a ***nested function call***, a function which itself calls another function, sum in our case.

3. *The lecture slides provide a lot of information about register calling and saving conventions.* Studying the comments in add_function.asm alongside with the notes should be sufficient to create to complete this assignment.

4. ***lab4_testbench_rev##.asm*** - This is the main testbench program you will run upon completion of all coding in Lab4 to ensure your Lab4 assignment works as expected. This file is initially provided such that if you run it as it is (with the other .asm files in the same directory), you will still get partially correctly generated output. This testbench will also run the the function *allocate_file_record_pointers* from *the allocate_file_record_pointers.asm* which will aide you in writing your program. **DO NOT MODIFY THIS FILE.**

5. ***allocate_file_record_pointers.asm*** - This .asm file contains a function that **creates an internal reference table** in memory to pointer pairs. These pointer pairs indicate 1) the location of the start of a string corresponding to the stock name and 2) the start of a location containing the stock price for each and every record/entry coming from the data.csv file. This function has been fully written out for you. **DO NOT MODIFY THIS FILE.**

6. macros_rev1.asm - *This file contains useful macros, mostly to do I/O, it uses and modifies a# registers, so be careful. Become familiar with these functions. They are your friends.*

6. *income_from_record.asm* - This. asm file contains a function that **you will write** to convert the string data from the income of a record/entry in the spreadsheet and convert it into an integer. Example, convert the string "1234" into the actual integer 1234 in base 10.

7. **income_from_record_simpler_rev2.asm** - This file is just like income_from_record.asm but it has been partially coded to give you a jump start. You can copy the contents of this file into income_from_record.asm if you feel you need the help. Note that the template does not include this file, use this for reference only.

7. *length_of_file.asm* - This. asm file contains a function that **you will write** to find the total amount of data bytes in the csv file. Refer to Figure 2 for an example.

8. *maxIncome.asm* - This. asm file contains a function that **you will write** to determine the name of the stock that has the maximum income in the csv file. Refer to Figure 2 for an example.

9. *minIncome.asm* - This. asm file contains a function that **you will write** to determine the name of the stock that has the minimum income in the csv file. (Figure 2 fails to show the corresponding output. It'll be added later)

10. *totalIncome.asm* - This. asm file contains a function that **you will write** to sum up all the stock incomes in the csv file. Refer to Figure 2 for an example.

Please download these files and make sure to open them in **RARS Text editor only**. Else the comments and other important code sections may not be properly highlighted and can be a hindrance to learning assembly language intuitively.

These files have enough comments in the source code to jump start your understanding of RISC-V assembly programming for Lab 4 if the lectures have not yet covered certain topics in assembly programming.

Beyond these three files, ***you should have all the required resources in the Lecture Slides themselves. The slides are very self-explanatory and it is encouraged you start reading them even if the instructor hasn't started discussing them in lecture.***

For the usage of macros (which are utilized heavily in this lab to generate ecalls), please also refer to the RARS documentation on macros and ecalls as well.

Please read the provided files carefully. You can learn a lot about assembler from reading these files. Note that using macros resembles calling functions. The macros have been written to make use of the a# registers, so don't assume that any values in your a# registers remain valid after calling a macro.

Memory arrangement as defined in Lab4

The memory of RISC V is used as per the given requirements.

File Data Buffer

The data.csv file is treated as an input and saved to the file buffer location 0xffff0000 (MMIO).

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0xffff0000	g u r K	I r e	s u d n	a i r t	m S l	h t o o	, g n i	\r 5 6 3
0xffff0020	a r K \n	i r e m	0 , a c	a V \n \r	l e d n	I y a	s u d n	e i r t
0xffff0040	0 5 , s	P \n \r 0	a d n e	P t n	i l b u	n i h s	0 l , g	J \n \r 0
0xffff0060	e P .	m r e t	C n a	l a t a	4 , g o	\0 \n \r 2	\0 \0 \0 \0	\0 \0 \0 \0
0xffff0080	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0
0xffff00a0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0
0xffff00c0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0	\0 \0 \0 \0

Figure 4 data segment window for MMIO after running completed Lab4 assignment.

This is achieved by running the provided fileRead macro in *lab4_testbench_rev##.asm* .

For reference, from Figure 4, note the first record in the given *data.csv* file, “Kruger Industrial Smoothing,365\r\n”. The location of the letter ‘K’(encoded in ASCII as byte 0x4b or 64 in base 10) is 0xffff0000. The location of the character digit ‘3’, i.e. the start of the income,(encoded in ASCII as byte 0x33 or 51 in base 10) is 0xffff001c. If you count the bytes in the string “Kruger Industrial Smoothing,365\r\n” with ‘K’ being the 0th character, then ‘3’is the 28th character (0x1c), so this makes sense.

File Record Pointers

We need a systematic way to reference the memory locations of both the stock name and income from the file buffer at 0xffff0000. Remember that the stock names and stock incomes can be both of varying lengths of characters. Thus, we set aside the memory location 0x10040000 (heap) for a table containing the locations (addresses) of the first character appearing for each stock name and income respectively (i.e. one for the name, one for the number) of each record in the CSV file.

Address	Value (+0)	Value (+4)	Value (+8)	Value (+c)	Value (+10)	Value (+14)	Value (+18)	Value (+1c)
0x10040000	0xffff0000	0xffff001c	0xffff0021	0xffff002b	0xffff002e	0xffff0042	0xffff0047	0xffff005a
0x10040020	0xffff005f	0xffff0073	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000	0x00000000

Figure 5 data segment window for heap after running completed Lab4 assignment.

This is achieved by running the provided function *allocate_file_record_pointers* in *lab4_testbench_rev##.asm* with the arguments in a0 and a1 registers being the file size in bytes (119 in our given example from *data.csv*) and the starting address of file buffer(0x0ffff0000 in our given example from *data.csv*), respectively. The *allocate_file_record _ pointers* function is provided in the *allocate_file_record_ pointers.asm* file separately through the .include statement in *lab4_testbench_rev##.asm.*

For reference, from Figure 5, note in *data.csv* the first record’s location of start of income name (0xffff0000) and income value(0xffff001c) are stored as words in consecutive heap memory locations 0x10040000 and 0x10040004 respectively. Likewise, the second record’s (i.e. “Kramerica,0\r\n”) location of start of income name (0xffff0021) and income value(0xffff002b) are stored as words in consecutive heap memory locations 0x10040008 and 0x1004000c respectively. And so on and so forth. ***It is left as a HIGHLY recommended exercise that the student verifies this pattern for the remaining records in the CSV file and how they are allocated in the memory locations as shown in Figure 5.*** As we see in Figure 5, the 10 non zero heap memory locations from 0x10040000 to 0x10040024 indicate there were originally 10/2 = 5 records in our *data.csv* file. This value (no. of records) is returned in a0.

Student coded functions

All student coded functions are to be written in the .asm files listed in the *lab4_testbench_rev##.asm* file using the .include statement (excluding *allocate_file_record_pointers.asm*). ***The functions written MUST abide by the register saving conventions of RISC-V.***

1. **length_of_file(a1)** - This function is to be written in *length_of_file.asm.* It accepts as argument in a1 register the buffer address holding file data and returns in a0 the length of the file data in bytes.
From our example involving *data.csv*, length_of_file(0xffff0000)=119

2. **income_from_record(a0)** - This function is to be written in *income_from_record.asm.* It accepts as argument in a0 register the pointer to start of numerical income in a record. It returns the income's numerical value in a0.

From our example involving *data.csv*, income_from_record(0x10040004)=365. This is the income from the stock of Kruger Industrial Smoothing. income_from_record(0x1004000c)= 0. This is the income from the stock of Kramerica.

You may use the ***mul*** instruction if you feel your student code involves the multiplication operation.

3. **totalIncome(a0,a1) -** This function is to be written in *totalIncome.asm.* a0 contains the file record pointer array location (0x10040000 in our example) But your code MUST handle any address value. a1 contains the number of records in the CSV file. a0 then returns the total income (add up all the record incomes).

From our example involving *data.csv*, totalIncome(0x10040000, 5)= 1007

4. **maxIncome(a0,a1) -** This function is to be written in *maxIncome.asm.* a0 contains the file record pointer array location (0x10040000 in our example) But your code MUST handle any address value. a1 contains the number of records in the CSV file. a0 then returns the heap memory pointer to the actual location of the record stock name in the file buffer.

From our example involving *data.csv*, maxIncome(0x10040000, 5)= 0x10040010. Observe from Figure 5 that this address value points to the location of the stock name "Vandelay Industries", which is valued at the maximum value of $500, and proving that even in times of market uncertainty , the latex polymer industry is booming as ever.

5. **minIncome(a0,a1) -** This function is to be written in *minIncome.asm.* a0 contains the file record pointer array location (0x10040000 in our example) But your code MUST handle any address value. a1 contains the number of records in the CSV file. a0 then returns the heap memory pointer to the actual location of the record stock name in the file buffer.

From our example involving *data.csv*, maxIncome(0x10040000, 5)= 0x10040008. Observe from Figure 5 that this address value points to the location of the stock name "Kramerica", which is valued at the minimum value of $0, proving once and for all, a sales pitch about a "coffee table book about coffee tables" is an absolutely terrible idea.

To keep the code simple for both maxIncome and minIncome functions, you may assume that no two entries in the CSV file will have the same income field value.

Test Cases

Your Lab4 folder in Google Drive contains some more test cases : *data1.csv, data2.csv, data3.csv* and *data4.csv* under directory TestCases. To test with these you have to copy them to data.csv. The initial data.csv is the same as data4.csv, and corresponds to the file illustrated in this write-up.

Automation

Note that our grading script is automated, so it is imperative that your program's output matches the specification exactly. The output that deviates from the spec will end up with a poor score. Submit as often as you want and get help from our staff if you get stuck.

Files to be submitted to Gradescope

length_of_file.asm
income_from_record.asm
maxIncome.asm
minIncome.asm
totalIncome.asm

*You will **NOT** be editing the following, so **DO NOT** upload them:*
lab4_testbench_rev##.asm
allocate_file_record_pointers.asm

You can if you want add macros to the file:
macros_rev1.asm
but if you do, do not delete any of the macros therein.
If you add some macros you can submit this file. If you don't you don't have to.

Do not upload any data files. We will use our data files to test your program.

Make your submission using Gradebook. Do it as many times as you want. If you submit it as given to you, without modifications, the program will assemble an you will get a free 20 points, just by submitting it. Do this right away.

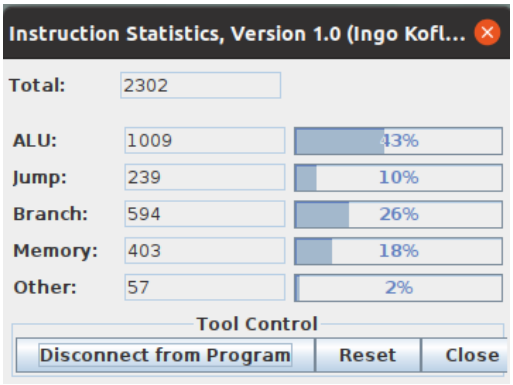
This is a medium difficulty lab. So start early and work with the TA's and tutors to help you complete it. DO NOT PROCRASTINATE.

POTENTIAL SIZABLE EXTRA CREDIT

This is *a great opportunity for you to learn assembly language, and become somewhat of a near expert in RISC-V programming, while you work on getting extra credit. With continuous regrading and some significant effort, you should be able to get a perfect score in this lab. If you do, I will be giving you the opportunity to get some extra credit, and learn more while you are at it.*

The ideas is that with some effort if you get 100 points on this lab, you can work on optimizing it, too. In particular you can use what you have learned about caller and callee saving conventions when using nested functions (which this lab does do). My implementation of this lab executes a total of **2320** instructions.

You can *learn how many instructions you executed by accessing the **Tools** menu then the **Instruction Statistics** function, connecting it to your program to it and running it. I put in a fair effort my at using simple tricks to optimize the code, also following the guidelines for saving registers. The register saving optimizations are described in the lecture notes. Sooo, if you can match or beat my number you will give you **an extra 33 points of credit** for Lab4 to help you improve your grade. Think of it. This is your opportunity at beating your teacher at his game. Not only will you get extra credit but also great bragging rights :) Worst case, even if you don't get the extra credit, you may have fun trying, and learn a thing or two. However, you have to complete the assignment first to perfection before you can do this.*



SOME TIPS

We will e discussing how to debug your code in class along with numerous tricks and techniques to make your life easier. You can use some of the macros on your code to print out intermediate results if you feel you need to. You can also put breakpoints in your code and use the powerful built-in debugger.

A caveat: ***Be careful with*** *the* ***addw*** *and* ***addwi*** *instructions. These tend to do sign-extension into 64-bits. If you use these to manipulate pointers, you will find yourself with 64-bit addresses that do not work in RARS and result in unfriendly run-time errors. RARS uses 32-bit pointers, and a 32-bit address space, even though the RV64I model has 64-bit registers.*

A Note About Academic Integrity

This is the lab assignment where most students continue to get flagged for cheating. Please review the pamphlet on Academic Dishonesty and look at the examples in the first lecture for acceptable and unacceptable collaboration.

You should be doing this assignment completely all by yourself!

Grading Rubric (100 points total)

The following rubric applies provided you have fulfilled all criteria in **Minimum Submission Requirements**. Failing any criteria listed in that section would result in an automatic grade of zero ***which cannot be eligible for applying for a regrade request.***

20 pt *lab4_testbench_rev##.asm* ***assembles*** without errors (so *even if you submit lab4_testbench_rev##.asm with all the other required .asm files COMPLETELY unmodified by you, you would still get 20 pts!*)

80 pt output in file *lab4_output.txt* matches the specification:

30 pt *length_of_file.asm* works

20 pt *income_from_record.asm* works

10 pt *totalIncome.asm* works

10 pt *maxIncome.asm* works

10 pt *minIncome.asm* works

AGAIN: Execute this program perfectly using 2321 instructions of execution or less, and you will get an extra 33 points of credit for this lab!! Note: efficient register spilling will help you with this. This is a good way to make up for lost points.

Regrade Requests

There wil not be any regrades for this Lab. Gradescope gives you the ability to see your score, and it is your responsibility to fix any grading issues prior to the deadline by working with the instructor, TA's and tutors.

Legal Notice

All course materials and relevant files located in the Lab4 folder in the course Google Drive must not be shared by the students outside of the course curriculum on any type of public domain site or for financial gain. Thus, if any of the Lab4 documents is found in any type of publicly available site (e.g., GitHub, stack Exchange), or for monetary gain (e.g., Chegg), then the original poster will be cited for misusing CSE12 course-based content and will be reported to UCSC for academic dishonesty.

In the case of sites such as Chegg.com, we have been able to locate course material shared by a previous quarter student. Chegg cooperated with us by providing the student's contact details, which was sufficient proof of the student's misconduct leading to an automatic failing grade in the course.