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**Course:** CSCI 312 Principles of Programming Languages

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## Part I - Potpourri

### POSIX Definitions

#### 1. Definitions:

(retyped from the official POSIX website <https://pubs.opengroup.org/onlinepubs/9699919799/>):

- 1.1 **Application Program Interface (API)** - The definition of syntax and semantics for providing computer system services.
- 1.2 **Built-In Utility** - A utility implemented within a shell. The utilities referred to as special built-ins have special qualities. Unless qualified, the term "built-in" includes the special built-in utilities. Regular built-ins are not required to be actually built into the shell on the implementation, but they do have special command-search qualities.
- 1.3 **Executable File** - A regular file acceptable as a new process image file by the equivalent of the exec family of functions, and thus usable as one form of a utility. The standard utilities described as compilers can produce executable files, but other unspecified methods of producing executable files may also be provided. The internal format of an executable file is unspecified, but a conforming application cannot assume an executable file is a text file.
- 1.4 **Protocol** - A set of semantic and syntactic rules for exchanging information.
- 1.5 **Shell** - A program that interprets sequences of text input as commands. It may operate on an input stream or it may interactively prompt and read commands from a terminal.
- 1.6 **Standard Error** - An output stream usually intended to be used for diagnostic messages.
- 1.7 **Standard Input** - An input stream usually intended to be used for primary data input.
- 1.8 **Standard Output** - An output stream usually intended to be used for primary data output.
- 1.9 **Terminal** - A character special file that obeys the specifications of the general terminal interface. A terminal may have a foreground process group associated with it. A terminal may belong to a process as its controlling terminal.
- 1.10 **Utility** - A program, excluding special built-in utilities provided as part of the Shell Command Language, that can be called by name from a shell to perform a specific task, or related set of tasks.

## Part II - Bash

### Learning the Shell

2. Directory made with `mkdir Final/`

3. Types of commands:

Type	Example
File Management	<code>ls, cp, mv</code>
Search	<code>grep, find</code>
Jobs Management	<code>fg, bg, kill, jobs</code>
Permissions	<code>chmod</code>

4. Redirection operators:

Redirection	Operator
Redirecting input	<
Redirecting output	1>
Redirecting error	2>
Appending redirected output	>>
Redirecting standard output and standard error	&>
Appending standard output and standard error	&>>

5. Types of expansion:

1.1 Pathname Expansion (ex: `*.txt` matches all files ending in “.txt”)

1.2 Tilde Expansion (`~` becomes `/home/username`)

1.3 Arithmetic Expansion (Shell calculator for integers)

1.4 Brace Expansion (ex: `echo {1..3}` → 1 2 3)

1.5 Parameter Expansion (shell variable replacement)

1.6 Command Substitution (command output acts as parameter expansion)

6. Types of quoting:

Type	What does it suppress?
Double Quote ”	Word splitting, pathname expansion, tilde expansion, and brace expansion
Single Quote ’	All expansions
Escape Character \	Expansion for a single character

7. Types of files:

Name	Attribute	Type
file1	-	Regular File
file2	b	Block Device File
file3	c	Character Device File
file4	d	Directory
file5	l	Symbolic Link
file6	p	Named Pipe
file7	s	Socket

8. The file mode is shown by the 9 characters to the right of the file type character in a long listing `ls -l`. These represent the permissions of the owner, then group, then public (each getting three characters in that order). Users can be granted read (r), write (w), and/or execute access (x). For the following file mode questions, I will convert the octal permission representation into abbreviated rwx format (where ‘-’ means that group does not have the permission).
9. Permissions— user: `rwx`, group: `r-`, public: `r-`
10. Permissions— user: `rwx`, group: `-x`, public: `-x`
11. Permissions— user: `rwx`, group: `r-x`, public: `r-x`
12. Permissions— user: `rw-`, group: `-`, public: `-`
13. Permissions— user: `rwx`, group: `rwx`, public: `rwx` (everyone has all permissions)
14. The `dir2` / directory only has public read permissions enabled. Therefore, while the directory can be viewed (along with its contents such as `file.txt`), it can neither be accessed with `cd` nor can its contents be accessed in any way (no matter the permissions on those contents).
15. The `dir2` / directory only has public executable permissions enabled. For a directory, this means that while the directory cannot be viewed itself, the contents of the directory may be accessed according to their own respective permissions. Since `dir2/file.txt` has public read permissions enabled, I am able to view its contents despite not being able to list its parent directory.
16. Both `wall` and `write` have execution file mode permissions enabled for all users, therefore anyone on the system should be able to use these commands. One reason some people in class may have struggled to use these commands is due to the way that W&M Department of CS sets up groups, where messaging is restricted to only others in the same group as the user.
- ```
ls -lL "$(which write)" "$(which wall)"
-rwxr-xr-x 1 root root 22912 Apr 9 2024 /usr/bin/wall
-rwxr-xr-x 1 root root 22920 Apr 9 2024 /usr/bin/write
```

## **Configuration and the Environment**

17. Types of data:
  - 1.1 User info
  - 1.2 System/Shell settings
18. The variable \$PATH stores a colon-separated list of directories for which to find commands. For example, most systems hold the ls command in the /usr/bin/ directory, which should appear in \$PATH.
19. Environment variable to store shared object file locations: LD\_LIBRARY\_PATH
20. Types of sessions:
  - 1.1 Login session
  - 1.2 Non-login session
21. Startup files:
  - 1.1 LOGIN: /etc/profile, ~/.bash\_profile, ~/.bash\_login, ~/.profile
  - 1.2 NON-LOGIN: /etc/bash.bashrc, ~/.bashrc

## **Common Tasks and Essential Tools**

22. Basic/Extended regular expressions (BRE/ERE) are designed to match patterns in text and both provide the same range of functionality. The difference is in how some metacharacters (characters that perform matching operations) are put to use. In BRE, the following symbols act as metacharacters: . ^ \$ [ ] \*. In ERE, metacharacters include all BRE metacharacters plus the following: ( ) { } ? + |. The escape backslash \ is used to convert characters between acting as string literals and metacharacters.

## **Part III - C**

### **Maintain your perceptron ADT**

23. Valgrind is a programming tool to identify memory bugs such as memory leaks, invalid memory access, uninitialized memory, memory corruption, and improper memory freeing. Valgrind can be called on executables that have been compiled with the -g option for debugging. Memcheck, the primary tool of valgrind, returns a list of memory warnings and the functions/source-code lines at which they occurred.
24. See memcheck output in Appendix. From the errors, there are two main issues: improper assignment and a lack of freeing memory. Firstly, new\_Data and new\_Model both perform numerous invalid reads and writes, likely due to a off-by-one error in each of their for loops causing improper assignment and array access attempts. The sgd function has the same issue except it only reads data and does not write new data. As for memory that

needs to be freed (memory leaks), there are the contents of `data`, `model`, and temporary variable I created to store misclassified data in `fit_model()`.

25. Delete operations have been added.
26. The output log requested is saved to the file `typescript` in the `c_perceptron` directory.

## Evolve your perceptron ADT

27. The `evaluate_model` method has been implemented for testing the % correct score of the model. Theoretically, a perceptron is not expected to be 100% correct; however, the `test.dat` data points are all far enough from the plane of separation that they are completely linearly solvable.

## Part IV - Python

### Evolve a simple interpreter

28. My additions: `print(a-b)` operation inside code array of tuples, `BINARY_SUB()` function inside `Interpreter` class, and `BINARY_SUB` string recognition in `ceval` method.

## Part V - Java

### Describe the functionality of a class

29. JPerceptron: located in `Final/java_perceptron`  
Compiled with `javac perceptron/*.java`  
Executed with `java perceptron.Client train.dat test.dat`  
Note that all the data (from `train.dat` and `test.dat`) will print upon execution due to the debugging statement originally from `mgwhite`.
30. JLexer (extra credit): comments have been add to each non-import line of code in `Final/JLexer.java`

# Appendix

```
==314567== Memcheck, a memory error detector
==314567== Copyright (C) 2002-2017, and GNU GPL'd, by Julian Seward et al.
==314567== Using Valgrind-3.18.1 and LibVEX; rerun with -h for copyright info
==314567== Command: ../../Assignment5/main.exe train.dat
==314567==
==314567== Invalid write of size 8
==314567== at 0x109502: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x10950D: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x109521: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid write of size 8
==314567== at 0x1095BF: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab048 is 0 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x1096DC: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab048 is 0 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
newData: loaded 20 examples
==314567== Invalid read of size 8
==314567== at 0x10979C: newModel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109363: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x1099A3: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x1099B1: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab050 is 8 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567== by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567== at 0x109A09: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567== Address 0x4aab048 is 0 bytes after a block of size 8 alloc'd
==314567== at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
```

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==314567==      by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567==      at 0x109AD9: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      Address 0x4aab048 is 0 bytes after a block of size 8 alloc'd
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x1093D5: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567==      at 0x109887: sgd (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109B07: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      Address 0x4aae038 is 0 bytes after a block of size 24 alloc'd
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x1097CC: newModel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109363: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid read of size 8
==314567==      at 0x10989F: sgd (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109B07: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      Address 0x4aad6b0 is 0 bytes after a block of size 16 alloc'd
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x109588: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== Invalid write of size 8
==314567==      at 0x1098C3: sgd (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109B07: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      Address 0x4aae038 is 0 bytes after a block of size 24 alloc'd
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x1097CC: newModel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109363: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
Enter x:
0.8
Enter y:
0.2
Prediction = -1
==314567== HEAP SUMMARY:
==314567==     in use at exit: 1,236 bytes in 71 blocks
==314567==     total heap usage: 77 allocs, 6 frees, 11,972 bytes allocated
==314567==
==314567== 8 bytes in 1 blocks are definitely lost in loss record 1 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x1094F7: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 8 bytes in 1 blocks are definitely lost in loss record 2 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x10978C: newModel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109363: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 16 bytes in 1 blocks are definitely lost in loss record 3 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x109BA9: runscoringengine (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109386: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 24 bytes in 1 blocks are definitely lost in loss record 4 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x1097CC: newModel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x109363: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 60 bytes in 15 blocks are indirectly lost in loss record 5 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x109AC9: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 120 bytes in 15 blocks are indirectly lost in loss record 6 of 10
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==      by 0x109A95: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==      by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 160 bytes in 1 blocks are definitely lost in loss record 7 of 10

```

```
==314567==      at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==    by 0x1095B4: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==    by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 320 bytes in 20 blocks are indirectly lost in loss record 8 of 10
==314567==    at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==    by 0x109588: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==    by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 480 (160 direct, 320 indirect) bytes in 1 blocks are definitely lost in loss record 9 of 10
==314567==    at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==    by 0x109540: newData (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==    by 0x109353: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== 540 (360 direct, 180 indirect) bytes in 15 blocks are definitely lost in loss record 10 of 10
==314567==    at 0x4848899: malloc (in /usr/libexec/valgrind/vgpreloadmemcheck-amd64-linux.so)
==314567==    by 0x109A87: fitmodel (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==    by 0x10937A: main (in /home/jbstawasz/stawasz-jack/Assignment5/main.exe)
==314567==
==314567== LEAK SUMMARY:
==314567==    definitely lost: 736 bytes in 21 blocks
==314567==    indirectly lost: 500 bytes in 50 blocks
==314567==    possibly lost: 0 bytes in 0 blocks
==314567==    still reachable: 0 bytes in 0 blocks
==314567==    suppressed: 0 bytes in 0 blocks
==314567==
==314567== For lists of detected and suppressed errors, rerun with: -s
==314567== ERROR SUMMARY: 254 errors from 20 contexts (suppressed: 0 from 0)
```