Week1

- Following permissions are required for file/directory level operations.

Permissions File type	Read	Write	Execute
File	Read file contents (cat)	Write/overwrite (touch, cat, edit)	Execute/run file (./file) Change permissions(chmod)
Directory	List files/sub-folders (ls)	Create files/subfolders (mkdir)	Change directory(cd) Delete (rmdir, rm -r)

- *ln file1 file1_hard* creates a hard-link of *file1*, and calls it *file1_hard.*
- *ln -s file1 file1_soft* creates a soft-link of *file1*, and calls it *file1_soft*.
- To see the *inode* numbers of files, use *ls -li*

```
anand@DESKTOP-GG7GDNK:~/dir_2$ ls -li
total 8
22254 -rw-r--r-- 1 anand anand 6 Sep 26 11:40 file1
13958 lrwxrwxrwx 1 anand anand 5 Sep 26 11:38 file1_soft -> file1
11199 -rw-r--r-- 1 anand anand 6 Sep 26 11:31 file2
19577 lrwxrwxrwx 1 anand anand 5 Sep 26 11:38 file2_soft -> file2
```

- Hard links to the same file have same inode. Modifying one affects the other, but deleting one doesn't delete the other.
- Soft links to the same file have different inodes. Modifying one affects the other, and deleting one renders the others dead.
- Once created, moving the location of a soft-link renders it dead, unless the soft-link was created with an absolute path. Thus, in order to create a soft link *file_soft* to the absolute path to *file,* use *ln -s `pwd`/file file_soft*
- Copies of the same file have different inodes, and are entirely independent of each other. Modifying one doesn't affect the other, and deleting one doesn't delete the other.
- It's not possible to create hard links for directories, since it can lead to self-reference and thus infinite recursion.
- To display the type of the file (file/directory/link), use *file* command as follows

```
anand@DESKTOP-GG7GDNK:~/dir_2$ file *
file1:      ASCII text
file1_soft: symbolic link to file1
file2:      ASCII text
file2_soft: symbolic link to file2
```

- To see the file properties, use *stat <file_name>*

Week2

- *echo* command accepts multiple parameters separated by a single space, and prints them.
- *echo* accepts multiline input by using quotes (single/doubt) around the input.
- To display shell variables, use command *echo <variable>*. Some shell variables include $HOME, $USER, $HOSTNAME, $PWD, $PATH. You may use double quotes around the variables, but not single-quotes, in which case the variable is treated as a literal string.

```
gphani@icme:~$ echo "$USERNAME"
gphani
gphani@icme:~$ echo '$USERNAME'
$USERNAME
```

  NOTE: Using double-quotes with a shell variable interpolates it inside a larger string, and escaping it using '\' treats it as a literal. It's a good idea to use braces around the variable while interpolating.
- *echo* prints the string/variable content, and terminates with a newline. *echo -n* doesn't print a newline at the end.
- *whoami* shows the current user of the terminal.
- *whatis <command>* displays a brief help on the command.
- *man <command>* shows the detailed help on the command. So does *<command> --help* and *info <command>*
- *whereis <command>* shows the location of the command executable.
- *which <command>* also shows the location of command executable, but has restricted scope of search in comparison to *whereis*.
- *echo $HOSTNAME* displays the hostname of the local system, as stored in */etc/hostname*
- *echo $SHELL* displays the path of the current shell.
- Assuming that the above command displays */bin/bash*, *echo ${SHELL:5:4}* displays *bash* (4 characters starting with the 5th character).
- *printenv, env, set* are commands that list the shell variables in the shell.
- Following are special shell variables used by the Linux bash shell, and their meanings.
  - *$0* – name of the shell
  - *$$* - process ID of the shell (same as what gets displayed in *ps* command)
  - *$?* – return code of the previous run program
  - *$-* - flags set in bash shell
- Process control commands
  - *ps* – list of current processes.
  - *&* - run a process in the background
  - *fg* - bring the background process to foreground
  - *coproc* – run processes in the simultaneously.
  - *jobs* – list jobs in shell
  - *top* – list processes that hog memory
  - *kill* – kill processes.
- Program exit codes (between 0 and 255)

    - 0 – Success (evaluated as true by shell script)
    - 1 – Failure
    - 2 – Misuse
    - 126 – Command cannot be executed
    - 127 – Command not found
    - 130 – Process killed using Ctrl + C
    - 137 – Process killed using kill -9 <pid>
- *date -R* prints the current system datetime in a format useful in email communications.
- *alias date="date -R"* creates an alias for *date* command and executes *date – R* in turn. If you want to NOT use the alias, use escaping as in *\date.* To unset the alias, use *alias date=date*
- *ps – ef* lists all processes, along with details about parent pid (ppid) and other details.
- *echo $BASH_SUBSHELL* gives a number indicating the #subshell where execution is happening now. Consider the following execution, where inside each pair of parenthesis the $BASH_SUBSHELL increments.

```
anand@DESKTOP-GG7GDNK:~$ echo $BASH_SUBSHELL;(echo $BASH_SUBSHELL;(echo $BASH_SUBSHELL;(echo $BASH_SUBSHELL)));
0
1
2
3
```

NOTE: To run multiple commands in a sequence, separate each by semi-colon.

- When *&&* is used in between two commands, both commands are executed one after the other. However, if the first one fails, the second one is ignored.
- When *||* is used in between two commands, the second one is executed, only if the first one fails and is ignored, when the first one passes.

```
anand@DESKTOP-GG7GDNK:~$ ls this_folder_does_not_exist;ls
ls: cannot access 'this_folder_does_not_exist': No such file or directory
check_sum.py  client  client.code-workspace  dir_2  go  push  server
anand@DESKTOP-GG7GDNK:~$ ls this_folder_does_not_exist && ls
ls: cannot access 'this_folder_does_not_exist': No such file or directory
anand@DESKTOP-GG7GDNK:~$ ls this_folder_does_not_exist || ls
ls: cannot access 'this_folder_does_not_exist': No such file or directory
check_sum.py  client  client.code-workspace  dir_2  go  push  server
anand@DESKTOP-GG7GDNK:~$ ls || ls
check_sum.py  client  client.code-workspace  dir_2  go  push  server
```

- Linux supports 3 file descriptors – stdin (0), stdout(1) and stderr(2)
- To redirect *stdout* to *out.txt*, use *>out.txt.* In this case, the output will not be displayed on the screen. If you want the output to also appear on the screen (In addition to redirecting to *out.txt*, use *| tee out.txt.* For example, *ls $HOME | tee out.txt* will create *out.txt* with the contents of the $HOME directory, as well display it on the screen. Note that *tee* command can be used to redirect output to multiple files by providing file names separated by space.
- To redirect *stderr* to *err.txt*, use *2>err.txt.* It's common to redirect *stderr* output to */dev/null* – *2>/dev/null*.
- To redirect *stderr* to the same file where *stdout* is redirected, use *2>&1.* For example, *ls $HOME /blah > file1 2>&1* will redirect *stderr* to *stdout* and list the files in the home directory and redirect *stdout* to *file1*. Thus, *file1* will contain the error (about non-existing directory /blah) as well as the listing of files in $HOME.
- *less <file>* displays the contents of <file> and allows scrolling line by line.
- *more <file>* displays the contents of <file> and allows scrolling page by page.

- *Cat > file1* will accept the text typed by the user and stores in file1. Stop entering text by pressing Ctrl + D on keyboard.
- Variables can be assigned with a numeric or a string value. It can also be assigned with the result of a Linux command, by enclosing the command in backquotes (``). For example, to assign the number of files in the current directory to a variable, run *num_files=` ls | wc -l `*. Now, *echo $num_files* will print the number of files in the directory.
- Variable name can have alphanumeric characters and _. Assigning values to variables can't have space around '='.
- In order to make a variable available on the shell and its sub-shells, use *export* command. Note that *export* will not affect the parent shell variables.
- To assign *v* to *v1*, use *v1=$v*.
- To unassign $*v*, use *unset v* command or *v=<empty>* (leave RHS of '=' empty)
- *[[-v v]]* returns 0, if $v is set, else returns 1.
- To echo a default value 'default' if the variable *$v* is not set, say *echo ${v:-default}*
- To set a default value 'default' if the variable *$v* is not set, say *echo ${v:=default}*
- To display a message 'msg' if the variable *$v* is not set, say *echo ${v:?msg}*.
- To echo a default value 'default' if the variable *$v* is set, say *echo ${v:+default}*
- *echo ${!H*}* gives the names of all shell variables that start with H
- *echo ${#v}* gives the number of characters in the shell variable *v*.
- *echo ${v: start:2}* returns the *2* characters from *$v* starting from *start*. *start* can be a negative number, in which case, it'll start counting from the end of *$v*. Note the space before *start.* Thus,

```
anand@DESKTOP-GG7GDNK:~/my_scripts/Mock1$ echo $a
17:24
anand@DESKTOP-GG7GDNK:~/my_scripts/Mock1$ echo ${a: -4:2}
7:
anand@DESKTOP-GG7GDNK:~/my_scripts/Mock1$ echo ${a: 1:2}
7:
```

- In order to extract part of a string that occurs at the start, use *#* after the variable. For example, in the last-but-one command below, characters after the first occurrence of *':'* is extracted. In the last command, characters after the last occurrence of *':'* is extracted.

```
anand@DESKTOP-GG7GDNK:~$ mydate=`date`
anand@DESKTOP-GG7GDNK:~$ echo $mydate
Fri, 29 Sep 2023 20:17:54 +0530
anand@DESKTOP-GG7GDNK:~$ echo ${mydate#*:}
17:54 +0530
anand@DESKTOP-GG7GDNK:~$ echo ${mydate##*:}
54 +0530
```

- In order to extract part of a string that occurs at the end, use *%* after the variable. For example, in the last-but-one command below, characters before the last occurrence of *':'* is extracted. In the last command, characters before the first occurrence of *':'* is extracted.

```
anand@DESKTOP-GG7GDNK:~$ mydate=`date`
anand@DESKTOP-GG7GDNK:~$ echo $mydate
Fri, 29 Sep 2023 20:29:04 +0530
anand@DESKTOP-GG7GDNK:~$ echo ${mydate%:*}
Fri, 29 Sep 2023 20:29
anand@DESKTOP-GG7GDNK:~$ echo ${mydate%%:*}
Fri, 29 Sep 2023 20
```

NOTE: Essentially, a single # performs non-greedy matching and ## performs greedy matching. Similarly, for % and %%

- Some additional notes on this is here - https://discourse.onlinedegree.iitm.ac.in/t/pattern-matching-doubt/107003/7
- In order to perform replacement of characters once, use *echo ${v/<find>/<replace>}*
- In order to perform replacement of characters globally, use *echo ${v//<find>/<replace>}*
- To convert first character in the string to lowercase, use *${string,}*
- To convert all characters in the string to lowercase, use *${string,,}*

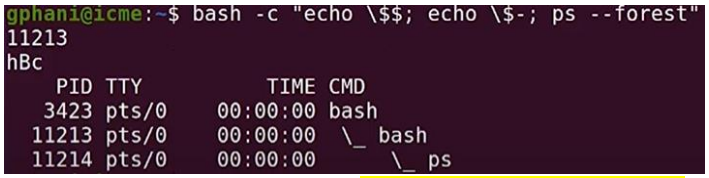
```
string="Hello World"
echo ${string,,}  # Output: hello world
echo ${string,}   # Output: hello World
```

- To convert first character in the string to uppercase, use *${string^}*
- To convert all characters in the string to uppercase, use *${string^^}*

```
string="hello world"
echo ${string^^}  # Output: HELLO WORLD
echo ${string^}   # Output: Hello world
```

- To store only numbers in shell variables, declare it as an integer using *declare -i <variable>*. When a non-numeric value is stored in this variable, it gets initialized to 0.
- To store only small case characters in shell variables, declare it so using *declare -l <variable>*. When a non-lowercase value is stored in this variable, it gets initialized to all lower-case.
- To store only upper case characters in shell variables, declare it so using *declare -u <variable>*. When a non-uppercase value is stored in this variable, it gets initialized to all upper-case.
- To declare an array *arr*, use *declare -a arr*. Now, array elements can be accessed as *arr[0], arr[1]* etc. For example, *declare -a arr=(1 2 3 4 5)* declares array *arr* with 5 integer values 1..5
- To append value1 to the array, use *arr+=(value1)*
- To insert value2 to the array at location 100, use *arr[100]=value2*
- In order to find the number of array elements, use *echo ${#arr[@]}*
- In order to list all the elements (values) in the array, *use echo ${arr[@]}*
- In order to list elements starting with 1st index (slicing), *use echo ${arr[@]:1}*
- In order to list all the indices in the array, *use echo ${!arr[@]}*
- To remove array element use unset. For instance, to remove the second index of arr, use *unset arr[2]*
- To declare a hashed array *hash*, use *declare -A hash*. Now, array elements can be accessed as *hash[<index>].* Note that the index could be a numeric value or a string.
- To automatically create an array *myfiles* (without explicit declaration) consisting of a list of files in the current folder, use *myfiles=(`ls`). It could also be stored as myfiles=($(ls)).*
- To print the values stored in *myfiles*, use *declare -p myfiles*
- To declare variables as read-only, use *declare -r <variable>*. Once the variable has been declared as read-only, it's not possible to turn off the attribute.
- In the above declarations, To turn off the restriction, declare it using +, instead of -
- *sleep <seconds>* sleeps for a specified number of seconds.

- *sleep 2 &* runs in the background (with only output pipe open), and *coproc sleep 2* runs asynchronously (and leaves input and output pipes open for communication)
- *Ctrl+C* kills the command, and *Ctrl+Z* suspends the command (and returns to the prompt)
- *jobs* lists background processes started using either methods
- To kill a job with process id <*p_id*>, use *kill -9 <p_id>*
- *top* will display all jobs active on the local system, ordered by decreasing order or CPU utilization.
- *type <command>* will show the type of <command>. Commands that don't have man pages available are typically *shell built-ins*. Help for such commands can be displayed using *<command> --help*.
- To start a new bash sub-shell and launch a set of commands, use *bash -c <commands>*.



- To export variable *myvar*, use *declare -x myvar="abc"* or *export myvar="abc"*

Week3

- *lsb_release -a* shows the Linux distribution used in the system.
- *uname -a* shows the kernel information
- *RPM* and *DEBIAN* are two most widely used Linux packaging systems. *RPM* uses *yum, dnf or rpm* package managers. *DEB* uses *apt*, which internally uses *dpkg*.
- *apt-cache search <keyword>* is used to search for packages that contain the specified keyword.
- To get all the packages installed, use *apt-cache pkgnames*. Pipe it to *sort* command to see the list in alphanumeric order.
- TO get a list of packages that start with *wg*, use *apt-cache pkgnames wg*
- To get more information of *wget*, use *apt-cache show wget*. Filename in the output shows the actual file name from where the package is installed. In the filename *wget_1.21.2-2ubuntu1_amd64.deb*, 1.21.2 is the version number, 2ubuntu1 is the revision number and amd64 is the architecture of the package.
- Packages have priorities as listed below - required, important, standard, optional, extra.
- Only sudoers (super users) are allowed to install, update or remove packages. Thus, if a user is available on */etc/sudoers*, then these operations are allowed for the user.
- *tail -10 /var/logs/auth.log* displays the last 10 lines of the auth.log, which displays the access information of protected files.
- */etc/apt/sources.list* contains the web URLs from where packages can be downloaded.
- In order to upgrade the packages to the latest version/release, run the following commands.
    - *sudo apt-get update*
    - *sudo apt-get upgrade*

  While the first command fetches the latest updates from the web locations as per *sources.list* to the cache, the second command applies these updates to the system.
- Use *sudo apt-get install <package>* to install the package into the system, and *sudo apt-get remove <package>* to remove the package from the system

Week4

- *grep* command can use regex, in order to create the pattern. Syntax is *grep <pattern> <file>*. Alternatively, *grep* can be used on the output of a command. Thus, in order to grep a <pattern> on the output of *ls -l*, use *ls -l | grep <pattern>*
- Non-greedy match is possible using *grep -P*.
- For extended grep, use *egrep* or *grep -e*
- Print only the matched part of the line using *grep -o*. For example, *ls -l | grep -eo '^\-[rwx\-]{9}'* will extract the permission bits only for files in the current folder.
- Ignore case sensitivity using *grep -i*
- In order to invert the matching by pattern, use *grep -v.* For example, *ls -l | egrep -o '\..{3}$'* will get a list of all 3-letter extensions of all files in the current folder. In order to get all files/folders that

doesn't have 3-letter extensions use it as *ls -l | egrep -v '\..{3}$'.* Note that none of the entries in this output has a 3-letter extension.

- In order to print all the fields following field #5 of every line, where each field is separated by a comma, use *cut -d ',' -f 5-*. Note that the field number starts from 1 (not 0)
- In order to cut characters use *cut -c*. For example, to cut the permission bits of files/folders in the current folder, use *ls -l|cut -c 2-10*
- In order to show line numbers in the grep results, use *grep -n*
- In grep, use of | (pipe symbol) is treated literally. If it needs to be interpreted as an *or* operation, then escape it. Else, use *egrep* or *grep -e*
- To detect empty lines, use grep '^$'. Thus, if you need to find the number of empty lines in a file called poem.txt, use *cat poem.txt | egrep '^$'|wc -l*
- Use of backreference in regex needs the original pattern to be parenthesized.

Week5

- *source <script>* runs the script from the login shell. Thus, when the script is *sourced*, all environment variables created in the script will be available after the script has finished running.
- *./<script>* runs it from within a child process. However, if the script is run as a child process, none of the changes made is available after the script finishes running.
- *printf supports format specifiers like in C. For example, printf "My home is %s\n" $HOME.*
- *read var* reads input from the user, and stores in var; now *echo $var* prints the stored value.
- *$0* contains name of the shell program (including the invocation path), *$1..$n* contains the command line arguments. *$#* contains the number of such arguments. *$** (or *"$*"*) contains all arguments as one string. *"$@"* contains all arguments as separate strings.
- To store output of a command into *var*, use *var=$(<command>)* or *var=`<command>`*
- To store the var into array *my*_arr, use *my_arr=($var).*
- Thus, the following are equivalent. Both create arrays containing the files in the current directory.

```
anand@DESKTOP-GG7GDNK:~$ ls
check_sum.py  client  go  output.txt  poem.txt  push  server  test.sh
anand@DESKTOP-GG7GDNK:~$ ls_arr=($(ls))
anand@DESKTOP-GG7GDNK:~$ declare -p ls_arr
declare -a ls_arr=([0]="check_sum.py" [1]="client" [2]="go" [3]="output.txt" [4]="poem.txt" [5]="push"
[6]="server" [7]="test.sh")
```

Is equivalent to

```
anand@DESKTOP-GG7GDNK:~$ ls_var=$(ls)
anand@DESKTOP-GG7GDNK:~$ echo $ls_var
check_sum.py client go output.txt poem.txt push server test.sh
anand@DESKTOP-GG7GDNK:~$ ls_arr1=($ls_var)
anand@DESKTOP-GG7GDNK:~$ declare -p ls_arr1
declare -a ls_arr1=([0]="check_sum.py" [1]="client" [2]="go" [3]="output.txt" [4]="poem.txt" [5]="push"
 [6]="server" [7]="test.sh")
```

- *if test $a - eq $b* compares the first operand with the second for equality, and returns *0* if both are equal and *1* otherwise. Alternatively, you can also use *if [$a -eq $b]*. Note that in both cases,

if *$a* or *$b* is empty or contains spaces, then you must use them within double quotes as *if ["$a" -eq "$b"]*. If you want to avoid double-quotes around the variables, use double brackets as in *if [[$a -eq $b]]*.

NOTE: Instead of *-eq*, a single equals sign *(=)* also can be used like in *if [$a = $b]*.

- To compare strings, use *>* symbol; *-gt* will not work.
- C-style loop uses two pairs of parentheses as in *for ((i=1; i<10; i++))*
- *find . -maxdepth 1 -name '*.sh'* prints the names of all files in the current folder. If the *maxdepth* parameter is 2, then it prints the file names in the sub-folder also, but doesn't go further.
- Following are different ways to increment the variable c
  - *let c=c+1*
  - *c=$(expr $c + 1)*
  - *c=$((c+1)) or ((c=c+1))*
  - *((c++))*
- Following are different ways to multiply the variable c with 2.
  - *let c=c*2*
  - *c=$(expr $c * 2)*
  - *c=$((c*2)) or ((c=c*2))*

  NOTE: *c=$(expr $c * 2)* wouldn't work, because * has special meaning and hence needs to be escaped.
- Following are different ways to add two numbers from the terminal (without using a variable)
  - *expr 1 + 2*
  - *let c=1+2; echo $c*
  - *echo $((1 + 2))*

  NOTE: *expr 1 + 2* cannot be rewritten as *expr 1+2* (without spaces)
- *expr* doesn't support exponentiation, so use a let command like *let c=c**2*
- To work with bench calculator, use *bc -l*
- Following are some interesting options available with if statement:
  - *[-z STRING]* - checks if *STRING* is empty.
  - *[-n STRING]* - checks if *STRING* is not empty (same as *[! -z STRING]*)
  - *[-d FILE]* - Checks if *FILE* exists and is a directory.
  - *[-e FILE]* - Checks if *FILE* exists.
  - *[-f FILE]* - Checks if *FILE* exists and is a regular file.
  - *[-x FILE]* - Checks if *FILE* exists and execute permission is granted.
  - *[-s FILE]* - Checks if *FILE* exists and it's size is greater than zero (i.e., it's not empty).
  - *[[$string =~ $pattern]]* - Checks if the pattern is found in string.
- Given a string <str>, you can replace a substring <sub> with <rep> using *str=${str/<sub>/<rep>}*. However, regex patterns cannot be used here. For this, use *sed*