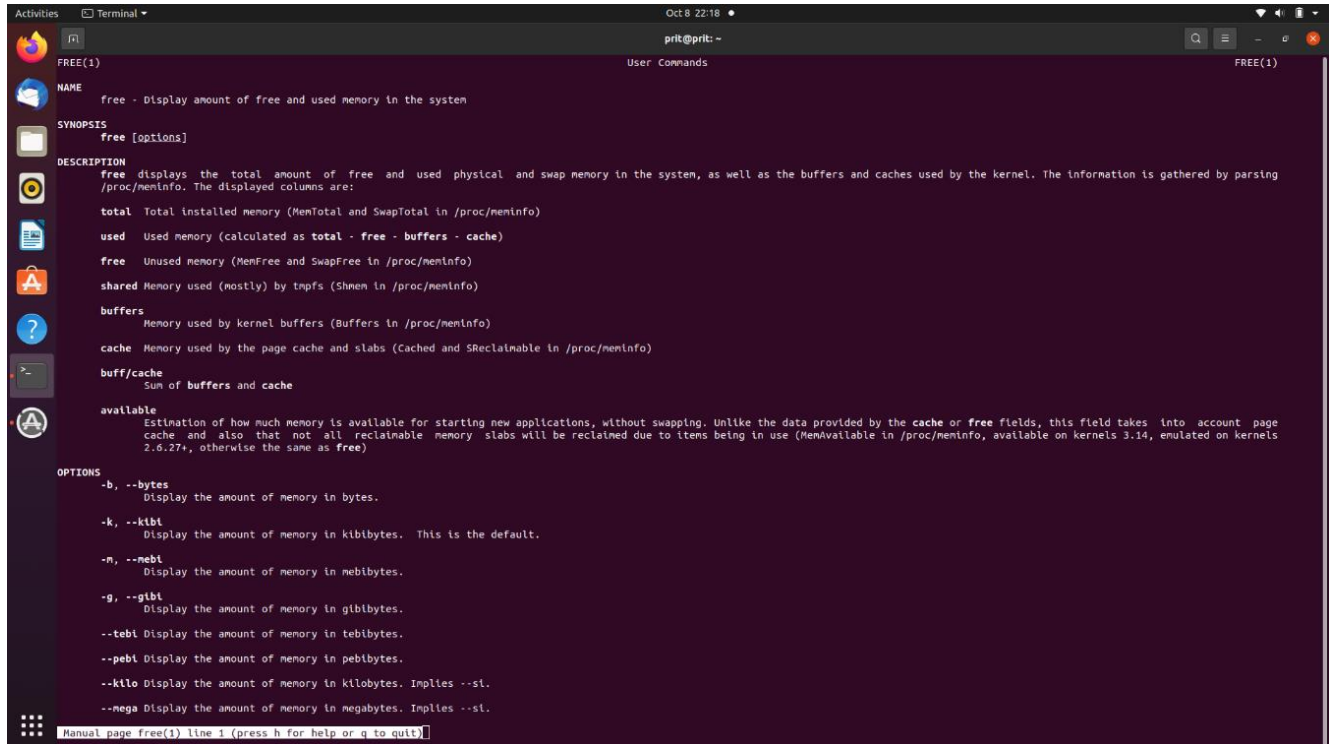


OS HW 2: Prithul Sarker

Problem 1

Man page of free command:



```
FREE(1)
NAME
    free - Display amount of free and used memory in the system

SYNOPSIS
    free [options]

DESCRIPTION
    free displays the total amount of free and used physical and swap memory in the system, as well as the buffers and caches used by the kernel. The information is gathered by parsing /proc/meminfo. The displayed columns are:

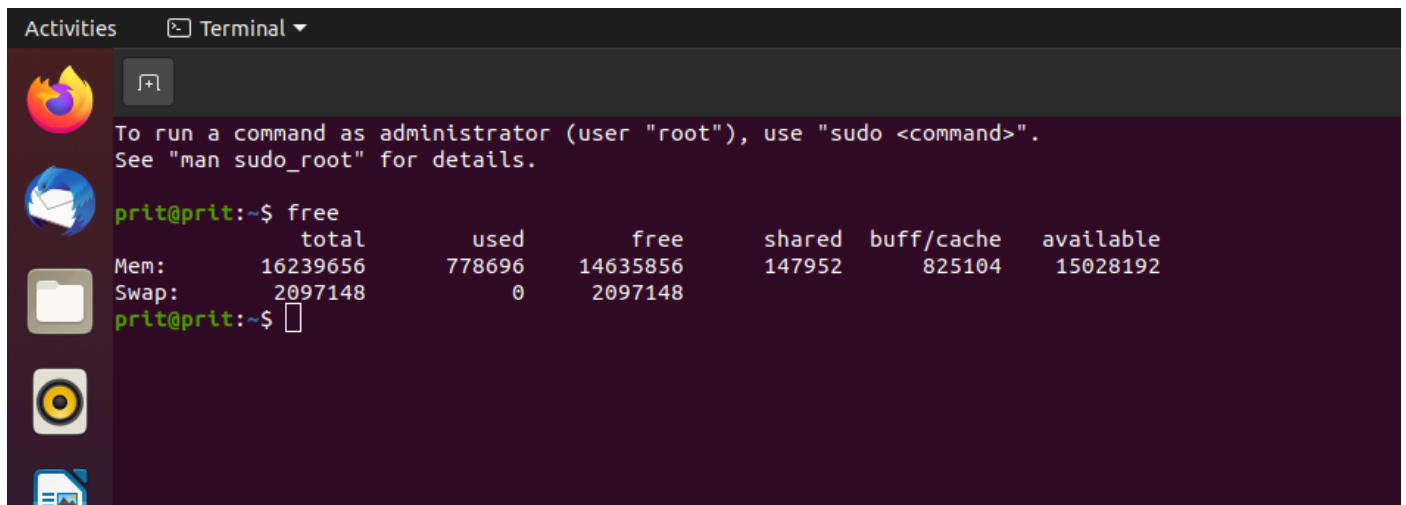
    total Total installed memory (MemTotal and SwapTotal in /proc/meminfo)
    used  Used memory (calculated as total - free - buffers - cache)
    free  Unused memory (MemFree and SwapFree in /proc/meminfo)
    shared Memory used (mostly) by tmpfs (Shmem in /proc/meminfo)
    buffers
        Memory used by kernel buffers (Buffers in /proc/meminfo)
    cache
        Memory used by the page cache and slabs (Cached and SReclaimable in /proc/meminfo)
    buff/cache
        Sum of buffers and cache
    available
        Estimation of how much memory is available for starting new applications, without swapping. Unlike the data provided by the cache or free fields, this field takes into account page cache and also that not all reclaimable memory slabs will be reclaimed due to items being in use (MemAvailable in /proc/meminfo, available on kernels 3.14, emulated on kernels 2.6.27+, otherwise the same as free)

OPTIONS
    -b, --bytes
        Display the amount of memory in bytes.
    -k, --kibi
        Display the amount of memory in kibibytes. This is the default.
    -m, --mebi
        Display the amount of memory in mebibytes.
    -g, --gibi
        Display the amount of memory in gibibytes.
    --tebi Display the amount of memory in tebibytes.
    --pebi Display the amount of memory in pebibytes.
    --kilo Display the amount of memory in kilobytes. Implies --si.
    --mega Display the amount of memory in megabytes. Implies --si.

Manual page free(1) line 1 (press h for help or q to quit)
```

In my computer free-o command does not work so I have done the same task using only free command.

Execution of free command:



```
Activities Terminal
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

prithu@prithu:~$ free
              total        used        free      shared  buff/cache   available
Mem:      16239656       778696      14635856      147952       825104      15028192
Swap:      2097148           0       2097148

prithu@prithu:~$
```

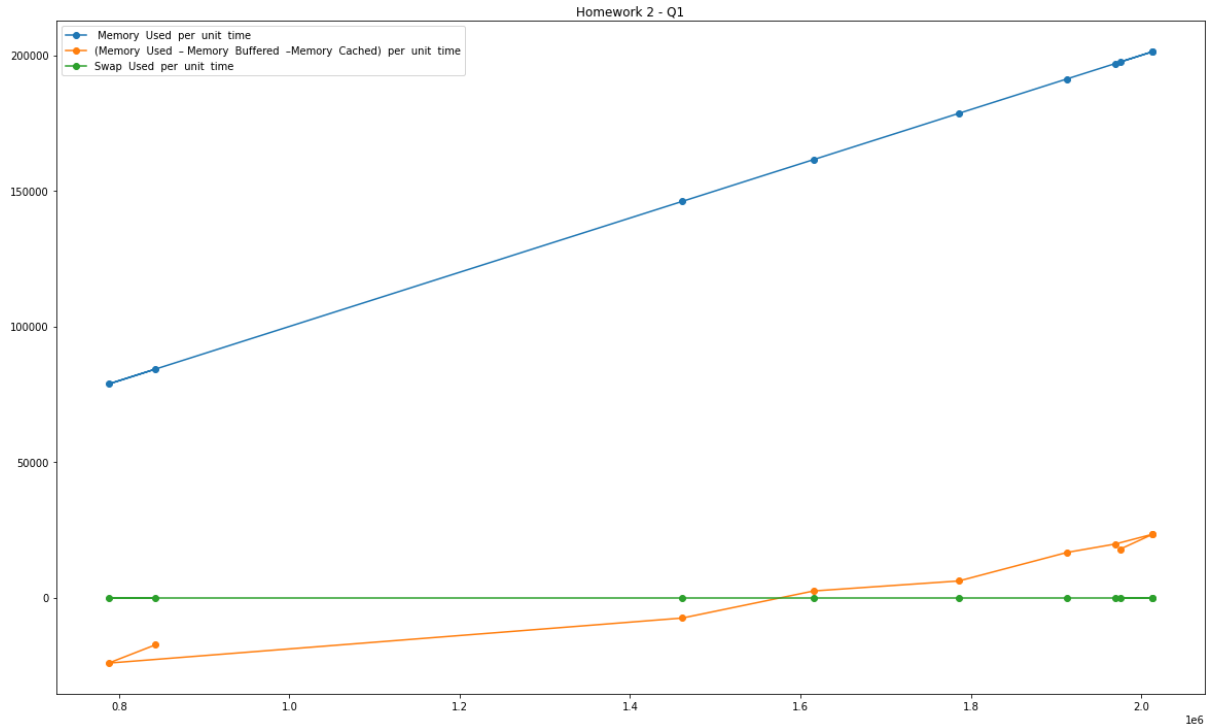
Executing free command 10 times at a constant time interval (10 seconds) running other programs in between:

```

prlt@prlt:~$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
prlt@prlt:~$ cd Documents
prlt@prlt:~/Documents$ free-w
free-w: command not found
prlt@prlt:~/Documents$ free
total        used        free      shared  buff/cache   available
Mem:    16239656    842460    14380340    163340    1016856    14946084
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free-s 10 -c 10
free-s: command not found
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    842964    14379836    163332    1016856    14945580
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    787720    14422768    175584    1029168    14988580
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1461292    13241764    397332    1536600    14089452
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1615672    13032968    441000    1591016    13890792
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1785976    12729164    557400    1724516    13602564
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1913160    12580148    563820    1746348    13468380
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1969680    12498004    582820    1771972    13392556
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    2012768    12447404    573212    1779484    13353668
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    2013472    12446152    571676    1780032    13354448
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ free -s 10 -c 10
total        used        free      shared  buff/cache   available
Mem:    16239656    1975572    12467728    587920    1796356    13376084
Swap:    2097148           0     2097148
prlt@prlt:~/Documents$ touch graph.txt
prlt@prlt:~/Documents$ ls
graph.txt  my-processes-1.txt  my-processes-2.txt  rootprocesses-1.txt  rootprocesses-2.txt
prlt@prlt:~/Documents$

```

	total	used	free	shared	buff/cache	available
Mem:		16239656	842964	14379836	163332	1016856
Swap:		2097148	0	2097148		14945580
	total	used	free	shared	buff/cache	available
Mem:	16239656	787720	14422768	175584	1029168	14988580
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1461292	13241764	397332	1536600	14089452
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1615672	13032968	441000	1591016	13890792
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1785976	12729164	557400	1724516	13602564
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1913160	12580148	563820	1746348	13468380
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1969680	12498004	582820	1771972	13392556
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	2012768	12447404	573212	1779484	13353668
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	2013472	12446152	571676	1780032	13354448
Swap:	2097148	0	2097148			
	total	used	free	shared	buff/cache	available
Mem:	16239656	1975572	12467728	587920	1796356	13376084
Swap:	2097148	0	2097148			



I used free command on an interval of 10 sec. So for the per unit time measurement, the memory used, buffered/cached and swap used are divided by 10 sec. In the above diagram, we can see that the memory used per unit time increases with the memory being used. However, swap memory could only be used when the main memory is full. So, the swap memory is zero for the figure. Again, at first, buffer is being used more than the memory used. For this reason, the (memory used - memory buffered - memory cached) per unit time values are in negative region. However, after few 10 second intervals, the buffer memory does not increase in the similar way compared to the memory used. This is why, (memory used - memory buffered - memory cached) per unit time is in the positive region.

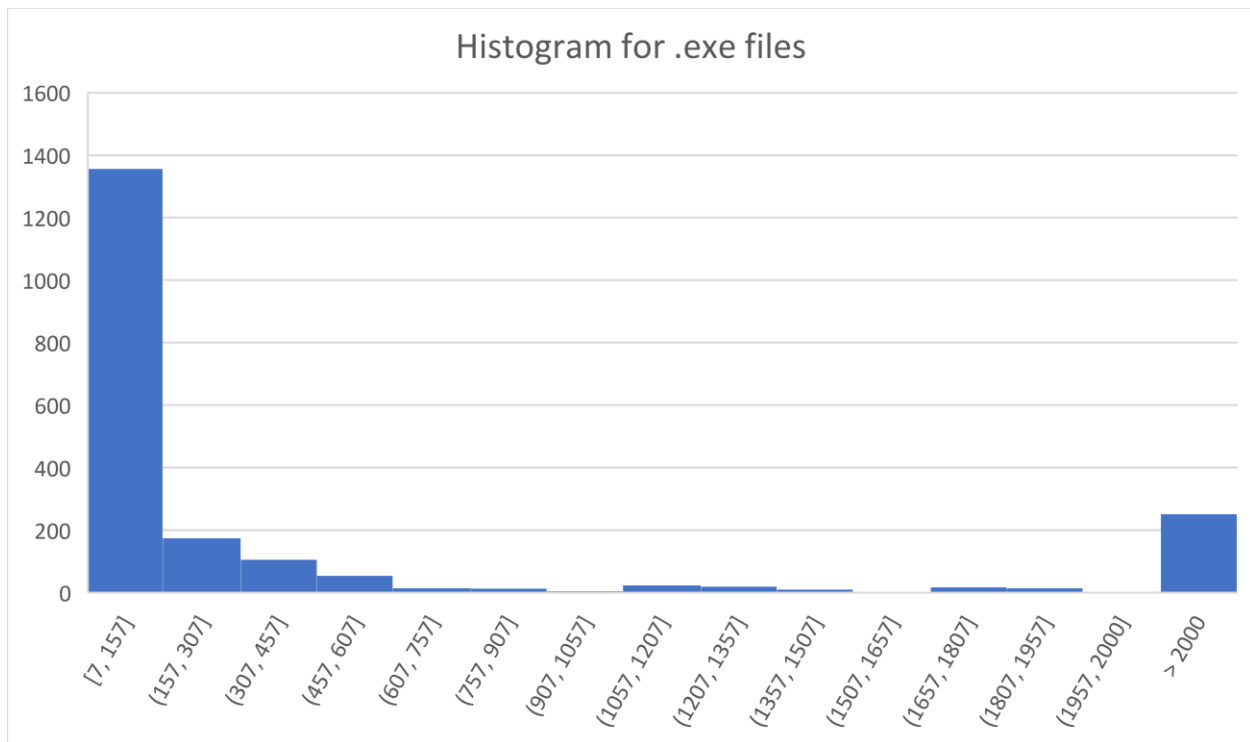
Problem 2

For .exe files, the mean and median of the files are 4617.24 and 73 Kb respectively.

And optimal page size = $(2 * s * e)^{1/2}$

Here, $e = 8$ bytes, and $s = \text{pages per process} * \text{page number} = 2^8 * 4617.24 * 1024$

Therefore, optimal page size = $(2 * 2^8 * 4617.24 * 1024 * 8)^{1/2} = 139162$ bytes

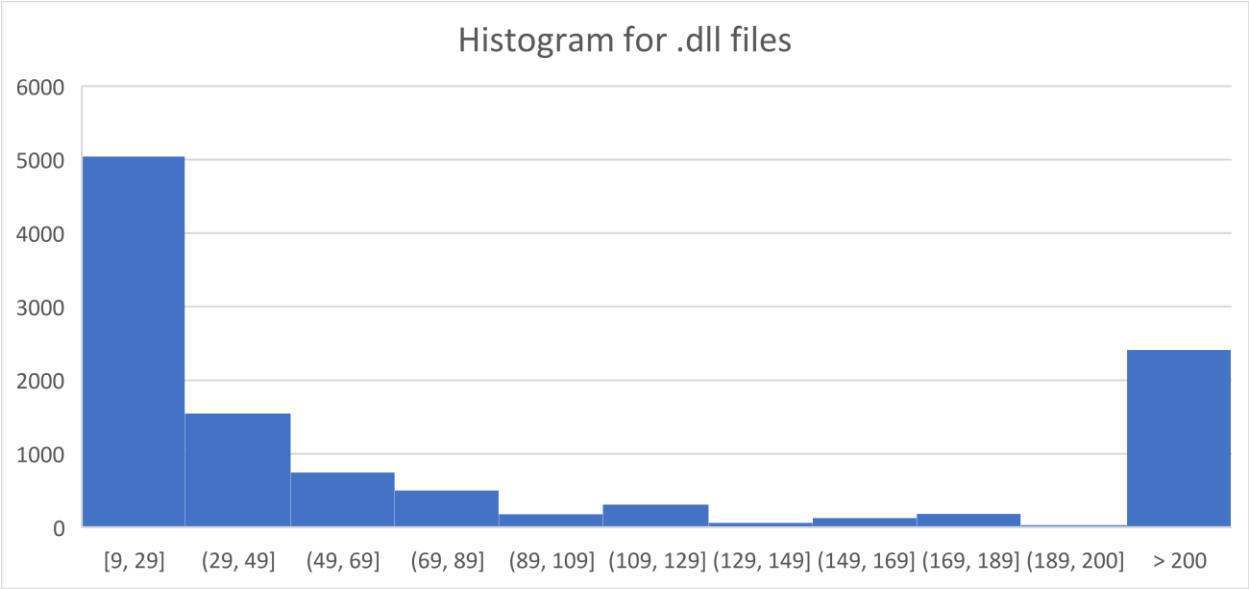


For .dll files, the mean and median of the files are 31121.72 and 35.375 Kb respectively.

And optimal page size = $(2 * s * e)^{1/2}$

Here, $e = 8$ bytes, and $s = \text{pages per process} * \text{page number} = 2^8 * 31121.72 * 1024$

Therefore, optimal page size = $(2 * 2^8 * 31121.72 * 1024 * 8)^{1/2} = 361294.83$ bytes



The text files containing all the .exe and .dll file names and sizes are uploaded separately inside the zip file.

Problem 3

Man page of df command:

```
df(1)
NAME
    df - report file system disk space usage

SYNOPSIS
    df [OPTION]... [FILE]...

DESCRIPTION
    This manual page documents the GNU version of df.  df displays the amount of disk space available on the file system containing each file name argument.  If no file name is given, the space available on all currently mounted file systems is shown.  Disk space is shown in 1K blocks by default, unless the environment variable POSIXLY_CORRECT is set, in which case 512-byte blocks are used.

    If an argument is the absolute file name of a disk device node containing a mounted file system, df shows the space available on that file system rather than on the file system containing the device node.  This version of df cannot show the space available on unmounted file systems, because on most kinds of systems doing so requires very nonportable intimate knowledge of file system structures.

OPTIONS
    Show information about the file system on which each FILE resides, or all file systems by default.

    Mandatory arguments to long options are mandatory for short options too.

    -a, --all
        Include pseudo, duplicate, inaccessible file systems

    -B, --block-size=SIZE
        scale sizes by SIZE before printing them; e.g., '-BM' prints sizes in units of 1,048,576 bytes; see SIZE format below

    -h, --human-readable
        print sizes in powers of 1024 (e.g., 1023M)

    -k, --k
        print sizes in powers of 1000 (e.g., 1.1G)

    -L, --local
        list inode information instead of block usage

    -l, --local
        limit listing to local file systems

    --no-sync
        do not invoke sync before getting usage info (default)

    --output=FIELD_LIST
        use the output format defined by FIELD_LIST, or print all fields if FIELD_LIST is omitted.

    -P, --portability
        use the POSIX output format

    --sync
        invoke sync before getting usage info

Manual page df(1) line 1: forked & for help see in the end
```

Execution of df Command:

```
Activities Terminal
priti@priti: ~/Documents

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

priti@priti:~/Documents$ df
Filesystem            1K-blocks      Used Available  Use% Mounted on
udev                  8090208         0   8090208    0% /dev
tmpfs                 1623968       2092   1621876    1% /run
/dev/nvme0n1p6       205369064 9855136 185011788    6% /
tmpfs                 8119828         0   8119828    0% /dev/shm
tmpfs                  5120          4     5116    1% /run/lock
tmpfs                 8119828         0   8119828    0% /sys/fs/cgroup
/dev/loop1             128         128         0 100% /snap/bare/5
/dev/loop2             66816       66816         0 100% /snap/gtk-common-themes/1519
/dev/loop0             56832       56832         0 100% /snap/core18/2074
/dev/loop4             33152       33152         0 100% /snap/snapd/13170
/dev/loop3             52224       52224         0 100% /snap/snap-store/547
/dev/loop5             66688       66688         0 100% /snap/gtk-common-themes/1515
/dev/loop8            224256     224256         0 100% /snap/gnome-3-34-1804/72
/dev/loop6            224256     224256         0 100% /snap/gnome-3-34-1804/66
/dev/loop7             52224       52224         0 100% /snap/snap-store/542
/dev/loop9             56832       56832         0 100% /snap/core18/2128
/dev/loop10           33152       33152         0 100% /snap/snapd/12883
/dev/nvme0n1p1        262144     33972    228172   13% /boot/efi
tmpfs                 1623964         76   1623888    1% /run/user/1000
```


The underlined numbers under “Available” column are the available disk sizes of the file system. The other non-underlined disk sizes are already 100 % used.

Execution of df-i command:

```
prit@prit:~/Documents$ df-i
df-i: command not found
prit@prit:~/Documents$ df -i
```

Filesystem	Inodes	IUsed	IFree	IUse%	Mounted on
udev	2022552	648	<u>2021904</u>	1%	/dev
tmpfs	2029957	1171	<u>2028786</u>	1%	/run
/dev/nvme0n1p6	13132800	213795	<u>12919005</u>	2%	/
tmpfs	2029957	1	<u>2029956</u>	1%	/dev/shm
tmpfs	2029957	5	<u>2029952</u>	1%	/run/lock
tmpfs	2029957	18	<u>2029939</u>	1%	/sys/fs/cgroup
/dev/loop1	29	29	0	100%	/snap/bare/5
/dev/loop2	65095	65095	0	100%	/snap/gtk-common-themes/1519
/dev/loop0	10803	10803	0	100%	/snap/core18/2074
/dev/loop4	474	474	0	100%	/snap/snapd/13170
/dev/loop3	15841	15841	0	100%	/snap/snap-store/547
/dev/loop5	64986	64986	0	100%	/snap/gtk-common-themes/1515
/dev/loop8	18500	18500	0	100%	/snap/gnome-3-34-1804/72
/dev/loop6	18508	18508	0	100%	/snap/gnome-3-34-1804/66
/dev/loop7	15841	15841	0	100%	/snap/snap-store/542
/dev/loop9	10803	10803	0	100%	/snap/core18/2128
/dev/loop10	474	474	0	100%	/snap/snapd/12883
/dev/nvme0n1p1	0	0	0	-	/boot/efi
tmpfs	2029957	98	<u>2029859</u>	1%	/run/user/1000

```
prit@prit:~/Documents$
```

In the above diagram the total number of I nodes are shown under the column of Inodes. The underlined numbers under the ‘Ifree’ column are the Inodes which are available, the used I nodes are shown under the Iused column.

df and df-l command execution after creating a new file with just a few characters in it:

```
prtt@prtt:~/Documents$ touch dfFolder.txt
prtt@prtt:~/Documents$ ls
dfFolder.txt  graph.txt  my-processes-1.txt  my-processes-2.txt  rootprocesses-1.txt  rootprocesses-2.txt
prtt@prtt:~/Documents$ df
Filesystem      1K-blocks    Used Available Use% Mounted on
udev            8090208         0   8090208   0% /dev
tmpfs           1623968     2108   1621860   1% /run
/dev/nvme0n1p6 205369064 9860648 185006276   6% /
tmpfs           8119828         0   8119828   0% /dev/shm
tmpfs           5120         4     5116   1% /run/lock
tmpfs           8119828         0   8119828   0% /sys/fs/cgroup
/dev/loop1       128         128         0 100% /snap/bare/5
/dev/loop2       66816     66816         0 100% /snap/gtk-common-themes/1519
/dev/loop0       56832     56832         0 100% /snap/core18/2074
/dev/loop4       33152     33152         0 100% /snap/snapd/13170
/dev/loop3       52224     52224         0 100% /snap/snap-store/547
/dev/loop5       66688     66688         0 100% /snap/gtk-common-themes/1515
/dev/loop8       224256    224256         0 100% /snap/gnome-3-34-1804/72
/dev/loop6       224256    224256         0 100% /snap/gnome-3-34-1804/66
/dev/loop7       52224     52224         0 100% /snap/snap-store/542
/dev/loop9       56832     56832         0 100% /snap/core18/2128
/dev/loop10      33152     33152         0 100% /snap/snapd/12883
/dev/nvme0n1p1   262144    33972    228172   13% /boot/efi
tmpfs           1623964         76   1623888   1% /run/user/1000
prtt@prtt:~/Documents$ df -l
Filesystem      Inodes    IUsed   IFree IUse% Mounted on
udev            2022552     648   2021904    1% /dev
tmpfs           2029957    1175   2028782    1% /run
/dev/nvme0n1p6 13132800 213920 12918880    2% /
tmpfs           2029957         1   2029956    1% /dev/shm
tmpfs           2029957         5   2029952    1% /run/lock
tmpfs           2029957        18   2029939    1% /sys/fs/cgroup
/dev/loop1       29         29         0 100% /snap/bare/5
/dev/loop2       65095    65095         0 100% /snap/gtk-common-themes/1519
/dev/loop0      10803    10803         0 100% /snap/core18/2074
/dev/loop4       474         474         0 100% /snap/snapd/13170
/dev/loop3      15841    15841         0 100% /snap/snap-store/547
/dev/loop5      64986    64986         0 100% /snap/gtk-common-themes/1515
/dev/loop8      18500    18500         0 100% /snap/gnome-3-34-1804/72
/dev/loop6      18508    18508         0 100% /snap/gnome-3-34-1804/66
/dev/loop7      15841    15841         0 100% /snap/snap-store/542
/dev/loop9      10803    10803         0 100% /snap/core18/2128
/dev/loop10      474         474         0 100% /snap/snapd/12883
/dev/nvme0n1p1     0         0         0  - /boot/efi
tmpfs           2029957         98   2029859    1% /run/user/1000
prtt@prtt:~/Documents$
```

Changes in available disk space are underlined in df command after few characters.

df and df-l command execution after an increasing character size over 5000:

```
prtt@prtt:~/Documents$ df
Filesystem      1K-blocks      Used Available Use% Mounted on
udev            8090208         0    8090208   0% /dev
tmpfs           1623968       2112    1621856   1% /run
/dev/nvme0n1p6 205369064 9877168 184989756   6% /
tmpfs           8119828         0    8119828   0% /dev/shm
tmpfs           5120          4        5116   1% /run/lock
tmpfs           8119828         0    8119828   0% /sys/fs/cgroup
/dev/loop1       128         128          0 100% /snap/bare/5
/dev/loop2       66816       66816          0 100% /snap/gtk-common-themes/1519
/dev/loop0       56832       56832          0 100% /snap/core18/2074
/dev/loop4       33152       33152          0 100% /snap/snapd/13170
/dev/loop3       52224       52224          0 100% /snap/snap-store/547
/dev/loop5       66688       66688          0 100% /snap/gtk-common-themes/1515
/dev/loop8       224256     224256          0 100% /snap/gnome-3-34-1804/72
/dev/loop6       224256     224256          0 100% /snap/gnome-3-34-1804/66
/dev/loop7       52224       52224          0 100% /snap/snap-store/542
/dev/loop9       56832       56832          0 100% /snap/core18/2128
/dev/loop10      33152       33152          0 100% /snap/snapd/12883
/dev/nvme0n1p1   262144     33972     228172   13% /boot/efi
tmpfs           1623964        76    1623888   1% /run/user/1000

prtt@prtt:~/Documents$ df -l
Filesystem      Inodes    IUsed    IFree IUse% Mounted on
udev            2022552     648    2021904    1% /dev
tmpfs           2029957    1176    2028781    1% /run
/dev/nvme0n1p6 13132800 214474 12918326    2% /
tmpfs           2029957         1    2029956    1% /dev/shm
tmpfs           2029957         5    2029952    1% /run/lock
tmpfs           2029957        18    2029939    1% /sys/fs/cgroup
/dev/loop1        29         29          0 100% /snap/bare/5
/dev/loop2       65095     65095          0 100% /snap/gtk-common-themes/1519
/dev/loop0       10803     10803          0 100% /snap/core18/2074
/dev/loop4        474         474          0 100% /snap/snapd/13170
/dev/loop3       15841     15841          0 100% /snap/snap-store/547
/dev/loop5       64986     64986          0 100% /snap/gtk-common-themes/1515
/dev/loop8       18500     18500          0 100% /snap/gnome-3-34-1804/72
/dev/loop6       18508     18508          0 100% /snap/gnome-3-34-1804/66
/dev/loop7       15841     15841          0 100% /snap/snap-store/542
/dev/loop9       10803     10803          0 100% /snap/core18/2128
/dev/loop10       474         474          0 100% /snap/snapd/12883
/dev/nvme0n1p1         0          0          0  - /boot/efi
tmpfs           2029957         99    2029858    1% /run/user/1000

prtt@prtt:~/Documents$
```

Changes in available disk space is underlined in df and df-l command after increasing the number of characters to over 5000.

Problem 4

Output of the code

```
prtt@prtt:~/Downloads$ gcc Prob4.c -o Prob4
prtt@prtt:~/Downloads$ ./Prob4
Enter Directory path: /home/prtt/Desktop
Enter bin width: 1024
Histogram of the given directory tree and bin width:
 0 - 1024 | *****
1024 - 2048 | **
2048 - 3072 |
3072 - 4096 |
4096 - 5120 | **
5120 - 6144 | *
6144 - 7168 |
7168 - 8192 |
8192 - 9216 | **
9216 - 10240 |
10240 - 11264 |
11264 - 12288 |
12288 - 13312 |
13312 - 14336 |
14336 - 15360 |
15360 - 16384 |
16384 - 17408 |
17408 - 18432 |
18432 - 19456 |
19456 - 20480 |
20480 - 21504 |
21504 - 22528 |
22528 - 23552 |
23552 - 24576 |
24576 - 25600 |
25600 - 26624 |
26624 - 27648 |
27648 - 28672 |
28672 - 29696 |
29696 - 30720 |
30720 - 31744 |
31744 - 32768 |
32768 - 33792 |
33792 - 34816 |
34816 - 35840 |
35840 - 36864 |
36864 - 37888 |
37888 - 38912 |
38912 - 39936 |
39936 - 40960 |
40960 - 41984 |
41984 - 43008 |
43008 - 44032 |
44032 - 45056 |
45056 - 46080 |
46080 - 47104 |
```

The c code file is uploaded in the zip file.