Linux Process Management — Lab Report

Concise lab report with commands, examples and screenshots — process states, monitoring, priorities and advanced tooling.

Objective

> Understanding and implementing process management concepts in Linux through hands-on examples.

Theory

What is a Process?

A process is an instance of a running program with its own memory space and system resources.

Process States

- R (Running/Runnable)
- S (Sleeping — waiting for event)
- D (Uninterruptible sleep)
- T (Stopped)
- Z (Zombie)

Process Types

- Foreground: Connected to terminal
- Background: Runs independently

Process Identifiers

- PID: Unique process ID
- PPID: Parent process ID

Core Concepts

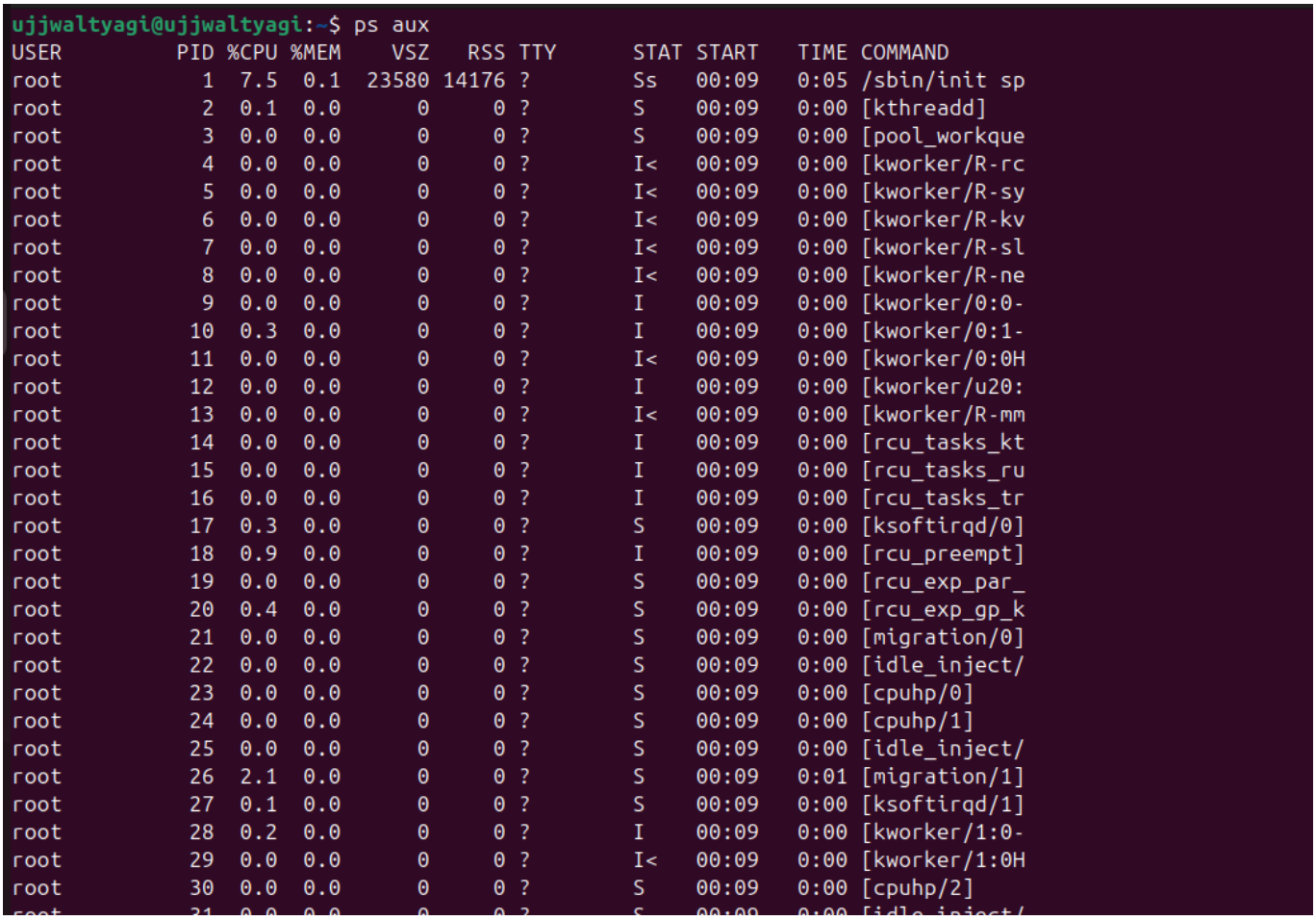
- Parent/Child processes
- Zombie processes
- Orphan processes

Commands & Examples

View all processes (detailed)

```
ps aux
```

Explanation: Shows all running processes with user, PID, %CPU, %MEM, VSZ, RSS, TTY, STAT, START, TIME, and COMMAND.



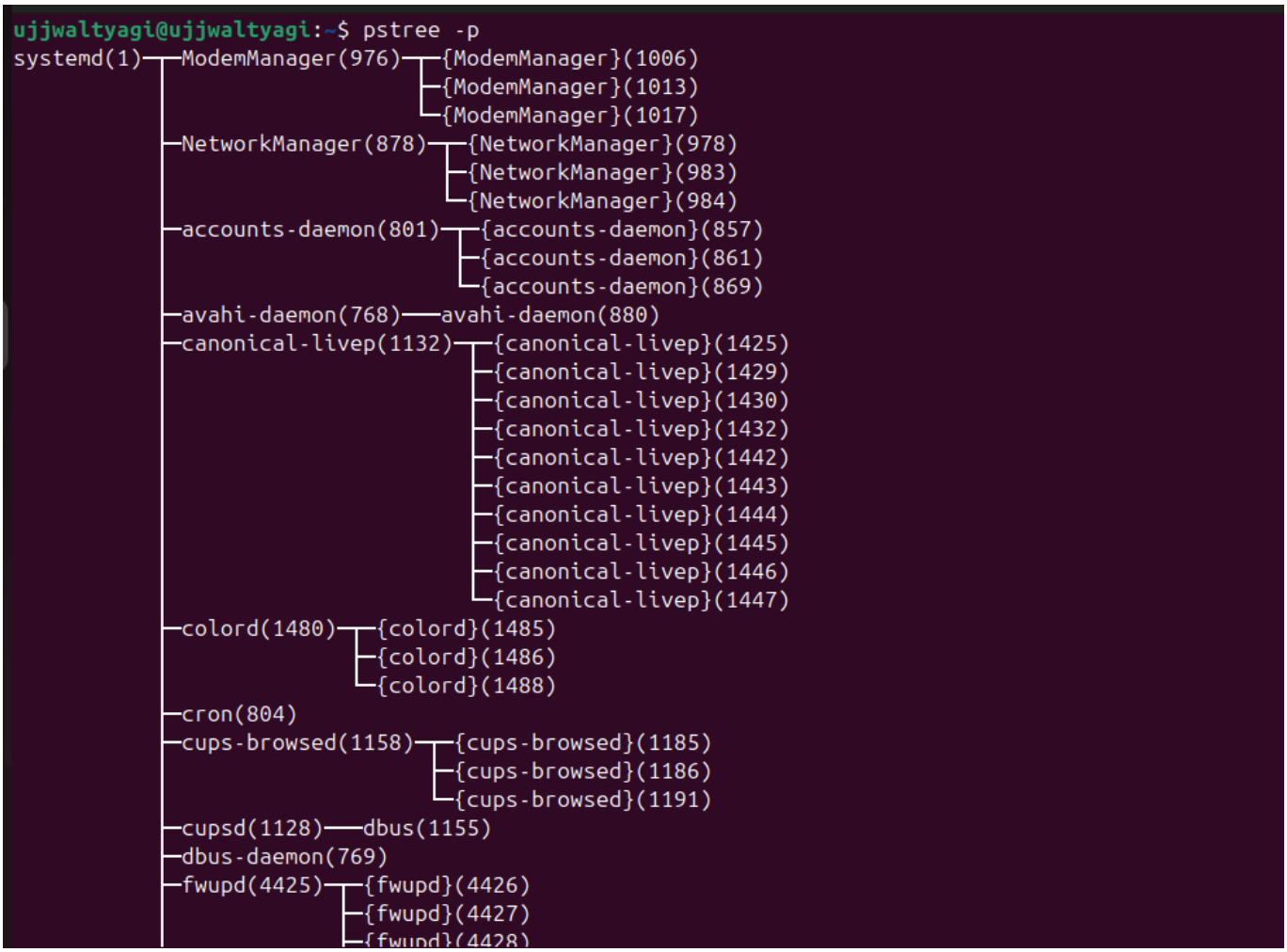
```
ujjwaltyagi@ujjwaltyagi:~$ ps aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  7.5  0.1  23580 14176 ?        Ss   00:09   0:05 /sbin/init sp
root           2  0.1  0.0      0     0 ?        S    00:09   0:00 [kthreadd]
root           3  0.0  0.0      0     0 ?        S    00:09   0:00 [pool_workque
root           4  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-rc
root           5  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-sy
root           6  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-kv
root           7  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-sl
root           8  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-ne
root           9  0.0  0.0      0     0 ?        I    00:09   0:00 [kworker/0:0-
root          10  0.3  0.0      0     0 ?        I    00:09   0:00 [kworker/0:1-
root          11  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/0:0H
root          12  0.0  0.0      0     0 ?        I    00:09   0:00 [kworker/u20:
root          13  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/R-mm
root          14  0.0  0.0      0     0 ?        I    00:09   0:00 [rcu_tasks_kt
root          15  0.0  0.0      0     0 ?        I    00:09   0:00 [rcu_tasks_ru
root          16  0.0  0.0      0     0 ?        I    00:09   0:00 [rcu_tasks_tr
root          17  0.3  0.0      0     0 ?        S    00:09   0:00 [ksoftirqd/0]
root          18  0.9  0.0      0     0 ?        I    00:09   0:00 [rcu_preempt]
root          19  0.0  0.0      0     0 ?        S    00:09   0:00 [rcu_exp_par_
root          20  0.4  0.0      0     0 ?        S    00:09   0:00 [rcu_exp_gp_k
root          21  0.0  0.0      0     0 ?        S    00:09   0:00 [migration/0]
root          22  0.0  0.0      0     0 ?        S    00:09   0:00 [idle_inject/
root          23  0.0  0.0      0     0 ?        S    00:09   0:00 [cpuhp/0]
root          24  0.0  0.0      0     0 ?        S    00:09   0:00 [cpuhp/1]
root          25  0.0  0.0      0     0 ?        S    00:09   0:00 [idle_inject/
root          26  2.1  0.0      0     0 ?        S    00:09   0:01 [migration/1]
root          27  0.1  0.0      0     0 ?        S    00:09   0:00 [ksoftirqd/1]
root          28  0.2  0.0      0     0 ?        I    00:09   0:00 [kworker/1:0-
root          29  0.0  0.0      0     0 ?        I<   00:09   0:00 [kworker/1:0H
root          30  0.0  0.0      0     0 ?        S    00:09   0:00 [cpuhp/2]
root          31  0.0  0.0      0     0 ?        S    00:09   0:00 [idle_inject/
```

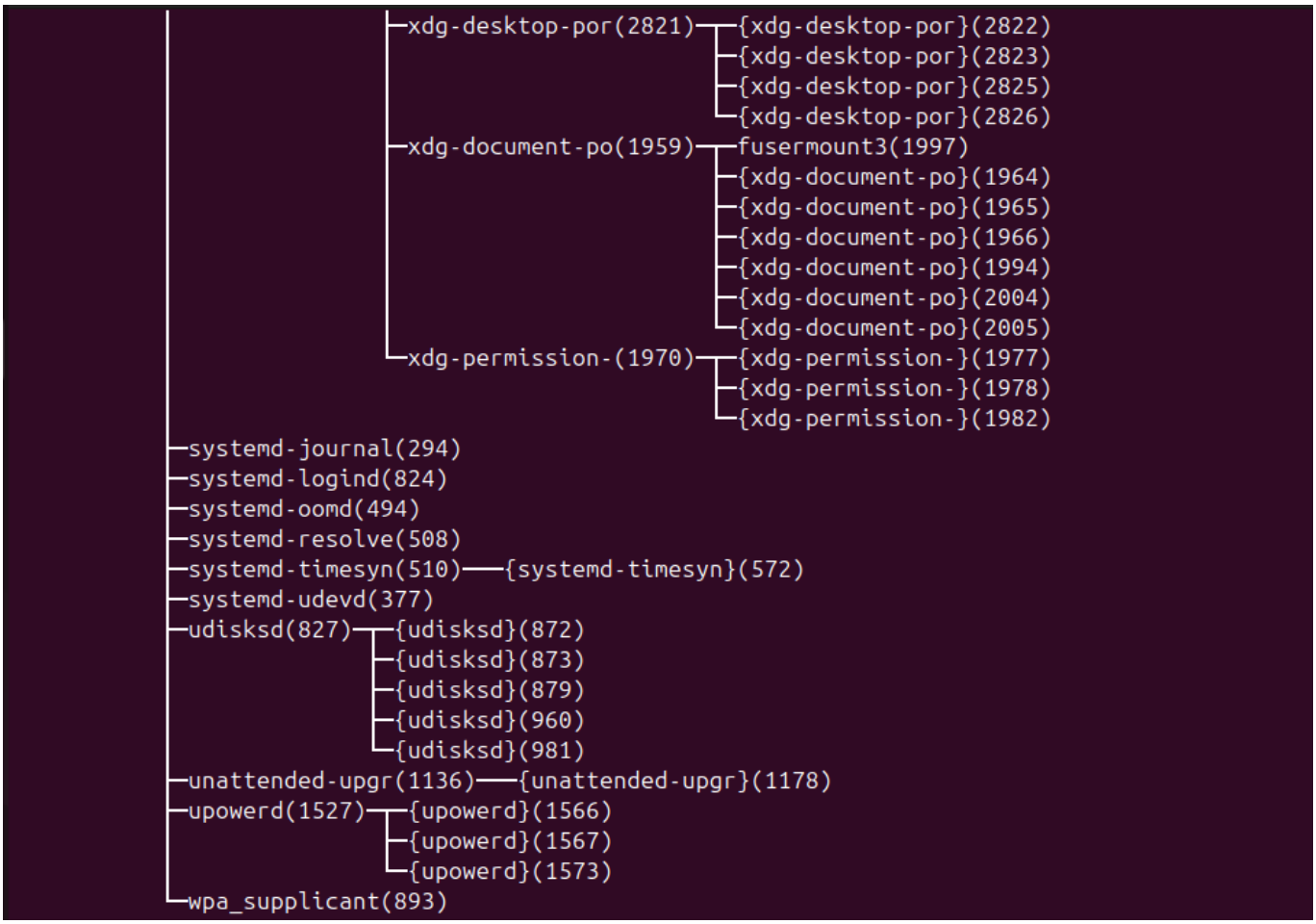
```
ujjwalt+    2414  2.2  0.1 471720 11164 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2425  0.6  0.1 424904 14808 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2450  0.2  0.0 245312  7104 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2452 42.3  0.3 429636 27968 ?        Sl   00:10   0:05 /usr/libexec/
ujjwalt+    2461  0.5  0.0 319092  7036 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2473  1.2  0.2 555328 23980 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2487  3.7  0.1  39136 11848 ?        Ss   00:10   0:00 /snap/snapd-d
ujjwalt+    2493  0.3  0.0 318440  6208 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2512  0.3  0.1 397792  8916 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2513  2.6  0.2 899384 24200 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2522  0.4  0.0 318460  6200 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2542  0.8  0.0 398044  7724 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2566  0.6  0.0 319428  6744 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2580  1.9  0.3 833976 29684 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2603  5.3  0.3 429612 30568 ?        Sl   00:10   0:00 /snap/snapd-d
ujjwalt+    2642  0.4  0.0 245436  7108 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2665  0.4  0.0 230220  5564 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2674  6.7  0.6 946744 50312 ?        Sl   00:10   0:00 /usr/bin/naut
ujjwalt+    2675  0.7  0.0 244936  6148 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2676  1.4  0.1 618108  8884 ?        Sl   00:10   0:00 /usr/libexec/
ujjwalt+    2709  2.6  0.1 562804 13816 ?        Ssl  00:10   0:00 /usr/libexec/
root        2739  0.0  0.0      0     0 ?        I<   00:10   0:00 [kworker/u27:
root        2740  0.0  0.0      0     0 ?        I<   00:10   0:00 [kworker/u27:
ujjwalt+    2754  4.1  0.2 742932 24924 ?        SNsl 00:10   0:00 /usr/libexec/
ujjwalt+    2755  5.4  0.4 925996 40952 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2766 11.3  0.7 3019200 61592 ?       Sl   00:10   0:00 gjs /usr/shar
ujjwalt+    2783  2.0  0.3 2544192 27792 ?       Sl   00:10   0:00 /usr/bin/gjs
ujjwalt+    2821  4.8  0.2 425872 24388 ?        Ssl  00:10   0:00 /usr/libexec/
ujjwalt+    2864 29.2  0.6 561652 51488 ?        Ssl  00:10   0:01 /usr/libexec/
ujjwalt+    2871  1.6  0.0  19692  5056 pts/0    Ss   00:10   0:00 bash
ujjwalt+    2879  150  0.0  22284  4620 pts/0    R+   00:10   0:00 ps aux
```

Hierarchical process view

```
pstree -p
```

Explanation: Displays processes in a tree form with PIDs — useful to see parent/child relations.


ujjwaltyagi@ujjwaltyagi:~$ pstree -p
systemd(1)─┬─ModemManager(976)─┬─{ModemManager}(1006)
├─{ModemManager}(1013)
└─{ModemManager}(1017)
├─NetworkManager(878)─┬─{NetworkManager}(978)
├─{NetworkManager}(983)
└─{NetworkManager}(984)
├─accounts-daemon(801)─┬─{accounts-daemon}(857)
├─{accounts-daemon}(861)
└─{accounts-daemon}(869)
├─avahi-daemon(768)──avahi-daemon(880)
├─canonical-livep(1132)─┬─{canonical-livep}(1425)
├─{canonical-livep}(1429)
├─{canonical-livep}(1430)
├─{canonical-livep}(1432)
├─{canonical-livep}(1442)
├─{canonical-livep}(1443)
├─{canonical-livep}(1444)
├─{canonical-livep}(1445)
├─{canonical-livep}(1446)
└─{canonical-livep}(1447)
├─colord(1480)─┬─{colord}(1485)
├─{colord}(1486)
└─{colord}(1488)
├─cron(804)
├─cups-browsed(1158)─┬─{cups-browsed}(1185)
├─{cups-browsed}(1186)
└─{cups-browsed}(1191)
├─cupsd(1128)──dbus(1155)
├─dbus-daemon(769)
├─fwupd(4425)─┬─{fwupd}(4426)
├─{fwupd}(4427)



Real-time monitoring

```
top
```

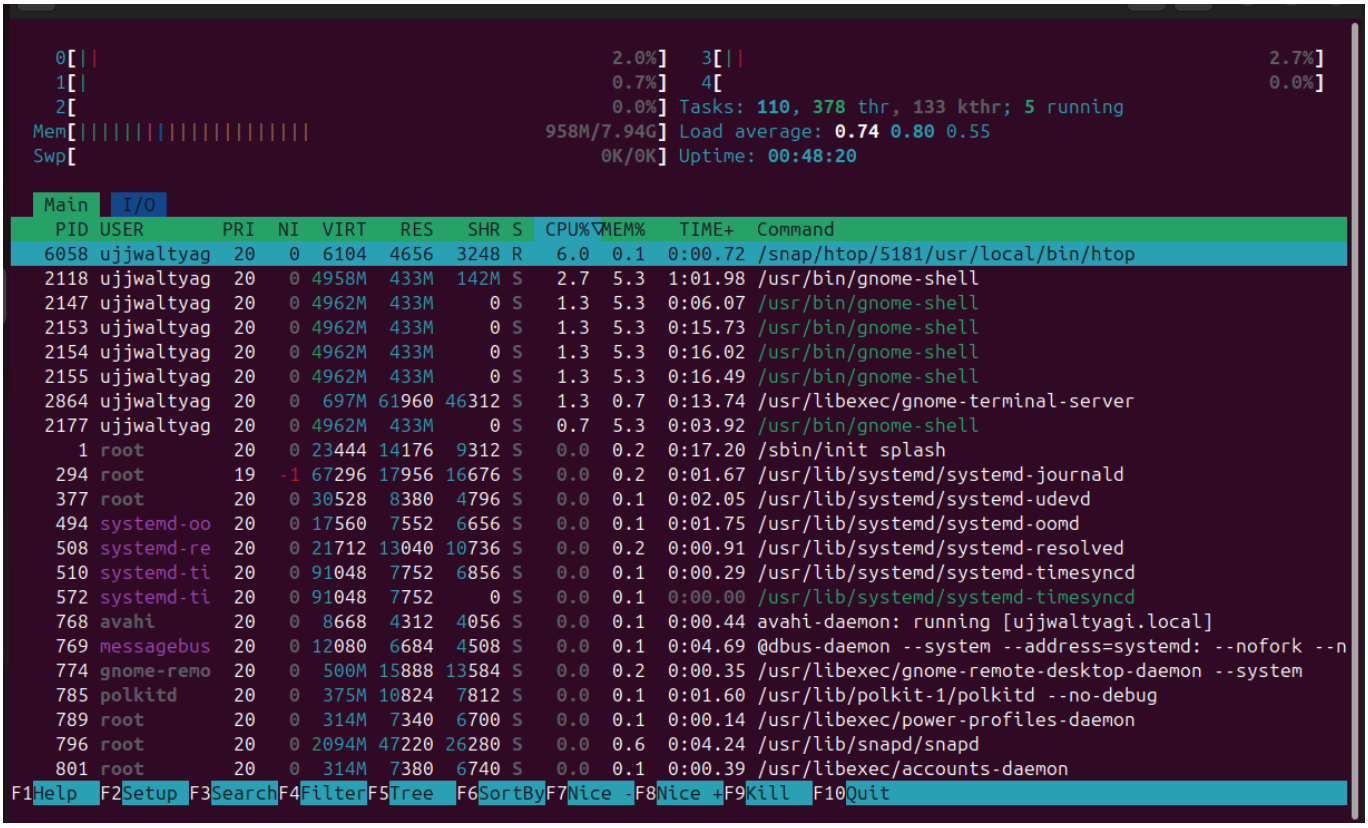
Explanation: Interactive display of processes sorted by CPU usage. Press `q` to quit.

```
top - 00:52:03 up 42 min,  1 user,  load average: 0.06, 0.31, 0.37
Tasks: 235 total,   1 running, 234 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.2 us,  0.4 sy,  0.0 ni, 99.3 id,  0.0 wa,  0.0 hi,  0.1 si,  0.0 st
MiB Mem :   8128.5 total,   5341.6 free,   1179.7 used,   1886.5 buff/cache
MiB Swap:      0.0 total,      0.0 free,      0.0 used.   6948.8 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
   2118 ujjwalt+  20   0 5077084 444020 145712 S   4.0   5.3   1:55.29 gnome-shell
   2864 ujjwalt+  20   0  638184  60264  45000 S   0.5   0.7   0:09.03 gnome-terminal-
   3525 root      20   0       0      0      0 I   0.3   0.0   0:00.54 kworker/u21:1-flush-8:0
      1 root      20   0   23444  14176   9312 S   0.0   0.2   0:10.56 systemd
      2 root      20   0       0      0      0 S   0.0   0.0   0:00.19 kthreadd
      3 root      20   0       0      0      0 S   0.0   0.0   0:00.00 pool_workqueue_release
      4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-rcu_gp
      5 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-sync_wq
      6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-kvfree_rcu_reclaim
      7 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-slub_flushwq
      8 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-netns
     10 root      20   0       0      0      0 I   0.0   0.0   0:05.36 kworker/0:1-events
     12 root      20   0       0      0      0 I   0.0   0.0   0:00.00 kworker/u20:0-ipv6_addrconf
     13 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/R-mm_percpu_wq
     14 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_kthread
     15 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_rude_kthread
     16 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tasks_trace_kthread
     17 root      20   0       0      0      0 S   0.0   0.0   0:04.77 ksoftirqd/0
     18 root      20   0       0      0      0 I   0.0   0.0   0:03.84 rcu_preempt
     19 root      20   0       0      0      0 S   0.0   0.0   0:00.00 rcu_exp_par_gp_kthread_worker/0
     20 root      20   0       0      0      0 S   0.0   0.0   0:00.42 rcu_exp_gp_kthread_worker
     21 root      rt   0       0      0      0 S   0.0   0.0   0:00.12 migration/0
     22 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_inject/0
     23 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
     24 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/1
```

```
htop
```

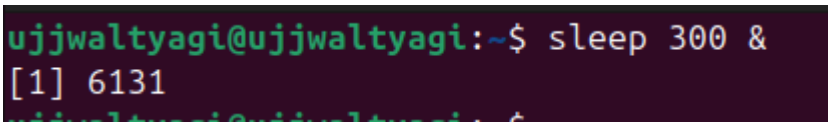
Explanation: Enhanced interactive viewer with process tree, colors, and easier navigation.



Run process in background

```
sleep 300 &
```

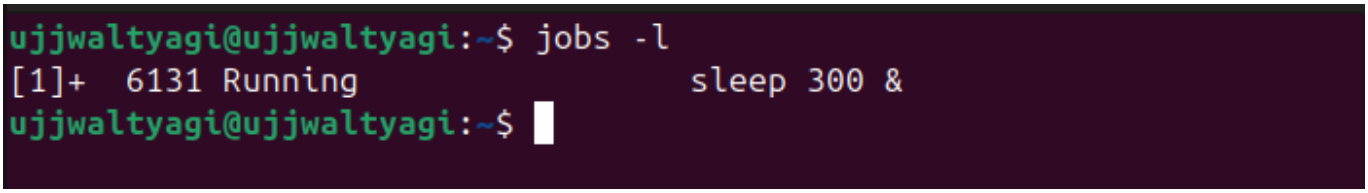
Explanation: Starts `sleep` in background; shell prints the job number and PID.



List jobs in current shell

```
jobs -l
```

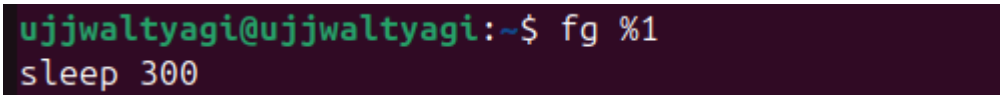
Explanation: Lists jobs started from the current shell with job IDs and PIDs.



Bring job to foreground / send to background

```
fg %1
bg %1
```

Explanation: `fg` brings job 1 to foreground; `bg` resumes job 1 in background.



Disown a background job

```
disown %1
```

Explanation: Removes job 1 from shell's job table so it will not receive SIGHUP on shell exit.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 400 &
[1] 3458
ujjwaltyagi@ujjwaltyagi:~$ jobs
[1]+  Running                 sleep 400 &
ujjwaltyagi@ujjwaltyagi:~$ disown %1
ujjwaltyagi@ujjwaltyagi:~$ jobs
ujjwaltyagi@ujjwaltyagi:~$
```

Run detached (nohup)

```
nohup python3 server.py > server.log 2>&1 &
```

Explanation: Starts `server.py` immune to hangups; output redirected to `server.log`.

```
ujjwaltyagi@ujjwaltyagi:~$ nohup python3 server.py > server.log 2>1 &
[1] 7049
```

Find process by name / PID

```
pgrep -a sshd
pidof bash
```

Explanation: `pgrep -a` lists PIDs and command lines matching `sshd`. `pidof` returns PID(s) for a program.

```
ujjwaltyagi@ujjwaltyagi:~$ pgrep -a sshd
[1]+  Exit 2                  nohup python3 server.py > server.log 2> 1
ujjwaltyagi@ujjwaltyagi:~$ pidof bash
6260
ujjwaltyagi@ujjwaltyagi:~$
```

Kill a process (graceful then force)

```
kill PID            # sends SIGTERM by default
kill -9 PID         # sends SIGKILL (force)
pkill -f processname
```

Explanation: `kill` sends signals to PIDs; `pkill -f` matches the full command line.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 1200 &
[1] 9184
ujjwaltyagi@ujjwaltyagi:~$ ps
\    PID TTY          TIME CMD
   6260 pts/0    00:00:00 bash
   9184 pts/0    00:00:00 sleep
   9277 pts/0    00:00:00 ps
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+    9184  0.0  0.0  16956  1908 pts/0    S    01:17   0:00 sleep 1200
ujjwalt+    9524  0.0  0.0  17812  2288 pts/0    S+   01:18   0:00 grep --color=
auto sleep
ujjwaltyagi@ujjwaltyagi:~$ kill 9184
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+    9688  0.0  0.0  17812  2272 pts/0    S+   01:19   0:00 grep --color=
auto sleep
[1]+  Terminated              sleep 1200
```

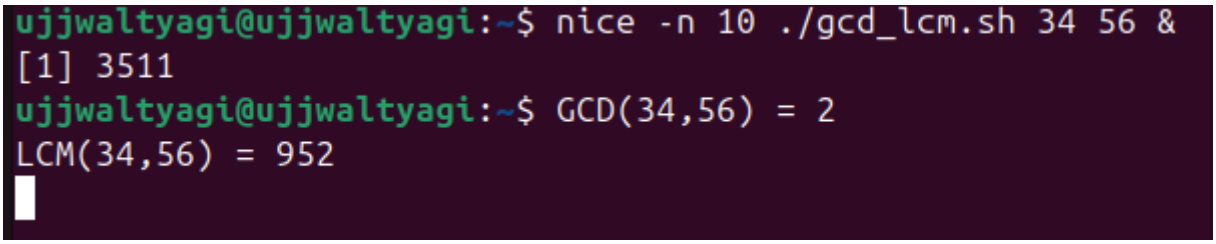
```
ujjwaltyagi@ujjwaltyagi:~$ sleep 1345 &
[1] 10099
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+   10099  0.0  0.0  16956  1980 pts/0    S    01:20   0:00 sleep 1345
ujjwalt+   10122  0.0  0.0  17812  2284 pts/0    S+   01:20   0:00 grep --color=
auto sleep
ujjwaltyagi@ujjwaltyagi:~$ kill -9 10099
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+   10208  0.0  0.0  17812  2288 pts/0    S+   01:21   0:00 grep --color=
auto sleep
[1]+  Killed                  sleep 1345
```

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 2312 &
[2] 10704
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+   10393  0.0  0.0  16956  1980 pts/0    S+   01:22   0:00 sleep 2345
ujjwalt+   10542  0.0  0.0  16956  1980 pts/1    S    01:22   0:00 sleep 2312
ujjwalt+   10704  0.0  0.0  16956  1980 pts/1    S    01:23   0:00 sleep 2312
ujjwalt+   10739  0.0  0.0  17812  2288 pts/1    S+   01:23   0:00 grep --color=
auto sleep
ujjwaltyagi@ujjwaltyagi:~$ pkill -f 10393
ujjwaltyagi@ujjwaltyagi:~$ ps aux | grep sleep
ujjwalt+   10393  0.0  0.0  16956  1980 pts/0    S+   01:22   0:00 sleep 2345
ujjwalt+   10542  0.0  0.0  16956  1980 pts/1    S    01:22   0:00 sleep 2312
ujjwalt+   10704  0.0  0.0  16956  1980 pts/1    S    01:23   0:00 sleep 2312
ujjwalt+   10889  0.0  0.0  17812  2288 pts/1    S+   01:23   0:00 grep --color=
auto sleep
```

Adjust process priority at start

```
nice -n 10 ./compute-heavy.sh
```

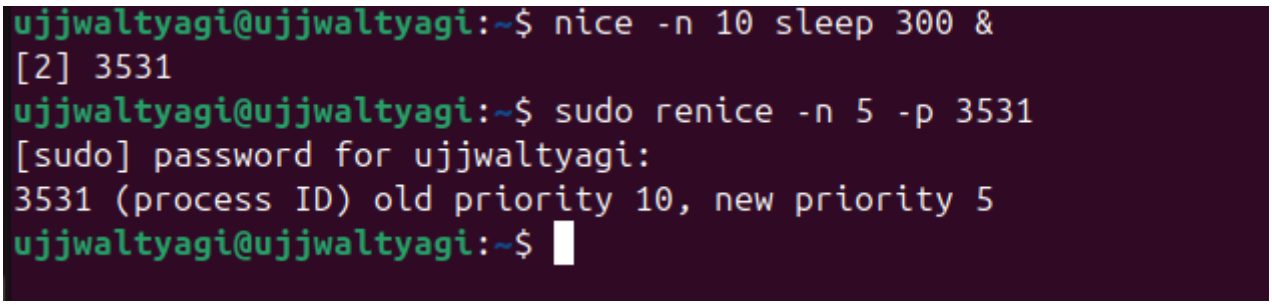
Explanation: Launches `compute-heavy.sh` with niceness 10 (lower priority).



Change priority of running process

```
renice +5 -p 12345
renice -n -10 -p 12345
renice -n 5 -p 12345
```

Explanation: `renice` changes niceness of PID 12345 (positive increases nice value = lower priority).



View process open files and resources

```
lsof -p 12345
```

Explanation: Lists files, sockets, and resources opened by PID 12345.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 450 &
[4] 3540
ujjwaltyagi@ujjwaltyagi:~$ lsof -p 3540
COMMAND  PID        USER   FD   TYPE DEVICE SIZE/OFF   NODE NAME
sleep   3540 ujjwaltyagi  cwd    DIR    8,2     4096 920385 /home/ujjwaltyagi
sleep   3540 ujjwaltyagi  rtd    DIR    8,2     4096      2 /
sleep   3540 ujjwaltyagi  txt    REG    8,2    35336 525644 /usr/bin/sleep
sleep   3540 ujjwaltyagi  mem    REG    8,2 14596880 526973 /usr/lib/locale/loca
le-archive
sleep   3540 ujjwaltyagi  mem    REG    8,2  2125328 535783 /usr/lib/x86_64-linu
x-gnu/libc.so.6
sleep   3540 ujjwaltyagi  mem    REG    8,2      613 567516 /usr/share/locale-la
ngpack/en/LC_MESSAGES/coreutils.mo
sleep   3540 ujjwaltyagi  mem    REG    8,2   236616 535601 /usr/lib/x86_64-linu
x-gnu/ld-linux-x86-64.so.2
sleep   3540 ujjwaltyagi    0u   CHR  136,1      0t0      4 /dev/pts/1
sleep   3540 ujjwaltyagi    1u   CHR  136,1      0t0      4 /dev/pts/1
sleep   3540 ujjwaltyagi    2u   CHR  136,1      0t0      4 /dev/pts/1
ujjwaltyagi@ujjwaltyagi:~$
```

Show process tree for a PID

```
ps f -p 12345
```

Explanation: Shows process hierarchy for PID 1 (or change PID as needed).

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 700 &
[1] 3558
ujjwaltyagi@ujjwaltyagi:~$ ps f -p 3558
    PID TTY      STAT   TIME COMMAND
   3558 pts/0    S      0:00 sleep 700
ujjwaltyagi@ujjwaltyagi:~$
```

🧠 Advanced Topics & Tools

This section adds detailed theory, commands and short examples for advanced process-management topics that supplement the previous sections.

Signals (SIGTERM vs SIGKILL and common signals)

- SIGTERM (15) — polite request to terminate; process can catch and clean up.
- SIGKILL (9) — immediate forced termination; cannot be caught or ignored.
- SIGHUP (1) — hangup; commonly used to tell daemons to reload config.
- SIGSTOP / SIGCONT — stop and continue a process (job control).

Example:

```
# polite terminate
kill -15 3050

# force kill
kill -9 3050
```

Explanation: Prefer SIGTERM then SIGKILL only if process doesn't exit.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[2] 3763
ujjwaltyagi@ujjwaltyagi:~$ echo $!
3763
ujjwaltyagi@ujjwaltyagi:~$ kill -15 3763
ujjwaltyagi@ujjwaltyagi:~$ ps -p 3763
    PID TTY          TIME CMD
[2]+  Terminated              sleep 3050
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[2] 4550
ujjwaltyagi@ujjwaltyagi:~$ kill -9 4550
ujjwaltyagi@ujjwaltyagi:~$ ps -p 4550
    PID TTY          TIME CMD
[2]+  Killed                  sleep 3050
ujjwaltyagi@ujjwaltyagi:~$
```

CPU Affinity — taskset (bind process to CPU cores)

- Use CPU affinity to bind a process to specific CPU core(s).

```
# view current affinity
taskset -cp 3050

# set affinity to core 1 only
taskset -cp 1 3050

# start a process on cores 0-1
taskset -c 0,1 ./compute-heavy.sh
```

Explanation: Useful to reduce cache thrashing or isolate workloads.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[2] 4553
ujjwaltyagi@ujjwaltyagi:~$ taskset -cp 4553
pid 4553's current affinity list: 0-4
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[3] 4566
ujjwaltyagi@ujjwaltyagi:~$ taskset -cp 1 4566
pid 4566's current affinity list: 0-4
pid 4566's new affinity list: 1
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[4] 4568
ujjwaltyagi@ujjwaltyagi:~$ taskset -c 0,1 ./print-number.sh
1
2
3
4
5
6
7
```

I/O Scheduling Priority — ionice

- Controls disk I/O scheduling class and priority.

```
# set process to idle I/O class (only uses disk when idle)
ionice -c 3 -p 3050

# run a command with best-effort class and priority 7
ionice -c 2 -n 7 tar -czf backup.tar.gz /home
```

Explanation: Helps limit I/O interference from background jobs.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 3400 &
[2] 4730
ujjwaltyagi@ujjwaltyagi:~$ sudo ionice -c 3 -p 4730
ujjwaltyagi@ujjwaltyagi:~$ ionice -p 4730
idle
```

```
ujjwaltyagi@ujjwaltyagi:~$ mkdir testdir
ujjwaltyagi@ujjwaltyagi:~$ echo "hello world" > testdir/file1.txt
ujjwaltyagi@ujjwaltyagi:~$ echo "more data" > testdir/file2.txt
ujjwaltyagi@ujjwaltyagi:~$ ionice -c 2 -n 7 tar -czvf backup.tar.gz testdir/
testdir/
testdir/file2.txt
testdir/file1.txt
ujjwaltyagi@ujjwaltyagi:~$
```

Per-Process Statistics — pidstat

- Monitor per-process CPU usage over time.

```
# sample PID 3050 every 2 seconds, 3 samples
pidstat -p 3050 2 3
```

Explanation: Useful to observe CPU trends for a specific PID.

```
ujjwaltyagi@ujjwaltyagi:~$ dd if=/dev/zero of=testfile bs=1M count=5000 &
[1] 4847
ujjwaltyagi@ujjwaltyagi:~$ pid=$!
ujjwaltyagi@ujjwaltyagi:~$ sudo ionice -c 3 -p $pid
ujjwaltyagi@ujjwaltyagi:~$ pidstat -p $pid 2 5
Linux 6.14.0-29-generic (ujjwaltyagi)   11/01/2025      _x86_64_        (5 CPU)

09:39:00 PM   UID       PID    %usr %system  %guest   %wait    %CPU   CPU  Command
09:39:02 PM  1000      4847    0.00   99.50    0.00    0.00   99.50     3  dd
09:39:04 PM  1000      4847    0.00  100.50    0.00    0.00  100.50     3  dd
09:39:06 PM  1000      4847    0.42   99.58    0.00    0.00  100.00     3  dd
09:39:08 PM  1000      4847    0.00   97.51    0.00    2.49   97.51     1  dd
09:39:10 PM  1000      4847    0.00   98.51    0.00    1.49   98.51     1  dd
Average:     1000      4847    0.10   99.14    0.00    0.77   99.23     -  dd
ujjwaltyagi@ujjwaltyagi:~$ 5000+0 records in
5000+0 records out
5242880000 bytes (5.2 GB, 4.9 GiB) copied, 46.481 s, 113 MB/s
```

Trace System Calls — strace

- Attach to a running process and inspect system calls.

```
# attach and view syscalls
sudo strace -p 3050

# run a command under strace
strace -o trace.txt ls
```

Explanation: Great for debugging why a process is failing (file access, network calls).

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 300 &
[1] 4906
ujjwaltyagi@ujjwaltyagi:~$ sudo strace -p 4906
[sudo] password for ujjwaltyagi:
strace: Process 4906 attached
restart_syscall(<... resuming interrupted read ...>
```

```
ujjwaltyagi@ujjwaltyagi:~$ sudo strace -o trace.txt ls
1              areaper                  global                   reverse
1_10_1.c       area_perimeter.c         int                      reverse.c
1_10_2.c       backup                   int.c                    salary
1_10_3.c       backup.tar.gz            kmtom                    scripts
1_10_4.c       block                    largest                  server.log
12             calc.c                   largest_smallest         snap
12.c           calculator               largest_smallest.c       sort_number_asec_desc.sh
1.c            calculator.c             largest_smallest_macro   square
2              checkfile1.sh            largest_smallest_macro.c starterkit
25596__1.c     check_file_permission.sh local                    starter_pack.sh
25596_1.c      checkfile.sh             marks                    static
25596__1.txt   count                    max3                     string_length_comparision.sh
25596__2.c     count_lines_words.sh     maximum_of_three_num.c   swap.c
25596_2.c      count-line-words.sh      modify                   swaptwo
25596_3.c     'c programs'              modify1                  Templates
25596_4_2.c    Desktop                  modify1.c                testdir
25596_4.c      dimen                    modify1.txt              testfile
25596_4.txt    Documents                modify.c                 trace.txt
29_09          Downloads                Music                    ujjwaltyagi@10.0.2.15
2int           ds_starter               myproject                unit_6
3              enhanced_number.sh       palindrome.sh            unit7
30_09_1.c      evenodd                  Pictures                 unit_8
30_09_2.c      even_odd.c               print-number.sh          Videos
30_09_3.c      factorial_function.sh    print_number.sh          wormhole-receive
30_09_4.c      factorial-fun.sh         product                  wormhole-send
30_09_5.c      floatint.c               project6s
30_09_6.c      floatint.txt             projects
app.py         gcd_lcm.sh               Public
ujjwaltyagi@ujjwaltyagi:~$
```

Find Process Using a Port — fuser / ss / netstat

```
# find PID using TCP port 8080
sudo fuser -n tcp 8080

# alternative: list sockets and PIDs
sudo ss -tulpn | grep 8080
```

Explanation: Identifies which process is bound to a port (useful before killing or reconfiguring).

```
ujjwaltyagi@ujjwaltyagi:~$ sudo fuser -n tcp 8080
[sudo] password for ujjwaltyagi:
8080/tcp:             5153
ujjwaltyagi@ujjwaltyagi:~$ sudo ss -tuln  -n tcp 8080
Error: an inet prefix is expected rather than "tcp".
Cannot parse dst/src address.
ujjwaltyagi@ujjwaltyagi:~$ sudo fuser -n tcp 8080
8080/tcp:             5153
ujjwaltyagi@ujjwaltyagi:~$ sudo ss -tuln | grep 8080
tcp   LISTEN 0      5            0.0.0.0:8080       0.0.0.0:*
ujjwaltyagi@ujjwaltyagi:~$
```

Control Groups (cgroups) — basic resource limiting

- Create a cgroup, set CPU and memory limits, add a PID:

```
# create cgroup (requires cgroup-tools or systemd)
sudo cgcreate -g cpu,memory:/testgroup

# limit CPU (cfs quota in microseconds)
echo 50000 | sudo tee /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us

# limit memory to 100MB
echo $((100*1024*1024)) | sudo tee
/sys/fs/cgroup/memory/testgroup/memory.limit_in_bytes

# add PID 3050 to the cgroup
echo 3050 | sudo tee /sys/fs/cgroup/cpu/testgroup/cgroup.procs
```

Explanation: cgroups provide strong isolation and resource controls for processes or groups.

```
ujjwaltyagi@ujjwaltyagi:~$ sudo cgcreate -g cpu,memory:/testgroup
ujjwaltyagi@ujjwaltyagi:~$ echo 50000 | sudo tee /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us
tee: /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us: No such file or directory
50000
ujjwaltyagi@ujjwaltyagi:~$ echo 50000 | sudo tee /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us
tee: /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us: No such file or directory
50000
ujjwaltyagi@ujjwaltyagi:~$ sudo cgcreate -g cpu,memory:/testgroup
ujjwaltyagi@ujjwaltyagi:~$ sudo cgcreate -g cpu,memory:/testgroup
ujjwaltyagi@ujjwaltyagi:~$ echo 50000 | sudo tee /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us
tee: /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us: No such file or directory
50000
ujjwaltyagi@ujjwaltyagi:~$ sudo mkdir /sys/fs/cgroup/testgroup
mkdir: cannot create directory ‘/sys/fs/cgroup/testgroup’: File exists
ujjwaltyagi@ujjwaltyagi:~$ echo "50000 100000" | sudo tee /sys/fs/cgroup/testgroup/cpu.max
50000 100000
ujjwaltyagi@ujjwaltyagi:~$ echo $((100*1024*1024)) | sudo tee /sys/fs/cgroup/testgroup/cpu.max
104857600
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[1] 10488
ujjwaltyagi@ujjwaltyagi:~$ echo 10488 | sudo tee /sys/fs/cgroup/testgroup/cpu.procs
tee: /sys/fs/cgroup/testgroup/cpu.procs: Permission denied
10488
ujjwaltyagi@ujjwaltyagi:~$ echo 10488 | sudo tee /sys/fs/cgroup/testgroup/cgroup.procs
10488
ujjwaltyagi@ujjwaltyagi:~$ echo $$ | sudo tee /sys/fs/cgroup/testgroup/cgroup.procs
8473
ujjwaltyagi@ujjwaltyagi:~$ cat /sys/fs/cgroup/testgroup/cgroup.procs
10488
8473
10505
ujjwaltyagi@ujjwaltyagi:~$
```

Real-Time Scheduling — chrt

- Set real-time scheduling policies (FIFO or RR).

```
# run command with FIFO policy, priority 50
sudo chrt -f 50 sleep 1000

# change scheduling of running PID
sudo chrt -p 50 3050
```

Explanation: Use with caution — real-time tasks can starve normal processes.

```
ujjwaltyagi@ujjwaltyagi:~$ sudo chrt -f 50 sleep 60 & echo $!
[2] 7052
7052
ujjwaltyagi@ujjwaltyagi:~$ [sudo] password for ujjwaltyagi:
2911019789
2911019789: command not found

[2]+  Stopped                 sudo chrt -f 50 sleep 60
```

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 3050 &
[6] 7116
ujjwaltyagi@ujjwaltyagi:~$ sudo chrt -p 50 7116
ujjwaltyagi@ujjwaltyagi:~$ s
```

schedtool (advanced scheduling tweaks)

```
# set round-robin priority 10 on PID
sudo schedtool -R -p 10 3050
```

Explanation: Alternative low-level scheduling tweaks; platform-dependent.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 200 &
[2] 8259
ujjwaltyagi@ujjwaltyagi:~$ sudo schedtool -R -p 10 8259
ujjwaltyagi@ujjwaltyagi:~$ schedtool 8259
PID  8259: PRIO  10, POLICY R: SCHED_RR      , NICE   0, AFFINITY 0x1f
ujjwaltyagi@ujjwaltyagi:~$
```

systemd-run — temporary scopes with resource settings

```
# run stress under systemd scope with CPUWeight control
systemd-run --scope -p CPUWeight=200 stress --cpu 4

# run a command and limit memory
systemd-run --scope -p MemoryMax=200M ./compute-heavy.sh
```

Explanation: Convenient to run one-off tasks with cgroup-based limits via systemd.

```
ujjwaltyagi@ujjwaltyagi:~$ sudo systemd-run --scope -p CPUWEIGHT=200
Command line to execute required.
ujjwaltyagi@ujjwaltyagi:~$ stress --cpu 4
stress: info: [8464] dispatching hogs: 4 cpu, 0 io, 0 vm, 0 hdd
```

```
ujjwaltyagi@ujjwaltyagi:~$ nano compute-heavy.sh
ujjwaltyagi@ujjwaltyagi:~$ nano compute-heavy.sh
ujjwaltyagi@ujjwaltyagi:~$ chmod 777 compute-heavy.sh
ujjwaltyagi@ujjwaltyagi:~$ sudo systemd-run --scope -p MemoryMax=200M ./compute-heavy.sh
Running as unit: run-r4f4ca10987434f0d880ab88581b5684d.scope; invocation ID: 155c8109066a424cb0c1d8e5c16a7c7f
stress: info: [8545] dispatching hogs: 4 cpu, 0 io, 0 vm, 0 hdd
stress: info: [8545] successful run completed in 31s
ujjwaltyagi@ujjwaltyagi:~$
```

lsof — list open files/resources per process

```
lsof -p 3050 | head -10
```

Explanation: Shows files, sockets and devices a process has open; helpful for debugging leaks.

```
ujjwaltyagi@ujjwaltyagi:~$ sleep 300 &
[2] 10369
ujjwaltyagi@ujjwaltyagi:~$ lsof -p 10369 | head -10
COMMAND   PID        USER   FD   TYPE DEVICE SIZE/OFF   NODE NAME
sleep   10369 ujjwaltyagi  cwd    DIR    8,2     4096 920385 /home/ujjwaltyagi
sleep   10369 ujjwaltyagi  rtd    DIR    8,2     4096      2 /
sleep   10369 ujjwaltyagi  txt    REG    8,2    35336 525644 /usr/bin/sleep
sleep   10369 ujjwaltyagi  mem    REG    8,2 14596880 526973 /usr/lib/locale/locale-archive
sleep   10369 ujjwaltyagi  mem    REG    8,2  2125328 535783 /usr/lib/x86_64-linux-gnu/libc.so.6
sleep   10369 ujjwaltyagi  mem    REG    8,2      613 567516 /usr/share/locale-langpack/en/LC_MESSAGES/coreutils.mo
sleep   10369 ujjwaltyagi  mem    REG    8,2   236616 535601 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2
sleep   10369 ujjwaltyagi    0u   CHR  136,0      0t0      3 /dev/pts/0
sleep   10369 ujjwaltyagi    1u   CHR  136,0      0t0      3 /dev/pts/0
ujjwaltyagi@ujjwaltyagi:~$
```

Summary: Tools & When to Use Them

Tool	Purpose	Use When...
ps, top, htop	Inspect processes	Quick snapshot or live monitoring
pstree, ps f	Parent/child view	Understanding process hierarchy
kill, pkill	Send signals	Terminate or signal processes
nice, renice	CPU niceness	Lower priority background jobs
taskset	CPU affinity	Bind to specific cores
ionice	I/O priority	Reduce disk contention
pidstat	Per-process stats	Time-series CPU analysis

Tool	Purpose	Use When...
strace	Syscall tracing	Debugging failing processes
fuser, ss	Port/process mapping	Identify service owners of ports
cgroups, systemd-run	Resource limits	Enforce QoS and isolation
chrt, schedtool	Real-time scheduling	Real-time workloads (careful)

☑ Practical examples (quick recap)

```
# Start low-priority background job
nice -n 10 sleep 300 &

# Bind a running PID to CPU 1
taskset -cp 1 3050

# Make process IO idle
ionice -c 3 -p 3050

# Trace syscalls
sudo strace -p 3050

# Limit memory with systemd-run
systemd-run --scope -p MemoryMax=150M sleep 600
```

🎓 Conclusion

This practical lab demonstrated essential Linux process management concepts through hands-on examples.

📚 References & Resources

- 📖 man pages: ps, top, kill, nice, renice
- 🌐 Linux kernel documentation
- 📄 System administration guides

~ End of Lab Report ~