

Problem 1. (40 POINTS) Any marks with a T or F anywhere else would be considered wrong.

TYPE A

1. **TRUE** A primary objective of an OS is to manage hardware resources and provide a useful interface of those resources to programmers.
2. **TRUE** Every process in Linux has its own unique PID (process ID).
3. **TRUE** Process management code in the kernel is always executed in kernel-mode.
4. **TRUE** Shortest process next is a non preemptive policy.
5. **FALSE** Switching between threads is as costly in time as switching between processes.
6. **FALSE** A user-mode process can modify the PCB of its own process.
7. **FALSE** It is possible for a process to have its state changed from BLOCKED directly into RUNNING.
8. **TRUE** A process terminating also terminates all the threads created by the process itself.

TYPE B

1. **TRUE** A primary objective of an OS is to manage hardware resources and provide a useful interface of those resources to programmers.
2. **FALSE** Every process in Linux is also assigned a unique PPID (parent process ID), different from the PID of every other process.
3. **FALSE** Process management code in the kernel is sometimes executed in user-mode.
4. **FALSE**. First come first served process next is a preemptive policy.
5. **TRUE** Switching between user-level threads is less costly in time than switching between kernel-level threads.
6. **TRUE** Main memory is a resource managed by an operating system.
7. **TRUE** It is possible for a process to have its state changed from BLOCKED directly into EXIT.
8. **TRUE** Without kernel-level or other support a user-level thread blocking will cause its process and all of the process's threads to block as well.

Problem 2. (50 POINTS)

1. Give a definition of the term process in no more than five words. **Ans: A program in execution**
2. Programs and data are stored in the same one memory. What architecture is it? **Ans: von-Neumann**
3. A UNIX/Linux fork that succeeds what positive value does it return to the parent process? **Ans: PID of the child**
4. What are the two types of locality (of reference)? **Ans: Temporal and Spatial locality**
5. Why is locality (of reference) important? **Ans: Speeds up/Increases effective memory access.**
6. When a system call occurs in a user program, a kernel stack is used that is separate from the user stack. Why? **Ans: Security/Safety issues; users can't interfere with kernel**
7. What is the difference between Blocked/Suspend and Blocked state for a process? **Process is in disk (Blocked/Suspend) and in main memory (Blocked).**
8. Below the seven states of the seven state process model are numbered 1-7. Give the number-index of the state(s) for which a process is in main memory. For example one answer is 6 as a Running process must be in main memory. Exclude from this answer also states 1 and 7 and thus list only states 2-6, as needed/required.
 - (a) New
 - (b) Read/Suspend
 - (c) Blocked/Suspend
 - (d) Ready
 - (e) Blocked
 - (f) Running
 - (g) Exit **Ans: 4,5 and of course as stated 6.**
9. Which of the four numbers is more typical to be the L1D cache size of a general purpose CPU nowadays. Circle the correct answer: **Ans: 32KiB**
10. What entity is called 'a lightweight process'? **Ans: A thread**

1. Give a definition of the term thread in no more than five words. **Ans: A lightweight process.**
2. Programs are stored in one memory, data are stored in another different memory. What architecture is it? **Ans: Harvard**
3. A UNIX/Linux fork that succeeds what positive value does it return to the child process? **Ans: (Unintentionally tricky): None. Also accepted: a zero value is returned to the child (zero is not positive!).**
4. What are the two types of locality (of reference)? **Ans. Temporal and Spatial locality**
5. Why is locality (of reference) important? **Ans: Speeds up/Increases effective memory access.**
6. Names two differences between the PCB (Process Control Block) of the parent process and the PCB of a child process created by that parent at completion of the fork() operation. Can you name a third difference? (Two correct diffs give you the full points) **Ans: 2 of (a) PID and (b) PPID, (c) kernel/user stack data related to return values eg of fork.**
7. What is the difference between Ready/Suspend and Ready state for a process? **Ans: Process is in disk (Ready/Suspend) and in main memory (Ready).**
8. Below the seven states of the seven state process model are numbered 1-7. Give the number-index of the state(s) for which a process is in the hard disk. For example one incorrect answer is 6 as a Running process must be in main memory and not on the hard disk. Exclude from this answer also states 1 and 7 and thus list only states 2-6, as needed/required.
 - (a) New
 - (b) Read/Suspend
 - (c) Blocked/Suspend
 - (d) Ready
 - (e) Blocked
 - (f) Running
 - (g) Exit **Ans: 2,3.**
9. Which of the four numbers is more appropriate to be the register size (number) of a general purpose CPU nowadays. Circle the correct answer: **16**
10. What entity is called 'a program in execution'? **Ans: A process**

Problem 3. (30 POINTS)

Only 48 of the 64 bit are for addressing; the rest are ignored (they are zeroes).

TYPE A Ans:

(2.1) A (associativity) = 8
 (2.2) C (line size) = 2048
 (2.3) K (block size) = 64
 (2.4) C num of bit = 11
 (2.5) K num of bit = 6
 (2.6) T num of bit = 31

TYPE B Ans:

(2.1) A (associativity) = 8
 (2.2) C (line size) = 512
 (2.3) K (block size) = 64
 (2.4) C num of bit = 9
 (2.5) K num of bit = 6
 (2.6) T num of bit = 33

Problem 4. (30 POINTS)**TYPE A**

We have $0.15 \times 200 = 20 \times H + (1 - H) \times (20 + 200)$
 and thus **Ans:** $H = 95\%$.

TYPE B

We have $0.20 \times 100 = 10 \times H + (1 - H) \times (10 + 100)$
 and thus **Ans:** $H = 90\%$.

Problem 5. (30 POINTS)**TYPE A**

Ans: One hello ; it precedes all the forks and thus printed by the parent process.

TYPE B

Ans: Four hello ; two forks preceding it give rise to 4 processes (including the parent) and each one of them prints a hello.

Problem 6. (30 POINTS)**TYPE A**

Ans:

Serial execution. Based on the pattern, A is 30min CPU-30min I/O and B is 30min I/O- 30min CPU.

Turnaround for the last job is 120min. (Say A executes first and then B , this makes B the last job.)

Processor Utilization is 60/120 i.e. 50%.

Multiprogramming. Based on the pattern, A is 30min CPU-30min I/O and B is 30min I/O- 30min CPU. In this case CPU of A and I/O of B and CPU of B and I/O of A can be combined. Therefore in 60min, both programs run.

Turnaround is now 60min. (For both A and B .)

Processor Utilization is 60/60 i.e. 100%.

TYPE B

Ans:

Serial execution. Based on the pattern, X is 30min CPU-30min I/O and Y is 30min CPU- 30min I/O.

Turnaround for the last job is 120min. (Say X executes first and then Y , this makes Y the last job.)

Processor Utilization is 60/120 i.e. 50%.

Multiprogramming. Based on the pattern, X is 30min CPU-30min I/O and Y is 30min CPU- 30min I/O. In this case CPU of one precedes, then I/O of other occurs concurrently with CPU of former, and then former terminates and after the I/O of the latter, the latter terminates. (Former can be X or Y ; latter the other way around.) Therefore in 90min, both programs run. Turnararound for one is 60min (not required as answer). Turnaround for last i.e. other is 90min.

Turnaround for last is now 90min.

Processor Utilization is 60/90 i.e. 67%.

Problem 7. (40 POINTS)

TYPE A.

1. First-Come-First-Served. The jobs are executed based on problem in order C,B,D,A,E.

This means turnaround time (each summand corresponds to the corresponding process C,B,D,A,E) is $6 + (6 + 8) + (6 + 8 + 4) + (6 + 8 + 4 + 10) + (6 + 8 + 4 + 10 + 2) = 6 + 14 + 18 + 28 + 30 = 96$.

Ans-1: Thus mean (average) turnaround time is $96/5 = 19.2s$.

2. Shortest Process Next.

This means turnaround time (as explained before) is $2 + (2 + 4) + (2 + 4 + 6) + (2 + 4 + 6 + 8) + (2 + 4 + 6 + 8 + 10) = 2 + 6 + 12 + 20 + 30 = 70$.

Ans-2: Thus mean (average) turnaround time is $70/5 = 14s$.

3. Round-Robin with time slice of 2s and the initial order is A,B,C,D,E.

This means that the execution pattern is ABCDE ABCD ABC AB A. This means $30 + 28 + 24 + 18 + 10 = 110$.

Ans-3: Thus mean (average) turnaround time is $110/5 = 22s$.

TYPE B.

1. First-Come-First-Served. The jobs are executed based on problem in order E,D,C,B,A.

This means turnaround time (each summand corresponds to the corresponding process E,D,C,B,A) is $2 + (2 + 4) + (2 + 4 + 6) + (2 + 4 + 6 + 8) + (2 + 4 + 6 + 8 + 10) = 2 + 6 + 12 + 20 + 30 = 70$.

Ans-1: Thus mean (average) turnaround time is $70/5 = 14s$.

2. Shortest Process Next.

This means turnaround time (as explained before) is $2 + (2 + 4) + (2 + 4 + 6) + (2 + 4 + 6 + 8) + (2 + 4 + 6 + 8 + 10) = 2 + 6 + 12 + 20 + 30 = 70$.

Ans-2: Thus mean (average) turnaround time is $70/5 = 14s$.

Note that the FCFS schedule is also an SPN schedule.

3. Round-Robin with time slice of 4s and the initial order is A,B,C,D,E.

This means that the execution pattern is ABCDE ABC A. The time slices (quantums) utilized are respectively 44442 442 2. This means that turn around times are $30(A) + 26(B) + 28(C) + 16(D) + 18(E)$ i.e $30 + 28 + 26 + 18 + 16 = 118$.

Ans-3: Thus mean (average) turnaround time is $118/5 = 23.6s$.