This is a closed book / closed notes exam. No electronic devices are allowed except regular calculator. You have 90 minutes to complete 37 questions. Please write neatly and clearly. You should have 12 pages (including one intentionally left blank page).

<table>
<thead>
<tr>
<th>Question</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-25</td>
<td>____/50</td>
</tr>
<tr>
<td>26 - 35</td>
<td>____/20</td>
</tr>
<tr>
<td>36</td>
<td>____/15</td>
</tr>
<tr>
<td>37</td>
<td>____/15</td>
</tr>
<tr>
<td>Total</td>
<td>____/100</td>
</tr>
</tbody>
</table>

Score : ____________/ 100
Multiple Choice

1. (2 points) Which of the following is not true about Operating Systems (OS):
   a) OS is a software layer between user applications and hardware
   b) OS manages / Optimizes hardware resources
   c) OS provides an environment for the execution of programs
   d) **OS is often written in Java**

2. (2 points) which of the following is not a part of a standard process cycle?
   a) New job queue
   b) Ready queue
   c) Wait queue
   d) **Interrupt queue**

3. (2 points) Each process is represented in the OS by a ________
   a) **Process control block (PCB)**
   b) A pointer to a memory location where the process is residing
   c) A fork() system call
   d) All of the above

4. (2 points) Once a child process is created through fork(), which of the following is not true?
   a) The execution order for parent and child is random in nature
   b) Child is a duplicate of its parent
   c) A pipe() created before the fork() will allow both parent and child to access the same memory location for read/write operations
   d) **Inside parent, OS returns a pid = 0**

5. (2 points) An unsuccessful fork() system call will return which of the following:
   a) 0
   b) -1
   c) 1
   d) None of the above

6. (2 points) For pid = fork(); which of the following is true?
   a) Inside parent, pid < 0
   b) Inside child, pid > 0
   c) pid will always be non-negative number
   d) **None of the above**
7. (2 points) Let’s assume a parent process P (pid = 10) has forked a child process C (pid = 11), and then child C forked its own child C_1 (pid = 12). If pid_x = getppid() is called from C_1, what would be the value of pid_x?
   a) 10
   b) 11
   c) 12
   b) None of the above

8. (2 points) In a single CPU OS environment, which of the following is true:
   a) Only one single process can run at any point of time
   b) Multiple processes can run simultaneously
   c) CPU switching between processes is not possible
   d) All of the above

9. (2 points) pid_t data type represents ________
   a) Process identifier
   b) Process memory location
   c) Newly-admitted process
   d) All of the above

10. (2 points) Which of the following system call can be used to halt the execution of a parent process until its child is completed?
    a) wait()
    b) sleep()
    c) alarm()
    d) signal()

11. (2 points) How many child processes will be created by the following program?
    ```c
    int main()
    {
        fork();
        fork();
        fork();
    }
    ```
    a) 3
    b) 4
    c) 6
    d) None of the above ($2^n - 1 = 8 - 1 = 7$)
12. (2 points) Let’s assume that Q is an external executable program. If execl(“Q”, “Q”, NULL) is called from a process P, which of the following is true?
   a) Q will be executed, and then P will resume
   b) **Q will be executed, and P will be replaced by program Q**
   c) OS will not allow P to call an external program Q
   d) None of the above

13. (2 points) The pipe() system call can be used to provide the _________
   a) shared memory access
   b) shared CPU access
   c) shared data file access
   d) All of the above

14. (2 points) In pipe(fd[2]), fd[0] refers to:
   a) **Read port**
   b) Write port
   c) Either read or write port
   d) None of the above

15. Which of the following system call should be used to capture an external interrupt such as Ctrl-C?
   a) **signal()**
   b) pause()
   c) sleep()
   d) alarm()

16. Process execution cycle consists of CPU execution cycle and _______
   a) **I/O wait cycle**
   b) Memory cycle
   c) Registers cycle
   d) All of the above
17. (2 points) In First Come First Serve (FCFS) scheduling algorithm, let’s assume two scheduling cases; Case 1: Three processes p1, p2, and p3 with a CPU burst time of 20 ms, 3 ms, and 2 ms respectively. Case 2: Three processes p1, p2, and p3 with a CPU burst time of 20 ms, 5 ms, and 6 ms respectively. The order of their arrival is p1, p2, and p3 for both Case 1 and Case 2. Which of the following statement is true for process p2:
   a) Higher waiting time in Case 1 than Case 2
   b) Higher waiting time in Case 2 than Case 1
   c) Equal awaiting time in both Case 1 and Case 2
   d) None of the above

18. (2 points) Which of the following is not a characteristic of Last In First Out (LIFO) scheduling algorithms?
   a) Improves response time for newly created processes
   b) Early processes always get CPU share
   c) New processes are placed at head of ready queue

19. (2 points) Which CPE scheduling algorithm gives relatively lower average waiting time for a given set of processes?
   a) Shortest Job First (SJF)
   b) First Come First Serve (FCFS)
   c) Last In First Out (LIFO)
   d) Round Robin (RR)

20. (2 points) One drawback of priority scheduling algorithm is:
   a) Possibility of starvation
   e) Aging
   f) Poor CPU utilization
   g) All of the above

21. (2 points) Assume a process runs for 200 milliseconds (i.e., actual runt time) in Linux OS and has a Nice value of 0. What would be the vruntime of that process when nice value < 0
   a) vruntime < 200 ms
   h) vruntime > 200 ms
   i) vruntime = 200 ms
   j) None of the above
22. (2 points) In Round Robin (RR) scheduling, if the time quantum q is too large then it shows ____ like behaviour
   a) FIFO
   b) LIFO
   c) SJF
   d) None of the above

23. (2 points) In Solaris OS, which one has the highest priority?
   a) Interrupt process class
   b) Real time process class
   c) System process class
   d) Interactive process class

24. (2 points) Completely Fair Schedule (CFS) is part of ____ OS
   a) Linux
   b) Windows
   c) MAC
   d) Solaris

25. (2 points) Which OS has the largest marker share in recent days Web Server business?
   a) Solaris
   b) Windows
   c) Linux
   d) MAC
True/False

26. (2 points) Child process created by a fork() is identical to the parent (T / F)

27. (2 points) CPU times are generally much shorter than I/O times. (T / F)

28. (2 points) An execl() system call loads a binary file into memory and destroying the memory image of the program calling it (T / F)

29. (2 points) dup2() system call is used to redirect the STDIN/STDOUT (T / F)

30. (2 points) If a read is attempted on an empty pipe, the process will block until data is available (T / F)

31. (2 points) Multiprogramming allows for the execution of multiple processes (T / F)

32. (2 points) In Windows OS, priority 0 is used for memory management processes (T / F)

33. (2 points) In Linux, tasks in Real Time (RT) have higher precedence than tasks in the Completely Fair Schedule (SCF) (T / F)

34. (2 points) In Linux, Tasks with lower nice values receive a higher proportion of CPU processing time than tasks with higher nice values (T / F)

35. (2 points) Android uses Linux for device managers, memory management, process management (T / F)
36. **Processes (15 points)**

a) (3 points) Process control block (PCB) holds various information related to a process. Name any three of them.

Answer:

Any three for the following:

1. **Process Identifier (PID)**
2. **Process state**
3. **Program counter and other program related information**
4. **CPU registers**
5. **CPU-Scheduling information**
6. **Memory-Management information**
7. **I/O status information**

b) (3 points) What is the expected outcome from the program below?

```c
int main(void)
{
    pid_t pid;
    int i = 10, j = 20;
    pid = fork();

    if (pid > 0)
    {
        wait(NULL);
        printf("From parent: i = %d", i);
    }
    if (pid == 0)
    {
        i = 20;
        printf("From child: i = %d", i);
    }
}
```

Answer:  

From child: i = 20  
From parent: i = 10
c) (3 points) Let’s assume B is an executable program that prints “Hello from B”. What would be the output of the following code?

```c
int main(void)
{
    printf("\n Hello from main");
    execl("B", "B", NULL);
    printf("\n exiting main program");
}
```

Answer:

Hello from main
Hello from B

d) (3 points) In systems call parameter passing, name three general methods to pass parameters to the OS.

Answer:

1. Registers
2. Block
3. Stack

e) (3 points) What is the main advantage of thread when compared to fork() based processes?

Answer:

1. Process creation is less time consuming and less resource intensive
2. Better and efficient resource sharing
3. Better responsiveness / Context-switching is faster
37. **CPU Scheduling (15 points)**

   a) (3 points) There are number of quantitative criteria for evaluating a scheduling algorithm. List any three of them.

   Answer:

   **Any three of the followings:**

   - CPU utilization:
   - Throughput:
   - Turnaround time:
   - Waiting time:
   - Response time:
   - Predictability:
   - Fairness:

   b) (12 points) Assuming the following table consists of a set of jobs to be processed on a single CPU. Assume that the processes arrive in the order p1, p2, p3, and p4

<table>
<thead>
<tr>
<th>Job</th>
<th>Burst</th>
</tr>
</thead>
<tbody>
<tr>
<td>p1</td>
<td>8 ms</td>
</tr>
<tr>
<td>p2</td>
<td>5 ms</td>
</tr>
<tr>
<td>p3</td>
<td>6 ms</td>
</tr>
<tr>
<td>p4</td>
<td>2 ms</td>
</tr>
</tbody>
</table>

   i. (4 points) Compute the average waiting time assuming that the scheduling policy is First Come First Serve (FCFS).

   Answer:

   \[ p_{1\text{\_wait}} = 0; \ p_{2\text{\_wait}} = 8; \ p_{3\text{\_wait}} = 13; \ p_{4\text{\_wait}} = 19 \]

   \[ \text{Avg\_wait} = (0 + 8 + 13 + 19) / 4 = 10\text{ms} \]
ii. (4 points) If a Shortest Job First (SJF) scheduling algorithm is assumed, then what is the average waiting time for this case?

Answer:

\[
P4(0)\rightarrow 2\rightarrow p2(2)\rightarrow 5\rightarrow p3(7)\rightarrow 6\rightarrow p1(13)\rightarrow 8\]

Avg\_wait = (13 + 2 + 7 + 0)/4 = 5.5 ms

iii. (4 points) If a round-robin scheduling algorithm with a time slice of 5 ms is assumed, then at what time p3 will be completed?

Answer:

\[
P1\rightarrow 5\rightarrow p2\rightarrow 5\rightarrow p3\rightarrow 5\rightarrow p4\rightarrow 2
\]

Round 1: P1(3)\rightarrow p2(completed)\rightarrow p3(1)\rightarrow p4(completed)
Round 2: P1(completed)\rightarrow p3(completed)

time takes for p3 to get completed: 5 + 5 + 5 + 2 + 3 + 1 = 21 ms