1. Suppose students from BITS campus visit a famous Chinese restaurant nearby. The total number of students is "n_student". Let us also assume that these students have special talent and they can eat with 2 or more than 2 chopsticks (instead of normally eating with two chopsticks). For e.g., the first student can eat with "i_1" chopsticks, the second student can eat with "i_2" chopsticks and similarly the "n_th" student can eat with "i_n" chopsticks. Now, let us note that i_1+i_2+…+i_n=n_c. Since it is a busy time for the restaurants, the available number of chopsticks is only "n_find" where n_find<n_c. Therefore, one of the students proposed that all "n_find" chopsticks should be placed in an empty glass at the centre of the table and that each diner should obey the protocol in the figure below. Please select the smallest value for "n_find" such that deadlock cannot occur. **(Marks: 5)**

   a) n_find=n_c-n_student+1
   b) n_find=n_c-n_student
   c) n_find=n_c-n_student-1
   d) n_find=n_c-n_student+2

2. Consider the following table in Figure below. Three resources X, Y and Z from a single processor system are shared by three processes P0, P1 and P2. Each resource type has 5 units. Which of these processes will finish second? **(Marks: 5)**

	Alloc			Request		
	X	Y	Z	X	Y	Z
P0	1	2	1	1	0	3
P1	2	0	1	0	1	2
P2	2	2	1	1	2	0

   a) P0
   b) P1
   c) P2
   d) None because of deadlock

3. Let us consider a machine with 4 bytes of page table entry size, page size of 8 KB and 8GB of physical memory. If every page table fits into a single page then to map a 46-bit virtual address space, how many levels of page tables are required? **(Marks: 3)**
   a) 2 levels
   b) 3 levels
   c) 4 levels
   d) 5 levels

4. Arrival time and CPU burst time for seven processes are shown in the figure below.

Process	P1	P2	P3	P4	P5	P6	P7
Arrival Time	2	4	5	7	9	15	16
CPU Burst Time	3	2	1	4	2	6	8

Assuming FCFS scheduling, please chose the best option for the average waiting time **(Marks: 2)**:

   a) Average waiting time is 1.82
   b) Average waiting time is 1.85
   c) Average waiting time is 1.61
   d) Average waiting time is 1.71

5. Consider the table in the figure below with different processes arriving at time 0 **(Marks: 2)**.

Process	Burst Time (ms)

P1	10
P2	29
P3	3
P4	7
P5	12

Please select the algorithm(s) that give the minimum waiting time.

a) FCFS
b) SJF (non-preemptive)
c) RR (quantum = 10)
d) Both FCFS and RR

6. Let us assume that the logical address is <3,1555> and the frame size is 1024. What is the physical address associated with the logical address (select the closest value) **(Marks: 2)**?
   a) 7345
   b) 3566
   c) 8834
   d) None of the above
7. Consider a system using hierarchical page table with two-level paging scheme. The logical address used by this system is depicted below **(Marks: 2)**.

P1	P2	d

The addressing scheme uses 32 inner page tables and each inner page table contains 64 entries. The size of each page of memory is 512 bytes. Determine the number of bits used to represent each of **`p1`**, **`p2`** and **`d`**.

a) 6
b) 7
c) 8
d) 9

8. Consider the tree-structured directory shown below. If the current directory is home/userA, then specify the relative path name for copy **(Marks: 2)**.
   a) home/userA/proj1/count
   b) proj1/copy
   c) userA/proj1/count
   d) /copy
9. Choose the correct options **(Marks: 2)**.
   a) The size of the page is typically a power of 2
   b) The minimum size of the page is 512 bytes per page
   c) The maximum size of the page is 16MB per page
   d) All of the above
10. Let us assume two scenarios. In Scenario 1, TLB lookup takes 4 nano sec, memory access time is 120 nano sec and Hit ratio is 80%. Effective Access Time (EAT) for Scenario 1 is EAT_1. Let us now assume Scenario 2, where TLB lookup takes 5 nano sec, memory access time is 140 nano sec and hit ratio is "h1%". Also assume that EAT for Scenario 2 is EAT_2. Please find the value of h1 such that effective access time for both scenarios are the same. **(Marks: 3)**
    a) 95%
    b) 98.5%
    c) 96%
    d) 97.85%
11. File 1.txt exists on disk and the following commands are run:

```
ln 1.txt 2.txt
```

```
ln -s 1.txt 3.txt
ln -s 3.txt 4.txt
ln -s 2.txt 5.txt
ln 5.txt 6.txt
```

Which of the following statement(s) are true? **(Marks: 1)**

a) 1.txt, 2.txt, 3.txt, 4.txt, 5.txt, 6.txt have the same inode number
b) 1.txt and 2.txt have the same inode number; 3.txt, 4.txt, 5.txt, 6.txt have the same inode number
c) 1.txt, 2.txt have the same inode number; 5.txt, 6.txt have the same inode number
d) 1.txt, 2.txt, 6.txt have the same inode number

12. The number of "hello"s printed by the following code is? **(Marks: 1)**

```
int main()
{
      for (int i=0; i<10; i++) {
            printf("hello¥n");
            fork();
      }
      return 0;
}
```

a) 10
b) 1024
c) infinite
d) 1023

13. Consider the following four processes with arrival times (in milliseconds) and their length of CPU bursts (in milliseconds) as shown below. These processes are run on a single processor using preemptive Shortest Remaining Time First scheduling algorithm. If the average waiting time of the processes is 1 millisecond, then the value of Z is________. **(Marks: 2)**

Process	P1	P2	P3	P4
Arrival time	0	1	3	4
CPU burst time	3	1	3	Z

a) 1
b) 2
c) 3
d) 4

14. Threads of a process share **(Marks: 1)**

a) global variables, but not heap
b) heap, but not global variables
c) neither global variables nor heap
d) both global variables and heap

15. Consider the following CPU processes with arrival times (in milliseconds) and length of CPU bursts (in milliseconds) as given below. If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes, then the average waiting time across all processes is __________ milliseconds. **(Marks: 2)**

Process	Arrival time	Burst time

P1	0	7
P2	3	3
P3	5	5
P4	6	2

a) 2
b) 3
c) 4
d) 5

16. Which of the following is/are shared by all the threads in a process? **(Marks: 1)**
   a) Program counter
   b) Stack
   c) Address space
   d) Registers
17. Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimize the average waiting time in the ready queue? **(Marks: 1)**
   a) Shortest remaining time first
   b) Round-robin with time quantum less than the shortest CPU burst
   c) Uniform random
   d) Highest priority first with priority proportional to CPU burst length
18. Consider the following two-process synchronization solution.

```
Process 0
Entry: loop while (turn == 1);
(critical section)
Exit: turn = 1;
Process 1
Entry: loop while (turn == 0);
(critical section)
Exit: turn = 0;
```

The shared variable turn is initialized to zero. Which one of the following is/are **TRUE**? **(Marks: 1)**

   a) This is a correct two-process synchronization solution.
   b) This solution violates mutual exclusion requirement.
   c) This solution violates progress requirement.
   d) This solution violates bounded wait requirement.
19. Consider a non-negative counting semaphore *S*. The operation *P(S)* decrements *S*, and *V(S)* increments *S*. During an execution, 20 *P(S)* operations and 12 *V(S)* operations are issued in some order. The largest initial value of *S* for which at least one *P(S)* operation will remain blocked is ______. **(Marks: 2)**
   a) 5
   b) 6
   c) 7
   d) 8

20. The following two functions P1 and P2 that share a variable B with an initial value of 2 execute concurrently. The number of distinct values that B can possibly take after the execution is? **(Marks: 2)**

```
P1(){
     C=B-1;
     B=2*c;
}
P2(){
     D=2*B;
     B=D-1;
}
```

   a) 2
   b) 3
   c) 4
   d) 5

21. The maximum number of processes that can be in *Ready* state for a computer system with *n* CPUs is? **(Marks: 1)**
   a) n
   b) n^2
   c) 2^n
   d) Independent of n

22. Consider the following code segment and choose the appropriate option(s): **(Marks: 1)**

```
sem_t sem;

void handler(void *ptr) {
    ...
    sem_wait(&sem);
    //Critical section begins
    ...
    //Critical section ends
    sem_post(&sem);
    ...
}

int main() {
    ...
    sem_init(&sem, 1, 0);
    pthread_create(&thread_a, NULL, (void *)&handler, (void *)&i[0]);
    pthread_create(&thread_b, NULL, (void *)&handler, (void *)&i[1]);
    ...
}
```

   a) This is a correct two-thread synchronization solution.
   b) This solution violates mutual exclusion requirement.

c) This solution violates progress requirement.
d) This solution violates bounded wait requirement.

23. Which of the following statement(s) is/are correct? **(Marks: 1)**
    a) A pipe is a unidirectional data channel between 2 processes
    b) A pipe is a unidirectional data channel within the same process
    c) pipe2() creates bidirectional pipes
    d) pipe3() creates pipes between 3 processes
24. A shared variable n, initialized to zero, is operated on by four concurrent processes *W*, *X*, *Y*, *Z* as follows. Each of the processes *W* and *X* reads n from memory, increments by one, stores it to memory, and then terminates. Each of the processes *Y* and *Z* reads n from memory, decrements by two, stores it to memory, and then terminates. Each process before reading n invokes *wait()* on a counting semaphore *S* and invokes *signal()* on *S* after storing n to memory. Semaphore *S* is initialized to two. What is/are the maximum possible value(s) of n after all processes complete execution? **(Marks: 3)**
    a) -2
    b) -1
    c) 1
    d) 2
25. The following program consists of 3 concurrent processes and 3 binary semaphores. The semaphores are initialized as S0=1, S1=0, S2=0. How many times will process P0 print '0'? **(Marks: 2)**

Process P0	**Process P1**	**Process P2**

`while (true) {`
` wait (S0);`
` print '0'`
` release (S1);`
` release (S2);`
`}`
	`wait (S1);`
	`Release (S0);`
		`wait (S2);`
		`release (S0);`

    a) At least twice
    b) Exactly twice
    c) Exactly thrice
    d) Exactly once