PART 1. Introduction to Computer Science

I. True or False

1. A stack follows a FIFO (first-in-first-out) rule. (2 points)
2. Prim's algorithm is a greedy algorithm that finds a shortest path for a weighted directed graph. (2 points)
3. A dynamic programming algorithm works by recursively breaking down a problem into two or more sub-problems of the same type, until these become simple enough to be solved directly. (2 points)
4. The Ford–Fulkerson algorithm (FFA) is an algorithm for topological sorting problem. (2 points)
5. A 2–3–4 tree is a non-balancing data structure for element searching. (2 points)

II. Query Answering

6. Draw the binary search tree that is created if the following numbers are inserted in the tree in the given order. (5 points)

   [12, 15, 3, 35, 21, 42, 14]

7. Which one of the following can significantly improve the query processing performance of a DBMS. (3 points)
   (a) Construct an Index on Tables
   (b) Enlarge the Disk Volume of the DBMS
   (c) Increase the Memory Capacity of the DBMS
   (d) Use a High Speed CPU to replace the old one

8. Determine the Big O( ) notation for ($10n^3 + 2n^5 + 200^n + 30n^3$) (2 points)

9. What is the value of Math.abs(-2147483648)? (2 points)

10. Why the greedy method strategy cannot always lead to an optimal result for the 0/1 knapsack problem? Please give an example to demonstrate this fact. (6 points)

11. Given the following table

ID	Subject	Score
103	Database	72
103	Linear Algebra	58
104	Database	68
104	Linear Algebra	66
106	Algorithms	49
107	Compiler	79
107	Linear Algebra	61
107	Algorithm	35

Please write an SQL query to find a list of the ID numbers and the scores of the students enrolled in Linear Algebra and scored 60 or higher for the Linear Algebra subject. (6 points)

12. According to the following code segment of C language, please show the printed results? (4 points)

```
#include <stdio.h>
#include <stdlib.h>
int main(void)
{
    int var1 = 65;
    char var2 = 'B';
    printf("1: %d\n", var1);
    printf("2: %c\n", var1);
    printf("3: %d\n", var2);
    printf("4: %c\n", var2);
    system("pause");
}
```

13. According to the following code segment of C language, please show the printed results? (4 points)

```
#include <stdio.h>
#include <stdlib.h>
int main(void)
{
    int a =10;
    int b =2;
    printf("1:%d\n",(a++)+b);
    printf("2:%d\n",(++a)+b);
    printf("3:%d\n",(a++)+b);
    printf("4:%d\n",(++a)+b);
    system("pause");
}
```

14. In mathematics, the Leibniz formula for π states that

$$\pi = 4\sum_{n=0}^{\infty}\frac{(-1)^n}{2n+1}$$

Please complete the following C code segment for Leibniz π approximation. (8 points)

```
#include <stdio.h>
#include <stdlib.h>

double Leibniz(int);
double power(double, int);
int main(void)
{
  printf("Leibniz(%d)=%f\n", 1000, Leibniz(1000));
  system("pause");
  return 0; }

double Leibniz(int n)
{
  int k;
  double sum=0.;



  return 4*sum;
}

// power() returns the value of the first argument raised to the power of the second argument.

double power(double base, int n)
{
  int i;
  double pow=1.0;




  return pow;
}
```

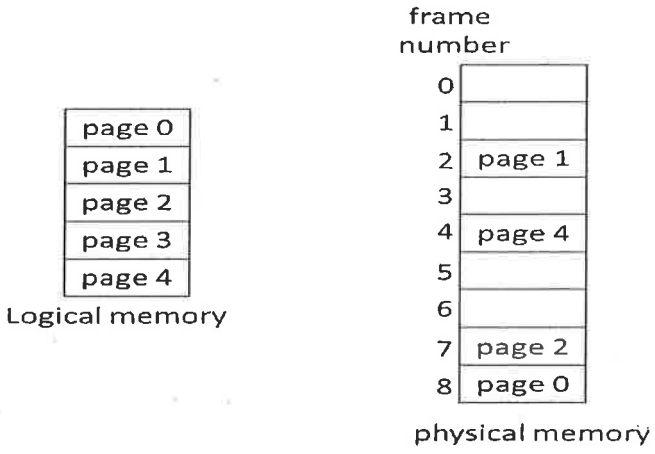
PART 2. Operating Systems

15. Please explain the following terms (6 pts).
    (a) Locality of references
    (b) Inverted page table
    (c) Context switch

16. Please briefly answer the following questions (10 pts).
    (a) The dual mode operation is provided by OS or CPU?
    (b) The goal of dual mode operation is to support protection. How to achieve protection by dual mode operation?
    (c) The application runs in the user mode and the OS runs in the kernel mode. Is it possible to also execute OS in the user mode? If not, please explain your reasons.
    (d) When a process executes an instruction to turn off the interrupt while in the user mode, what problem would be occurred?
    (e) Please list all of the possible cases that the mode would switch from user mode into the kernel mode.

17. The registers are very high speed memory and are within CPUs. However, the process control block (PCB) or processor descriptor also have the register field. Why? (5 pts).

18. Following figure shows a process's logical memory and the corresponding physical memory. Please show the process's page table with valid/invalid bit in each entry. (4 pts).



PART 3. Computer Organizations

19. True or False (10%)
    (a) The processor comprises two main components: datapath and register.
    (b) In the immediate addressing mode, the operand is a constant within the instruction itself.
    (c) TLB can be used to speed up the virtual-to-physical address translation.
    (d) In cache write hit, we can use the write buffer to improve the performance of write-through scheme.
    (e) Program counter (PC) is the register that contains the data address in the program being executed.

20. Answer the following questions briefly. (15%)
(a) Please define a basic block in the program.
(b) Suppose the cache size is 4096 bytes, and block size is 16-byte. In the 32-bit address format, find the tag size for a 2-way set associative cache.
(c) Suppose you want to achieve a speedup of 2 times faster with 6 processors. What percentage of the original computation can be sequential?