

Indian Statistical Institute
Computer Science I BACK PAPER EXAM
First Year Students
31Jan2022

Total Marks: 65

ANSWER Q1 to Q5 (all five) and Either Q6 or Q7

Q1. [Total Marks:2+2+2+2=8]

Consider the following C program:

```
#include <stdio.h>
main()
{
    int i;
    float x=0.56,z;
    char ch='B'; // The constant character 'B' is represented by the number 66
    z=i+x+ch;
    printf("i=%4d\n",i);
    printf("z=%c4.4f\n",z);
}
```

- a. Explain the purpose of “ #include <stdio.h> ” in the above program. What kind of error message is likely to be generated if this line is not included. Is the error message likely to be generated during compile time or run time?
- b. Explain carefully how the statement “z=i+x+ch; ” is executed in C since the statement deals with variables of different data types
- c. What will be the output of the above program?
- d. What will be the output of the above program if we change the statement “z=i+x+ch;” to “i=z+x+ch;” ?

Q2 [Total Marks: 4+6=10]

One way of factoring an integer n into primes is by trial division. This algorithm can be described by the following pseudo code:

```
Begin: given a positive integer n

Set d = 2 // the trial divisor
While n > 1,
  If d divides n,
  then
    write down the factor d
    replace n by n/d
  else
    replace d by d + 1

go to Begin
```

- a.) Implement the algorithm in a C function
- b.) Write a complete C program which accepts an integer from the standard i/o and outputs to the standard i/o each prime factor with its exponent. For example, output for 45 will be

3 to the power 2
5 to the power 1

Q3 [Total Marks: 2+2+3+5=12]

- a.) What is a pointer in C? Use an example to explain what the data type of a pointer is and how a pointer is declared.
- b.) If ptr is a pointer pointing to an integer variable i which has a current value of 100, what is the value *ptr? If the current value of the variable i is 100, what will be the value of i right after the statement “*ptr +=50;” is executed.
- c.) What will be output of the following program?

```
#include <stdio.h>
int main()
{ int x=25;
  int
  *ptr=&x;

  int **temp=&ptr;
  //pointer to pointer
  printf("%d\n",x);
  printf("%d\n",*ptr);
  printf("%d\n",**temp); return 0; }
```

d.) Using pointers, write a C functions which takes a string as input and reverses the string.

Q4 [Total Marks: 4+6=10]

One way of factoring an integer n into primes is by trial division. This algorithm can be described by the following pseudo code:

```
Begin: given a positive integer n

Set d = 2 // the trial divisor
While n > 1,
  If d divides n,
  then
    write down the factor d
    replace n by n/d
  else
    replace d by d + 1

go to Begin
```

- 4 Implement the algorithm in a C function
- 5 Write a complete C program which accepts an integer from the standard i/o and outputs to the standard i/o each prime factor with its exponent. For example, output for 45 will be

3 to the power 2
5 to the power 1

Q5 [Total:2+4+4=10]

Given the following declaration:

```
struct student { int
id;
struct student * next;
};
struct student a,b,c;
struct student * p, * head, * new;
```

Write the C statements / code for each of the following, assuming `head` is pointing to the first item of a linked list of items:

- a. Print the **id** of all elements in the linked list starting from the item pointed to by `head`.
- b. Assuming that `new` is pointing to a new initialized structure; and assuming `p` is pointing to some structure in the linked list, insert the structure that `new` is pointing to into the linked list at the position after `p`.
- c. Assuming `p` is pointing to some structure in the linked list, delete the structure in the linked list at the position after `p`.

Q6 [Total Marks: 6+9=15]

Recall the insertion sort algorithm: suppose you are given n cards on a table. Move one card at a time from the table to your hand such that after every move the cards in your hand are sorted. In other words, the card that you pick from the table is placed at its “appropriate place” in the hand. After moving the last card, it is clear that the set of cards in your hand is sorted.

- (a) Derive a formula for $T(n)$, the worst-case computational complexity of insertion sort. Your answer must be based on an analysis of a pseudo code which you will need to write.
- (b) Write a C function that sorts a set of integers in increasing order, using insertion sort. Assume that the set of integers are given in an array.

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Q7 [Total Marks 3+12=15]

Consider the following algorithm:

1. input integer $n > 0$
2. print n
3. if $n = 1$ then STOP
4. if n is odd then replace n by $3n+1$

5. else replace n by $n/2$
6. GOTO 2

For example, if the input is 5, then the numbers printed will be 5 16 8 4 2 1. The number of numbers printed for any input integer is called its cycle length. In our example of 5, the algorithm terminates, and the cycle length is 6.

- (a) Given the input 22, what is the sequence of numbers printed?
 - (b) For any two numbers i and j write a C program to determine the maximum cycle length over all numbers between (and including) i and j .
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