

**Department of Computer Science and Engineering**  
**National Sun Yat-sen University**  
**Data Structures - Middle Exam, Nov. 9, 2020**

1. What are printed by each of the following C programs? (20%)

- (a) `int c = -1;`  
`printf("%d %d \n", c << 3, c >> 3);`
- (b) `int a=68, b=35;`  
`a = a^b; b = a^b; a = a^b; // ^:XOR`  
`printf("%d %d \n", a, b);`
- (c) `int b=36;`  
`printf("%d \n", (b&(-b)) + 2);`
- (d) `void f(int a[ ], int b[ ], int *c, int *d)`  
`{ printf("%d %d %d %d \n", a[2], b[5], *(c+3), d[2]); }`  
`int main( )`  
`{ int e[ ]={50,51,52,53,54,55,56,57,58,59,60};`  
 `f(e,e+2,&e[3],&e[2]+4); }`
- (e) `int c[ ]={10, 20, 30, 40, 50, 60}; int *p,*q;`  
`p=c+1; q=p; *q=13; *p=*(c+2)+5; p++; *p=19; *(c+2)=(*q)+3;`  
`printf("%d %d %d %d \n", c[0], c[1], c[2], *q);`

2. Given a prefix expression  $++A**BCD/+EFG$ , please draw its expression tree, and then give the infix and postfix forms. (10%)

3. Suppose that a matrix  $M$  stores the nonnegative integer with the following way. The upper left corner of  $M$  is the first element  $M[0][0]=0$ , then  $M[0][1] = 1$  and  $M[0][2] = 4$ , and so on. What is the value of  $M[i][j]$ ? Please represent the value with  $i$  and  $j$ . (10%)

0	1	4	9	...
3	2	5	10	...
8	7	6	11	...
15	14	13	12	...
...	...	...	...	...

4. Suppose that there are 12 polygons, numbered as 1 through 12. Let  $\equiv$  denote the symbol for representing two equal polygons. The following relations are known :  $12 \equiv 4$ ,  $3 \equiv 1$ ,  $6 \equiv 10$ ,  $8 \equiv 9$ ,  $7 \equiv 4$ ,  $6 \equiv 8$ ,  $3 \equiv 5$ ,  $2 \equiv 11$ ,  $11 \equiv 12$ . Please partition the 12 polygons into equivalence classes with the relation  $\equiv$ . (10%)

5. Let  $f(n)$  denote the count of ones in all numbers, with binary representation, between 0 and a positive integer  $n$ . For example, suppose  $n=6$ . There are seven

numbers between 0 and 6, which are 000, 001,010,011,100,101,110. The count of ones in these seven numbers is 9.

- (a) What is the value of  $f(15)$ ? (3%)
- (b) What is the general solution of  $f(n)$  for  $n=2^b-1$ ? Please write the solution expressed by  $n$  and  $b$ . (5%)
- (c) What is the value of  $f(134)$ ? (6%)

6. Explain each of the following terms. (12%)

- (a) template in C++ language
- (b) the positions of front and rear in a queue implemented by an array
- (c) Hanoi tower problem

7. Write a recursive C/C++ function to perform the *binary search* on a nondecreasingly sorted array. (12%)

```
int BSearch(int a[ ], int x, int left, int right)
// a[ ]: nondecreasingly sorted array
// search for x in a[left], a[left+1], ..., a[right-1], a[right]
//Return the index if found. Return -1 if not found.
{
```

Please write the body of BSearch( ).

```
} // end of BSearch( )
```

8. Write a C++ function to reverse a singly linked list. For example, suppose that the given list  $X=(x_1, x_2, \dots, x_{n-1}, x_n)$ . After the reversing process, the list will become  $(x_n, x_{n-1}, \dots, x_2, x_1)$ . (12%)

```
class ChainNode {
    int data;
    ChainNode *link;
};
class Chain {
    ChainNode *first; // first node of the list
    void reverse( ) // reverse the list.
    {
        ChainNode *p, *c; // p:previous, c:current
```

Please write the body of reverse ( ).

```
} // end of reverse ( )
```

```
};
```

**Answer:**

1. (a) -8 -1 (b) 35 68 (c) 6 (d) 52 57 56 58 (e) 10 35 38 35

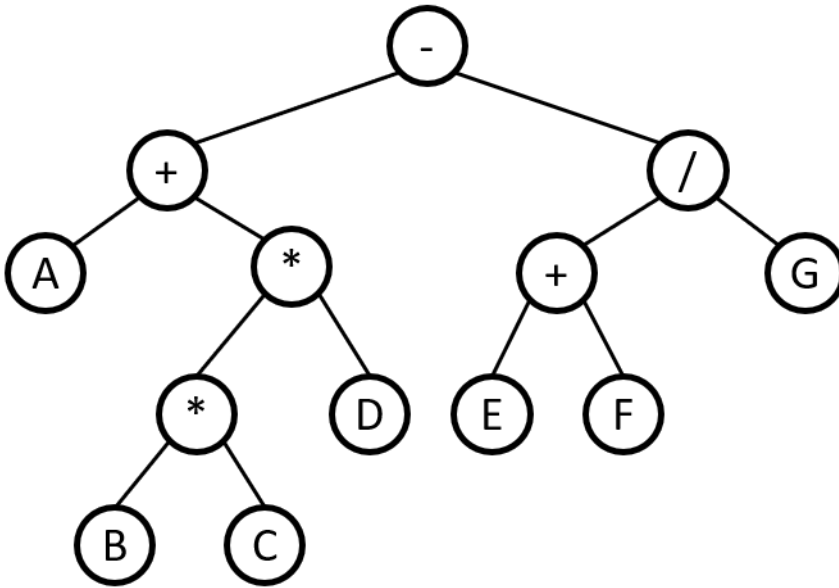
解說：

(a) -1 以 2's complement 表示，則為 111..1111。向左移 3 位，即在右側補上 3 個零，也就等於-8；向右移 3 位，左側補進來的為最左位的 1，仍為 111...1111，也就是-1。

(b) 此運算相當於 a 與 b 互換。

(c)  $b=36=000100100$ ； $b \& (-b)$  等於找出 b 最右側的 1 所在，計算後為  $00..0100=4$ 。

2.



Infix:  $A+(B*C)*D-(E+F)/G$  or  $A+B*C*D-(E+F)/G$

Postfix:  $ABC*D*+EF+G/-$

3.  $j^2 + i, \quad i \leq j$   
 $i^2 + 2i - j, \quad i > j$

or

$j^2 + i, \quad i < j$   
 $i^2 + 2i - j, \quad i \geq j$

4.  $\{2, 4, 7, 11, 12\}; \{1, 3, 5\}; \{6, 8, 9, 10\}$

5. (a)  $f(15) = 32$ ，解說如下：

$$0000=0$$

$$0001=1$$

$$0010=2$$

$$0011=3$$

...

$$1111=15$$

0~15 為全滿的情形，每個 column 有一半的 0，有一半的 1，因此每個 column 有 8 個 1。  $8*4=32$  個 1。

(b)  $f(n) = b*2^{b-1} = b*\left(\frac{n+1}{2}\right)$  or

$$f(n) = 2*f(2^{b-1}-1) + 2^{b-1} = 4*(f(2^{b-1}-1) - f(2^{b-2}-1))$$
 or

$$f(n) = \sum_1^b i * C_i^b$$

解說： $n=2^b-1$  是全滿的情形，每個 column 有一半是 1，也就是有  $2^{b-1}$  個 1，而 column 數量就是 bit 數量  $b$ 。故為  $f(n) = b * 2^{b-1}$ 。

(c)  $f(134)=f(127)+7+f(6)=7*64+7+9=464$

解說：最接近 134 而全滿是 127，剩下為 128,129,...134，相當於  $2^7(0, 1, 2, \dots, 6)$ ，最前方有一個 1，共計 7 個數，其餘 0~6，題目有說共計 9 個 1。

- 6. (a)
- (b)
- (c)

7.

```

if(left > right)
    return -1;
int mid = (left + right)/2;
if(a[mid] == x)
    return mid;
if(a[mid] > x)
    Bsearch(a, x, left, mid-1);
if(a[mid] < x)
    Bsearch(a, x, mid +1, right);

```

8.

```

void Reverse( )
    // Reverse the list.
{
    ChainNode *p, *c;    // p:previous, c:current
    c = first
    p = 0;    // before current
    while (c) {
        ChainNode *r = p;
        p = c;
        c = c ->link;    // moves to next node
        p->link = r; // reverse the link
    }
    first = p;
} // end of Reverse ( )

```