Department of Computer Science and Engineering
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Data Structures - Middle Exam, Nov. 11, 2019

1. Suppose an array is declared as *a*[3][5], where the address of *a*[0][0] is 100 and each element requires four bytes. Also suppose the addresses of *a*[*i*][*j*] calculated by the row-major and the column-major representations are the same. Please write down all possible values of *i* and *j*. (8%).

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

   (a)
   ```
   char c[ ]="ABCDE";
   printf("%d %d %d %d\n",c[1], c[3]-c[1], sizeof(c), c[5]);
   ```

   (b)
   ```
   unsigned char a = -1;
   char b = -1;
   printf("%d  %d\n", a, b);
   ```

   (c)
   ```
   void func(int a, int b, int * c, int & d)
   {  a=b+d;  b=23;  *c=d;  d=19;  }
   int main( )
   { int p=5, q=6, r=7, s=8;
     func(p, q, &r, s);
     printf("%d  %d  %d  %d\n", p, q, r, s); }
   ```

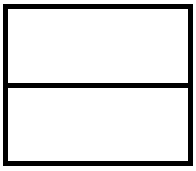
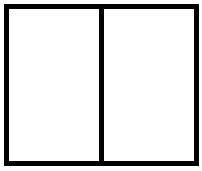
   (d)
   ```
   int c[ ]={12, 16, 20, 24, 28, 32};  int *p,*q;
   p=c;  q=(p++);  *p=*(c+2)+9;  *q=13;  *(c+3)=(*q)+5;
   printf("%d %d %d %d \n", c[0], c[1],c[2],c[3]);
   ```

   (e)
   ```
   int c = -1;
   printf("%d  %d  \n", (c << 5) + 5, c >> 28);
   ```

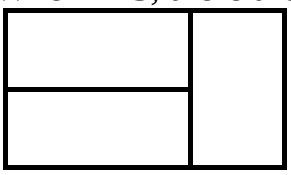
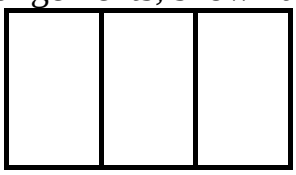
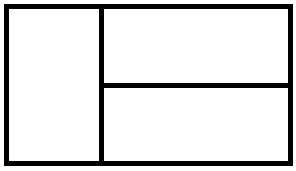
3. Ackerman's function is defined as follows：
   A(m,n)=n+1 if m=0
   A(m,n)=A(m-1,1) if m≠0，n=0
   A(m,n)=A(m-1,A(m,n-1)) if m≠0，n≠0
   What are the values of A(1,4) and A(2,2)? (8%)

4. Given a prefix expression +*-AB+CD/EF, please draw its expression tree, and then give the infix and postfix forms. (10%)

5. Rectangle papers, each with 20 cm × 10 cm, are used to paste up on a bulletin board with 20 cm × 10*n* cm, where *n* is a positive integer. Each paper can be placed horizontally or vertically. For example, when *n*=2, there are two arrangements, shown as follows.

When n=3, there are three arrangements, shown as follows.

Let $f(n)$ denote the number of arrangements for an arbitrary positive integer n. Please derive a general formula for $f(n)$. (10%)

6. Explain each of the following terms. (8%)
   (a) constructor in C++ language
   (b) equivalence class

7. The operation m % n yields the remainder of m upon division by n. Write a recursive C function to find the greatest common divisor (GCD) of two positive integers. (12%)

8. Write a C/C++ function to perform *Push* and *Pop* operations of a stack implemented with an array. (12%)

```
int top;      // array index, top pointer of the stack. top=-1 for an empty stack.
int capacity=100;       // size of the stack
char s[100];            // array for the stack
void Push(char x)
   // Push (add) x to the stack. Before the push operation,
   // you have to check if the stack is full.
{
```

(a) Please write the body of Push( ).

```
} // end of Push( )
char Pop( )
// Remove the top element from the stack, and return the removed element.
// Before the pop operation, you have to check if the stack is empty.
{
```

(b) Please write the body of Pop( ).

```
} // end of Pop( )
```

9. Let $x=(x_1, x_2, \ldots, x_{m-1}, x_m)$ and $y=(y_1, y_2, \ldots, y_{n-1}, y_n)$ be two linear chains (linked lists), where there is a “first” pointer points to the first node, and a “last” pointer

points to the last node in each chain. Write a C++ function to concatenate the two chains into a linear chain $z=(x_1, x_2, \ldots, x_{m-1}, x_m, y_1, y_2, \ldots, y_{n-1}, y_n)$. Note that x or y may be empty. (12%)

```
class ChainNode {
  public:
    int data;
    ChainNode *link;    // Point to the next node
};
class Chain {
  public:
    ChainNode *first, *last;      // first and last pointers
}
Chain & concatenate(Chain &x, Chain &y )
        // y is concatenated to the end of x. You have to consider empty chains.
{
    Chain z;          // The resulting chain
```

Please write the body of concatenate( ).

```
    return z;
} // end of concatenate( )
```

Answer:

1. Two answers: (i=0, j=0), (i=1, j=2), (i=2, j=4)
2. (a) 66 2 6 0 (b) 255 -1 (c) 5 6 8 19 (d) 13 29 20 18
   (e) -27 -1
3. A(1,4)=6, A(2,2)=7
4. Infix: (A-B)*(C+D)+(E/F) or (A-B)*(C+D)+E/F
   Postfix: AB-CD+*EF/+
5. f(n)= f(n-2)+f(n-1), n>=3, f(1)=1, f(2)=2
6. (a) 與 class 相同名稱的函數，對物件進行初始化。
   (b) 具備 reflexive, symmetric, transitive 的 binary relation，其所劃分出來同等的集合。

7.

```
int  gcd(int m,int n)
{
     if(m<n) return gcd(n,m);
     if(n==0) return n;
     return gcd(n,m%n);
}
```

8(a)

```
void Push(char x)
{
   if(top!=capacity-1){    // not full
       top++;
       s[top]=x;
   }
}
```

8(b)

```
char Pop( )
{
   char temp=0;
   if(top!=-1){      // not empty
       temp=s[top];
       top--;
   }
   return temp;
}
```

9.

```
Chain & concatenate(Chain &x, Chain &y )
{
   Chain z;
   if(y.first == 0){    // y.first=NULL, empty y
       z.first=x.first;
       z.last=x.last;
   }
   else if(x.first == 0){    // x.first=NULL, nonempty y and empty x
       z.first=y.first;
       z.last=y.last;
   }
   else{        // nonempty y and nonempty x
     z.first=x.first;
     x.last->link=y.first;
     z.last=y.last;
   }
  return z;
}
```