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Calculating floor and ceiling:

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

void main(){
   double x, f, c;
   char q;
   do{
      printf("\n Enter a number: ");
      scanf("%lf", &x);
      f=floor(x);
      c=ceil(x);
      printf("\n The floor and ceiling of %lf is %lf and %lf respectively.", x, f, c);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   } while (q=='y');
}
```

Recursive factorial function:

```
#include <stdio.h>

long factorial(int n){
   if (n==0) return 1;
   else return n*factorial(n-1);
}
void main(){
   int n;
   long fact;
   char q;
   do{
      printf("\n Enter a nonnegative integer: ");
      scanf("%d", &n);
      fact=factorial(n);
      printf("\n The factorial of %d is %ld.", n, fact);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
    }
    while (q=='y');
 }
```

Recursive power function:

```
#include <stdio.h>

double power(float a, int n){
   if (n==0) return 1;
   else return a*power(a, n-1);
}
void main(){
   float a;
   int n;
   double pow;
   char q;
   do{
      printf("\n Enter a nonzero real number: ");
      scanf("%f", &a);
      printf("\n Enter a nonnegative integer: ");
      scanf("%d", &n);
      pow=power(a, n);
      printf("\n The value of %f raised to the power %d is %f.", a, n, pow);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   }
   while (q=='y');
}
```

Recursive gcd calculation:

```
#include <stdio.h>

int gcd(int a, int b){
   if (a==0) return b;
   else return gcd(b%a, a);
}
void main(){
   int a, b, g;
   char q;
   do{
      printf("\n Enter two nonnegative integers a and b: ");
      scanf("%d%d", &a, &b);
      g=gcd(a, b);
      printf("\n gcd(%d, %d)=%d", a, b, g);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   }
   while (q=='y');
}
```

① gcd(143, 227)=1

② gcd(24, 138)=6

③ gcd(1769, 2378)=29

④ gcd(272, 1479)=17

⑤ gcd(56, 72)=8

Recursive linear search:

```
#include <stdio.h>
#define max 20

int search(int a[], int i, int j, int x){
   if (a[i]==x) return i;
   else if (i==j) return 0;
   else return search(a, i+1, j, x);
}
void main(){
   int a[max], n, x, i=1, j, k, location;
   char q;
   printf("\n Enter the number of elements in the list: ");
   scanf("%d", &n);
   j=n;
   printf("\n Enter the elements of the list: ");
   for(k=1;k<=n;k++)
   scanf("%d", &a[k]);
   do{
        printf("\n Enter the element to search in the list: ");
        scanf("%d", &x);
        location = search(a, i, j, x);
        printf("\n The location of the element %d is at %d.", x, location);
        printf("\n Do you want to search another element?(y/n): ");
        scanf(" %c", &q);
   }
   while (q=='y');
}
```

a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
2	4	3	9	12	7	11	1	15

Search $x = 9$: location = 4

Search $x = 5$: location = 0

Recursive calculation of power modulo m:

```
#include <stdio.h>

int mpower(int b, int n, int m){
   if (n==0) return 1;
   else if (n%2==0) return (mpower(b, n/2, m)*mpower(b, n/2, m)) % m;
   else return (((mpower(b, (n-1)/2, m)*mpower(b, (n-1)/2, m)) % m)*b%m)%m;
}
void main(){
   int b, n, m, mpow;
   char q;
   do{
      printf("\n To calculate b^n mod m");
      printf("\n Enter integers b, n and m:");
      scanf("%d%d%d", &b, &n, &m);
      mpow=mpower(b, n, m);
      printf("\n %d^%d mod %d=%d", b, n, m, mpow);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   }
   while (q=='y');
}
```

(1) $2^5 \bmod 11 = 10$

(2) $3^7 \bmod 4 = 3$

(3) $3^6 \bmod 5 = 4$

Implementing Euclidean algorithm:

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

void main(){
   int x, y, r;
   char q;
   do{
      printf("\n Enter first positive integer: ");
      scanf("%d", &x);
      printf("\n Enter second positive integer: ");
      scanf("%d", &y);
      while (y!=0){
         r=x%y;
         x=y;
         y=r;
      }
      printf("\n The gcd of these integers is %d.", x);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   } while (q=='y');
}
```

① gcd(143, 227) = 1

② gcd(24, 138) = 6

③ gcd(1769, 2378) = 29

④ gcd(272, 1479) = 17

⑤ gcd(56, 72) = 8

Implementing extended Euclidean algorithm:

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

void main(){
   int x, y;
   char b;
   do{
      printf("\n Enter first positive integer: ");
      scanf("%d", &x);
      printf("\n Enter second positive integer: ");
      scanf("%d", &y);
      int a=x, b=y;
      int s1=0, s2=1, t1=1, t2=0;
      int q, r, s, t;
      while (b!=0){
        q=a/b; r=a%b; s=s2-q*s1; t=t2-q*t1;
        a=b; b=r; s2=s1; s1=s; t2=t1; t1=t;
      }
      printf("\n The gcd of %d and %d is %d with coefficients %d and %d respectively.", x, y, a, s2,
t2);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &b);
   } while(b=='y');
}
```

(1) $\gcd(143, 227) = 1 = (-100) \times 143 + 63 \times 227$

(2) $\gcd(24, 138) = 6 = 6 \times 24 + (-1) \times 138$

(3) $\gcd(1769, 2378) = 29 = 39 \times 1769 + (-29) \times 2378$

(4) $\gcd(272, 1479) = 17 = (-38) \times 272 + 7 \times 1479$

(5) $\gcd(56, 72) = 8 = 4 \times 56 + (-3) \times 72$

Addition of two bit strings:

```
#include <stdio.h>
#include <math.h>
#define max 20

void main()
{
   int a[max], b[max], s[max], n;
   char q;
   do{
      int i, c, d;
      printf("\n Enter the length of bit strings ");
      scanf("%d", &n);
      printf("\nEnter first bit string, one bit at a time: ");
      for (i=n-1;i>=0;i--)
      scanf("%d", &a[i]);
      printf("\nEnter second bit string, one bit at a time: ");
      for (i=n-1;i>=0;i--)
      scanf("%d", &b[i]);
      c=0;
      for(i=0;i<=n-1;i++){
         d=floor((a[i]+b[i]+c)/2);
         s[i]=a[i]+b[i]+c-(2*d);
         c=d;
      }
      s[n]=c;
      printf("\n The sum of the bit strings is: ");
      for(i=n;i>=0;i--)
      printf("%d", s[i]);
      printf("\n Do you want to continue?(y/n):");
      scanf(" %c", &q);
   }
   while (q=='y');
}
```

(1)

```
  1 1 0 1 0 1
  1 0 1 1 1 0
-------------
1 1 0 0 0 1 1
```

(2)

```
  0 1 1 0 0
  1 1 1 0 1
-----------
1 0 1 0 0 1
```

Division and Remainder:

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

void main(){
   int a, d;
   char q, p;
   do{
      printf("\n Enter a divided: ");
      scanf("%d", &a);
      printf("\n Enter a positive divisor: ");
      scanf("%d", &d);
      int q=0;
      int r=abs(a);
      while (r>=d){
         r=r-d;
         q=q+1;
      }
      if (a<0){
         if (r>0) then{
            r=d-r;
            q=-(q+1);
         }
         elseif (r==0) then
         q=-q;
      }
      printf("\n The quotient and remainder are %d and %d respectively.", q, r);
      printf("\n Do you want to continue?(y/n): ");
      scanf("%c", &p);
   }
   while (p=='y');
}
```

Dividend:	11	7	22	-35	-57
Divisor:	2	9	11	7	4
quotient:	5	0	2	-5	-15
remainder:	1	7	0	0	3

Solving linear congruence:

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

int inverse(int a, int b){
   int s1=0, s2=1, t1=1, t2=0;
      int q, r, s, t;
      while (b!=0){
        q=a/b; r=a%b; s=s2-q*s1; t=t2-q*t1;
        a=b; b=r; s2=s1; s1=s; t2=t1; t1=t;
      }
   return s2;
}


void main(){
   int a, b, m, s, soln;
   char q;
   printf("\n Solving the linear congruence ax=b (mod m)\n");
   do{
      printf("\n Enter the integers a, b and m: ");
      scanf("%d%d%d", &a, &b, &m);
      s=inverse(a, m);
      printf("\n Solution of the given linear congruence is %d ", s*b);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   } while (q=='y');
}
```

Solving Chinese remainder theorem:

```
#include <stdio.h>
#include <math.h>
#define max 10

int inverse(int a, int b){
   int s1=0, s2=1, t1=1, t2=0;
      int q, r, s, t;
      while (b!=0){
        q=a/b; r=a%b; s=s2-q*s1; t=t2-q*t1;
        a=b; b=r; s2=s1; s1=s; t2=t1; t1=t;
      }
   return s2;
}

void main(){
   int n, i, M, a[max], m[max], s[max], Mk[max];
   char q;
   do{
      printf("\n Enter the number of equations: ");
      scanf("%d", &n);
      printf("\n Enter the integers a and m one line at a time: ");
      for(i=1;i<=n;i++)
         scanf("%d%d", &a[i], &m[i]);
      M=1;
      for(i=1;i<=n;i++)
         M=M*m[i];
      for(i=1;i<=n;i++)
         Mk[i]=M/m[i];
      for(i=1;i<=n;i++)
         s[i]=inverse(Mk[i], m[i]);
      int x=0;
      for(i=1;i<=n;i++)
         x=x+a[i]*Mk[i]*s[i];
      x=x % M;
      printf("\n The solution of the given system is %d+%dk where k is an integer.", x, M);
      printf("\n Do you want to continue?(y/n): ");
      scanf(" %c", &q);
   } while (q=='y');
}
```

(1) $x \equiv 1 \pmod 3$, $x \equiv 2 \pmod 5$, $x \equiv 3 \pmod 7$: 52

(2) $x \equiv 5 \pmod 6$, $x \equiv 4 \pmod{11}$, $x \equiv 3 \pmod{17}$: 785

(3) $x \equiv 1 \pmod 5$, $x \equiv 9 \pmod 6$, $x \equiv 1 \pmod 7$, $x \equiv 9 \pmod{11}$: 141

Join of two Boolean matrices:

```
#include <stdio.h>
#define rmax 10
#define cmax 10

void main(){
   int A[rmax][cmax], B[rmax][cmax];
   int r, c, i, j;
   printf("\n Enter the number of rows and columns of the matrices: ");
   scanf("%d%d", &r, &c);
   printf("\n Enter the elements of the first matrix A, one row at a time:\n");
   for(i=0;i<=r-1;i++)
      for(j=0;j<=c-1;j++)
         scanf("%d", &A[i][j]);
   printf("\n Enter the elements of the second matrix B, one row at a time:\n");
   for(i=0;i<=r-1;i++)
      for(j=0;j<=c-1;j++)
         scanf("%d", &B[i][j]);
   printf("\n The join of the matrices A and B is:\n");
   for(i=0;i<=r-1;i++){
      for(j=0;j<=c-1;j++)
         printf("%d ", A[i][j] || B[i][j]);
      printf("\n");
   }
}
```

$$A = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$A \vee B = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 \end{bmatrix}$$

Meet of two Boolean matrices:

```
#include <stdio.h>
#define rmax 10
#define cmax 10

void main(){
   int A[rmax][cmax], B[rmax][cmax];
   int r, c, i, j;
   printf("\n Enter the number of rows and columns of the matrices: ");
   scanf("%d%d", &r, &c);
   printf("\n Enter the elements of the first matrix A, one row at a time:\n");
   for(i=0;i<=r-1;i++)
      for(j=0;j<=c-1;j++)
         scanf("%d", &A[i][j]);
   printf("\n Enter the elements of the second matrix B, one row at a time:\n");
   for(i=0;i<=r-1;i++)
      for(j=0;j<=c-1;j++)
         scanf("%d", &B[i][j]);
   printf("\n The meet of the matrices A and B is:\n");
   for(i=0;i<=r-1;i++){
      for(j=0;j<=c-1;j++)
         printf("%d ", A[i][j] && B[i][j]);
      printf("\n");
   }
}
```

$$A = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$A \wedge B = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Boolean product of two Boolean matrices:

```
#include <stdio.h>
#define rmax 10
#define cmax 10

void main(){
   int A[rmax][cmax], B[rmax][cmax], C[rmax][cmax];
   int r1, c1, r2, c2, i, j, k;
   printf("\n Enter the number of rows and columns of the first matrix: ");
   scanf("%d%d", &r1, &c1);
   printf("\n Enter the number of rows and columns of the second matrix: ");
   scanf("%d%d", &r2, &c2);
   if (c1!=r2)
   printf("\n The dimensions of the matrices do not match.");
   else{
      printf("\n Enter the elements of the first matrix A, one row at a time:\n");
      for(i=0;i<=r1-1;i++)
         for(j=0;j<=c1-1;j++)
            scanf("%d", &A[i][j]);
      printf("\n Enter the elements of the second matrix B, one row at a time:\n");
      for(i=0;i<=r2-1;i++)
         for(j=0;j<=c2-1;j++)
            scanf("%d", &B[i][j]);
      printf("\n The join of the matrices A and B is:\n");
      for(i=0;i<=r1-1;i++){
         for(j=0;j<=c2-1;j++){
            C[i][j]=0;
            for(k=0;k<=r2-1;k++)
               C[i][j]=C[i][j] || (A[i][k] && B[k][j]);
            printf("%d ", C[i][j]);
         }
         printf("\n");
      }
   }
}
```

Boolean product

$$A = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \quad B = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 \end{bmatrix}$$

$$A \odot B = \begin{bmatrix} 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 \end{bmatrix}$$

Testing properties of relations:

```
#include <stdio.h>
#define max 10

void main()
{
   int i, j, n, mat[max][max];
   printf("Enter the number of elements in set A: ");
   scanf("%d", &n);
   printf("\n Enter the matrix representation of relation");
   printf("\n one row at a time: \n");
   for(i=0;i<=n-1;i++)
      for(j=0;j<=n-1;j++)
         scanf("%d", &mat[i][j]);
   int key=1;
   for(i=0;i<=n-1;i++)
      key=key && mat[i][i];
   if (key==1)
      printf("\n The given relation is reflexive.");
   else
      printf("\n The given relation is not reflexive.");
   key=1;
   for(i=0;i<=n-1;i++)
      for(j=0;j<=n-1;j++)
         if (mat[i][j]!=mat[j][i]) key=0;
   if (key==1)
      printf("\n The given relation is symmetric.");
   else
      printf("\n The given relation is not symmetric.");
   key=1;
   for(i=0;i<=n-1;i++)
      for(j=0;j!=i && j<=n-1;j++)
         if ((mat[i][j] && mat[j][i])==1) key=0;
    if (key==1)
      printf("\n The given relation is antisymmetric.");
   else
      printf("\n The given relation is not antisymmetric.");
}
```

① $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ → $A=\{a,b,c\}$, $R=\{(a,a),(a,c),(b,b),(b,c),(c,a),(c,b),(c,c)\}$ → reflexive, symmetric, not antisymmetric.

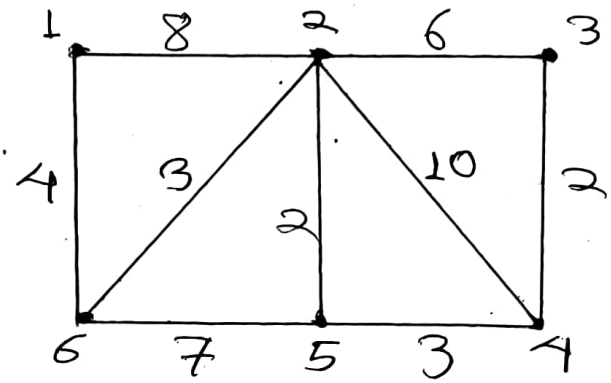
② $\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$ → $A=\{a,b,c,d\}$, $R=\{(a,a),(a,d),(b,c),(c,a),(c,b),(d,b),(d,d)\}$ → not reflexive, not symmetric, not antisymmetric.

③ $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ → $A=\{a,b,c\}$, $R=\{(a,a),(a,c),(b,b)\}$ → not reflexive, not symmetric, antisymmetric.

Dijkstra's algorithm for shortest path problem:

```
#include<stdio.h>
#include<conio.h>
#define INFINITY 9999
#define MAX 10

void dijkstra(int G[MAX][MAX], int n, int startnode);
 void main()
{
   int G[MAX][MAX], i, j, n, u;
   printf("Enter number of vertices:");
   scanf("%d", &n);
   printf("\n Enter the cost adjacency matrix with entry 0 for nonadjacent vertices:\n");

   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
         scanf("%d", &G[i][j]);

   printf("\n Enter the starting node:");
   scanf("%d", &u);
   dijkstra(G, n, u);
}
 void dijkstra(int G[MAX][MAX], int n, int startnode)
{

   int cost[MAX][MAX], distance[MAX], pred[MAX];
   int visited[MAX], count, mindistance, nextnode, i, j;

   //pred[] stores the predecessor of each node
   //count gives the number of nodes seen so far
   //create the cost matrix
   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
         if(G[i][j]==0)
            cost[i][j]=INFINITY;
         else
            cost[i][j]=G[i][j];

   //initialize pred[], distance[] and visited[]
   for(i=1; i<=n; i++)
   {
      distance[i]=cost[startnode][i];
      pred[i]=startnode;
      visited[i]=0;
   }

   distance[startnode]=0;
   visited[startnode]=1;
   count=1;

   while(count<n-1)
   {
      mindistance=INFINITY;

      //nextnode gives the node at minimum distance
      for(i=1; i<=n; i++)
         if(distance[i]<mindistance && !visited[i])
```

```
        {
            mindistance=distance[i];
            nextnode=i;
        }

        //check if a better path exists through nextnode
        visited[nextnode]=1;
        for(i=1; i<=n; i++)
            if(!visited[i])
                if(mindistance+cost[nextnode][i]<distance[i])
                {
                    distance[i]=mindistance+cost[nextnode][i];
                    pred[i]=nextnode;
                }
        count++;
    }

    //print the path and distance of each node
    for(i=1; i<=n; i++)
        if(i!=startnode)
        {
            printf("\n Distance of node%d=%d", i, distance[i]);
            printf("\n Path=%d", i);

            j=i;
            do
            {
                j=pred[j];
                printf("<-%d", j);
            }while(j!=startnode);
        }
}
```



Start node = 1

	1	2	3	4	5	6
1	0	8	0	0	0	4
2	8	0	6	10	2	3
3	0	6	0	2	0	0
4	0	10	2	0	3	0
5	0	2	0	3	0	7
6	4	3	0	0	7	0

Path	Length
1→2 : 2←6←1	7
1→3 : 3←2←6←1	13
1→4 : 4←5←2←6←1	12
1→5 : 5←2←6←1	9
1→6 : 6←1	4