1 STL Useful Tips

1.1 Common libraries

1.2 I/O

1.3 Useful constant

1.4 Space waster

1.5 Tricks in cmath

1.6 Initialize array with predefined value

1.7 Modifying sequence operations

1.8 Merge

1.9 String

1.10 Heap

1.11 Sort

1.12 Permutations

1.13 Searching

1.14 Random algorithm

2 Number Theory

2.1 Prime number under 100

2.5 If prime number

2.6 Prime factorization

2.7 Leap year

2.8 Binary exponential

2.10 Factorial mod

2.11 Generate combinations

2.12 10-ary to m-ary

2.13 m-ary to 10-ary

2.14 Binomial coefficient

2.15 Catalan numbers

2.16 Eulerian numbers

2.17 Karatsuba algorithm in Java

2.18 Euler’s totient function

2.19 Split plane

3 Searching Algorithms

3.1 Find rank k in array

3.2 KMP Algorithm

4 Dynamic Programming

4.1 0/1 Knapsack problems

4.2 Complete Knapsack problems

4.3 Longest common subsequence (LCS)

4.4 Longest increasing common sequence (LICS)

4.5 Longest Increasing Subsequence (LIS) 4.6 Maximum submatrix

4.7 Partitions of integers

4.8 Partitions of sets

5 Trees

5.1 Tree traversal

5.2 Depth and width of tree

6 Graph Theory 19

6.1 Graph representation

6.2 Flood fill algorithm

6.3 SPFA — shortest path

6.4 Floyd-Warshall algorithm – shortest path of all pairs

6.5 Prim — minimum spanning tree

6.6 Eulerian circuit

6.7 Topological sort

7 Individual Templates

**1.2 I/O**

getline(cin, str) // wasted getline

getline(cin, str) // real input string

**1.9 String**// Searching

unsigned int find(const string &s2, unsigned int pos1 = 0);

unsigned int rfind(const string &s2, unsigned int pos1 = end);

unsigned int find\_first\_of(const string &s2, unsigned int pos1 = 0);

unsigned int find\_last\_of(const string &s2, unsigned int pos1 = end);

unsigned int find\_first\_not\_of(const string &s2, unsigned int pos1 = 0);

unsigned int find\_last\_not\_of(const string &s2, unsigned int pos1 = end);

// Insert, Erase, Replace

string& insert(unsigned int pos1, const string &s2);

string& insert(unsigned int pos1, unsigned int repetitions, char c);

string& erase(unsigned int pos = 0, unsigned int len = npos);

string& replace(unsigned int pos1, unsigned int len1, const string &s2);

string& replace(unsigned int pos1, unsigned int len1, unsigned int repetitions, char c);

// String streams

stringstream s1;int i = 22;

s1 << "Hello world! " << i;

cout << s1.str() << endl;

**1.11 Sort**

void sort(iterator first, iterator last);

void sort(iterator first, iterator last, LessThanFunction comp);

void stable\_sort(iterator first, iterator last);

void stable\_sort(iterator first, iterator last, LessThanFunction comp);

void partial\_sort(iterator first, iterator middle, iterator last);

void partial\_sort(iterator first, iterator middle, iterator last, LessThanFunction comp);

bool is\_sorted(iterator first, iterator last);

bool is\_sorted(iterator first, iterator last, LessThanOrEqualFunction comp);

// example for sort, if have array x, start\_index, end\_index;

sort(x+start\_index, x+end\_index);

/\*\* sort a map \*\*/

// You cannot directly sort a map<key type, mapped data type>

// if you only want to sort in key type

// you can use insert method to copy map into another map

// b.insert(make\_pair(it->first, it->second) /\* it is a map iterator \*/

// this will result a map which sorts key type in increasing order

// if you want to sort key type in decreasing order, then declare your map as

// something like:

// map<char, int, greater<char> >

// if you want to sort based on key, you need to copy the data to a vector

// where elements of vector are pair.

// you can define a PAIR type by using:

                    typedef pair<char, int> PAIR;

// suppose this is the map

                    map<char, int> a;

// sort vector in decreasing order

                    bool cmp\_by\_value(const PAIR& lhs, const PAIR& rhs)

{

    return lhs.second > rhs.second;

}

// sort key in increasing order

bool cmp\_by\_char(const PAIR& lhs, const PAIR& rhs)

{

    return lhs.first < rhs.first;

}

// copy map data to vector

vector<PAIR> b(a.begin(), a.end());

// sort data

sort(b.begin(), b.end(), cmp\_by\_value);

// you can still call your data by b[i].first and b[i].second.

// THE ABOVE CODES ARE EXAMPLE FOR SORTING A MAP.

// PLEASE USE IT FOR YOUR OWN DEMANDS.

**1.12 Permutations**

bool next\_permutation(iterator first, iterator last);

bool next\_permutation(iterator first, iterator last, LessThanOrEqualFunction comp);

bool prev\_permutation(iterator first, iterator last);

bool prev\_permutation(iterator first, iterator last, LessThanOrEqualFunction comp);

**1.13 Searching**

// will return address of iterator, call result as \*iterator;

iterator find(iterator first, iterator last, const T &value);

iterator find\_if(iterator first, iterator last, const T &value, TestFunction test);

bool binary\_search(iterator first, iterator last, const T &value);

bool binary\_search(iterator first, iterator last, const T &value, LessThanOrEqualFunction comp);

**1.14 Random algorithm**

srand(time(NULL));

// generate random numbers between [a,b)

rand() % (b - a) + a;

// generate random numbers between [0,b)

rand() % b;

// generate random permutations

random\_permutation(anArray, anArray + 10);

random\_permutation(aVector, aVector + 10);

**2 Number Theory**

**2.1 Prime number under 100**

// there are 25 numbers

2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37,

41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97

**2.5 If prime number-O(sqrt(n))**

bool prime(int n)

{

    if (n<2) return false;

    if (n<=3) return true;

    if (!(n%2) || !(n%3)) return false;

    for (int i=5; i\*i<=n; i+=6)

        if (!(n%i) || !(n%(i+2))) return false;

    return true;

}

**2.6 Prime factorization-O(sqrt(n))**

// smallest prime factor of a number.

function factor(int n)

{

    int a;

    if (n%2==0)

        return 2;

    for (a=3; a<=sqrt(n); a+=2)

    {

        if (n%a==0)

            return a;

    }

    return n;

}

// complete factorization

int r;

while (n>1)

{

r = factor(n);

    printf("%d", r);

    n /= r;

}

**2.7 Leap year**

bool isLeap(int n)

{

    if (n%100==0)

        if (n%400==0) return true;

        else return false;

    if (n%4==0) return true;

    else return false;

}

**2.8 Binary exponiential**

int binExpIte(int a,int b){

int ans=1;

while(b){

if(b&1){

ans\*=a;

}

a\*=a;

b>>=1;

}

return ans;

}

**2.9 a^b mod p**

long powmod(long base, long exp, long modulus)

{

    base %= modulus;

    long result = 1;

    while (exp > 0)

    {

        if (exp & 1) result = (result \* base) % modulus;

        base = (base \* base) % modulus;

        exp >>= 1;

    }

    return result;

}

**2.10 Factorial mod**

**//n! mod p**

int factmod (int n, int p)

{

    long long res = 1;

    while (n > 1)

    {

        res = (res \* powmod (p-1, n/p, p)) % p;

        for (int i=2; i<=n%p; ++i)

            res=(res\*i) %p;

        n /= p;

    }

    return int (res % p);

}

**2.11 Generate combinations**

// n>=m, choose M numbers from 1 to N.

void combination(int n, int m)

{

    if (n<m) return ;

    int a[50]= {0};

    int k=0;

    for (int i=1; i<=m; i++) a[i]=i;

    while (true)

    {

        for (int i=1; i<=m; i++)

            cout << a[i] << " ";

        cout << endl;

        k=m;

        while ((k>0) && (n-a[k]==m-k)) k--;

        if (k==0) break;

        a[k]++;

        for (int i=k+1; i<=m; i++)

            a[i]=a[i-1]+1;

    }

}

**2.12 10-ary to m-ary**

char a[16]= {’0’,’1’,’2’,’3’,’4’,’5’,’6’,’7’,’8’,’9’,

             ’A’,’B’,’C’,’D’,’E’,’F’

            };

            string tenToM(int n, int m)

{

    int temp=n;

    string result="";

    while (temp!=0)

    {

        result=a[temp%m]+result;

        temp/=m;

    }

    return result;

}

**2.13 m-ary to 10-ary**

string num="0123456789ABCDE";

           int mToTen(string n, int m)

{

    int multi=1;

    int result=0;

    for (int i=n.size()-1; i>=0; i--)

    {

        result+=num.find(n[i])\*multi;

        multi\*=m;

    }

    return result;

}

**2.14 Binomial coefficient**

#define MAXN 100 // largest n or m

long binomial\_coefficient(n,m) // compute n choose m

int n,m;

{

    int i,j;

    long bc[MAXN][MAXN];

    for (i=0; i<=n; i++) bc[i][0] = 1;

    for (j=0; j<=n; j++) bc[j][j] = 1;

    for (i=1; i<=n; i++)

        for (j=1; j<i; j++)

            bc[i][j] = bc[i-1][j-1] + bc[i-1][j];

    return bc[n][m];

}

**2.15 Catalan numbers**

Cn =

    nX−1

    k=0

      CkCn−1−k =

          1

          n + 1

          n

          k

          (1)

          The first terms of this sequence are 2, 5, 14, 42, 132, 429, 1430 when C0 = 1. This is the number of ways to build a balanced

                  formula from n sets of left and right parentheses. It is also the number of triangulations of a convex polygon, the number of

    rooted binary tress on n + 1 leaves and the number of paths across a lattice which do not rise above the main diagonal.

**2.16 Eulerian numbers**

n

k= k

n − 1

k

+ (n − k + 1)

n − 1

k − 1

(2)

// This is the number of permutations of length n with exactly k ascending sequences or runs.

// Basis: k=0 has value 1

#define MAXN 100 // largest n or k

          long eularian(n,k)

          int n,m;

{

    int i,j;

    long e[MAXN][MAXN];

    for (i=0; i<=n; i++) e[i][0] = 1;

    for (j=0; j<=n; j++) e[0][j] = 0;

    for (i=1; i<=n; i++)

        for (j=1; j<i; j++)

            e[i][j] = k\*e[i-1][j] + (i-j+1)\*e[i-1][j-1];

    return e[n][k];

}

**2.17 Karatsuba algorithm in Java**

// fast algorithm to find multiplication of two big numbers.

import java.math.BigInteger;

import java.util.Random;

class Karatsuba

{

    private final static BigInteger ZERO = new BigInteger("0");

    public static BigInteger karatsuba(BigInteger x, BigInteger y)

    {

        int N = Math.max(x.bitLength(), y.bitLength());

        if (N <= 2000) return x.multiply(y);

        N=(N/2)+(N %2);

        BigInteger b = x.shiftRight(N);

        BigInteger a = x.subtract(b.shiftLeft(N));

        BigInteger d = y.shiftRight(N);

        BigInteger c = y.subtract(d.shiftLeft(N));

        BigInteger ac = karatsuba(a, c);

        BigInteger bd = karatsuba(b, d);

        BigInteger abcd = karatsuba(a.add(b), c.add(d));

        return ac.add(abcd.subtract(ac).subtract(bd).shiftLeft(N)).add(bd.shiftLeft(2\*N));

    }

    public static void main(String[] args)

    {

        long start, stop, elapsed;

        Random random = new Random();

        int N = Integer.parseInt(args[0]);

        BigInteger a = new BigInteger(N, random);

        BigInteger b = new BigInteger(N, random);

        start = System.currentTimeMillis();

        BigInteger c = karatsuba(a, b);

        stop = System.currentTimeMillis();

        System.out.println(stop - start);

        start = System.currentTimeMillis();

        BigInteger d = a.multiply(b);

        stop = System.currentTimeMillis();

        System.out.println(stop - start);

        System.out.println((c.equals(d)));

    }

}

**2.18 Euler’s totient function**

// the positive integers less than or equal to n that are relatively prime to n.

int phi (int n)

{

    int result = n;

    for (int i=2; i\*i<=n; ++i)

        if(n %i==0)

        {

            while(n %i==0)

                n /= i;

            result -= result / i;

        }

    if (n > 1)

        result -= result / n;

    return result;

}

**2.19 Split plane**

n lines can split a plane in (n+1)n

2 + 1 sub-regions.

**3 Searching Algorithms**

**3.1 Find rank k in array**

int find(int l, int r, int k)

{

    int i=0,j=0,x=0,t=0;

    if (l==r) return a[l];

    x=a[(l+r)/2];

    t=a[x];

    a[x]=a[r];

    a[r]=t;

    i=l-1;

    for (int j=l; j<=r-1; j++)

        if (a[j]<=a[r])

        {

            i++;

            t=a[i];

            a[i]=a[j];

            a[j]=t;

        }

    i++;

    t=a[i];

    a[i]=a[r];

    a[r]=t;

    if (i==k) return a[i];

    if (i<k) return find(i+1, r,k);

    return find(l, i-1, k);

}

**3.2 KMP Algorithm-O(n)**

#include <iostream>

#include <string>

#include <vector>

using namespace std;

typedef vector<int> VI;

void buildTable(string& w, VI& t)

{

    t = VI(w.length());

    int i = 2, j = 0;

    t[0] = -1;

    t[1] = 0;

    while(i < w.length())

    {

        if(w[i-1] == w[j])

        {

            t[i] = j+1;

            i++;

            j++;

        }

        else if(j > 0) j = t[j];

        else

        {

            t[i] = 0;

            i++;

        }

    }

}

int KMP(string& s, string& w)

{

    int m = 0, i = 0;

    VI t;

    buildTable(w, t);

    while(m+i < s.length())

    {

        if(w[i] == s[m+i])

        {

            i++;

            if(i == w.length()) return m;

        }

        else

        {

            m += i-t[i];

            if(i > 0) i = t[i];

        }

    }

    return s.length();

}

int main(void)

{

    string a = (string) "The example above illustrates the general technique for assembling "+

               "the table with a minimum of fuss. The principle is that of the overall search: "+

               "most of the work was already done in getting to the current position, so very "+

               "little needs to be done in leaving it. The only minor complication is that the "+

               "logic which is correct late in the string erroneously gives non-proper "+

               "substrings at the beginning. This necessitates some initialization code.";

    string b = "table";

    int p = KMP(a, b);

    cout << p << ": " << a.substr(p, b.length()) << " " << b << endl;

    return 0;

}

**4 Dynamic Programming**

**4.1 0/1 Knapsack problems-O(n\*w)**

**//Top Down**

int ks(int W, int i){

if(i==0 || W<=0) return 0;

if(weight[i]>W) return ks(W,i-1);

if(mem[W][i]==0) mem[W][i]=max(ks(W,i-1),value[i]+ks(W-weight[i],i-1));

return mem[W][i];

}

//Bottom Up

int knapsack(int capacity, int ind){

for(int i=1;i<=ind;i++){

for(int c=1;c<=capacity;c++){

if(weight[i]>c){

mem[i][c]=mem[i-1][c];

}

else{

int k1=mem[i-1][c];

int k2=value[i]+mem[i-1][c-weight[i]];

mem[i][c]=max(k1,k2);

}

}

}

int max\_profit=mem[ind][capacity];

return max\_profit;

}

**4.2 Complete Knapsack problems**

#include<iostream>

using namespace std;

int f[1000]= {0};

             int n=0, m=0;

             int main(void)

{

    cin >> n >> m;

    for (int i=1; i<=n; i++)

    {

        int price=0, value=0;

        cin >> price >> value;

        for (int j=price; j<=m; j++)

            if (f[j-price]+value>f[j])

                f[j]=f[j-price]+value;

    }

    cout << f[m] << endl;

    return 0;

}

**4.3 Longest common subsequence (LCS)-O(n\*m)**

int dp[1001][1001];

int lcs(const string &s, const string &t)

{

    int m = s.size(), n = t.size();

    if (m == 0 || n == 0) return 0;

    for (int i=0; i<=m; ++i)

        dp[i][0] = 0;

    for (int j=1; j<=n; ++j)

        dp[0][j] = 0;

    for (int i=0; i<m; ++i)

        for (int j=0; j<n; ++j)

            if (s[i] == t[j])

                dp[i+1][j+1] = dp[i][j]+1;

            else

                dp[i+1][j+1] = max(dp[i+1][j], dp[i][j+1]);

    return dp[m][n];

}

**4.4 Longest increasing common sequence (LICS)**

#include<iostream>

using namespace std;

int a[100]= {0};

            int b[100]= {0};

            int f[100]= {0};

            int n=0, m=0;

            int main(void)

{

    cin >> n;

    for (int i=1; i<=n; i++) cin >> a[i];

    cin >> m;

    for (int i=1; i<=m; i++) cin >> b[i];

    for (int i=1; i<=n; i++)

    {

        int k=0;

        for (int j=1; j<=m; j++)

        {

            if (a[i]>b[j] && f[j]>k) k=f[j];

            else if (a[i]==b[j] && k+1>f[j]) f[j]=k+1;

        }

    }

    int ans=0;

    for (int i=1; i<=m; i++)

        if (f[i]>ans) ans=f[i];

    cout << ans << endl;

    return 0;

}

**4.5 Longest Increasing Subsequence (LIS)-O(n^2)**

#include<iostream>

using namespace std;

int n=0;

      int a[100]= {0}, f[100]= {0}, x[100]= {0};

      int main(void)

{

    cin >> n;

    for (int i=1; i<=n; i++)

    {

        cin >> a[i];

        x[i]=INT\_MAX;

    }

    f[0]=0;

    int ans=0;

    for(int i=1; i<=n; i++)

    {

        int l=0, r=i;

        while (l+1<r)

        {

            int m=(l+r)/2;

            if (x[m]<a[i]) l=m;

            else r=m;

// change to x[m]<=a[i] for non-decreasing case

        }

        f[i]=l+1;

        x[l+1]=a[i];

        if (f[i]>ans) ans=f[i];

    }

    cout << ans << endl;

    return 0;

}

**4.6 Maximum submatrix**

// URAL 1146 Maximum Sum

#include<iostream>

using namespace std;

int a[150][150]= {0};

                 int c[200]= {0};

                 int maxarray(int n)

{

    int b=0, sum=-100000000;

    for (int i=1; i<=n; i++)

    {

        if (b>0) b+=c[i];

        else b=c[i];

        if (b>sum) sum=b;

    }

    return sum;

}

int maxmatrix(int n)

{

    int sum=-100000000, max=0;

    for (int i=1; i<=n; i++)

    {

        for (int j=1; j<=n; j++)

            c[j]=0;

        for (int j=i; j<=n; j++)

        {

            for (int k=1; k<=n; k++)

                c[k]+=a[j][k];

            max=maxarray(n);

            if (max>sum) sum=max;

        }

    }

    return sum;

}

int main(void)

{

    int n=0;

    cin >> n;

    for (int i=1; i<=n; i++)

        for (int j=1; j<=n; j++)

            cin >> a[i][j];

    cout << maxmatrix(n);

    return 0;

}

**4.7 Partitions of integers**

#define MAXN 100 // largest n or m

long int\_coefficient(n,k) // compute f(n,k)

int n,m;

{

    int i,j;

    long f[[MAXN][MAXN];

                 f [1][1] = 1;

                 for (i=0; i<=n; i++) f[i][0] = 0;

                 for (i=1; i<=n; i++)

                 for (j=1; j<i; j++)

                 if (i-j <= 0)

                 f[i][j] = f[i][k-1];

                 else

                 f[i][j] = f[i-j][k]+f[i][k-1];

                 return f[n][k];

      }

**4.8 Partitions of sets**

      Number of ways to partition n + 1 items into k sets.

      n

      k

          = k

            n − 1

            k

            +

            n − 1

            k − 1

            (3)

      where

      n

      1

      =

          n

          n

          = 1 (4)

            5 Trees

            5.1 Tree traversal

            int L[100]= {0};

int R[100]= {0};

            void DLR(int m)

{

    cout << m << " ";

    if (L[m]!=0) DLR(L[m]);

    if (R[m]!=0) DLR(R[m]);

}

void LDR(int m)

{

    if (L[m]!=0) LDR(L[m]);

    cout << m << " ";

    if (R[m]!=0) LDR(R[m]);

}

void LRD(int m)

{

    if (L[m]!=0) LRD(L[m]);

    if (R[m]!=0) LRD(R[m]);

    cout << m << " ";

}

int main(void)

{

    cin >> n;

    for (int i=1; i<=n; i++)

        cin >> L[i] >> R[i];

    DLR(1);

    cout << endl;

    LDR(1);

    cout << endl;

    LRD(1);

    cout << endl;

    return 0;

}

**5.2 Depth and width of tree**

#include <iostream>

#include <queue>

#include <stack>

using namespace std;

int l[100]= {0};

            int r[100]= {0};

            stack<int> mystack;

            int n=0;

            int w=0;

            int d=0;

            int depth(int n)

{

    if (l[n]==0 && r[n]==0)

        return 1;

    int depthl=depth(l[n]);

    int depthr=depth(r[n]);

    int dep=depthl>depthr ? depthl:depthr;

    return dep+1;

}

void width(int n)

{

    if (n<=d)

    {

        int t=0,x;

        stack<int> tmpstack;

        while (!mystack.empty())

        {

            x=mystack.top();

            mystack.pop();

            if (x!=0)

            {

                t++;

                tmpstack.push(l[x]);

                tmpstack.push(r[x]);

            }

        }

        w=w>t?w:t;

        mystack=tmpstack;

        width(n+1);

    }

}

int main(void)

{

    cin >> n;

    for (int i=1; i<=n; i++)

        cin >> l[i] >> r[i];

    d=depth(1);

    mystack.push(1);

    width(1);

    cout << w << " " << d << endl;

    return 0;

}

***6 Graph Theory***

**6.1 Graph representation**

// The most common way to define graph is to use adjacency matrix

// example:

// (1) (2) (3) (4) (5)

// (1) 2 0 5 0 0

// (2) 4 2 0 0 1

// (3) 3 0 0 1 4

// (4) 6 9 0 0 0

// (5) 1 1 1 1 5

// it’s always a square matrix.

// suppose a graph has n nodes, if given exactly adjacency matrix

for (int i=1; i<=n; i++)

for (int j=1; i<=n; j++)

{

    cin << a[i][j] << endl;

    }

// Usually will go like this representation in data

// start\_node end\_node weight

// suppose m lines

for (int i=1; i<=m; i++)

{

int x=0, y=0, t=0;

cin >> x >> y >> t;

a[x][y]=t;

// if undirected graph

    a[y][x]=t;

}

// another variant: on the ith line, has data as

// end\_node weight

// when you read data, you can assign matrix as

a[i][x]=t;

// if undirected graph

        a[x][i]=t;

// Initialization of graph !!!IMPORTANT

// Depends on usage, normally initialize as 0 for all elements in matrix.

// so that 0 means no connection, non-0 means connection

// (for problem without weight, use weight as 1)

// If weights are important in this context (especially searching for path)

// Initialize graph as infinity for all elements in matrix.

// Another way to store graph is Adjacency list

// No space advantage if using array (unknown maximum number for in-degree).

// Big space advantage if using dynamic data structure (like list, vector).

// each row represent a node and its connectivity.

// we don’t need it so much due to it’s search efficiency.

// let’s define a node as

        struct Node

{

    int id; // node id

    int w; // weight

};

// suppose n nodes and m lines of inputs as

// start\_node end\_node weight

// assume using <vector> in this example

// g is a vector, and each element of g is also a vector of Node

for (int i=1; i<=m; i++)

{

int x=0, y=0, t=0;

cin >> x >> y >> t;

Node temp;

temp.id=y;

temp.w=t;

g[x].push\_back(temp);

// if undirected

    temp.id=x;

    g[y].push\_back(temp);

}

// Note that you don’t need this node structure if graph has only connectivity information.

/\*\*\*\* Special Structure \*\*\*\*/

// Special structure here is usually not a typical graph, like city-blocks, triangles

// They are represented in 2-d array and shows weights on nodes instead of edges.

// Note that in this case travel through edge has no cost, but visit node has cost.

// Triangles: Read data like this

// 1

// 1 2

// 4 2 7

// 7 3 1 5

// 6 2 9 4 6

for (int i=1; i<=n; i++)

for (int j=i; j<=n; j++)

    cin >> a[i][j];

// Simple city-blocks: it’s just like first form of adjacency matrix, but this time

// represents weights on nodes, may not be square matrix.

// 1 2 4 5 6

// 2 4 5 1 3

// 4 5 2 3 6

        for (int i=1; i<=n; i++)

            for (int j=1; <=m; j++)

                cin >> a[i][j];

// More complex data structures: typical city-block structure may has some constraints on

// questions, but it has no boundaries. However, some questions requires to form a maze.

// In these cases, data structures can be very flexible, it totally depends on how the question

// presents the data. A usual way is to record it’s adjacent blocks information:

                struct Block

        {

            bool l[4]; // if has 8 neighbors then use bool l[8];

// label them as your favor, e.x.

// 1 1 2 3

// 4 x 2 8 x 4

// 3 7 6 5

// true if there is path, false if there is boundary

// other informations (optional)

                int weight;

                int component\_id;

// etc.

            };

// Note that usually we use array from index 1 instead of 0 because sometimes

// you need index 0 as your boundary, and start from index 1 will give you

// advantage on locating nodes or positions

**6.2 Flood fill algorithm O(mxn)**

//component(i) denotes the

//component that node i is in

void flood\_fill(new\_component)

do

num\_visited = 0

for all nodes i

if component(i) = -2

num\_visited = num\_visited + 1

component(i) = new\_component

for all neighbors j of node i

if component(j) = nil

component(j) = -2

until num\_visited = 0

void find\_components()

num\_components = 0

for all nodes i

component(node i) = nil

for all nodes i

if component(node i) is nil

num\_components = num\_components + 1

component(i) = -2

flood\_fill(component num\_components)

**6.3 SPFA — shortest path O(VxE)**

int q[3001]= {0}; // queue for node

it d[1001]= {0}; // record shortest path from start to ith node

bool f[1001]= {0};

int a[1001][1001]= {0}; // adjacency list

int w[1001][1001]= {0}; // adjacency matrix

int main(void) {

  int n=0, m=0;

  cin >> n >> m;

  for (int i=1; i<=m; i++){

  int x=0, y=0, z=0;

cin >> x >> y >> z; // node x to node y has weight z

a[x][0]++;

 a[x][a[x][0]]=y;

  w[x][y]=z;

/\*

// for undirected graph

 a[x][0]++;

 a[y][a[y][0]]=x;

w[y][x]=z;

\*/

}

int s=0, e=0;

cin >> s >> e; // s: start, e: end

SPFA(s);

cout << d[e] << endl;

return 0;

}

void SPFA(int v0)

{

    int t,h,u,v;

    for (int i=0; i<1001; i++) d[i]=INT\_MAX;

    for (int i=0; i<1001; i++) f[i]=false;

    d[v0]=0;

    h=0;

    t=1;

    q[1]=v0;

    f[v0]=true;

    while (h!=t)

    {

        h++;

        if (h>3000) h=1;

        u=q[h];

        for (int j=1; j<=a[u][0]; j++)

        {

            v=a[u][j];

            if (d[u]+w[u][v]<d[v]) // change to > if calculating longest path

            {

                d[v]=d[u]+w[u][v];

                if (!f[v])

                {

                    t++;

                    if (t>3000) t=1;

                    q[t]=v;

                    f[v]=true;

                }

            }

        }

        f[u]=false;

    }

}

**6.4 Floyd-Warshall algorithm – shortest path of all pairs O(n^3)**

// map[i][j]=infinity at start

void floyd()

{

    for (int k=1; k<=n; k++)

        for (int i=1; i<=n; i++)

            for (int j=1; j<=n; j++)

                if (i!=j && j!=k && i!=k)

                    if (map[i][k]+map[k][j]<map[i][j])

      map[i][j]=map[i][k]+map[k][j];}

**6.5 Prim — minimum spanning tree o(ElogV)**

int d[1001]= {0};

             bool v[1001]= {0};

             int a[1001][1001]= {0};

             int main(void)

{

    int n=0;

    cin >> n;

    for (int i=1; i<=n; i++)

    {

        int x=0, y=0, z=0;

        cin >> x >> y >> z;

        a[x][y]=z;

    }

    for (int i=1; i<=n; i++)

        for (int j=1; j<=n; j++)

            if (a[i][j]==0) a[i][j]=INT\_MAX;

    cout << prim(1,n) << endl;

}

int prim(int u, int n)

{

    int mst=0,k;

    for (int i=0; i<d.length; i++) d[i]=INT\_MAX;

    for (int i=0; i<v.length; i++) v[i]=false;

    d[u]=0;

    int i=u;

    while (i!=0)

    {

        v[i]=true;

        k=0;

        mst+=d[i];

        for (int j=1; j<=n; j++)

            if (!v[j])

            {

                if (a[i][j]<d[j]) d[j]=a[i][j];

                if (d[j]<d[k]) k=j;

            }

        i=k;

    }

    return mst;

}

//Kruskal

#include<bits/stdc++.h>

#define lili long long int

using namespace std;

lili n,e;

class DSU{

lili\* parent;

lili\* \_size;

public:

DSU(lili n){

parent = new lili[n+1];

\_size = new lili[n+1];

for(lili i=1;i<=n;i++){

parent[i]=i;

\_size[i]=1;

}

}

lili find\_set(lili x){

if(x==parent[x]) return x;

lili y=find\_set(parent[x]);

parent[x]=y;

return y;

}

void Union(lili x, lili y){

lili rx=find\_set(x);

lili ry=find\_set(y);

if(rx==ry) return;

if(\_size[rx]<=\_size[ry]){

parent[rx]=parent[ry];

\_size[ry]+=\_size[rx];

}

else{

parent[ry]=parent[rx];

\_size[rx]+=\_size[ry];

}

}

~DSU(){

delete parent;

delete \_size;

}

};

lili Kruskal(pair<lili,pair<lili,lili>>edges[]){

DSU d(n);

sort(edges,edges+n+1);

lili weight=0;

for(lili i=0;i<e;i++){

lili w=edges[i].first;

lili u=edges[i].second.first;

lili v=edges[i].second.second;

if(d.find\_set(u)!=d.find\_set(v)){

weight+=w;

d.Union(u,v);

}

}

return weight;

}

int main(){

cin>>n>>e;

pair<lili,pair<lili,lili>>edges[e];

for(lili i=0;i<e;i++){

lili u,v,w; cin>>u>>v>>w;

edges[i].first=w;

edges[i].second.first=u;

edges[i].second.second=v;

}

lili ans=Kruskal(edges);

cout<<ans<<"\n";

}

**6.6 Eulerian circuit O(V+E)**

// USACO Fence

#include<iostream>

using namespace std;

int f[100]= {0}, ans[100]= {0};

            bool g[100][100]= {0}, v[100]= {0};

            int n=0, m=0, c=0;

            void dfs(int k)

{

    for (int i=1; i<=n; i++)

        if (g[k][i])

        {

            g[k][i]=false;

            g[i][k]=false;

            dfs(i);

        }

    m++;

    ans[m]=k;

}

int main(void)

{

    cin >> n >> m;

    for (int i=1; i<=m; i++)

    {

        int x=0, y=0;

        g[x][y]=true;

        g[y][x]=true;

        f[x]++;

        f[y]++;

    }

    m=0;

    int k1=0;

    for (int i=1; i<=n; i++)

    {

        if (f[i]%2==1) k1++;

        if (k1>2)

        {

            cout << "error" << endl;

            return 0;

        }

        if (f[i]%2 && c==0) c=i;

    }

    if (c==0) c=1;

    dfs(x);

    for (int i=m; i>=1; i--) cout << ans[i] << endl;

    return 0;

}

**6.7 Topological sort**

// Find any solution of topological sort.

#include<iostream>

using namespace std;

int f[100]= {0}, ans[100]= {0};

            bool g[100][100]= {0}, v[100]= {0};

            int n=0, m=0;

            void dfs(int k)

{

    int i=0;

    v[k]=true;

    for (int i=1; i<=n; i++)

        if (g[k][i] && !v[i]) dfs(i);

    m++;

    ans[m]=k;

}

int main(void)

{

    cin >> n >> m;

    for (int i=1; i<=m; i++)

    {

        int x=0, y=0;

        cin >> x >> y;

        g[y][x]=true;

    }

    m=0;

    for (int i=1; i<=n; i++)

        if (!v[i]) dfs(i);

    for (int i=1; i<=n; i++) cout << ans[i] << endl;

    return 0;

}

**// Find the order of topological sort is dictionary minimum**

#include<iostream>

using namespace std;

int f[100]= {0}, ans[100]= {0};

            bool g[100][100]= {0}, v[100]= {0};

            int n=0, m=0;

            int main(void)

{

    cin >> n >> m;

    for (int i=1; i<=m; i++)

    {

        int x=0, y=0;

        cin >> x >> y;

        g[x][y]=true;

        f[y]++;

    }

    for (int i=1; i<=n; i++)

    {

        for (int j=1; j<=n; j++)

        {

            if (f[j]==0 && !v[j]) break;

            if (f[j]!=0)

            {

                cout << "error" << endl;

                return 0;

            }

            ans[i]=j;

            v[j]=true;

            for (int k=1; k<=n; k++)

                if (g[j][k]) f[k]--;

        }

    }

    for (int i=1; i<=n; i++) cout << ans[i] << endl;

    return 0;

}

**6.8 Dijkstra O(V^2)**

const int N = 1e5 + 100;

vector<pii> gra[N];

ll dis[N];

int par[N];

int main()

{

    int node, edge; cin >> node >> edge;

    rep(i, edge)

    {

        int a, b, w; cin >> a >> b >> w;

        gra[a].emplace\_back(b, w);

        gra[b].emplace\_back(a, w);

    }

    priority\_queue<pii> pq;

    rep(i, node) dis[i] = 1e18 + 100;

    int src = 1;

    dis[src] = 0;

    par[1] = -1;

    pq.push ({ -dis[src], src});

    while (pq.size() > 0)

    {

        auto t = pq.top();

        pq.pop();

        int u = t.ss, d = -t.ff;

        if (dis[u] < d) continue;

        for (auto it : gra[u])

        {

            int v = it.ff, w = it.ss;

            if (dis[v] > dis[u] + w)

            {

                dis[v] = dis[u] + w;

                pq.push({ -dis[v], v});

                par[v] = u;

            }

        }

    }

vector<int>path;

    int xx = node;

    while (xx != -1)

    {

        path.em(xx);

        xx = par[xx];

        if (xx == 0)

        {

            cout << -1;

            return 0;

        }

    }

    reverse(all(path));

    for (int it : path) cout << it << ' ';

}

**7 Individual Templates**

***7.1***

**///Basics**

->cout << n << " " << flush;

->map<int,int>m={{1,2},{3,3},{2,1},{5,1}};

it1 = m.lower\_bound(5);

if(it1==m.end()) cout<<"Not found\n";

**///No. of Triangle from different lengths**

for(i=0;i<(n-2);i++){

for(j=i+1;j<(n-1);j++){

int t = a[j]+a[i];

auto itr = upper\_bound(a.begin()+j,a.end(), t);

int idx=itr-a.begin();

if(\*itr==t && itr!=a.end()){

++idx, sum+=(n-idx);

}

else if((\*itr>t)&& itr!=a.end()){sum+=(n-idx);}

}}cout<<sum<<'\n';

**///Binary Search**

Return the indx less than or equal to the element:

int lower\_bound(int a[],int lo,int hi,int x)

{

if(a[0]>x) return 0;

int mid=(lo+hi+1)/2;

if(lo>=hi) return mid+1;

else if(a[mid]<=x) return lower\_bound(a,mid,hi,x);

else return lower\_bound(a,lo,mid-1,x);

}

**///Number Theory**

**///GCD**

int gcd(int a,int b){

if(b==0) return a;

return gcd(b,a%b);

}

**//PRIME FACTORIZATION**

vector<int>prime\_factors;

for(int i=2;(i\*i)<=n;i++){

while(n%i==0){

prime\_factors.push\_back(i);

n/=i;

}

}

if(n>1)prime\_factors.push\_back(n);

**///bitset**

#include<bits/stdc++.h>

#define ll long long

#define ld long double

using namespace std;

int main()

{

bitset<2>arr;

arr[0]=1, arr[1]=0; cout<<arr<<endl<<endl; ///01

/// int to binary/bitset and vise-versa

bitset<4>a(8) ; cout<<a<<endl; ///1000

int n=(int)a.to\_ulong();

cout<<n<<endl<<endl; ///8 (back into int)

/// string to bitset

string str="1010110100";

bitset<10>b(str); cout<<b[0]<<" "<<b[2]<<endl; ///0 1

string new\_str=b.to\_string(); cout<<new\_str<<endl; ///1010110100

///count the no of Ones

cout<<b.count()<<endl<<endl;

///basic operations

bitset<4>a1(string("0101"));

bitset<4>b1(string("1010"));

cout<<(a1 & b1)<<endl;

cout<<(b1<<1)<<endl<<endl;

/// streams in bitset

string str1="10 101101 10";

istringstream stream(str1);

bitset<2>s1; bitset<6>s2;

stream>>s1; cout<<s1<<endl; ///10

stream>>s2; cout<<s2<<endl<<endl; ///101101

///check if any bit is set

bitset<4>a2(string("1101")); cout<<a2.any()<<endl; ///true

///check if none of the bits is set

cout<<a2.none()<<endl; ///false ///is none or not

///check if all bits is set

bitset<3>a3(string("111")); cout<<a3.all()<<endl<<endl;

///flip all or any particular bit

cout<<a3.flip()<<endl;

cout<<a3.flip(2)<<endl;

cout<<a3.flip(1)<<endl<<endl;

///Reset all or any particular bit

cout<<a3.reset(1)<<endl; a3.reset();

cout<<a3<<endl<<endl;

///Set all or any particular bit

cout<<a3.set(1)<<endl; cout<<a3.set()<<endl<<endl;

}

**///BFS**

vector<int>adj[100];

int visited[100],int par[100],int dis[100];

void bfs(int s){

queue<int>q;

q.push(s);

visited[s]=1;

par[s]=-1;

dis[s]=0;

while(q.size()!=0){

int u = q.front();

q.pop();

for(int i=0; i<adj[u].size(); i++){

int v = adj[u][i];

if(visited[v]==0){

q.push(v);

visited[v]=1;

par[v]=u;

dis[v]=dis[u]+1;

}

}

}

}

void path(int x){

if(x==-1) return;

path(par[x]);

cout<<x<<" ";

}

int main(){

int n,e,s;

cin>>n>>e;

while(e--){

int x,y; cin>>x>>y;

adj[x].push\_back(y);

adj[y].push\_back(x);

}

cin>>s;

bfs(s);

while(1){

cout<<"Enter the vertex whose shortest path and shortest distance from "<<s<<" to be displayed: ";

int x;

cin>>x;

cout<<"Shortest distance from "<<s<<" to "<<x<<" is: "<<dis[x]<<endl;

cout<<"Shortest path from "<<s<<" to "<<x<<" is: ";

path(x);

cout<<endl;

}

}

**///Biparitite**

const int N=1000;

int adj[N][N];

int n,e;

bool isBicolored(int s){

int colorArray[n];

for(int i=0;i<n;i++)

colorArray[i]=-1; ///initially no color;

queue<int>q;

q.push(s);

colorArray[s]=1; ///assigning first color

while(!q.empty()){

int senior = q.front();

q.pop();

if(adj[senior][senior]==1) ///self loop

return false;

for(int i=0;i<n;i++){

int junior=i;

if(adj[senior][junior]==1){

if(colorArray[junior]==colorArray[senior]) ///successor(child/junior) having same color

return false;

///if(colorArray[junior]!=-1) continue; ///not same color but have a color

else if(colorArray[junior]==-1){ ///No color assigned

q.push(junior);

colorArray[junior]=!colorArray[senior]; ///assigning diff color

}}}} return true;}

**///All possible ways of a problem**

void bfs()

{

queue<int>q;

q.push(x);

vis[x]=1;

dis[x]=0;

while(!q.empty()){

int senior=q.front();

q.pop();

for(int i=1;i<=2;i++){

int junior;

if(i==1) junior=(2\*senior);

else junior=senior-1;

if(junior<=0 || junior>10000) continue;

if(!vis[junior]){

q.push(junior);

vis[junior]=1;

dis[junior]=dis[senior]+1;

if(junior==y) return;

}

}

}

}

int main()

{

cin>>x>>y;

bfs();

cout<<dis[y]<<"\n";

}

**///Guilty Prince**

string lands[10000];

int row,column,counts;

bool vis[10000][10000];

void dfs(int r,int c)

{

if(r<0 || r>=row || c<0 || c>=column || lands[r][c]=='#' || vis[r][c]==1)

return;

vis[r][c]=1, counts++;

dfs(r-1,c); ///up

dfs(r+1,c); ///down

dfs(r,c-1); ///left

dfs(r,c+1); ///right

}

int main()

{

counts=0;

cin>>column>>row;

for(int i=0;i<row;i++){

cin>>lands[i];

}

for(int i=0;i<row;i++){

for(int j=0;j<column;j++){

vis[i][j]=0;

}}

for(int i=0;i<row;i++){

for(int j=0;j<column;j++){

if(lands[i][j]=='@')

dfs(i,j);

}}

cout<<counts<<"\n";}

**///Two farthest node**

vector<int>adj[30001];

map<pair<int,int>,int>weight;

map<int,int>vis,dis;

void dfs(int node)

{

vis[node]=1;

for(int i=0;i<adj[node].size();i++){

int child=adj[node][i];

if(vis[child]==1) continue;

dis[child]+=dis[node]+weight[{node,child}];

dfs(child);

}

}

void reset()

{

for(int i=0;i<30001;i++){

adj[i].clear();

}

dis.clear(),weight.clear(),vis.clear();

}

int main()

{

int t; cin>>t;

for(int p=1;p<=t;p++)

{

int n,u,v,w; cin>>n;

for(int i=0;i<n-1;i++){

cin>>u>>v>>w;

adj[u].push\_back(v);

adj[v].push\_back(u);

weight[{u,v}]=w;

weight[{v,u}]=w;

}

dfs(0);

int max\_dis=0,farthestVertex;

map<int,int>::iterator i;

for(i=dis.begin();i!=dis.end();i++){

if(i->second>max\_dis){

max\_dis=i->second;

farthestVertex=i->first;

}

}

vis.clear();

dis.clear();

dfs(farthestVertex);

max\_dis=0;

for(i=dis.begin();i!=dis.end();i++){

if(i->second>max\_dis){

max\_dis=i->second;

}

}

cout<<"Case "<<p<<": "<<max\_dis<<"\n";

reset();

}

}

**///HASHING**

#include <bits/stdc++.h>

#define ff first

#define ss second

#define mp make\_pair

using namespace std;

typedef long long LL;

typedef pair<LL, LL> PLL;

const PLL M=mp(1e9+7, 1e9+9);   ///Should be large primes

const LL base=347;              ///Should be a prime larger than highest value

const int N = 1e6+7;            ///Highest length of string

ostream& operator<<(ostream& os, PLL hash) {

    return os<<"("<<hash.ff<<", "<<hash.ss<<")";

}

PLL operator+ (PLL a, LL x)     {return mp(a.ff + x, a.ss + x);}

PLL operator- (PLL a, LL x)     {return mp(a.ff - x, a.ss - x);}

PLL operator\* (PLL a, LL x)     {return mp(a.ff \* x, a.ss \* x);}

PLL operator+ (PLL a, PLL x)    {return mp(a.ff + x.ff, a.ss + x.ss);}

PLL operator- (PLL a, PLL x)    {return mp(a.ff - x.ff, a.ss - x.ss);}

PLL operator\* (PLL a, PLL x)    {return mp(a.ff \* x.ff, a.ss \* x.ss);}

PLL operator% (PLL a, PLL m)    {return mp(a.ff % m.ff, a.ss % m.ss);}

PLL power (PLL a, LL p) {

    if (p==0)   return mp(1,1);

    PLL ans = power(a, p/2);

    ans = (ans \* ans)%M;

    if (p%2)    ans = (ans\*a)%M;

    return ans;

}

///Magic!!!!!!!

PLL inverse(PLL a)  {

    return power(a, (M.ff-1)\*(M.ss-1)-1);

}

PLL pb[N];      ///powers of base mod M

PLL invb;

///Call pre before everything

void hashPre() {

    pb[0] = mp(1,1);

    for (int i=1; i<N; i++)

        pb[i] = (pb[i-1] \* base)%M;

    invb = inverse(pb[1]);

}

///Calculates Hash of a string

PLL Hash (string s) {

    PLL ans = mp(0,0);

    for (int i=0; i<s.size(); i++)

        ans=(ans\*base + s[i])%M;

    return ans;

}

///appends c to string

PLL append(PLL cur, char c) {

    return (cur\*base + c)%M;

}

///prepends c to string with size k

PLL prepend(PLL cur, int k, char c) {

    return (pb[k]\*c + cur)%M;

}

///replaces the i-th (0-indexed) character from right from a to b;

PLL replace(PLL cur, int i, char a, char b) {

    cur = (cur + pb[i] \* (b-a))%M;

    return (cur + M)%M;

}

///Erases c from the back of the string

PLL pop\_back(PLL hash, char c) {

    return (((hash-c)\*invb)%M+M)%M;

}

///Erases c from front of the string with size len

PLL pop\_front(PLL hash, int len, char c) {

    return ((hash - pb[len-1]\*c)%M+M)%M;

}

///concatenates two strings where length of the right is k

PLL concat(PLL left, PLL right, int k) {

    return (left\*pb[k] + right)%M;

}

///Calculates hash of string with size len repeated cnt times

///This is O(log n). For O(1), pre-calculate inverses

PLL repeat(PLL hash, int len, LL cnt) {

    PLL mul = (pb[len\*cnt] - 1) \* inverse(pb[len]-1);

    mul = (mul%M+M)%M;

    PLL ans = (hash\*mul)%M;

    if (pb[len].ff == 1)    ans.ff = hash.ff\*cnt;

    if (pb[len].ss == 1)    ans.ss = hash.ss\*cnt;

    return ans;

}

///Calculates hashes of all prefixes of s including empty prefix

vector<PLL> hashList(string s) {

    int n = s.size();

    vector<PLL> ans(n+1);

    ans[0] = mp(0,0);

    for (int i=1; i<=n; i++)

        ans[i] = (ans[i-1] \* base + s[i-1])%M;

    return ans;

}

///Calculates hash of substring s[l..r] (1 indexed)

PLL substringHash(const vector<PLL> &hashlist, int l, int r) {

    int len = (r-l+1);

    return ((hashlist[r] - hashlist[l-1]\*pb[len])%M+M)%M;

}

///Solves LightOJ 1255-Substring Frequency

///You are given two strings A and B. You have to find

///the number of times B occurs as a substring of A.

char buffer[N];

int main()

{

    hashPre();

    int t;

    scanf("%d", &t);

    for (int cs=1; cs<=t; ++cs)

    {

        string a, b;

        scanf("%s", buffer); a = buffer;

        scanf("%s", buffer); b = buffer;

        int na = a.size(), nb = b.size();

        PLL hb = Hash(b);

        vector<PLL> ha = hashList(a);

        int ans = 0;

        for (int i=1; i+nb-1<=na; i++)

            if (substringHash(ha, i, i+nb-1) == hb)  ans++;

        printf("Case %d: %d\n", cs, ans);

    }

}

**/// TRIE**

const int N = 1e6 + 100;

int tot\_node = 1;

int to[N][26];

int add(string &s) {

    int cur = 1; // root node

    for(int i = 0; i < s.size(); i++) {

        int c = s[i]-'a';

        if(!to[cur][c]) to[cur][c] = ++tot\_node;

        cur = to[cur][c];

    }

    return cur; // leaf node where this string ends

}

///

/// KMP PI TABLE (FUCKING MATERIALS)

vector<int> prefix\_function(string s) /// this will  return kmp pi table

{

    int n = s.size();

    vector<int> pi(n);/// pi[0] = 0, as per kmp condition

    for (int i = 1; i < n; i++)

    {   /// j = prefix length and end at j-1

        int j = pi[i - 1]; /// max prefix matched at i-1

        while (j > 0 and s[i] != s[j]) j = pi[j - 1];

        if (s[i] == s[j]) ++j;

        pi[i] = j;

    }

    return pi;

}

///TC:Insert and Search: O(n)

**/// DIGIT DP**

//  How many numbers x are there in the range a to b, where the digit d occurs exactly k times in x?

int a, b, d, k;

vii digit;

int n;

int dp[30][30][3];

/// DP[p][c][f] = Number of valid numbers <= b from this state

/// p = current position from left side (zero based)

/// c = number of times we have placed the digit d so far

/// f = the number we are building has already become smaller than b? [0 = no, 1 = yes]

int call(int idx, int cnt, int f)

{

    if (cnt > k) return 0;

    if (idx >= n) return cnt == k;

    if (dp[idx][cnt][f] != -1) return dp[idx][cnt][f];

    int limit;

    if (!f) limit = digit[idx];

    /// Digits we placed so far matches with the prefix of b

    /// So if we place any digit > num[pos] in the current position, then the number will become greater than b

    else limit = 9;

    /// The number has already become smaller than b. We can place any digit now.

    int xx = 0;

    /// Try to place all the valid digits such that the number doesn't exceed b

    for (int i = 0; i <= limit; i++)

    {

        int cnt1 = 0;

        int ff = f;

        if (!f and i < limit) ff = 1;/// The number is getting smaller at this position

        if (i == d) cnt1 = 1;

        xx += call(idx + 1, cnt + cnt1, ff);

    }

    return dp[idx][cnt][f] = xx;

}

int solve(int x)

{

    mem(dp, -1);

    digit.clear();

    while (x)

    {

        digit.em(x % 10);

        x /= 10;

    }

    reverse(all(digit));

    /// Stored all the digits of x in num for simplicity

    n = digit.size();

    return call(0, 0, 0);

}

signed main()

{

#ifndef ONLINE\_JUDGE

    freopen("input.txt", "r", stdin);

    freopen("output.txt", "w", stdout);

#endif

    cin >> a >> b >> d >> k;

    cout << solve(b) - solve(a - 1) << endll;

}

///TC: **O(10\*idx\*sum\*tight)**

**/// SEGMENT TREE LAZY**

const int N = 1e5 + 100;

int tree[N << 2], lz[N << 2];

void propagate(int u, int st, int en)

{

if (!lz[u]) return;

tree[u] += lz[u] \* (en - st + 1);

if (st != en)

{

lz[2 \* u] += lz[u];

lz[2 \* u + 1] += lz[u];

}

lz[u] = 0;

}

void update(int u, int st, int en, int l, int r, int x)

{

propagate(u, st, en);

if (r < st or en < l) return;

else if (st >= l and en <= r)

{

lz[u] += x;

propagate(u, st, en);

}

else

{

int mid = (st + en) >> 1;

update(2 \* u, st, mid, l, r, x);

update(2 \* u + 1, mid + 1, en, l, r, x);

tree[u] = tree[2 \* u] + tree[2 \* u + 1];

}

}

int query(int u, int st, int en, int l, int r)

{

propagate(u, st, en);

if (r < st or en < l) return 0;

else if (st >= l and en <= r) return tree[u];

else

{

int mid = (st + en) >> 1;

int left = query(2 \* u, st, mid, l, r);

int right = query(2 \* u + 1, mid + 1, en, l, r);

return left + right;

}

}

**// dp print**

int dp[60][1500];

int dir[60][1500];

int knap(int i,int now)

{

if(i>=cap)

return 0;

if(dp[i][now] != -1)

return dp[i][now];

int t1=0,t2=0;

if(now + arrw[i] <= n)

t1 = arrc[i] + knap(i+1,now+arrw[i]);

t2 = knap(i+1,now);

if(t1>t2)

dir[i][now] = 1;

else

dir[i][now] = 2;

return dp[i][now] = max(t1,t2);

}

vector <int> pri;

void print(int i,int now)

{

if(dir[i][now] == -1)

return;

if(dir[i][now] == 1)

{

pri.push\_back(i);

print(i+1,now+arrw[i]);

}

else

print(i+1,now);

}///**TC: O(n\*m)**

***7.2***

// typedef long long int;

const int MX = 1e6+5;

#define pii pair<int, int>

template<typename T>

bool comp(T a, T b){//sort by descending

    return a > b;

}

**optimized Sieve(finds (n+1)th prime)**

vector<int> nth\_prime;

bitset<MX> visited;

void optimized\_prime(){

    nth\_prime.push\_back(2);

    for(int i=3; i<MX; i+=2){

            if(visited[i])

                continue;

            nth\_prime.push\_back(i);

            if(1ll\*i\*i > MX)

                continue;

            for(int j = i\*i; j< MX; j+= i+i)

                visited[j] = true;

    }

}///TC: O(log(logn))

**stores smallest prime divisor of every num from 1 to x**

int spf[MX];

void sieve(){

    for(int i=1; i<MX; ++i)

        spf[i] = i;

    for(int i=2; i\*i<MX; ++i){

        if(spf[i] != i) continue;

        for(int j=i\*i; j<MX; j += i){

            if(spf[j]==j)

                spf[j] = i;

        }

    }

}

map<int, int> mp; **//prime factorization**

void factorize(int n)

{

    while(n != 1){

        mp[spf[n]]++;

        n /= spf[n];

    }

}///TC: O(log(n))

**when phi(1) to phi(n) is neeeded**

int phi[MX];

//bitset<MX> visited;// declared before in optimized SIEVE

void sieve\_phi(){

    for(int i=1; i<MX; ++i) phi[i] = i;

    visited[1] = 1;

    for(int i=2; i<MX; ++i){

        if(!visited[i]){

            for(int j = i; j<MX; j+=i){

                visited[j] = 1;

                phi[j] = phi[j]/i\*(i-1);

            }

        }

    }

}///O(log(logn))

**when only phi(n) is needed**

int phi(int n){ //O(sqrt(n))

    int res = n;

    for(int p=2; p\*p<=n; ++p){

        if(n%p== 0){

            while(n%p == 0)

                n /= p;

            res -= res/p;

        }

    }

    if(n>1) res -= res/n;

    return res;

}

**claculate nCR start**

typedef long long LL;

const LL MOD = 1e9+7;

const LL MAX = 2e5+5;

vector<LL> fact(MAX), inv(MAX);

void factorial(){

fact[0] = 1;

for(LL i=1; i<MAX; i++)

fact[i] = (i\*fact[i-1])%MOD;

}

LL bigmod(LL a, LL n, LL M=MOD){

LL res = 1;

while(n){

if(n&1) res = (res\*a)%M;

a = (a\*a)%M, n /= 2;

}

return res;

}

void inverse(){

for(int i=0; i<MAX; ++i)

inv[i] = bigmod(fact[i], MOD-2);

}

LL C(LL a, LL b){

if(a<b or a<0 or b<0) return 0;

LL de = (inv[b]\*inv[a-b])%MOD;

return (fact[a]\*de)%MOD;

}

//call factorial() and inverse() from main function

**// end nCR**

LL ModInv(int a, int M){    //M is prime

    return bigmod(a, M-2, M);

}

***7.3***

**Knight Moves**

int X[8]={2,1,-1,-2,-2,-1,1,2};

int Y[8]={1,2,2,1,-1,-2,-2,-1};

**//bit count in O(1)**

int BitCount(unsigned int u){

unsigned int uCount;

uCount = u - ((u >> 1) & 033333333333) - ((u >> 2) & 011111111111);

return ((uCount + (uCount >> 3)) & 030707070707) % 63;

}

**Matrix Exponentiation**

// A technique of computing a number raised to a square matrix in a fast and efficient manner.

// Uses properties of exponentiation and binary numbers for fast computation.

//

// Running time:

// O(m^3\*log(n)) where m is the size of the matrix and n is the power the matrix is being raised to.

//

// INPUT:

// - size of matrix m

// - the matrix A

// - the power n

// - modulo value mod

//

// OUTPUT:

// - the matrix A^n (all values mod m)

//

#include<bits/stdc++.h>

using namespace std;

typedef long long LL;

LL arr[60][60],res[60][60],tmp[60][60],m;

void matMul (LL a[][60], LL b[][60], LL mod)

{

for(int i=0; i<m; i++)

for(int j=0; j<m; j++)

{

tmp[i][j] = 0;

for(int k=0; k<m; k++)

{

tmp[i][j] += (a[i][k]\*b[k][j])%mod;

tmp[i][j] %= mod;

}

}

}

void power(LL n, LL mod)

{

for(int i=0; i<m; i++)

for(int j=0; j<m; j++)

if(i==j) res[i][j] = 1;

else res[i][j] = 0;

while(n)

{

if(n&1)

{

matMul(res,arr,mod);

for(int i=0; i<m; i++)

for(int j=0; j<m; j++) res[i][j] = tmp[i][j];

n--;

}

else

{

matMul(arr,arr,mod);

for(int i=0; i<m; i++)

for(int j=0; j<m; j++) arr[i][j] = tmp[i][j];

n/=2;

}

}

}

**7.4** Given an undirected graph G with n nodes and m edges.We are required to find in it all the connected components,

i.e, several groups of vertices such that within a group each vertex can be reached from another and no path exists between different groups.

// O(n+m)

int n;

vector<int> g[MAXN];

bool used[MAXN];

vector<int> comp;

void dfs(int v)

{

used[v] = true;

comp.push\_back(v);

for (size\_t i = 0; i < (int)g[v].size(); ++i)

{

int to = g[v][i];

if (!used[to])

dfs(to);

}

}

void find\_comps(){

for (int i = 0; i < n; ++i)

used[i] = false;

for (int i = 0; i < n; ++i){

if (!used[i]){

comp.clear();

dfs(i);

cout << "Component:";

for (size\_t j = 0; j < comp.size(); ++j)

cout << ' ' << comp[j];

cout << endl;

}

}

}

**7.5 SCC**

const int N = 1002;

vector<int> adj[N], rev[N];

bitset<N> vis;

int n, m;

int comp[N]; // stores nth node is includedto which scc\_no

void DFS1(int node, stack<int> &TS){

vis[node] = true;

for (int child : adj[node])

if (!vis[child])

DFS1(child, TS);

TS.push(node);

}

void DFS2(int node, const int cc\_no, vector<int> &vec){

vis[node] = true;

comp[node] = cc\_no;

vec.push\_back(node);

for (int child : rev[node])

if (!vis[child])

DFS2(child, cc\_no,

vec);

}

auto SCC(){

vis.reset();

stack<int> TS;

for (int i = 1; i <= n; ++i)

if (!vis[i])

DFS1(i, TS);

// finding the SCCs using TopSort

vis.reset();

int cc\_no = 1;

vector<vector<int>> components;

while (!TS.empty())

{

int idx = TS.top();

TS.pop();

if (!vis[idx])

{

vector<int> vec;

DFS2(idx, cc\_no++, vec);

components.push\_back(vec);

}

}

return components;

}

signed main(){

cin >> n >> m;

for (int i = 0; i < m; ++i){

int u, v;

cin >> u >> v;

// --u, --v;

adj[u].push\_back(v);

rev[v].push\_back(u);

}

auto res = SCC();

int sz = res.size(), scc\_no = 1;

cout << "No. of SCC: " << sz << '\n';

for (auto x : res)

{

cout << "SCC no." << scc\_no++ << " includes nodes : ";

for (auto y : x) cout<<y<<' ';

cout << '\n';

}

}

**no. of ways and min cost of connecting the sccs**

const int MOD = 1e9 + 7, N = 1e5 + 2, INF = 1e18 + 2;

int n, m, comp[N];

vector<int> adj[N], rev[N];

bitset<N> vis;

void DFS1(int u, stack<int> &TS){

vis[u] = true;

for (int v : adj[u])

if (!vis[v])

DFS1(v, TS);

TS.push(u);

}

void DFS2(int u, const int scc\_no, int &min\_cost, int &ways, vector<int> &cost){

vis[u] = true;

comp[u] = scc\_no;

for (int v : rev[u])

if (!vis[v])

{

if (min\_cost == cost[v])

++ways;

else if (min\_cost > cost[v])

{

ways = 1;

min\_cost = cost[v];

}

DFS2(v, scc\_no, min\_cost, ways,

cost);

}

}

signed main(){

FIO cin >> n;

vector<int> cost(n + 1);

for (int i = 1; i <= n; ++i)

cin >> cost[i];

cin >> m;

while (m--){

int u, v;

cin >> u >> v;

adj[u].push\_back(v);

rev[v].push\_back(u);

}

int tot = 0, ways = 1;

stack<int> TS;

for (int i = 1; i <= n; ++i)

if (!vis[i])

DFS1(i, TS);

vis.reset();

int scc\_no = 0;

while (!TS.empty()){

int u = TS.top();

TS.pop();

if (!vis[u]){

int tmp\_cst = cost[u], tmp\_ways = 1;

DFS2(u, ++scc\_no, tmp\_cst,

tmp\_ways, cost);

tot += tmp\_cst;

ways = (ways \* tmp\_ways) % MOD;

}

}

cout << tot << ' ' << ways;

}//**TC: O(V+E)**

**7.6 sqrt decomposition(MO’s Algo)**

// https://www.spoj.com/problems/DQUERY/

#include <bits/stdc++.h>

using namespace std;

const int SIZE\_1 = 1e6 + 10, SIZE\_2 = 3e4 + 10;

class query{

public:

int l, r, indx;

};

int block\_size, cnt = 0;

int frequency[SIZE\_1], a[SIZE\_2];

void add(int indx){

++frequency[a[indx]];

if (frequency[a[indx]] == 1)

++cnt;

}

void sub(int indx){

--frequency[a[indx]];

if (frequency[a[indx]] == 0)

--cnt;

}

bool comp(query a, query b){

if (a.l / block\_size == b.l / block\_size)

return a.r < b.r;

return a.l / block\_size < b.l / block\_size;

}

signed main(){

int n; cin >> n;

for(int i = 0; i < n; ++i) cin>>a[i];

int q; cin >> q;

int ans[q] = {};

query Qur[q];

for (int i = 0; i < q; ++i){

int l, r; cin>>l>>r;

Qur[i].l = l - 1;

Qur[i].r = r - 1;

Qur[i].indx = i;

}

block\_size = sqrt(n); // sqrt(q) dileo hobe, but n is more accurate

sort(Qur, Qur + q, comp);

int ML = 0, MR = -1;

for(int i = 0; i < q; ++i) {

int L = Qur[i].l;

int R = Qur[i].r;

// fixing right pointer

while (MR < R) add(++MR);

while (MR > R) sub(MR--);

// fixiing left pointer

while (ML < L) sub(ML++);

while (ML > L) add(--ML);

ans[Qur[i].indx] = cnt;

}

for (int i = 0; i < q; ++i)

cout << ans[i] << '\n';

}//sqrt(n)

**7.7 Meet in the middle**

#include <bits/stdc++.h>

using namespace std;

int les\_equal(vector<int> &s, int key){

int siz = s.size();

int lo = 0, hi = siz - 1, ans = 0;

while (hi >= lo){

int mid = lo + (hi - lo) / 2;

if (s[mid] <= key){

ans = max(ans, mid);

lo = mid + 1;

}

else hi = mid - 1;

}

return ans;

}

signed main(){

FIO int n, n1, n2, t;

cin >> n >> t;

n1 = (n + 1) / 2;

n2 = n / 2;

int a1[n1]; for(int &i: a1) cin>>i;

int a2[n2]; for(int &i: a2) cin>>i;

vector<int> set1, set2;

for(int mask=0; mask < (1<<n1); ++mask){

int temp\_sum = 0;

for (int i = 0; i < n1; ++i){

int f = 1 << i;

if (f & mask)

temp\_sum += a1[i];

}

set1.push\_back(temp\_sum);

}

for(int mask=0; mask < (1<<n2); ++mask){

int temp\_sum = 0;

for (int i = 0; i < n2; ++i){

int f = 1 << i;

if (f & mask)

temp\_sum += a2[i];

}

set2.push\_back(temp\_sum);

}

sort(set2.begin(), set2.end());

// for(auto itr: set2) cout<<itr<<' ';

// cout<<'\n';

// for(auto itr: set1) cout<<itr<<' ';

// cout<<'\n';

int ans = 0;

for (auto it : set1){

int left = t - it;

if (left < 0) continue;

int indx = les\_equal(set2, left);

int temp\_sum\_set2 = (indx != -1 ? (it + set2[indx]) : 0);

if (temp\_sum\_set2 <= t)

ans = max(ans, temp\_sum\_set2);

}

cout<<ans;

}//TC: O(2^(LK+1))

**7.8 PIE(inclusion - exclusion)**

#include <bits/stdc++.h>

using namespace std;

inline int LCM(int a, int b){

return a \* b / \_\_gcd(a, b);

}

int PIE(int div[], int n, int num){

int sum = 0;

for(int msk=1; msk < (1<<n); ++msk){

int bit\_cnt = 0;

int cur\_lcm = 1;

for (int i = 0; i < n; ++i){

if (msk & (1 << i)){

++bit\_cnt;

cur\_lcm = LCM(cur\_lcm, div[i]);

}

}

int cur = num / cur\_lcm;

if (bit\_cnt & 1) sum += cur;

else sum -= cur;

}

return num - sum;

}

signed main(){

int n, m;

while (cin >> n >> m){

int a[m];

for(int &i : a)cin >> i;

cout << PIE(a, m, n) << '\n';

}

}

{

"cmd": ["g++.exe","-std=c++14", "${file}",

"-o", "${file\_base\_name}.exe", "&&" ,

"${file\_base\_name}.exe<inputf.in>outputf.i

n"],

"shell":true,

"working\_dir":"$file\_path",

"selector":"source.cpp"

}

**topic : Expected Value**

If the probability that your candidate will win is strictly greater than W%, print

GET A CRATE OF CHAMPAGNE FROM THE BASEMENT!

If your candidate has no chance of winning,

Print RECOUNT!

Otherwise, print PATIENCE, EVERYONE!

#include <bits/stdc++.h>

using namespace std;

#define err 1e-15

double dp[103][103]; // dp[confirmed votes][unknown votes]

signed main(){

dp[0][0] = 1.0;

for(int i = 1; i < 101; ++i){

for(int j=0; j <= i; ++j){

dp[i][j] += 0.5 \* dp[i - 1][j];

// confirmed vote increased but the vote didn't go to my favour

dp[i][j + 1] += 0.5 \* dp[i - 1][j];

// confirmed vote increased and went to my favour

}

}

TC{

int n, a, b, w;

cin >> n >> a >> b >> w;

int un\_c = n - (a + b);

int flag = 101;

for(int i=0; i <= un\_c; ++i){

if(2\*a + 2\*i > n){

flag = i;

break;

}

}

double sum = 0;

for (int i = flag; i <= un\_c; ++i)

sum += dp[un\_c][i];

sum \*= 100;

sum -= err;

if (sum > w)

cout<<"GET A CRATE OF CHAMPAGNE FROM THE BASEMENT !\n";

else if(flag==101) cout<<"RECOUNT!\n";

else cout<<"PATIENCE,EVERYONE!\n";

}

}

**//DSU**

#For every i, set parent[i]=I ans size[i]=1

int find\_set(int x){

if(parent[x]==x) return x;

int y=find\_set(parent[x]);

parent[x]=y;

return y;

}

void Union(int x, int y){

x=find\_set(x); y=find\_set(y);

if(x==y) return;

if(Size[x]>Size[y]) swap(x,y);

parent[x]=y;

Size[y]+=Size[x];

}

**//SEGMENT TREE**

const int N=200005;

int tree[4\*N];

int a[N];

void build(int node, int start, int end){

if(start==end){

tree[node]=a[start];

return;

}

int left=2\*node, right=2\*node+1, mid=(start+end)/2;

build(left,start,mid);

build(right,mid+1,end);

tree[node]=tree[left]+tree[right];

}

int sum(int node, int start, int end, int l, int r){

if(l>end || r<start){

return 0;

}

if(start>=l && end<=r){

return tree[node];

}

int left=2\*node, right=2\*node+1, mid=(start+end)/2;

int sum1=sum(left,start,mid,l,r);

int sum2=sum(right,mid+1,end,l,r);

return sum1+sum2;

}

**//SEGMENT TREE LAZY**

lili a[N];

lili tree[4\*N];

lili lazy[4\*N];

void update\_range(lili node, lili start, lili end, lili i, lili j, lili value){

lili left=2\*node, right=2\*node+1;

if(lazy[node]!=0){

tree[node]+=(lazy[node]\*(end-start+1));

if(start!=end){

lazy[left]+=lazy[node];

lazy[right]+=lazy[node];

}

lazy[node]=0;

}

if(start>end || start>j || end<i ) return;

if(start>=i && end<=j){

tree[node]+=(value\*(end-start+1));

if(start!=end){

lazy[left]+=value;

lazy[right]+=value;

}

return;

}

lili mid=(start+end)/2;

update\_range(left,start,mid,i,j,value);

update\_range(right,mid+1,end,i,j,value);

tree[node]=tree[left]+tree[right];

}

lili segment\_sum(lili node, lili start, lili end, lili i, lili j){

lili left=2\*node, right=2\*node+1;

if(start>end || start>j || end<i) return 0;

if(lazy[node]!=0){

tree[node]+=(lazy[node]\*(end-start+1));

if(start!=end){

lazy[left]+=lazy[node];

lazy[right]+=lazy[node];

}

lazy[node]=0;

}

if(start>=i && end<=j) return tree[node];

lili mid=(start+end)/2;

lili sum1=segment\_sum(left,start,mid,i,j);

lili sum2=segment\_sum(right,mid+1,end,i,j);

return (sum1+sum2);

}

int main() {

ioi;

lili t; cin>>t;

for(lili tc=1;tc<=t;tc++){

cout<<"Case "<<tc<<":"<<"\n";

memset(a,0,sizeof(a));

memset(tree,0,sizeof(tree));

memset(lazy,0,sizeof(lazy));

lili n,q; cin>>n>>q;

while(q--){

lili type,l,r;

cin>>type>>l>>r;

if(type==0){

lili value; cin>>value;

update\_range(1,1,n,l+1,r+1,value);

}

else{

lili sum=segment\_sum(1,1,n,l+1,r+1);

cout<<sum<<"\n";

}

}

}

}

**//BITWISE SIEVE**

int prime[3125005];

bool is\_set(int n, int pos){

if(n & (1<<pos)) return true;

return false;

}

int set\_bit(int n, int pos){

return (n | (1<<pos));

}

void sieve(){

for(int i=0;i<3125005;i++) prime[i]=0;

prime[0]=set\_bit(0,0); prime[0]=set\_bit(prime[0],1);

for(int i=4;i<=N;i+=2){

prime[i/32]=set\_bit(prime[i/32],i%32);

}

for(int i=3;i\*i<=N;i+=2){

if(!is\_set(prime[i/32],i%32)){

for(int j=i\*i;j<=N;j+=2\*i){

prime[j/32]=set\_bit(prime[j/32],j%32);

}

}

}

}

bool isPrime(int n){

if(!is\_set(prime[n/32],n%32)) return true;

return false;

}

**//LARGEST POWER OF K IN N!**

int largestPower(int k, int n){

int cnt=0;

lili x=k;

while(x<=n){

cnt+=(n/x);

x\*=k;

}

return cnt;

}

//Smallest Prime Factor, Greatest Prime Factor, No of Distinct Prime Factors, No of Total Prime Factors, No. of Divisors, Sum of Divisors

const lili N=1e6+5;

lili spf[N];

lili lpf, gpf , tpf, dpf, sum, dv;

void sieve(){

for(int i=0;i<N;i++){

spf[i]=0; }

for(lili i=2;i\*i<N;i++){if(spf[i]==0){for(lili j=i\*i;j<N;j+=i){if(spf[j]==0)spf[j]=i;}}}

for(lili i=2;i<N;i++){

if(spf[i]==0){ spf[i]=i; }}}

lili power(lili a, lili b){

if(b==0) return 1;

lili x=power(a,b/2);

if(b%2==0) x=x\*x;

else x=x\*x\*a;

return x;

}

int main(){

ios\_base::sync\_with\_stdio(false);

cin.tie(NULL);

sieve();

lili m,n; cin>>m;

while(m--){

cin>>n;

lpf=spf[n]; gpf=-1; tpf=0; dpf=0; dv=1; sum=1;

while(n>1){

lili x=spf[n];

lili cnt=0;

dpf++;

while(n%x==0){

tpf++;

gpf=max(gpf,x);

cnt++;

n/=x;

}

dv\*=(cnt+1);

lili k=(power(x,cnt+1)-1)/(x-1);

sum\*=k;

}

cout<<lpf<<" "<<gpf<<" "<<dpf<<" "<<tpf<<" "<<dv<<" "<<sum<<"\n";}}

**//Towers of Doom**

lili t; cin>>t;

for(lili tc=1;tc<=t;tc++){

lili n,m; cin>>n>>m;

lili a[n], s[m];

for(lili i=0;i<n;i++) cin>>a[i];

for(lili i=0;i<m;i++) cin>>s[i];

lili ans=0;

for(lili i=0;i<n;i++){

bitset<15>bst;

lili div=0;

for(lili j=1;j < (1LL<<m); j++){

bst=j;

lili cnt=0;

lili product=1;

for(lili k=0;k<m;k++){

if(bst[k]==1){

product=product\*s[k];

cnt++;

}

}

lili temp=a[i]/product;

if(cnt&1) div+=temp;

else div-=temp;

}

div++;

ans=ans^div;

}

cout<<"Case "<<tc<<": ";

if(ans==0) cout<<"Bob\n";

else cout<<"Alice\n";

**//Generating Permutations**

#include<bits/stdc++.h>

#define lili long long int

using namespace std;

int length, perm\_left\_to\_print;

bool placed[10000];

vector<char>perm;

void generate\_permutations(int curr\_length){

if(perm\_left\_to\_print==0) return;

if(curr\_length==length){

for(int i=0;i<length;i++){

cout<<perm[i];

}

cout<<"\n";

perm\_left\_to\_print--;

return;

}

for(char ch='A';ch<('A'+length);ch++){

if(!placed[ch-'A']){

perm.push\_back(ch);

placed[ch-'A']=true;

generate\_permutations(curr\_length+1);

perm.pop\_back();

placed[ch-'A']=false;

}

}

}

int main(){

ioi;

int t; cin>>t;

for(int tc=1;tc<=t;tc++){

cin>>length>>perm\_left\_to\_print;

cout<<"Case "<<tc<<":\n";

generate\_permutations(0);

}

}

**//MCM**

lili dimensions[105];

lili mem[105][105];

int MCM(int i, int j){

if(i==j){

return 0;

}

if(mem[i][j]==-1){

mem[i][j]=LLONG\_MAX;

for(int split=i;split<=j-1;split++){

lili value=MCM(i,split)+MCM(split+1,j)+dimensions[i-1]\*dimensions[split]\*dimensions[j];

if(value<mem[i][j]){

mem[i][j]=value;

}

}

}

return mem[i][j];

}

int main(){

ioi;

memset(mem,-1,sizeof(mem));

int n; cin>>n;

for(int i=1;i<=n;i++){

cin>>dimensions[i-1]>>dimensions[i];

}

lili ans=MCM(1,n);

cout<<ans<<"\n";

}