Sumário

Lista de Tabelas

Algoritmos

1 Tabelas

tipo	bits	min...max	precisao
char	8	0..127	2
signed char	8	-128..127	2
unsigned char	8	0..255	2
short	16	-32.768 .. 32.767	4
unsigned short	16	0 .. 65.535	4
int	32	-2x10**9 .. 2 x 10**9	9
unsigned int	32	0 .. 4x10**9	9
int64_t	64	-9 x 10**18 .. 9 x 10**18	18
uint64_t	64	0 .. 18 x 10**18	19

Tabela 1: Limites de representação de dados

0! = 1
1! = 1
2! = 2
3! = 6
4! = 24
5! = 120
6! = 720
7! = 5.040
8! = 40.320
9! = 362.880
10! = 3.628.800
11! = 39.916.800
12! = 479.001.600 [limite do (unsigned) int]
13! = 6.227.020.800
14! = 87.178.291.200
15! = 1.307.674.368.000
16! = 20.922.789.888.000
17! = 355.687.428.096.000
18! = 6.402.373.705.728.000
19! = 121.645.100.408.832.000
20! = 2.432.902.008.176.640.000 [limite do (u)int64_t]

Tabela 2: Fatorial

Tipo	%
char	c
int	d
float	e, E, f, g, G
int (octal)	o
int (hexa)	x, X
uint	u
char*	s

Tabela 3: scanf() - %[*][width][modifiers]type

modifiers	tipo
h	short int (d, i, n), or unsigned short int (o, u, x)
l	long int (d, i, n), or unsigned long int (o, u, x), or double (e, f, g)
ll	long long int (d, i, n), or unsigned long long int (o, u, x)
L	long double (e, f, g)

Tabela 4: scanf() %[*][width][modifiers]type

função	descrição
atof	Convert string to double
atoi	Convert string to integer
atol	Convert string to long integer
strtod	Convert string to double
strtol	Convert string to long integer
strtoul	Convert string to unsigned long integer

Tabela 5: stdlib

função	descrição
cos	Compute cosine
sin	Compute sine
tan	Compute tangent
acos	Compute arc cosine
asin	Compute arc sine
atan	Compute arc tangent
atan2	Compute arc tangent with two parameters
cosh	Compute hyperbolic cosine
sinh	Compute hyperbolic sine
tanh	Compute hyperbolic tangent
exp	Compute exponential function
frexp	Get significand and exponent
ldexp	Generate number from significand and exponent
log	Compute natural logarithm
log10	Compute common logarithm
modf	Break into fractional and integral parts
pow	Raise to power
sqrt	Compute square root
ceil	Round up value
fabs	Compute absolute value
floor	Round down value
fmod	Compute remainder of division

Tabela 6: math (angulos em radianos)

2 Codigos

2.1 Exemplos

Código 1: Modelo

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

#include <inttypes.h>
#include <ctype.h>
#include <limits.h>

#include <algorithm>
#include <utility>
#include <iostream>

#include <map>
#include <set>
#include <vector>
#include <list>
#include <queue>
#include <sstream>

using namespace std;

#define abs(a) ((a) > 0 ? (a) : -(a))

int main()
{
    int n;

    cin >> n;

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

    }

    while (cin >> n)
    {

    }
    return 0;
}
```

Código 2: comparcao de ponto flutuante

```
/**
 * -1 se x < y
 * 0 se x = y
 * 1 se x > y
 */
```

```
const double EPS = 1e-10;
#define _inline(f...) f() __attribute__((always_inline)); f
_inline(int cmp)(double x, double y = 0, double tol = EPS)
{
    return (x <= y + tol) ? (x + tol < y) ? -1 : 0 : 1;
}
```

Código 3: .vimrc para a configuração do vim

```
set ai noet ts=4 sw=4 bs=2
set cindent
```

Código 4: função que acelara o cin. Não deve ser usada com printf

```
std::cout.sync_with_stdio(false);
```

Código 5: printf

```
/* printf example */
#include <stdio.h>

int main()
{
    printf ("Characters: %c %c \n", 'a', 65);
    printf ("Decimals: %d %ld\n", 1977, 650000L);
    printf ("Preceding with blanks: %10d \n", 1977);
    printf ("Preceding with zeros: %010d \n", 1977);
    printf ("Some different radixes: %d %x %o %#x %#o \n", 100, 100, 100,
         100, 100);
    printf ("floats: %4.2f %+.0e %E %4.2f\n", 3.1416, 3.1416, 3.1416,
        3.1);
    printf ("Width trick: %*d \n", 5, 10);
    printf ("%s \n", "A string");
    return 0;
}
/* %[flags (-, +, etc)][width][.precision][length (h,l,L)]specifier
Characters: a A
Decimals: 1977 650000
Preceding with blanks:       1977
Preceding with zeros: 0000001977
Some different radixes: 100 64 144 0x64 0144
floats: 3.14 +3e+000 3.141600E+000 3.10
Width trick:    10
A string
*/
```

Código 6: exemplo de map

```
#include <iostream>
#include <map>
using namespace std;

int main ()
{
  map<char,int> mymap;
  map<char,int>::iterator it;
  pair<map<char,int>::iterator,bool> ret;

  // first insert function version (single parameter):
  mymap.insert ( pair<char,int>('a',100) );
  mymap.insert ( pair<char,int>('z',200) );

  ret=mymap.insert (pair<char,int>('z',500) );
  if (ret.second==false)
  {
    cout << "element 'z' already existed";
    cout << " with a value of " << ret.first->second << endl;
  }

  // third insert function version (range insertion):
  map<char,int> anothermap;
  anothermap.insert(mymap.begin(),mymap.find('c'));

  // showing contents:
  cout << "mymap contains:\n";
  for ( it=mymap.begin() ; it != mymap.end(); it++ )
    cout << (*it).first << " => " << (*it).second << endl;

  map<char,string> mymap;
  mymap['a']="an element";
  if (mymap.count('a') > 0)
      cout << mymap['a'] << " is an element of mymap.\n";

  while (!mymap.empty())
  {
     cout << mymap.begin()->first << " => ";
     cout << mymap.begin()->second << endl;
     map<char, int>::iterator erasedelement = mymap.erase(mymap.begin())
         ;
  }

  return 0;
}
```

Código 7: exemplo de set e multset

```
#include <iostream>
#include <set>
using namespace std;

int main ()
{
  multiset<int> mymultiset;
  multiset<int>::iterator it;

  // set some initial values:
  for (int i=1; i<=5; i++) mymultiset.insert(i*10);   // 10 20 30 40 50

  cout << "size: " << (int) mymultiset.size() << endl;
```

```
14    cout << "count: " << (int) mymultiset.count(10) << endl;
15
16    it=mymultiset.find(20);
17    mymultiset.erase (it);
18
19    if (! mymultiset.empty)
20     mymultiset.erase (mymultiset.find(40));
21
22    for (it=mymultiset.begin(); it!=mymultiset.end(); it++)
23      cout << " " << *it;
24
25    int myints[]={19,72,4,36,20,20};
26    multiset<int> first (myints,myints+3);      // 4,19,72
27    multiset<int> second (myints+3,myints+6);   // 20,20,36
28
29    first.swap(second); // troca conteudo. o primeiro fica [20,20,36] e o
          segundo [4,19,72]
30
31    return 0;
32  }
```

Código 8: exemplo de list

```
1  #include <iostream>
2  #include <list>
3  using namespace std;
4
5  int main ()
6  {
7    list<int> mylist (2,100);          // two ints with a value of 100
8    mylist.push_front (200);
9    mylist.push_back (300);
10
11   it = mylist.begin();
12   mylist.insert (it,10);
13   mylist.insert (it,2,20); // two ints with a value of 20
14
15   mylist.reverse(); // Reverses the order of the elements in the list.
16
17   cout << "mylist contains:";
18   for (list<int>::iterator it=mylist.begin(); it!=mylist.end(); ++it)
19     cout << " " << *it;
20
21   cout << "Popping out the elements in mylist:";
22   while (!mylist.empty())
23   {
24     cout << " " << mylist.front();
25     mylist.pop_front();
26   }
27
28   while (!mylist.empty())
29   {
30     cout << " " << mylist.back();
31     mylist.pop_back();
32   }
33
34   cout << mylist.size() << endl;
35
36   return 0;
37 }
```

Código 9: exemplo de queue

```
1  #include <iostream>
2  #include <queue>
3  using namespace std;
4
5  int main ()
6  {
7    queue<int> myqueue;
8    int sum (0);
9
10   for (int i=1;i<=10;i++) myqueue.push(i);
11
12   myqueue.back() -= myqueue.front();
13
14   cout << "size: " << (int) myqueue.size() << endl;
15
16   while (!myqueue.empty())
17   {
18      sum += myqueue.front();
19      myqueue.pop();
20   }
21
22   cout << "total: " << sum << endl;
23
24   return 0;
25 }
```

Código 10: exemplo de priority queue

```
1  #include <iostream>
2  #include <queue>
3  using namespace std;
4
5  int main ()
6  {
7    priority_queue<int> mypq;
8
9    mypq.push(30);
10   mypq.push(100);
11   mypq.push(25);
12   mypq.push(40);
13
14   cout << "size: " << (int) mypq.size() << endl;
15
16   cout << "Popping out elements...";
17   while (!mypq.empty())
18   {
19      cout << " " << mypq.top();
20      mypq.pop();
```

```
21    }
22    cout << endl;
23
24    return 0;
25  }
```

Código 11: exemplo de stack

```
1  #include <iostream>
2  #include <stack>
3  using namespace std;
4
5  int main ()
6  {
7    stack<int> mystack;
8    int sum = 0;
9
10   mystack.push(10);
11   mystack.push(20);
12
13   mystack.top() -= 5;
14
15   while (!mystack.empty())
16   {
17      sum += mystack.top();
18      mystack.pop();
19   }
20
21   cout << "size: " << (int) mystack.size() << endl;
22
23   return 0;
24 }
```

Código 12: exemplo de vector

```
1  #include <iostream>
2  #include <vector>
3  using namespace std;
4
5  int main ()
6  {
7    vector<int> myvector (3,100); // (100 100 100)
8    vector<int>::iterator it;
9
10   myvector.reserve(100);
11
12   for (int i=0; i<myvector.size(); i++)
13     myvector.at(i)=i; // = myvector[i] = i
14
15   it = myvector.begin();
16   it = myvector.insert ( it , 200 );
17   myvector.insert (it,2,300);
18
19   vector<int> anothervector (2,400);
20   int myarray [] = { 501,502,503 };
21   vector<int> initializer(myarray/*PointerInicio*/, myarray+sizeof(
       myarray)/sizeof(int)/*PointerFim*/);
22   myvector.insert (it+2,anothervector.begin(),anothervector.end());
23   myvector.insert (myvector.begin(), myarray, myarray+3);
24
25   cout << "myvector contains:";
26   for (it=myvector.begin(); it<myvector.end(); it++)
27     cout << " " << *it;
28   cout << endl;
29
30   // erase the 6th element
31   myvector.erase (myvector.begin()+5);
32   int sum;
33   while (!myvector.empty())
34   {
35      sum += myvector.back();
36      myvector.pop_back();
37   }
38
39   return 0;
40 }
```

Código 13: exemplo de string

```
1  #include <iostream>
2  #include <string>
3  using namespace std;
4
5  int main ()
6  {
7    string str ("There are two needles in this haystack with needles.");
8    string str2 ("needle");
9    size_t found;
10
11   // different member versions of find in the same order as above:
12   found=str.find(str2);
13   if (found!=string::npos)
14     cout << "first 'needle' found at: " << int(found) << endl;
15
16   found=str.find("needles are small",found+1,6);
17   if (found!=string::npos)
18     cout << "second 'needle' found at: " << int(found) << endl;
19
20   found=str.find("haystack");
21   if (found!=string::npos)
22     cout << "'haystack' also found at: " << int(found) << endl;
23
24   found=str.find('.');
25   if (found!=string::npos)
26     cout << "Period found at: " << int(found) << endl;
27
28   // let's replace the first needle:
29   str.replace(str.find(str2),str2.length(),"preposition");
30   cout << str << endl;
31
32   string str="We think in generalities, but we live in details.";
```

```
                                // quoting Alfred N. Whitehead
  string str2, str3;
  size_t pos;

  str2 = str.substr (12,12); // "generalities"

  pos = str.find("live");     // position of "live" in str
  str3 = str.substr (pos);    // get from "live" to the end

  cout << str2 << ' ' << str3 << endl;


  return 0;
}
/*
first 'needle' found at: 14
second 'needle' found at: 44
'haystack' also found at: 30
Period found at: 51
There are two prepositions in this haystack with needles.
generalities live in details.
*/
```

Código 14: exemplo de stringstream

```
#include <string>
#include <sstream>
#include <iostream>


using namespace std;


int main() {
   string linha="Olah mundo";
   stringstream separador(linha); // Tokenizador
   string word;
   separador >> word; // word=Olah
   char mu[4];
   separador.readsome(mu, 3); // Le " mu" (inclui espaco)
   cout << separador.tellg() << endl; // 7 (posicao de leitura)
   cout << separador.tellp() << endl; // 0, posicao de escrita

   separador.seekp(separador.str().size());
   separador << " cruel"; // separador = "Olah mundo cruel"

   separador.seekp(5);
   separador << "doido"; // separador = "Olah doido cruel" (sobrescrito)
   return 0;
}
```

Código 15: exemplo de ordenação

```
#include <iostream>
#include <algorithm>
#include <vector>
using namespace std;

bool myfunction (int i,int j) { return (i<j); }

struct myclass {
  bool operator() (int i,int j) { return (i<j);}
} myobject;

int compare (const void * a, const void * b)
{
  return ( *(int*)a - *(int*)b );
}


int main () {
  int myints[] = {32,71,12,45,26,80,53,33};
  vector<int> myvector (myints, myints+8);                  // 32 71 12 45
      26 80 53 33

  // using default comparison (operator <):
  sort (myvector.begin(), myvector.begin()+4);              //(12 32 45 71)
      26 80 53 33
  // using function as comp
  sort (myvector.begin()+4, myvector.end(), myfunction); // 12 32 45
      71(26 33 53 80)
  // using object as comp
  sort (myvector.begin(), myvector.end(), myobject);      //(12 26 32 33
      45 53 71 80)

  // if stable is need
  stable_sort (myvector.begin(), myvector.end(), myfunction);

  // Rearranges the elements in the range [first,last), in such a way
      that the subrange [first,middle)
  // contains the smallest elements of the entire range sorted in
      ascending order, and the subrange
  // [middle,end) contains the remaining elements without any specific
      order.
  partial_sort (myvector.begin(), myvector.begin()+3, myvector.end());

  qsort (myints, 8, sizeof(int), compare);

  return 0;
}
```

Código 16: pesquisa binária

```
int compareMyType (const void * a, const void * b)
{
  if ( *(MyType*)a >  *(MyType*)b ) return 1;
  if ( *(MyType*)a == *(MyType*)b ) return 0;
  if ( *(MyType*)a <  *(MyType*)b ) return -1;
}

int key = 40;
```

```
item = (int*) bsearch (&key, values, n, sizeof (int), compareMyType);
```

Código 17: Arredondamento e output em outras bases

```
#include <iostream>
#include <iomanip> // setprecision()
using namespace std;

int main () {
  double a = 3.1415926534;
  double b = 2006.0;
  double c = 1.0e-10;

  // setprecision(1) => 1 casa decimal apos a virgula
  cout << fixed << setprecision(1) << 9.09090901 << endl;
  cout << fixed << setprecision(2) << 9.09090901 << endl;
  cout << fixed << setprecision(3) << 9.09090901 << endl;
  cout << fixed << setprecision(2) << 9.1 << endl;

  // anula o efeito de setprecision
  cout.unsetf(ios::floatfield);

  // 5 digitos no maximo
  cout.precision(5);

  cout << a << '\t' << b << '\t' << c << endl;
  cout << fixed << a << '\t' << b << '\t' << c << endl;
  cout << scientific << a << '\t' << b << '\t' << c << endl;

  // Sets the basefield format flag for the str stream to dec, hex or
      oct.
  int n =70;
  cout << dec << n << endl;
  cout << hex << n << endl;
  cout << oct << n << endl;

  return 0;
}
/* output
9.1
9.09
9.091
9.10
3.1416   2006     1e-10
3.14159  2006.00000       0.00000
3.14159e+00      2.00600e+03      1.00000e-10
70
46
106
*/
```

2.2 Teoria dos números

Código 18: máximo divisor comum e mínimo multiplo comum

```
int gcd(int x, int y)
{
   return y ? gcd(y, x % y) : abs(x);
}
uint64_t lcm(int x, int y)
{
   if (x && y) return abs(x) / gcd(x, y) * uint64_t(abs(y));
   else return uint64_t(abs(x | y));
}
```

Código 19: decide se um número é primo

```
bool isPrime(int n)
{
   if (n < 0) return isPrime(-n);
   if (n == 1) return true;
   if (n < 5 || n % 2 == 0 || n % 3 == 0) return (n == 2 || n == 3);

   int maxP = sqrt(n) + 2;
   for (int p = 5; p < maxP; p += 6)
   {
      if (n % p == 0 || n % (p+2) == 0) return false;
   }
   return true;
}
```

Código 20: Retorna a fatoração em números primos de abs(n).

```
typedef map<int, int> prime_map;
void squeeze(prime_map& M, int& n, int p)
{
   for (; n % p == 0; n /= p) M[p]++;
}
void factor(int n, prime_map& M)
{
   if (n < 0) { factor(-n, M); return; }
   if (n < 2) return;

   squeeze(M, n, 2);
   squeeze(M, n, 3);

   int maxP = sqrt(n) + 2;
   for (int p = 5; p < maxP; p += 6)
   {
      squeeze(M, n, p);
      squeeze(M, n, p+2);
   }
   if (n > 1) M[n]++;
}
```

Código 21: Calcula Valor de $a^b mod$ n de forma rápida.

```
int mpow(int a, int b, int n = 10)
{
  if(b == 0)
    return 1;
  else {
    long long res = mpow(a, b/2, n);
    res = (res*res) % n;
    if(b%2 == 1)
      res = (res*a) % n;
    return (int) res;
  }
}
```

Código 22: Calcula (a*b)%c de forma rápida.

```
long long mulmod(long long a, long long b, long long c)
{
    long long x = 0;
    long long y = a % c;
    while(b > 0)
    {
        if(b & 1ll) x = (x + y) % c;
        y = (y << 1) % c;
        b >>= 1;
    }
    return x % c;
}
```

Código 23: Computa x tal que a*x = b (mod c). Quando a equação não tem solução, retorna algum valor arbitrário errado, mas basta conferir o resultado.

```
long long axbmodc(long long a, long long b, long long c)
{
    return a ? (axbmodc(c % a, (a - b % a) % a, a) * c + b) / a : 0;
}
```

Código 24: **Baby-step Giant-step algorithm** Calcula o menor valor de e para $b^e = n \mod p$. Retorna -1 se eh impossivel

```
#define inv_mult( a, n ) axbmodc(a, 1, n)

long long discreteLlogarithm( long long b, long long n, long long p )
{
    if ( n == 1 ) return 0;

    map < long long, int > table;
    long long m = sqrt(p) + 1, pot = 1, pot2 = 1;

    for (int j = 0; j < m; j++)
    {
        if ( pot == n ) return j;
        table[( n * inv_mult( pot, p ) ) % p] = j;
        pot = ( pot * b ) % p;
    }

    for (int i = 0; i < m; i++)
    {
        if ( table.find( pot2 ) != table.end() ) return i * m + table[pot2
            ];
        pot2 = ( pot * pot2 ) % p;
    }

    return -1;
}
```

2.3 Estruturas de dados

Código 25: Números de precisão harbitrária.

```
const int DIG = 4;
const int BASE = 10000; // BASE**3 < 2**51
const int TAM = 1000;

struct BigInt
{
    int num[TAM], numDigits;
    BigInt(int x = 0): numDigits(1)
    {
        memset(num, 0, sizeof(num));
        num[numDigits++] = x; fixInvariant();
    }
    BigInt(char *s): numDigits(1)
    {
        memset(num, 0, sizeof(num));
        int sign = 1;

        while (*s && !isdigit(*s))
        {
            if (*s++ == '-') sign *= -1;
        }

        char *t = strdup(s), *p = t + strlen(t);

        while (p > t)
        {
            *p = 0; p = max(t, p - DIG);
            sscanf(p, "%d", &num[numDigits]);
            num[numDigits++] *= sign;
        }

        free(t);
        fixInvariant();
    }

    BigInt& fixInvariant(int m = 0)
    {
        numDigits = max(m, numDigits);
```

```
39      int sign = 0;
40
41      for (int i = 1, carry = 0; i <= numDigits || carry && (numDigits =
            i); i++)
42      {
43         num[i] += carry;
44         carry = num[i] / BASE;
45         num[i] %= BASE;
46         if (num[i]) sign = (num[i] > 0) ? 1 : -1;
47      }
48
49      for (int i = 1; i < numDigits; i++)
50      {
51         if (num[i] * sign < 0)
52         {
53            num[i] += sign * BASE;
54            num[i+1] -= sign;
55         }
56      }
57
58      while (numDigits && !num[numDigits]) numDigits--;
59      return *this;
60   }
61
62   //Comparacao
63   int cmp(const BigInt& x = 0) const
64   {
65      int i = max(numDigits, x.numDigits), t = 0;
66      while (1)
67      {
68         if ((t = ::cmp(num[i], x.num[i])) || i-- == 0) return t;
69      }
70   }
71
72   bool operator <(const BigInt& x) const { return cmp(x) < 0; }
73   bool operator >(const BigInt& x) const { return cmp(x) > 0; }
74   bool operator <=(const BigInt& x) const { return cmp(x) <= 0; }
75   bool operator >=(const BigInt& x) const { return cmp(x) >= 0; }
76   bool operator ==(const BigInt& x) const { return cmp(x) == 0; }
77   bool operator !=(const BigInt& x) const { return cmp(x) != 0; }
78
79   //operacoes fundamentais
80   BigInt& operator +=(const BigInt& x)
81   {
82      for (int i = 1; i <= x.numDigits; i++) num[i] += x.num[i];
83      return fixInvariant(x.numDigits);
84   }
85   BigInt& operator -=(const BigInt& x)
86   {
87      for (int i = 1; i <= x.numDigits; i++) num[i] -= x.num[i];
88      return fixInvariant(x.numDigits);
89   }
90
91   void multiAndAcumWithShift(const BigInt& x, int m, int b)
92   { // *this += (x * m) << b;
93      for (int i = 1, carry = 0; (i <= x.numDigits || carry) && (
           numDigits = i + b); i++)
94      {
95         num[i+b] += x.num[i] * m + carry;
96         carry = num[i+b] / BASE;
97         num[i+b] %= BASE;
98      }
99   }
100
101  BigInt operator *(const BigInt& x) const
102  {
103     BigInt r;
104     for (int i = 1; i <= numDigits; i++) r.multiAndAcumWithShift(x,
           num[i], i-1);
105     return r;
106  }
107
108  BigInt div(const BigInt& x)
109  {
110     if (x == 0) return 0;
111
112     BigInt q;
113     q.numDigits = max(numDigits - x.numDigits + 1, 0);
114     int d = x.num[x.numDigits] * BASE + x.num[x.numDigits-1];
115
116     for (int i = q.numDigits; i > 0; i--)
117     {
118        int j = x.numDigits + i - 1;
119        q.num[i] = int((num[j] * double(BASE) + num[j-1]) / d);
120        multiAndAcumWithShift(x, -q.num[i], i-1);
121        if (i == 1 || j == 1) break;
122        num[j-1] += BASE * num[j];
123        num[j] = 0;
124     }
125
126     fixInvariant(x.numDigits);
127     return q.fixInvariant();
128  }
129
130  BigInt& operator *=(const BigInt& x) { return *this = (*this) * x; }
131  BigInt operator +(const BigInt& x) { return BigInt(*this) += x; }
132  BigInt operator -(const BigInt& x) { return BigInt(*this) -= x; }
133  BigInt operator -() { BigInt r = 0; return r -= *this; }
134  BigInt& operator /=(const BigInt& x) { return *this = div(x); }
135  BigInt& operator %=(const BigInt& x) { div(x); return *this; }
136  BigInt operator /(const BigInt& x) { return BigInt(*this).div(x); }
137  BigInt operator %(const BigInt& x) { return BigInt(*this) %= x; }
138
139  // I/O
140  operator string() const
141  {
142     ostringstream s; s << num[numDigits];
143     for (int i = numDigits - 1; i > 0; i--)
144     {
145        s.width(DIG);
146        s.fill('0');
```

```
147             s << abs(num[i]);
148         }
149
150         return s.str();
151     }
152
153     friend ostream& operator <<(ostream& o, const BigInt& x)
154     {
155         return o << (string) x;
156     }
157
158     friend istream& operator >>(istream& in, BigInt& x)
159     {
160         string num;
161         in >> num;
162         x = BigInt((char*) num.c_str());
163         return in;
164     }
165
166     // potencia e raiz
167     BigInt pow(int x)
168     {
169         if (x < 0) return (*this == 1 || *this == -1) ? pow(-x) : 0;
170         BigInt r = 1;
171         for (int i = 0; i < x; i++) r *= *this;
172         return r;
173     }
174
175     BigInt root(int x)
176     {
177         if (cmp() == 0 || cmp() < 0 && x % 2 == 0) return 0;
178         if (*this == 1 || x == 1) return *this;
179         if (cmp() < 0) return -(-*this).root(x);
180         BigInt a = 1, d = *this;
181         while (d != 1)
182         {
183             BigInt b = a + (d /= 2);
184             if (cmp(b.pow(x)) >= 0) { d += 1; a = b; }
185         }
186
187         return a;
188     }
189 };
```

2.4 Programação Dinâmica

Código 26: **Sub Set Sum**: Verifica se há um sobconjunto dos elementos do vetor cuja soma seja igual a soma pedida.

```
1  //soma maxima dos elementos do vetor
2  #define MAX_SUM 10000
3  int n;
4  int vet[TAM];
5  bool m[MAX_SUM];
6
7  //M->soma maxima dos elementos do vetor c->soma procurada
8  bool subSetSum(int M, int c)
9  {
10     for (int i = 0; i <= M; i++) m[i] = false;
11     m[0] = true;
12
13     for(int i = 0; i < n; i++)
14     {
15         for(int j = M; j >= vet[i]; j--)
16         {
17             m[j] |= m[j - vet[i]];
18         }
19     }
20
21     return m[c];
22 }
```

Código 27: **Lis: longest increasing (decreasing) subsequence** $O(n^2)$

```
1  #define TAM 10000
2  int c[TAM];
3  int A[TAM];
4  int H[TAM];
5
6  void ssctf(int n)
7  {
8      for (int m = 1; m <= n; m++)
9      {
10         c[m] = H[m];
11         for (int i = m -1; i > 0; i--)
12         {
13             if (A[i] < A[m] && c[i] + H[m] > c[m])
14             {
15                 c[m] = c[i] + H[m];
16             }
17         }
18     }
19 }
20
21 void ssdtf(int n)
22 {
23     for (int m = 1; m <= n; m++)
24     {
25         c[m] = H[m];
26         for (int i = m -1; i > 0; i--)
27         {
28             if (A[i] > A[m] && c[i] + H[m] > c[m])
29             {
30                 c[m] = c[i] + H[m];
31             }
32         }
33     }
34 }
35
36 int lis1d(int n, bool inc = true)
```

```
{
    if (inc) ssctf(n);
    else ssdtf(n);

    int max = 0;

    for (int i = 1; i <= n; i++)
        if (max < c[i])
            max = c[i];

    return max;
}
```

Código 28: **Lis: longest increasing subsequence** O(n*logn)

```
// Longest Increasing Subsequence - LIS O(n log n)
#define fori(i, n) for ( int i = 0; i < (n); ++i )
void lis( const vector< int > & v, vector< int > & asw )
{
    vector<int> pd(v.size(),0), pd_index(v.size()), pred(v.size());
    int maxi = 0, x, j, ind;

    fori(i,v.size())
    {
        x = v[i];
        j = lower_bound( pd.begin(), pd.begin() + maxi, x ) - pd.begin();
        //j = upper_bound( pd.begin(), pd.begin() + maxi, x ) - pd.begin()
            ; para lds
        pd[j] = x;
        pd_index[j] = i;
        if( j == maxi ) { maxi++; ind = i; }
        pred[i] = j ? pd_index[j-1] : -1;
    }
    // return maxi; se a sequencia nao precisa ser refeita

    int pos = maxi-1, k = v[ind];
    asw.resize( maxi );

    while ( pos >= 0 )
    {
        asw[pos--] = k;
        ind = pred[ind];
        k = v[ind];
    }
}
```

2.5 Grafos

Código 29: Verifica se o grafo é aciclico.

```
#define TAM 100
#define BRANCO 0
#define CINZA 1
#define PRETO 2
bool grafo[TAM][TAM];
int pass[TAM];

bool dfs(int v)
{
    pass[v] = CINZA;

    for (int i = 0; i < TAM; i++)
    {
        if (grafo[v][i])
        {
            if (pass[i] == CINZA) return false;
            if (pass[i] == BRANCO && !dfs(i)) return false;
        }
    }

    pass[v] = PRETO;
    return true;
}

bool aciclico()
{
    memset(pass, BRANCO, TAM*sizeof(int));

    for (int i = 0; i < TAM; i++)
    {
        if (pass[i] == BRANCO)
        {
            if (!dfs(i)) return false;
        }
    }

    return true;
}
```

Código 30: **Dijkstra** Caminho minimo 1 para todos pesos positivos.

```
#include <queue>

typedef vector<map<int, int> > AdjList;
typedef AdjList Grafo;

int dist[MAX_VERTICES];
int prev[MAX_VERTICES]; // para recuperar o caminho usando um dijoint
    forest set

void dijkstra(Grafo& grafo, int source)
{
    for (int i = 0; i < grafo.size(); i++)
    {
        dist[i] = INF;
        prev[i] = -1;
    }

    dist[source] = 0;
```

```
    priority_queue<pair<int, int> > heap;
    heap.push(make_pair(0, source));

    while (!heap.empty())
    {
       int u = heap.top().second;
       heap.pop();

       // para cada vizinho de u
       for (map<int,int>::iterator i = grafo[u].begin(); i != grafo[u].
           end(); i++)
       {
          int totalDist = dist[u] + (*i).second;
          if (totalDist <= dist[(*i).first])
          {
             dist[(*i).first] = totalDist;
             heap.push(make_pair(totalDist, (*i).first));
             prev[(*i).first] = u;
          }
       }
    }
}
```

Código 31: Floresta dijunta de arvores

```
#define SIZE 100

struct dsf
{
    int element_count;
    int parent[SIZE];
    int rank[SIZE];
};
typedef struct dsf * disjoint_set_forest_p;

void dsf_init(disjoint_set_forest_p forest, int element_count)
{
   forest->element_count = element_count;
   memset(forest->parent, 0, element_count*sizeof(int));
   memset(forest->rank, 0, element_count*sizeof(int));

   for (int i = 0; i < element_count; ++i)
      forest->parent[i] = i;
}

int dsf_find_set(disjoint_set_forest_p forest, int i)
{
    if (i != forest->parent[i])
    {
        forest->parent[i] = dsf_find_set(forest, forest->parent[i]);
    }
    return forest->parent[i];
}

void dsf_union(disjoint_set_forest_p forest, int i, int j)
{
    int x = dsf_find_set(forest, i);
    int y = dsf_find_set(forest, j);

    if (forest->rank[x] > forest->rank[y])
    {
        forest->parent[y] = x;
    }
    else
    {
        forest->parent[x] = y;
        if (forest->rank[x] == forest->rank[y])
        {
            forest->rank[y]++;
        }
    }
}
```

Código 32: **Kruskal** Arvore geradora mínima kruskal

```
typedef vector<map<int, int> > AdjList;
struct Grafo
{
   int edgeCnt;
   AdjList adj;
};

struct edge
{
    int u;
    int v;
    int weight;
};

int edge_compare(const void * e1, const void * e2)
{
    struct edge * p1 = (struct edge *) e1;
    struct edge * p2 = (struct edge *) e2;
    int f = p1->weight - p2->weight;
    if (f < 0)
    {
       return -1;
    }
    else  if (f == 0)
    {
        return edge_compare1(e1, e2);
    }
    else
    {
        return 1;
    }
}

struct edge * get_edge_list(Grafo& graph)
{
    int edge_count = graph.edgeCnt;
```

```
37      struct edge *edges = (struct edge*) malloc(edge_count * sizeof(
            struct edge));
38
39      int current_edge = 0;
40
41      for (int i = 0; i < graph.adj.size(); ++i)
42      {
43          for (map<int, int>::iterator j = graph.adj[i].begin(); j !=
                graph.adj[i].end(); j++)
44          {
45              struct edge e;
46              e.u = i < (*j).first ? i : (*j).first;
47              e.v = i > (*j).first ? i : (*j).first;
48              e.weight = (*j).second;
49              edges[current_edge++] = e;
50          }
51      }
52
53      return edges;
54  }
55
56  void kruskal(Grafo& graph, Grafo& mst)
57  {
58      // Obtain a list of edges and sort it by weight in O(E lg E) time
59      int edge_count = graph.edgeCnt;
60      struct edge *edges = get_edge_list(graph);
61      qsort(edges, edge_count, sizeof(struct edge), edge_compare);
62
63      disjoint_set_forest dsf;
64     dsf_init(&dsf, edge_count);
65
66      for (int i = 0; i < edge_count; ++i)
67      {
68          struct edge e = edges[i];
69          int uset = dsf_find_set(dsf, e.u);
70          int vset = dsf_find_set(dsf, e.v);
71          if (uset != vset)
72          {
73              mst.adj[e.u][e.v] = e.weight;
74           mst.edgeCnt++;
75              dsf_union(dsf, uset, vset);
76          }
77      }
78
79      free(edges);
80  }
```

Código 33: verifica se um grafo é bipartido

```
1  #define TAM 200
2
3  bool grafo[TAM][TAM];
4  int pass[TAM];
5  int n;
6
7  bool bipartido(int v, int color = 1)
8  {
9      pass[v] = color;
10     int thisColor = color;
11     bool ret = true;
12
13     color = color == 1 ? 2 : 1;
14
15     for (int i = 0; i < n; i++)
16     {
17        if (grafo[v][i])
18        {
19           if (!pass[i]) ret = dfs(i, color);
20           else if (pass[i] == thisColor) return false;
21
22           if (!ret) return false;
23        }
24     }
25
26     return ret;
27 }
```

Código 34: faz a ordenação topológica de um grafo acíclico

```
1  #define UNVISITED -1
2
3  int grafo[SIZE][SIZE];
4  int prof[SIZE];
5  int sorted[SIZE];
6  int nordem;
7
8  void dfsTopsort(int no)
9  {
10    for (int viz = 0; viz < SIZE; viz++)
11    {
12       if (grafo[no][viz])
13       {
14          if (prof[viz] == UNVISITED)
15          {
16             prof[viz] = prof[no] + 1;
17             dfsTopsort(viz);
18          }
19       }
20    }
21
22    sorted[nordem--] = no;
23 }
24
25 void topSort(int nvt)
26 {
27    memset(prof, UNVISITED, nvt*sizeof(int));
28    nordem = nvt - 1;
29
30    for (int i = 0; i < nvt; i++)
31    {
32       if (prof[i] == UNVISITED)
33       {
```

```
            prof[i] = 0;
            dfsTopsort(i);
        }
    }
}
```

Código 35: calcula fluxo máximo, **Ford-Fulkerson**

```
#define TAM 1000
#define MAX_INT 1000000

int grafo[TAM][TAM];
int pred[TAM];
int f[TAM][TAM];
bool visitados[TAM];
int fila[TAM];

bool bfs(int n, int ini, int fim)
{
    int no, s = 0, e = 0;
    fila[e++] = ini;

    while (s != e)
    {
        no = fila[s++];

        if (visitados[no] == 2) continue;
        visitados[no] = 2;

        for (int i = 0; i < n; i++)
        {
            if (visitados[i] < 2)
            {
                if(grafo[no][i] - f[no][i] > 0)
                {
                    pred[i] = no;
                    if (i == fim) return true;
                    if(visitados[i] == 0)
                    {
                        fila[e++] = i;
                        visitados[i] = 1;
                    }
                }
            }
        }
    }

    return false;
}

bool dfs(int s, int t, int size)
{
    visitados[s] = true;
    if(s == t) return true;

    for(int v = 0; v < size; v++)
    {
        if(!visitados[v] && grafo[s][v] - f[s][v] > 0)
        {
            pred[v] = s;
            if(dfs(v, t, size)) return true;
        }
    }

    return false;
}

bool findPath(int s, int t, int size)
{
    memset(visitados, false, sizeof(bool)*size);
    pred[s] = s;
    // Aqui pode ser usado tanto busca em largura quanto em profundidade.
    // busca em largura geralmente apresenta tempos de execucao bem
        menores.
    return bfs(size, s, t);
    //return dfs(s, t, size);
}

int maxFlow(int size, int s, int t)
{
    int delta;

    for(int i = 0; i < size; i++)
    {
        memset(f[i], 0, sizeof(int)*size);
    }

    while(1)
    {
        bool path = findPath(s, t, size);
        if (!path) break;

        delta = MAX_INT;
        for(int c = t; pred[c] != c; c = pred[c])
        {
            delta = min(delta, grafo[pred[c]][c] - f[pred[c]][c]);
        }

        for(int c = t; pred[c] != c; c = pred[c])
        {
            f[pred[c]][c] += delta;
            f[c][pred[c]] -= delta;
        }
    }

    int soma = 0;

    for(int i = 0; i < size; i++)
    {
        soma += f[i][t];
    }

```

```
    return soma;
}
```

Código 36: calcula fluxo máximo, algoritmo mais eficiente porém muito maior em tempo de codificação

```
const int VT = 100;
const int AR = VT * VT;

struct grafo
{
   // lista de adjacencias representada na forma de vetor
   int nvt, nar;
   int dest[2 * AR];
   int adj[VT][2 * VT];
   int nadj[VT];

   int cap[AR]; // capacidade do arco
   int fluxo[AR];
   int ent[VT];

   int padj[VT], lim[VT], nivel[VT], qtd[VT];

   int inv(int a) { return a ^ 0x1; }
   int orig(int a) { return dest[inv(a)]; }
   int capres(int a) { return cap[a] - fluxo[a]; }

   void inic(int n = 0)
   {
      nvt = n;
      nar = 0;
      memset(nadj, 0, sizeof(nadj));
   }

   ////////////////////////////////////////////////////
   // Adiciona uma aresta ao grafo.
   //
   // "int u" apenas para Fluxos;
   //
   int aresta(int i, int j, int u = 0)
   {
      int ar = nar;
      cap[nar] = u;
      dest[nar] = j;
      adj[i][nadj[i]] = nar++;
      nadj[i]++;

      cap[nar] = 0;
      dest[nar] = i;
      adj[j][nadj[j]] = nar++;
      nadj[j]++;
      return ar;
   }

   void revbfs(int ini, int fim)
   {
      int i, no, viz, ar;
      queue<int> fila;

      memset(nivel, NULO, sizeof(nivel));
      memset(qtd, 0, sizeof(qtd));

      nivel[fim] = 0;
      fila.push(fim);

      while (!fila.empty())
      {
         no = fila.front();
         fila.pop();
         qtd[nivel[no]]++;

         for (i = 0; i < nadj[no]; i++)
         {
            ar = adj[no][i];
            viz = dest[ar];

            if (cap[ar] == 0 && nivel[viz] == NULO)
            {
               nivel[viz] = nivel[no] + 1;
               fila.push(viz);
            }
         }
      }
   }

   int admissivel(int no)
   {
      while (padj[no] < nadj[no])
      {
         int ar = adj[no][padj[no]];
         if (nivel[no] == nivel[dest[ar]] + 1 && capres(ar) > 0) return
             ar;
         padj[no]++;
      }

      padj[no] = 0;
      return NULO;
   }

   int retrocede(int no)
   {
      int i, ar, viz, menor = NULO;

      if (--qtd[nivel[no]] == 0) return NULO;

      for (i = 0; i < nadj[no]; i++)
      {
         ar = adj[no][i]; viz = dest[ar];
         if (capres(ar) <= 0) continue;
         if (menor == NULO || nivel[viz] < nivel[menor]) menor = viz;
      }

```

```
106         if (menor != NULO) nivel[no] = nivel[menor];
107         qtd[++nivel[no]]++;
108
109         return ((ent[no] == NULO) ? no : orig(ent[no]));
110     }
111
112     int avanca(int no, int ar)
113     {
114         int viz = dest[ar];
115         ent[viz] = ar;
116         lim[viz] = min(lim[no], capres(ar));
117         return viz;
118     }
119
120     int aumenta(int ini, int fim)
121     {
122         int ar, no = fim, fmax = lim[fim];
123
124         while (no != ini)
125         {
126             fluxo[ar = ent[no]] += fmax;
127             fluxo[inv(ar)] -= fmax;
128             no = orig(ar);
129         }
130
131         return fmax;
132     }
133
134     int maxflow(int ini, int fim)
135     {
136         int ar, no = ini, fmax = 0;
137
138         memset(fluxo, 0, sizeof(fluxo));
139         memset(padj, 0, sizeof(padj));
140
141         revbfs(ini, fim);
142
143         lim[ini] = INF;
144         ent[ini] = NULO;
145
146         while (nivel[ini] < nvt && no != NULO)
147         {
148             if ((ar = admissivel(no)) == NULO)
149             {
150                 no = retrocede(no);
151             }
152             else if ((no = avanca(no, ar)) == fim)
153             {
154                 fmax += aumenta(ini, fim);
155                 no = ini;
156             }
157         }
158         return fmax;
159     }
160 };
```

2.6 Geometria

Código 37: ponto e poligono

```
1  struct point
2  {
3      double x, y;
4      double z; // para pontos no espaco
5      point(double x = 0, double y = 0, double z = 0): x(x), y(y), z(z) {}
6
7      point operator +(point q) { return point(x + q.x, y + q.y, z + q.z);
           }
8      point operator -(point q) { return point(x - q.x, y - q.y, z - q.z);
           }
9      point operator *(double t) { return point(x * t, y * t, z * t); }
10     point operator /(double t) { return point(x / t, y / t, z / t); }
11     double operator *(point q) { return x * q.x + y * q.y + z * q.z; }
12     point vec(point q) { return point(y * q.z - z * q.y, z * q.x - x * q.
           z, x * q.y - y * q.x); }
13     double operator %(point q) { return x * q.y - y * q.x; }
14
15     int cmp(point q) const
16     {
17         if (int t = ::cmp(x, q.x)) return t;
18         else if (int t = ::cmp(y, q.y)) return t;
19         return ::cmp(z, q.z);
20     }
21
22     bool operator ==(point q) const { return cmp(q) == 0; }
23     bool operator !=(point q) const { return cmp(q) != 0; }
24     bool operator < (point q) const { return cmp(q) < 0; }
25
26     friend ostream& operator <<(ostream& o, point p) {
27       return o << "(" << p.x << ", " << p.y << ", " << p.z << ")";
28     }
29     static point pivot;
30 };
31
32 // para pontos 2D
33 double abs(point p) { return hypot(p.x, p.y); }
34 double arg(point p) { return atan2(p.y, p.x); }
35
36 point point::pivot;
37
38 typedef vector<point> polygon;
39
40 int ccw(point p, point q, point r)
41 {
42     return cmp((p - r) % (q - r));
43 }
44
45 double angle(point p, point q, point r)
46 {
47     point u = p - q, v = r - q;
48     return atan2(u % v, u * v);
49 }
```

Código 38: Decide se q está sobre o segmento fechado pr.

```
bool between(point p, point q, point r)
{
    return ccw(p, q, r) == 0 && cmp((p - q) * (r - q)) <= 0;
}
```

Código 39: Decide se os segmentos fechados pq e rs têm pontos em comum.

```
bool seg_intersect(point p, point q, point r, point s)
{
    point A = q - p;
    point B = s - r;
    point C = r - p;
    point D = s - q;

    int a = cmp(A % C) + 2 * cmp(A % D);
    int b = cmp(B % C) + 2 * cmp(B % D);

    if (a == 3 || a == -3 || b == 3 || b == -3) return false;
    if (a || b || p == r || p == s || q == r || q == s) return true;

    int t = (p < r) + (p < s) + (q < r) + (q < s);
    return t != 0 && t != 4;
}
```

Código 40: Calcula a distância do ponto r ao segmento pq.

```
double seg_distance(point p, point q, point r)
{
    point A = r - q;
    point B = r - p;
    point C = q - p;

    double a = A * A, b = B * B, c = C * C;

    if (cmp(b, a + c) >= 0) return sqrt(a);
    else if (cmp(a, b + c) >= 0) return sqrt(b);
    else return fabs(A % B) / sqrt(c);
}
```

Código 41: Classifica o ponto p em relação ao polígono T. Retorna 0, -1 ou 1 dependendo se p está no exterior, na fronteira ou no interior de T, respectivamente.

```
int in_poly(point p, polygon& T)
{
    double a = 0;
    int N = T.size();
    for (int i = 0; i < N; i++)
    {
        if (between(T[i], p, T[(i+1) % N])) return -1;
        a += angle(T[i], p, T[(i+1) % N]);
    }
    return cmp(a) != 0;
}
```

Código 42: Convex Hull.

```
#include <cstdio>
#include <algorithm>
#include <vector>
#include <string>
#include <cmath>

using namespace std;

#define INF 1e9
#define EPS 1e-9

int cmp(double a, double b = 0.0) {
    return a+EPS < b ? -1 : a-EPS > b;
}

struct Point {
    double x, y;
    Point(double a=0.0,double b=0.0){x=a,y=b;}
    Point operator+(const Point &P) const {return Point(x+P.x,y+P.y);}
    Point operator-(const Point &P) const {return Point(x-P.x,y-P.y);}
    Point operator*(double c) const {return Point(x*c,y*c);}
    Point operator/(double c) const {return Point(x/c,y/c);}
    double operator!() const {return sqrt(x*x+y*y);}
    bool operator==(const Point &p) const {return !cmp(x,p.x) && !cmp(y,p
        .y);}
    bool operator<(const Point &p) const {if (cmp(x,p.x)) return cmp(x,p.
        x) < 0; return cmp(y,p.y) < 0;}
    void print(string prefix = "") const {printf("%s%.3lf %.3lf\n",prefix
        .c_str(),x,y);}
};

typedef vector<Point> Polygon;

double cross(Point A, Point B) {
    return A.x*B.y - B.x*A.y;
}

Point pmin;

bool lessThan(Point A, Point B) {
    if (cmp(cross(A-pmin,B-pmin))) return cmp(cross(A-pmin,B-pmin)) > 0;
    return cmp(!(pmin-A),!(pmin-B)) < 0;
}

int sort(Polygon &p) {
    int imin = 0, i, j, n = p.size();

    for (i=1; i < p.size(); i++) {
        if (p[i] < p[imin]) imin = i;
    }

    swap(p[0],p[imin]);
}
```

```
    pmin = p[0];

    sort(p.begin()+1,p.end(),lessThan);

    for (i=n-1; i > 0 && !cmp(cross(p[i]-p[0],p[i-1]-p[0])); i--);
    if (i == 0) return 1;
    for (j=0; j < (n-i)/2; j++) swap(p[i+j],p[n-j-1]);
    return 0;
}

Polygon convex_hull(Polygon &p) { // tirar o & para nao alterar o poligono original
    int hs = 2, n = p.size();
    Polygon hull;

    if (p.size() < 3) return p;

    int isline = sort(p);
    hull.push_back(p[0]), hull.push_back(p[1]);

    for (int i=2; i <= n-isline; i++) {
        while (hull.size() > 1 && cmp(cross(p[i%n]-hull[hs-1],hull[hs-2]-hull[hs-1])) <= 0) { // trocar o <= para < para manter pontos intermediarios
            hull.pop_back(), hs--;
        }
        if (i < n) hull.push_back(p[i]), hs++;
    }

    return hull;
}

int main() {
    Polygon p;

    while (...) {
        double x = ...;
        double y = ...;
        p.push_back(Point(x,y));
    }

    Polygon hull = convex_hull(p);

    for (int i=0; i < hull.size(); i++) {
        ...
    }
}
```

2.7 Algebra Linear

Código 43: Simplex

```
#include <iostream>
#include <vector>
#include <algorithm>

using namespace std;

#define fori(i,n) for(int i=0; i < (n); ++i)
#define forr(i,a,b) for(int i=(a); i <= (b); ++i)
#define ford(i,a,b) for(int i=(a); i >= (b); --i)
#define sz size()

const double EPS=1e-9; const int INF = 0x3f3f3f3f;

#define all(x) (x).begin(),(x).end()

int cmpD(double x, double y=0, double tol=EPS) {
    return (x <= y+tol) ? (x+tol<y) ? -1 : 0 : 1;
}

struct simplex {
    // max c * x, s.t: A * x <= b; x >= 0
    simplex( const vector< vector< double > > & A_, const vector< double > & b_,
        const vector< double > & c_ ) : A( A_ ), b( b_ ), c( c_ ) {}
    vector< vector< double > > A; vector< double > b, c, sol;
    vector< bool > N; vector< int > kt; int m, n;
    void pivot( int k, int l, int e ) {
        int x = kt[l]; double p = A[l][e];
        fori(i,k) A[l][i] /= p;
        b[l] /= p; N[e] = false;
        fori(i,m) if (i != l) {b[i] -= A[i][e]*b[l]; A[i][x] = -A[i][e]*A[l][x];}
        fori(j,k) if ( N[j] ) {
            c[j] -= c[e] * A[l][j];
            fori(i,m) if ( i != l ) A[i][j] -= A[i][e] * A[l][j];
        }
        kt[l] = e; N[x] = true; c[x] = -c[e] * A[l][x];
    }
    vector< double > go( int k ) {
        vector< double > res;
        while ( 1 ) {
            int e = -1, l = -1;
            fori(i,k) if ( N[i] && cmpD( c[i] ) > 0 ) { e = i; break; }
            if ( e == -1 ) break;
            fori(i,m) if ( cmpD(A[i][e]) > 0 && ( l == -1 || cmpD( b[i] / A[i][e],
                    b[l] / A[l][e], 1e-20 ) < 0 ) ) l = i;
            if ( l == -1 ) return vector< double >(); // unbounded
            pivot( k, l, e );
        }
        res.resize( k, 0 );
        fori(i,m) res[kt[i]] = b[i];
        return res;
    }
    vector< double > solve() {
        m = A.sz; n = A[0].sz; int k = m+n+1;
        N = vector< bool >( k, true ); vector< double > c_copy = c;
        c.resize(n+m); kt.resize(m);
```

```
56        fori(i,m) {
57           A[i].resize(k); A[i][n+i] = 1; A[i][k-1] = -1;
58           kt[i] = n+i; N[kt[i]] = false;
59        }
60        int l = min_element(all(b)) - b.begin();
61        if(cmpD(b[l] ) < 0 ) {
62           c = vector<double>(k,0);
63           c[k-1] = -1; pivot(k, l, k-1); sol=go(k);
64           if(cmpD(sol[k-1])>0) return vector<double>(); // infeasible
65           fori(i,m) if(kt[i] == k-1) {
66              fori(j,k-1) if(N[j] && cmpD( A[i][j] ) != 0 ) {
67                 pivot( k, i, j); break;
68              }
69           }
70           c=c_copy; c.resize(k,0);
71           fori(i,m) fori(j,k) if(N[j]) c[j] -= c[kt[i]]*A[i][j];
72        }
73        sol = go(k-1);
74        if(!sol.empty()) sol.resize(n);
75        return sol;
76     }
77  };
78
79  // Como usar
80  int main() {
81     /* Exemplo: Maximize cx Subject to Ax <= b */
82     vector<vector<double> > A(9);
83     double Av[][3] = {{1,1,0}, {0,0,-1}, {-1,-1,0},
84                       {0,0,1}, {1,0,0}, {0,1,0},
85                       {0,0,1}, {1,0,1}, {0,1,0}};
86
87     for(int i=0; i < 9; i++) {
88        A[i].insert(A[i].begin(), &(Av[i][0]), &(Av[i][3])); // Sim, [3]!
              Ou seja, idx-final+1
89     }
90
91     vector<double > c(3, 1); // c=[1 1 1]
92     double bv[] = {2,-1,-2,1,2,1,1,2,1};
93     vector<double > b(bv, bv+sizeof(bv)/sizeof(double));
94
95     simplex sim(A,b,c);
96     vector<double> s = sim.solve();
97     if(!s.size()) cout << "Impossivel\n";
98     else
99     for(int i=0; i < s.size(); i++) {
100       cout << s[i] << endl;
101    }
102 }
```

2.8 Casamento de strings

Código 44: String matching - Algoritmo **KMP** - O(n + m)

```
1  // F[i] - size of the largest prefix of pattern[0..i] that is also a
2  // suffix of pattern[1..i]. Ex: pattern = {a,b,a,c,a,b}, F =
       {0,0,1,0,1,2}
3  #define MAX_PATTERN_SIZE 10010
4  int F[MAX_PATTERN_SIZE];
5  void build_failure_function( const string & pattern )
6  {
7     int m = pattern.size();
8     F[0] = -1;
9     for (int i = 0; i < m; i++)
10    {
11       F[i+1] = F[i] + 1;
12       while ( F[i+1] > 0 && pattern[i] != pattern[ F[i+1]-1 ] )
13          F[i+1] = F[ F[i+1]-1 ] + 1;
14    }
15 }
16
17 // retorna a posicao inicial de cada ocorrencia de pattern em text
18 vector<int> KMP( const string & text, const string & pattern )
19 {
20    build_failure_function( pattern );
21    vector<int> start_positions;
22    int j = 0, m = pattern.size(), n = text.size();
23
24    for (int i = 0; i < n; i++)
25    {
26       while ( true )
27       {
28          if ( text[i] == pattern[j] )
29          {
30             if ( ++j == m )
31             {
32                start_positions.push_back( i - m + 1 );
33                j = F[j];
34             }
35             break;
36          }
37
38          if ( j == 0 ) break;
39          j = F[j];
40       }
41    }
42
43    return start_positions;
44 }
```

2.9 Outros

Código 45: josephus problem

```
1  /**
2  The Josephus problem (or Josephus permutation) is a theoretical problem
       related to a certain counting-out game. There are people standing in
       a circle waiting to be executed. After the first man is executed,
       certain number of people are skipped and one man is executed. Then
```

```
    again, people are skipped and a man is executed. The elimination
    proceeds around the circle (which is becoming smaller and smaller as
    the executed people are removed), until only the last man remains,
    who is given freedom. The task is to choose the place in the initial
    circle so that you are the last one remaining and so survive.
 */

using namespace std;

int josephus(int n, int m)
{
    int res = 0;
    vector <int> people;
    int loc = 0;

    for (int i = 0; i < n; i++) people.push_back(i+1);

    while (people.size() > 1)
    {
        if (loc >= people.size())
            loc %= people.size();

        people.erase(people.begin()+loc);
        loc += (m-1);
    }

    return people[0];
}
```

Código 46: Gera as permutações dos elementos da string

```
bool nextPermutation(string& number)
{
        bool isBigger = true;
        int i, j;

        for (i = number.size() - 1; i >= 0; i--)
        {
                if (number[i] < number[i+1]) break;
        }

        if (i != -1)
        {
                isBigger = false;

                for (j = number.size() - 1; j >= i+1; j--)
                {
                        if (number[j] > number[i])
                        {
                                break;
                        }
                }

                int tmp = number[i];
                number[i] = number[j];
                number[j] = tmp;

                j = number.size() -1;
                i++;

                while (i < j)
                {
                        tmp = number[i];
                        number[i] = number[j];
                        number[j] = tmp;
                        i++;
                        j--;
                }
        }

        return isBigger;
}
```

Código 47: Exemplo de geração de permutações dos elementos da string, usando backtracking

```
#define TAM 10
int cnt = 0;
int total; //numero de elementos de elem
int elem[TAM];
bool usados[TAM]; //ZERE ME

void enumera(int num)
{
    if (num == total)
    {
        cnt++;
        for (int i = 0; i < total; i++) cout << elem[i];
        cout << endl;
        return;
    }

    for (int i = 0; i < total; i++)
    {
        if (!usados[i])
        {
            elem[num] = i;
            usados[i] = true;
            enumera (num + 1);
            usados[i] = false;
        }
    }
}
```

3 Biblioteca C/C++

3.1 I/O

Ignorando entradas na família scanf:

Código 48: Ignora os dois floats do meio. Retornará 2 no sucesso.

```
1  scanf("%f %*f %*f %d", &a, &b);
```

3.2 Map

Código 49: Referencias map

```
1  #include <map>
2  #include <string>
3  #include <cstdio>
4
5  using namespace std; // USE ISTO!!!
6
7  class Comparadora;
8
9  class Pessoa {
10    int idade;
11    string nome;
12    friend class Comparadora;
13 public:
14    Pessoa(string nome, int idade) {
15       this->idade = idade;
16       this->nome = nome;
17    }
18    void print() const {
19       printf("Nome: %s Idade: %d\n", nome.c_str(), idade);
20    }
21 };
22
23 class Comparadora { // Ordena crescentemente
24 public: // <- IMPORTANTE
25    bool operator() (const Pessoa &a, const Pessoa &b)
26    {
27       int idDif = a.idade-b.idade;
28       if(idDif < 0) return true;
29       else if(idDif==0) return a.nome.compare(b.nome) < 0 ? true : false
             ;
30       else return false;
31    }
32 };
33
34 int main() {
35    Pessoa r("Rangelz", 86);
36    Pessoa r2("Rangelzao", 86);
37
38    map<Pessoa, string, Comparadora> alunos;
39    alunos[r]="UFMG";
40    alunos[r2]="PUC";
41    // Iterator
42    for(map<Pessoa, string, Comparadora>::iterator it=alunos.begin(); it
          != alunos.end(); it++) {
43       it->first.print();
44       printf("\t%s\n\n", it->second.c_str());
45    }
46    // Find
47    if(alunos.find(Pessoa("Rangelz", 86)) != alunos.end()) { // Achou!
48       printf("Achei Rangel!\n");
49    }
50    return 0;
51 }
```