



# Notebook - Maratona de Programação

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# 1 Algoritmos

## 1.1 Recursive-BS

```
1 // Recursive binary search
2
3 int bs(int x, int ini, int fim)
4 {
5     if(fim>=ini)
6     {
7         int meio = (ini+fim)/2;
8
9         if(vetor[mid]==x)
10            return x;
11
12        if(vetor[meio]<x)
13            return bs(x, ini, meio-1);
14        else
15            return bs(x, meio+1, fim);
16    }
17
18    return -1;
19 }
```

## 2 Grafos

### 2.1 BFS

```
1 //BFS (Breadth First Search) O(V+A)
2
3 void BFS(int x)
4 {
5     int atual, v, u;
6     queue<int> fila;
7     fila.push(x);
8
9     componente[x] = valor;
10    atual = 0;
11    while(!fila.empty())
12    {
13        v = fila.front();
14        fila.pop();
15
16        for(int i = 0; i < (int)vizinhos[v].size(); i
17        ++)
18        {
19            u = vizinhos[v][i];
20            if(componente[u] == -1)
21            {
22                componente[u] = componente[v];
23                fila.push(u);
24            }
25        }
26    }
```

### 2.2 Dijkstra

```
1 // Dijkstra - Shortest Path
2
3 #define pii pair<int, int>
4 #define vi vector<int>
5 #define vii vector< pair<int,int> >
6 #define INF 0x3f3f3f3f
7
8 vector<vii> grafo;
9 vi distancia;
10 priority_queue< pii, vii, greater<pii> > > fila;
12 void dijkstra(int k)
```

```
13 {
14     int dist, vert, aux;
15     distancia[k]=0;
16
17     fila.push(mp(k, 0));
18
19     while(!fila.empty())
20     {
21         aux=fila.top().f;
22         fila.pop();
23
24         for(int i=0; i<grafo[aux].size(); i++)
25         {
26             vert=grafo[aux][i].f;
27             dist=grafo[aux][i].s;
28             if(distancia[vert]>distancia[aux]+dist)
29             {
30                 distancia[vert]=distancia[aux]+dist;
31                 fila.push(mp(vert, distancia[vert]));
32             }
33         }
34     }
35 }
36
37 int main()
38 {
39     dist.assign(N+1, INF);
40     grafo.assign(N+1, vii());
41
42     for(int i=0; i<M; i++)
43     {
44         cin >> a >> b >> p;
45         grafo[a].pb(mp(b, p));
46         grafo[b].pb(mp(a, p));
47     }
48 }
```

### 2.3 Floyd-Warshall

```
1 // Floyd Warshall
2
3 int dist[MAX][MAX];
4
5 void Floydwarshall()
6 {
7     for(int k = 1; k <= n; k++)
8         for(int i = 1; i <= n; i++)
9             for(int j = 1; j <= n; j++)
10                 dist[i][j] = min(dist[i][j], dist[i][k] + dist[k][j]);
11 }
```

### 2.4 Kruskal

```
1 // Kruskal - Minimum Spanning Tree
2
3 typedef struct
4 {
5     int A, B;
6     int dist;
7 } vertice;
8
9 vertice grafo[MAX];
10 int pai[MAX];
11
12 int find(int X) // Union-Find
13 {
14     if(pai[X]==X)
15         return X;
16     else
17         return pai[X]=find(pai[X]);
```

```

18 }
19
20 void join(int X, int Y)
21 {
22     int paix = find(X);
23     int paiz = find(Y);
24     pai[paix]=paiz;
25 }
26
27 bool comp(vertex A, vertex B)
28 {
29     return A.dist < B.dist;
30 }
31
32 void kruskal()
33 {
34     for(int i=1;i<=N;i++)
35         pai[i]=i;
36
37     for(int i=1;i<=M;i++)
38         cin >> grafo[i].A >> grafo[i].B >> grafo[i].
dist;
39
40     sort(grafo+1, grafo+M+1, comp);
41
42     for(int i=1;i<=M;i++)
43     {
44         if(find(grafo[i].A)!=find(grafo[i].B))
45         {
46             join(grafo[i].A, grafo[i].B);
47             soma+=grafo[i].dist;
48         }
49     }
50
51     cout << soma << endl;
52 }

```

## 2.5 DFS

```

1 //DFS (Depth First Search) O(V+A)
2
3 void DFS(int x)
4 {
5     for(int i=0; i<(int)vizinhos[x].size(); i++)
6     {
7         int v = vizinhos[x][i];
8         if(componente[v] == -1)
9         {
10             componente[v] = componente[x];
11             DFS(v);
12         }
13     }
14 }

```

## 2.6 Represent

```

1 // Grafos
2
3 // List of edges
4
5     vector< pair<int, int> > arestas;
6     arestas.push_back(make_pair(1, 2));
7     arestas.push_back(make_pair(1, 3));
8
9 // Adjacency Matrix
10
11     int grafo[10][10];
12
13     grafo[1][2] = grafo[2][1] = 1;
14     grafo[1][3] = grafo[3][1] = 2;
15
16 // Adjacency List

```

```

17
18     vector<int> vizinhos[10];
19
20     vizinhos[1].push_back(2);
21     vizinhos[1].push_back(3);

```

# 3 Geometria

## 3.1 Inter-Retas

```

1 // Intersection between lines
2
3 typedef struct
4 {
5     int x, y;
6 } pnt;
7
8 bool collinear(pnt p, pnt q, pnt r)
9 {
10     if(q.x<=max(p.x,r.x) && q.x>=min(p.x,r.x) && q.y
<=max(p.y,r.y) && q.y>=min(p.y,r.y))
11         return true;
12
13     return false;
14 }
15
16 int orientation(pnt p, pnt q, pnt r)
17 {
18     int val=(q.y-p.y)*(r.x-q.x)-(q.x-p.x)*(r.y-q.y);
19
20     if(val==0)
21         return 0;
22     else if(val>0)
23         return 1;
24     else
25         return 2;
26 }
27
28 bool intersect(pnt p1, pnt q1, pnt p2, pnt q2)
29 {
30     int o1 = orientation(p1, q1, p2);
31     int o2 = orientation(p1, q1, q2);
32     int o3 = orientation(p2, q2, p1);
33     int o4 = orientation(p2, q2, q1);
34
35     if(o1!=o2 and o3!=o4)
36         return true;
37
38     if(o1==0 && collinear(p1, p2, q1))
39         return true;
40
41     if(o2==0 && collinear(p1, q2, q1))
42         return true;
43
44     if(o3==0 && collinear(p2, p1, q2))
45         return true;
46
47     if(o4==0 && collinear(p2, q1, q2))
48         return true;
49
50     return false;
51 }
52 }

```

# 4 ED

## 4.1 Iterative-SegTree

```

1 // Segment Tree Iterativa - Range maximum query
2

```

```

3  #define N 100010
4
5  struct Segtree
6  {
7      int t[2*N]={0};
8
9      void build()
10     {
11         for(int i=N-1; i>0; i--)
12             t[i]=max(t[i<<1], t[i<<1|1]);
13     }
14
15     int query(int l, int r)
16     {
17         int ans=0;
18         for(i+=N, r+=N; l<r; l>>=1, r>>=1)
19         {
20             if(l&1)
21                 ans=max(ans, t[l++]);
22             if(r&1)
23                 ans=max(ans, t[--r]);
24         }
25         return ans;
26     }
27
28     void update(int p, int value)
29     {
30         for(t[p+=n]=value; p>1; p>>=1)
31             t[p>>1]= max(t[p], t[p^1]);
32     }
33 }
34
35 };
36
37 int main()
38 {
39     Segtree st;
40
41     for(int i=0;i<n;i++)
42     {
43         cin >> aux;
44         st.t[N+i]=aux; //Leaves are stored in
45         continuous nodes with indices starting with N
46     }
47
48     st.build();
49     x = st.query(inicio, fim);
50     st.update(ind, value);
51 }

```

## 4.2 Recursive-SegTree

```

1  // Segment Tree Recursiva - Range maximum query
2
3  vector<int> val(MAX, 0);
4  vector<int> vet(N);
5
6  void monta(int i, int j, int no)
7  {
8      if(i==j)
9      {
10         val[no]=vet[i];
11         return;
12     }
13
14     int esq = 2*no;
15     int dir = 2*no+1;
16     int meio = (i+j)/2;
17
18     monta(i, meio, esq);
19     monta(meio+1, j, dir);
20

```

```

21     val[no]=max(val[esq], val[dir]);
22 }
23
24 void atualiza(int no, int i, int j, int pos, int
25     novo_valor)
26 {
27     if(i==j)
28     {
29         val[no]=novo_valor;
30     }else
31     {
32         int esq = 2*no;
33         int dir = 2*no+1;
34         int meio = (i+j)/2;
35
36         if(pos<=meio)
37             atualiza(esq, i, meio, pos, novo_valor);
38         else
39             atualiza(dir, meio+1, j, pos, novo_valor)
40         ;
41
42         if(val[esq]>val[dir])
43             val[no]=val[esq];
44         else
45             val[no]=val[dir];
46     }
47 }
48
49 int consulta(int no, int i, int j, int A, int B)
50 {
51     if(i>B || j<A)
52         return -1;
53     if(i>=A and j<=B)
54         return val[no];
55
56     int esq = 2*no;
57     int dir = 2*no+1;
58     int meio = (i+j)/2;
59
60     int resp_esq = consulta(esq, i, meio, A, B);
61     int resp_dir = consulta(dir, meio+1, j, A, B);
62
63     if(resp_dir==-1)
64         return resp_esq;
65     if(resp_esq==-1)
66         return resp_dir;
67
68     if(resp_esq>resp_dir)
69         return resp_esq;
70     else
71         return resp_dir;
72 }
73
74 int main()
75 {
76     monta(1, N, 1);
77     atualiza(1, 1, N, pos, valor);
78     x = consulta(1, 1, N, inicio, fim);
79 }

```

## 4.3 Delta-Encoding

```

1  // Delta encoding
2
3  for(int i=0;i<q;i++)
4  {
5      int l,r,x;
6      cin >> l >> r >> x;
7      delta[l] += x;
8      delta[r+1] -= x;
9  }
10

```

```

11 int atual = 0;
12
13 for(int i=0;i<n;i++)
14 {
15     atual += delta[i];
16     v[i] += atual;
17 }

```

## 4.4 BIT-2D

```

1 // BIT 2D
2
3 int bit[MAX][MAX];
4
5 int sum(int x, int y)
6 {
7     int resp=0;
8
9     for(int i=x;i>0;i-=i&-i)
10         for(int j=y;j>0;j-=j&-j)
11             resp+=bit[i][j];
12
13     return resp;
14 }
15
16 void update(int x, int y, int delta)
17 {
18     for(int i=x;i<MAX;i+=i&-i)
19         for(int j=y;j<MAX;j+=j&-j)
20             bit[i][j]+=delta;
21 }
22
23 int query(int x1, y1, x2, y2)
24 {
25     return sum(x2,y2) - sum(x2,y1) - sum(x1,y2) + sum
26     (x1,y1);
27 }

```

## 4.5 BIT

```

1 // (BIT) Fenwick Tree
2
3 int bit[MAX];
4
5 int soma(int x)
6 {
7     int resp=0;
8
9     // for(int i=x;i>0;i-=i&-i)
10     //     resp+=bit[i];
11
12     while(x > 0)
13     {
14         resp += bit[x];
15         x -= (x & -x);
16     }
17
18     return resp;
19 }
20
21 int query(int L, R)
22 {
23     return soma(R)-soma(L);
24 }
25
26 void update(int x, int v)
27 {
28     // for(;x<=n;x+=x&-x)
29     //     bit[x] += v;
30
31     while(x <= N)
32     {

```

```

33         bit[x] += v;
34         x += (x & -x);
35     }
36 }

```

## 4.6 Union-Find

```

1 // Union-Find Functions
2
3 int pai[MAX], peso[MAX];
4
5 int find(int aux)
6 {
7     if(pai[aux]==aux)
8         return aux;
9     else
10         return pai[aux]=find(pai[aux], pai);
11 }
12
13 void join(int x, int y)
14 {
15     x = find(x);
16     y = find(y);
17
18     if(pesos[x]<pesos[y])
19         pai[x] = y;
20     else if(pesos[x]>pesos[y])
21         pai[y] = x;
22     else if(pesos[x]==pesos[y])
23     {
24         pai[x] = y;
25         pesos[y]++;
26     }
27 }
28
29 int main()
30 {
31     for(int i=1;i<=N;i++)
32         pai[i]=i;
33 }

```

## 5 STL

### 5.1 Pair

```

1 pair<string, int> P;
2
3 cin>>P.first>>P.second;
4
5 // Pair of pair
6
7 pair<string, pair<double, double>> P;
8
9 P.first = "Joao";
10 P.second.first = 8.2;
11 P.second.second = 10;
12
13 // Vector of pair
14
15 vector<pair<int, string> > V;
16 sort(V.begin(), V.end());
17
18 //make_pair()
19
20 P = make_pair("Joao", 10);
21
22 for(int i=1;i<10;i++)
23 {
24     cin>>a>>b;
25     V.push_back(make_pair(a,b));
26 }

```

## 5.2 Set

```
1 // Set - Red-Black Trees - O(logn)
2
3 set<int> S;
4
5 //S.insert()
6
7     S.insert(10); // O(logN)
8
9 //S.find()
10
11     if(S.find(3) != S.end())// O(logN)
12
13 //S.erase
14
15     S.erase(10);
16
17     //Outros
18     S.clear();
19     S.size();
20     S.begin();
21     S.end();
22
23     p = S.lower_bound(n); // Retorna um ponteiro para
24                          // o primeiro elemento maior ou igual a n (not less
25                          // than n)
26     p = S.upper_bound(n); // Retorna um ponteiro para
27                          // o primeiro elemento maior que n (greater than n)
28
29 // (set<int>::iterator)
30
31     for(set<int>::iterator it=S.begin(); it!=S.end();
32         it++)
33     {
34         cout << *it << " ";
35     }
```

## 5.3 Stack

```
1 // Stack
2
3 stack<int> pilha;
4
5 //pilha.push()
6
7     pilha.push(N);
8
9 //pilha.empty()
10
11     if(pilha.empty()==true/false)
12
13 //pilha.pop()
14
15     pilha.pop();
16
17 //pilha.front()
18
19     p = pilha.top();
```

## 5.4 Queue

```
1 // Queue
2
3 queue<int> fila;
4
5 //fila.push()
6
7     fila.push(N);
8
9 //fila.empty()
```

```
10
11     if(fila.empty()==true/false)
12
13 //fila.pop()
14
15     fila.pop();
16
17 //fila.front()
18
19     p = fila.front();
20
```

## 5.5 Priority-Queue

```
1 // Priority Queue - O(logn)
2
3 priority_queue<int> plista;
4
5 //plista.push()
6
7     plista.push(N);
8
9 //plista.empty()
10
11     if(plista.empty()==true/false)
12
13 //plista.pop()
14
15     plista.pop();
16
17 //plista.front()
18
19     p = plista.top();
```

## 5.6 Map

```
1 // Map - Red-Black Trees
2
3 map<string, int> M;
4
5 //S.insert()
6
7     M.insert(make_pair("Tiago", 18));
8     //ou
9     M["Tiago"]=18; // O(logN)
10
11 //S.find()
12
13     if(M.find("Tiago") != M.end()) // O(logN)
14
15         cout << M["Tiago"] << endl;
16
17 //S.erase
18
19     M.erase("Tiago"); // O(logN)
20
21
22 //S.count()
23
24     if(S.count(N))
25
26 //Other
27
28     M.clear();
29     M.size();
30     M.begin();
31     M.end();
32
33 // (map<int>::iterator)
34
35     for(map<string,int>::iterator it=M.begin(); it!=M
36         .end(); it++)
```

```

36     {
37         cout << "(" << it->first << ", " << it->
second << ") ";
38     }

```

## 5.7 Vector

```

1 // Vector - Vetor
2
3 vector<int> V;
4 vector<tipo> nome;
5 vector<tipo> V(n, value);
6
7 //push_back()
8
9     V.push_back(2);
10    V.push_front(2);
11
12 // front() back()
13
14    cout << V.front() << endl;
15    cout << V.back() << endl;
16
17 //size()
18
19    tamanho = V.size();
20
21 //resize()
22
23    V.resize(10);
24    V.resize(n, k);
25
26 //pop_back()
27
28    V.pop_back();
29
30 //clear()
31
32    V.clear();
33    sort(V.begin(), V.end());
34
35 //upper_bound() e lower_bound()
36
37    vector<int>::iterator low,up;
38    low=lower_bound(v.begin(), v.end(), 20);
39    up=upper_bound(v.begin(), v.end(), 20);
40    cout << "lower_bound at position " << (low- v.
begin()) << '\n';
41    cout << "upper_bound at position " << (up - v.
begin()) << '\n';
42
43 //binary_search()
44
45    if(binary_search(vet.begin(), vet.end(), 15))
46
47 //accumulate()
48
49    cout << accumulate(first, last, sum, func) <<
endl;
50    //first - pointer to the first element
51    //last - last element
52    //sum - inicial value
53    //func
54
55    int func(int x, int y)
56    {
57        //return x*y;
58        return x+y;
59    }
60
61 //partial_sum()
62
63    partial_sum(first, last, vet, func);

```

```

64
65    int func(int x, int y)
66    {
67        //return x*y;
68        return x+y;
69    }
70
71 //assign()
72 //Diferente do resize() por mudar o valor de
todos os elementos do vector
73
74    vector<int> vet;
75    vet.assign(N, x);
76
77    vector< vector<int> > vet;
78    vet.assign(N, vector<int>());
79
80 //sort()
81
82    sort(vet, vet+N, func);
83
84    bool func(Aluno a, Aluno b)
85    {
86        return a.nota < b.nota; // True caso a venha
antes de b, False caso contrario
87    }
88
89 //fill()
90
91    vector<int> vet(5); // 0 0 0 0 0
92
93    fill(vet.begin(), vet.begin()+2, 8); // 8 8 0 0 0

```

## 6 Math

### 6.1 Verif-primo

```

1 // prime verrification sqrt(N)
2
3 long long eh_primo(long long N)
4 {
5     if(N==2)
6     {
7         return true;
8     }
9     else if(N==1 or N%2==0)
10    {
11        return false;
12    }
13    for(long long i=3;i*i<=N;i+=2)
14        if(N%i==0)
15            return false;
16
17    return true;
18 }

```

### 6.2 Crivo

```

1 // Sieve of Eratosthenes
2
3 int N;
4 vector<bool> primos(100010, true);
5 cin >> N;
6
7 primos[0]=false;
8 primos[1]=false;
9
10 for(int i=2;i<=N;i++)
11     if(primos[i])
12         for(int j=i+i; j<=N; j+=i)
13             primos[j]=false;

```

## 6.3 Kamenetsky

```
1 // Number of digits in n! 0(1)
2
3 #define Pi 3.14159265358979311599796346854
4 #define Eul 2.71828182845904509079559829842
5
6 long long findDigits(int n)
7 {
8     double x;
9
10    if (n < 0)
11        return 0;
12    if (n == 1)
13        return 1;
14
15    x = ((n * log10(n / euler) + log10(2 * Pi * n)
16         / 2.0));
17
18    return floor(x) + 1;
19 }
```

## 7 Misc

### 7.1 Bitwise

```
1 // Bitwise
2
3 unsigned char a = 5, b = 9; // a = (00000101), b
4 = (00001001)
5
6 AND -          a&b    // The result is 00000001
7 (1)
8 OR -           a|b    // The result is 00001101
9 (13)
10 XOR -          a^b    // The result is 00001100
11 (12)
12 NOT -          ~a     // The result is 11111010
13 (250)
14 Left shift -    b<<1  // The result is 00010010
15 (18)
16 Right shift -   b>>1  // The result is 00000100
17 (4)
18
19 // Exchange two int variables
20
21     a^=b;
22     b^=a;
23     a^=b;
24
25 // Even or Odd
26
27     (x & 1)? printf("Odd"): printf("Even");
28
29 // Turn on the j-th bit
30
31     int S = 34; //(100010)
32     int j = 3;
33
34     S = S | (1<<j);
35
36 // Turn off the j-th bit
37
38     int S = 42; //(101010)
39     int j = 1;
40
41     S &= ~(1<<j)
```

```
35
36     S == 40 //(101000)
37
38 // Check the j-th element
39
40     int S = 42; //(101010)
41     int j = 3;
42
43     T = S & (1<<j); // T = 0
44
45 // Exchange o j-th element
46
47     S ^= (1<<j)
48
49 // Position of the first bit on
50
51     T = (S & (-S))
52     T -> 4 bit ligado //(1000)
53
54 // Most significant digit of N
55
56
57     double K = log10(N);
58     K = K - floor(K);
59     int X = pow(10, K);
60
61 // Number of digits in N
62
63     X =floor(log10(N)) + 1;
64
65 // Power of two
66
67     bool isPowerOfTwo(int x)
68     {
69         return x && (!(x&(x-1)));
70     }
```

### 7.2 Complexity

```
1 // Complexity
2
3     If n <= 12, the time complexity can be O(n!).
4     If n <= 25, the time complexity can be O(2^n).
5     If n <= 100, the time complexity can be O(n^4).
6     If n <= 500, the time complexity can be O(n^3).
7     If n <= 10^4, the time complexity can be O(n^2).
8     If n <= 10^6, the time complexity can be O(n log
9     n).
10    If n <= 10^8, the time complexity can be O(n).
11    If n > 10^8, the time complexity can be O(log n)
12    or O(1).
```

### 7.3 Aprox

```
1 // Approximation
2
3 value-   round() floor() ceil() trunc()
4 -----
5 +2.3     +2.0     +2.0     +3.0     +2.0
6 +3.8     +4.0     +3.0     +4.0     +3.0
7 +5.5     +6.0     +5.0     +6.0     +5.0
8 -2.3     -2.0     -3.0     -2.0     -2.0
9 -3.8     -4.0     -4.0     -3.0     -3.0
10 -5.5     -6.0     -6.0     -5.0     -5.0
```

## 8 Strings