Блог пользователя FieryPhoenix

Codeforces Round #638 (Div. 2) Editorial

Автор FieryPhoenix, 6 дней назад,

1348A - Phoenix and Balance

Tutorial

1348A - Phoenix and Balance

We observe that the coin with the weight 2^n is greater than the sum of all the other weights combined. This is true because $\sum_{i=1}^{n-1} 2^i = 2^n - 2$. Therefore, the pile that has the heaviest coin will always weigh more. To minimize the weight differences, we put the $n/2 - 1$ lightest coins into the pile with the heaviest coin. The answer will be $(2^n + \sum_{i=1}^{n/2-1} 2^i) - \sum_{i=n/2}^{n-1} 2^i$.

Time complexity for each test case: $O(n)$

You can also solve the problem in $O(1)$ by simplifying the mathematical expression.

Solution

```
#include <bits/stdc++.h>
using namespace std;

void solve(){
  int N;
  cin>>N;
  //note: 1<<X means 2^X
  //we put largest coin in first pile
  int sum1=(1<<N), sum2=0;
  //we put n/2-1 smallest coins in first pile
  for (int i=1;i<N/2;i++)
    sum1+=(1<<i);
  //we put remaining n/2 coins in second pile
  for (int i=N/2;i<N;i++)
    sum2+=(1<<i);
  cout<<sum1-sum2<<endl;
}

int main(){
  int t; cin>>t;
  while (t--)
    solve();
}
```

1348B - Phoenix and Beauty

Tutorial

1348B - Phoenix and Beauty

For an array to be beautiful for some k, the array must be periodic with period k. If there exists more than k distinct numbers in the array a, there is no answer and we print -1 (because the array cannot be periodic with period k). Otherwise, we propose the following construction.

Consider a list of all the distinct numbers in array a. If there are less than k of them, we will append some 1s (or any other number) until the list has size k. We can just print this list n times. The length of our array b is nk, which never exceeds 10^4. Array b can always be constructed by inserting some numbers into array a because every number in a corresponds to one list.

Time complexity for each test case: $O(n \log n + nk)$

Solution

```
#include <bits/stdc++.h>
using namespace std;

void solve(){
  int N,K;
  cin>>N>>K;
  set<int>s;
  for (int i=0;i<N;i++){
    int a;
    cin>>a;
    s.insert(a);
  }
  //if more than K distinct numbers, print -1
  if (s.size()>K){
    cout<<-1<<endl;
    return;
  }
  cout<<N*K<<endl;
  for (int i=0;i<N;i++){
    //print the distinct numbers
    for (int b:s)
      cout<<b<<' ';
    //print the extra 1s
    for (int j=0;j<K-(int)s.size();j++)
      cout<<1<<' ';
  }
  cout<<endl;
}

int main(){
  int t; cin>>t;
  while (t--)
    solve();
}
```

1348C — Phoenix and Distribution

Tutorial

1348C - Phoenix and Distribution

We first try to assign one letter to each string a_i. Let's denote the smallest letter in s as c. If there exists at least k occurrences of c in s, we will assign c as the first letter of each string a_i. Otherwise, the minimal solution is the kth smallest letter in s. For example, if $s =$ aabbb and $k = 3$, the 3rd smallest letter is b and that will be the answer.

Otherwise, we consider the letters that are left in s. If they are all the same letter (or there are no letters left because $n = k$), we split the remaining letters as evenly as possible among a_i. If not, we will show that it is optimal to sort the remaining letters in s and append them to arbitrary a_i.

Всё →

For example, let's suppose after assigning a letter to each a_i that the remaining letters in s are `aaabb`. We want to assign the bs as late as possible, so any string a_i that receives a b should have some number of as before. It makes sense in fact that the string that receives a b should receive **all** the as, because if not it will be lexicographically larger. It can then be shown that all remaining larger letters should be sorted and added to the same string a_i to minimize the answer.

Time complexity for each test case: $O(n \log n)$ (for sorting s)

Solution

```
#include <bits/stdc++.h>
using namespace std;

void solve(){
  int n,k;
  cin>>n>>k;
  string s;
  cin>>s;
  sort(s.begin(),s.end());
  //if smallest k letters are not all the same, answer is kth smallest letter
  if (s[0]!=s[k-1]){
    cout<<s[k-1]<<endl;
    return;
  }
  cout<<s[0];
  //if remaining letters aren't the same, we append remaining letters to
answer
  if (s[k]!=s[n-1]){
    for (int i=k;i<n;i++)
      cout<<s[i];
  }
  else{
    //remaining letters are the same, so we distribute evenly
    for (int i=0;i<(n-k+k-1)/k;i++)
      cout<<s[n-1];
  }
  cout<<endl;
}

int main(){
  int t; cin>>t;
  while (t--)
    solve();
}
```

1348D - Phoenix and Science

Tutorial

1348D - Phoenix and Science

There exists many constructive solutions, here is one I think is very elegant. We will try to approach the problem by considering how much the total mass increases every night. If there are x bacteria some day before the splitting, that night can have a mass increase between x and $2x$ inclusive (depending on how many bacteria split that day).

Therefore, we can reword the problem as follows: construct a sequence a of minimal length $a_0 = 1, a_1, \ldots, a_k$ such that $a_i \leq a_{i+1} \leq 2a_i$ and the sum of a_i is n. To minimize the length of sequence a, we will start building our sequence with $1, 2, \ldots, 2^x$ such that the total sum s is less than or equal to n. If the total sum is n, we are done. Otherwise, we insert $n - s$ into our sequence and sort. This gives a valid sequence of minimal length.

To transform our sequence a into the answer, we can just print the differences $a_i - a_{i-1}$ because the number of bacteria that split during the day is equal to how much the mass increase changes.

Time complexity for each test case: $O(\log n)$, if you sort by insertion

Solution

```
#include <bits/stdc++.h>
using namespace std;

void solve(){
  vector<int>inc;
  int N;
  cin>>N;
  //construct sequence 1, 2, 4, ... while sum <= N
  for (int i=1;i<=N;i*=2){
    inc.push_back(i);
    N-=i;
  }
  //if sum is not N, we insert and sort
  if (N>0){
    inc.push_back(N);
    sort(inc.begin(),inc.end());
  }
  cout<<inc.size()-1<<endl;
  for (int i=1;i<(int)inc.size();i++)
    cout<<inc[i]-inc[i-1]<<' ';
  cout<<endl;
}

int main(){
  int t; cin>>t;
  while (t--)
    solve();
}
```

1348E - Phoenix and Berries

Tutorial

1348E - Phoenix and Berries

There is no obvious greedy solution, so we will try dynamic programming. Let $dp[i][j]$ be a boolean array that denotes whether we can have j extra red berries after considering the first i shrubs. A berry is extra if it is not placed into a full basket (of any kind). Note that if we know that there are j extra red berries, we can also easily calculate how many extra blue berries there are. Note that we can choose to never have more than $k-1$ extra red berries, because otherwise we can fill some number of baskets with them.

To transition from shrub $i-1$ to shrub i, we loop over all possible values l from 0 to $min(k-1, a_i)$ and check whether or not we can leave l extra red berries from the current shrub i. For some i and j, we can leave l extra red berries and put the remaining red berries in baskets possibly with blue berries from the same shrub if $(a_i - l) \ mod \ k + b_i \geq k$. The reasoning for this is as follows:

First of all, we are leaving l red berries (or at least trying to). We show that from this shrub, there will be at most one basket containing both red and blue berries (all from this shrub). To place the remaining red berries into full baskets, the more blue berries we have the better. It is optimal to place the remaining $a_i - l$ red berries into their own separate baskets first before merging with the blue berries (this way requires fewest blue berries to satisfy the condition). Then, if $(a_i - l) \ mod \ k + b_i$ is at least k, we can fill some basket with the remaining red berries and possibly some blue berries. Remember that we do not care about how many extra blue berries we leave because that is uniquely determined by the number of extra red berries.

Also note that we can always leave $a_i \ mod \ k$ extra red berries.

Denote the total number of berries as t. The answer will be maximum over all $(t-j)/k$ such that $dp[n][j]$ is true, $0 \leq j \leq k-1$.

Time Complexity: $O(nk^2)$

There exists faster solutions (like $O(nk)$), can you find it?

Solution

```
#include <bits/stdc++.h>
using namespace std;

int N,K;
int a[505],b[505];
bool dp[505][505];  //number of shrubs considered, "extra" red berries

int main(){
  cin>>N>>K;
  long long totA=0,totB=0;
  for (int i=1;i<=N;i++){
    cin>>a[i]>>b[i];
    totA+=a[i];
    totB+=b[i];
  }
  dp[0][0]=true;
  for (int i=1;i<=N;i++){
    for (int j=0;j<K;j++){
      //leave a[i]%K extra red berries
      dp[i][j]=dp[i-1][(j-a[i]%K+K)%K];
      for (int k=0;k<=min(K-1,a[i]);k++){
        //check if we can leave k extra red berries
        if ((a[i]-k)%K+b[i]>=K)
          dp[i][j]|=dp[i-1][(j-k+K)%K];
      }
    }
  }
  long long ans=0;
  for (int i=0;i<K;i++){
    if (dp[N][i])
      ans=max(ans,(totA+totB-i)/K);
  }
  cout<<ans<<endl;
}
```

1348F - Phoenix and Memory

Tutorial

1348F - Phoenix and Memory

There are many many many solutions to this problem (which is cool!). I describe two of them below.

Both solutions first find an arbitrary valid ordering. This can be done in $O(n \log n)$ with a greedy algorithm. We can sort the intervals (a_i, b_i) and sweep from left to right. To see which position that we can assign friend j to, we process all intervals with $a_i \leq j$ and insert b_i into a multiset (or similar) structure. We match friend j to the interval with minimal b_i.

Solution 1:

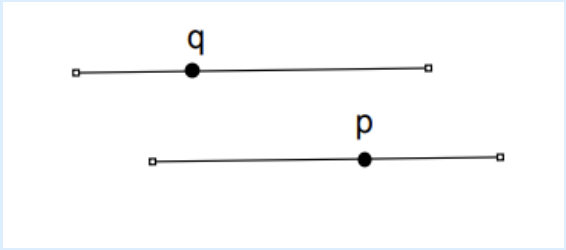
We prove that if there exists more than one valid ordering, we can transform one into another by swapping two friends.

Proof:

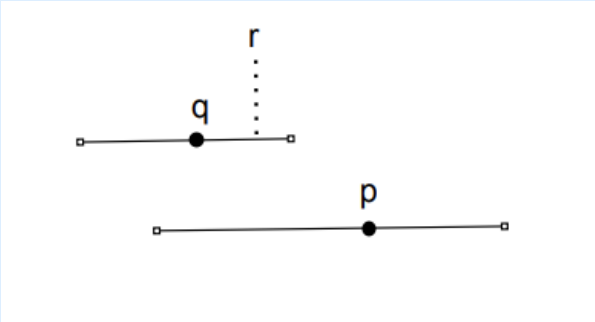
In our valid ordering, each friend is assigned a position. We can think of this as a point being assigned to an interval (Friend - point, position - interval). We will prove there exists a cycle of length 2 or there exists no cycle at all.

Suppose we have a cycle: each point is on its interval and its predecessor's interval. Let's take the shortest cycle of length at least two. Let q be the leftmost point, p be q's predecessor, and r be q's successor.

Case 1: q's interval's right endpoint is to the right of p. p and q form a cycle of length 2.



Case 2: q's interval's right endpoint is to the left of p. r must be between q and p. So, we can remove q and get a shorter cycle. This is a contradiction.



□

Denote p_i as the position that friend i is assigned to in our arbitrary ordering. Now, we are interested whether or not there exists a friend i such that there also exists some friend j with p_j such that $p_i < p_j \leq b_{p_i}$ and $a_{p_j} \leq p_i$. If there does, we can swap friends i and j to make another valid ordering. This can be done with a segment tree (build it with values a_i).

Time Complexity: $O(n \log n)$

Solution 2:

The problem is equivalent to checking if there is a unique perfect matching in the following bipartite graph:

The vertices on the left correspond to position. The vertices on the right correspond to labels of the friends. An edge from a position to a label exists iff the friend with that label can be at that position.

Find a perfect matching (corresponding to finding any valid assignment) as described above.

The matching is unique iff contracting the edges (merging nodes connected by edges from our perfect matching into one node) in the perfect matching creates a DAG. This can be done by DFS in $O(n^2)$, but this is too slow. We can speed it up by storing a set of unvisited vertices and only iterating across those (by binary search on set-like structure).

Time Complexity: $O(n \log n)$

Solution 1

```
#include <bits/stdc++.h>
using namespace std;

const int INF=1e9+7;

int as[200005], bs[200005];

vector<pair<int,int> > start[200005];
int ans[200005];
int where[200005];
int N;

void show(){
  for(int i=1;i<=N;i++)
    cout<<ans[i]<<' ';
  cout<<endl;
```

```
}

pair<int,int> st[400005];

int query(int l,int r){
  l--;
  pair<int,int> res{INF,INF};
  for(l+=N,r+=N;l<r;l>>=1,r>>=1){
    if(l&1) res=min(res,st[l++]);
    if(r&1) res=min(res,st[--r]);
  }
  return res.second;
}

int main(){
  cin>>N;
  for(int i=1;i<=N;i++){
    cin>>as[i]>>bs[i];
    start[as[i]].push_back({bs[i],i});
  }
  set<pair<int,int> > active;//(right,index)
  for(int i=1;i<=N;i++){
    active.insert(start[i].begin(),start[i].end());
    ans[active.begin()->second]=i;
    where[i]=active.begin()->second;
    active.erase(active.begin());
  }
  for(int i=0;i<N;i++){
    st[i+N]={as[where[i+1]],i+1};
  }
  for(int i=N-1;i>0;i--){
    st[i]=min(st[i<<1],st[i<<1|1]);
  }
  for(int i=1;i<=N;i++){
    int j=query(i+1,bs[where[i]]);
    if(j==INF) continue;
    if(as[where[j]]<=i){
      cout<<"NO"<<endl;
      show();
      swap(ans[where[i]],ans[where[j]]);
      show();
      return 0;
    }
  }
  cout<<"YES"<<endl;
  show();
}
```

Solution 2

```
#include <bits/stdc++.h>
using namespace std;

int N;
int a[200005],b[200005];
int label[200005]; //the label of the person at i-th position in our perfect
matching
int label2[200005]; //which position the i-th person is at

void perfectMatch(){ //finds a perfect matching
  deque<pair<pair<int,int>,int>>v;
  for (int i=1;i<=N;i++)
    v.push_back({{a[i],b[i]},i});
  sort(v.begin(),v.end());
  multiset<pair<int,int>>mst;
```

```
  for (int i=1;i<=N;i++){
    while ((int)v.size()>0 && v[0].first.first<=i){
      mst.insert({v[0].first.second,v[0].second});
      v.pop_front();
    }
    //match person with label to earliest ending interval
    label2[i]=mst.begin()->second;
    label[mst.begin()->second]=i;
    mst.erase(mst.find(*mst.begin()));
  }
}

set<int>active;
int vis[200005];
int from[200005];
int ans[200005];

void foundAnother(int node, int nextNode){
  vector<int>v;
  int cur=node;
  //backtracks on cycle to find other ordering
  while (cur!=label2[nextNode]){
    v.push_back(cur);
    cur=from[cur];
  }
  reverse(v.begin(),v.end());
  v.push_back(label2[nextNode]);
  reverse(v.begin(),v.end());
  cout<<"NO"<<endl;
  for (int i=1;i<=N;i++)
    cout<<label[i]<<' ';
  cout<<endl;
  for (int i=1;i<=N;i++)
    ans[i]=label[i];
  int temp=ans[v.back()];
  for (int i=0;i<(int)v.size();i++)
    swap(temp,ans[v[i]]);
  for (int i=1;i<=N;i++)
    cout<<ans[i]<<' ';
  cout<<endl;
  exit(0);
}

void dfs(int node){
  //activates node
  vis[node]=1;
  queue<int>toRemove;
  for (;;){
    //binary search for unvisisited neighbor
    auto it=active.lower_bound(a[node]);
    if (it!=active.end() && *it==label[node]){
      toRemove.push(*it);
      it++;
    }
    if (it==active.end() || *it>b[node])
      break;
    if (vis[label2[*it]]==1) //found cycle (another ordering)
      foundAnother(node,*it);
    toRemove.push(*it);
    if (vis[label2[*it]]==2)
      continue;
    from[label2[*it]]=node;
    dfs(label2[*it]);
  }
  //removes visited nodes from set
```

```
  while (!toRemove.empty()){
    if (active.count(toRemove.front()))
      active.erase(toRemove.front());
    toRemove.pop();
  }
  //deactivates and retire node
  vis[node]=2;
}

int main(){
  cin>>N;
  for (int i=1;i<=N;i++)
    cin>>a[i]>>b[i];
  perfectMatch();
  for (int i=1;i<=N;i++)
    active.insert(i);
  for (int i=1;i<=N;i++)
    if (vis[i]==0)
      dfs(i);
  cout<<"YES"<<endl;
  for (int i=1;i<=N;i++)
    cout<<label[i]<<' ';
  cout<<endl;
}
```

Разбор задач Codeforces Round #638 (Div. 2)

codeforces, 638, editorial, phoenix

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Wow! I didn't expect the editorial published so fast.

→ Ответить

cheissmart

81 минуту назад, # ^ | ☆ +1

ryPhoenix's blog

deforces Round #638 (Div. 2) Edito

Mikepayne14

Yeah, I also didn't expected this fast Editorial! XD

→ Ответить

12 часов назад, # | ☆ +26

Thanks for the fast editorial!

→ Ответить

Tman

6 часов назад, # ^ | ☆ +7

Video solutions:

1. Phoenix and Beauty
2. Phoenix and Distribution

striver_79