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## Josephus for large n (Facebook Hacker Cup)

Asked 11 years, 4 months ago Modified 5 years, 10 months ago Viewed 7k times

One of the problems was basically the <u>Josephus problem</u>

 $f(n,k) = (f(n-1,k) + k) \mod n$ , with f(1,k) = 0



Last week I participated in round 1b of the Facebook Hacker cup.

11

I've studied the Josephus problem before as a discrete math problem, so I basically understand how to get the recurrence:





But that didn't work in the Facebook Hacker Cup, because the max value of n was 10^12. The mak value of k was 10^4.

Wikipedia mentions an approach when k is small and n is large. Basically remove people from a single round, and then renumber. But it's not described much and I don't understand why the renumbering works.

I looked at sample working source code for the solution, but I still don't understand that final portion.

```
long long joseph (long long n,long long k) {
   if (n==1LL) return 0LL;
   if (k==1LL) return n-1LL;
   if (k>n) return (joseph(n-1LL,k)+k)%n;
   long long cnt=n/k;
   long long res=joseph(n-cnt,k);
   res-=n%k;
   if (res<0LL) res+=n;
   else res+=res/(k-1LL);
   return res;
}</pre>
```

The part I really don't understand is starting from res-=n%k (and the lines thereafter). How do you derive that that is the way to adjust the result?

Could someone show the reasoning behind how this is derived? Or a link that derives it? (I didn't find any info on UVA or topcoder forums)

algorithm math josephus

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```
asked Jan 30, 2011 at 20:20

Edward Tonai

111 • 1 • 5
```

```
Which if does the last else belong to? – biziclop Jan 30, 2011 at 21:06
```

2 @biziclop - isn't it rather obvious it belongs to the last one...? – IVlad Jan 30, 2011 at 21:14

@IVlad: Isn't it obvious to you that if the question has to be asked the code suffers from lack of clarity? – JimR Jan 30, 2011 at 21:36

- 1 @JimR The logic behind the code is indeed not clear, but that's what the question is about, so it can't be helped. The syntax however is very clear. IVlad Jan 30, 2011 at 21:40 🖍
- @JimR actually, I have about 5 years experience working with this type of algorithm-competition code. It might be a bit cryptic and not follow the best industry standards, but I can assure you it's correct and written as it is intended to work, because it is the official (or at least a correct) solution to the given problem. I apologize to @biziclop if my question sounded rude or anything, that was not my intention. I just meant to emphasize that the code **works**, and the question is about **why it works**. IVlad Jan 30, 2011 at 21:46

## 1 Answer

Sorted by: Highest score (default) \$



Right, I think I cracked it.

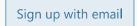


Let's look at how the iterations go with n=10, k=3:

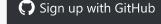


```
0 1 2 3 4 5 6 7 8 9 n=10,k=3
1 2 3 4 5 6 0 n=7,k=3
```

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0 1 2 3 4 n=5,k=3 2 3 0 1 n=4,k=3

Now j(4,3) returns 0, which corrected by 5%3 turns out to be -2. This only happens if the result of the second row is in the last group, in which case adding n to the result will give us our original index.

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answered Jan 30, 2011 at 22:37



May I ask what's the complexity of this algorithm? Even faster than O(n)? so O(logn) I suppose? – noooooooob Feb 27, 2014 at 11:15

2 I didn't invent the algorithm so I'm not entirely certain but Wikipedia claims it's O(k\*logn), which looks about right. – biziclop Mar 4, 2014 at 11:46

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