COP 3502 - 4/18/2022

4/18 - Binary Search
4/20 - Foundation Exam
4/22 - Backtracking
4/25 - final exam review

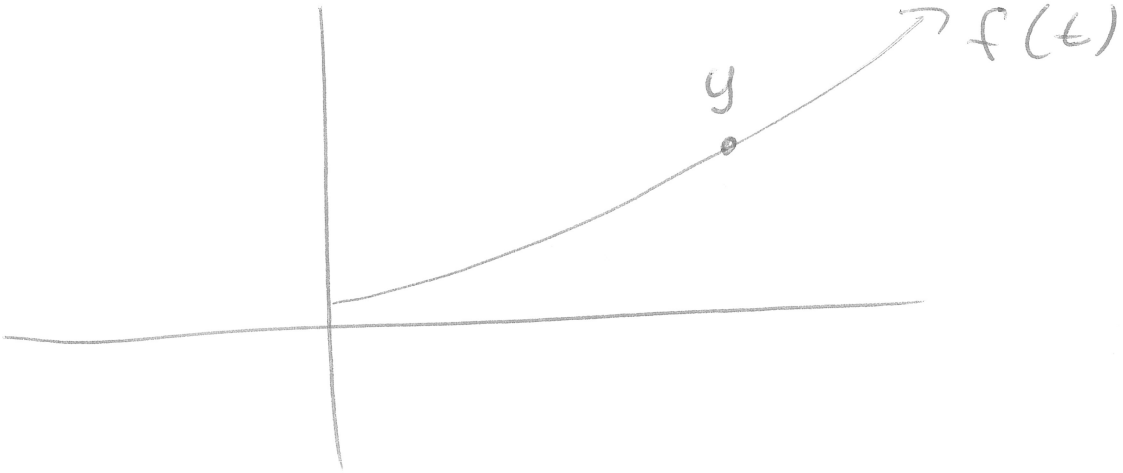
Binary Search
- Simple
- Powerful

Textbook binary search
Input: Sorted Array, Value
Output: true iff value is in the array.

Crystal Etching

$$\frac{f_2 - f_1}{f_1 f_2} = at + b(1 - e^{-ct})$$

1) function on right (in t) is increasing function
2) set low, high bounds for what t could be
3) guess halfway in between + see if your guess was too high or too low, adjust low or high as necessary!



4) hallmarks
- $f(t)$ is easy to calculate forward
- $f(t)$ hard to invert
- $f(t)$ is increasing OR decreasing.

Binary Search is a good approach!

This example: real valued binary search

(1) be really careful setting low, high
(2) Watch out for overflow or meta errors in setting low, high.
(3) fixed # iterations (usually 50-60 will suffice)
(4) either set low = mid
high = mid

Problem E: Airport Shuttle

Filename: `airport`
Time limit: `2 seconds`

When all of the out of state campers arrived to Orlando International Airport, the SI@UCF staff had to make several runs to the airport to pick up all of the campers. Naturally, none of the staff members wanted to wait too long at the airport. Each staffer's wait time was simply the difference in arrival times between the first and last camper he/she picked up.

Luckily, all of the staffers have access to arbitrarily large shuttle buses! But, in addition to wanting to minimize their wait time at the airport, none of the staffers want to make more than one airport run.

Given the number of SI@UCF staffers, as well as the arrival times of each camper flying into Orlando International Airport, determine the minimum amount of time, T, in minutes, such that no staffer will have to wait more than T minutes.

Input

The first line of input contains two space separated positive integers: ***n*** ($n \leq 10^5$), and ***k*** ($k \leq n$), where ***n*** represents the number of campers flying into the airport and ***k*** represents the number of staffers. The second line of input contains the ***n*** arrival times, in minutes, separated by spaces, of each camper. Each of these arrival times will be positive integers less than or equal to 10^9.

Output

On a single line by itself, output the minimum number of minutes T, such that no staffer waits more than T minutes, no staffer takes more than one trip, and each camper gets picked up.

Samples

campers shuttles

Input	Output
9 3 10 10 30 200 205 210 215 220 500	20
5 2 10 2 16 19 5	8

2,5,10, 16,19

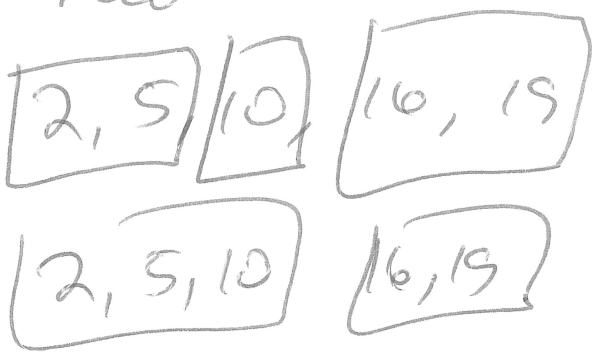
Example #2: Integer binary search

Airport Shuttle

Hard to know whether it's good to wait for the next kid!

10, 10, 30, ?

But If I know how long I'm willing to wait, it's easy to calculate # shuttles I'll need



t = 5 min
need 3 shuttles

t = 10 min
need 2 shuttles

$5 < \text{realans} \leq 10$

Int binary search because ans must be an int (all arrivals are at int times, ans must be a difference of 2 of these #s)

low = 6
high = 10

Int Binary Search Advice

1) while loop (low <= high) or
   (low < high)

2) mid = (low+high)/2 OR
   = (low+high+1)/2
   Problem Specific.

I plug in low=2, high=3 and try both possibilities of the if stmt.
→ if you still get low=2, high=3 BAD
Should get either low=2, high=2 OR
low=3, high=3.

Pay attention!

3) depending on the problem, you might want
   low = mid or low = mid+1
   high = mid or high = mid-1.