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ĐẠI HỌC BÁCH KHOA HÀ NỘI

HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

ONE LOVE. ONE FUTURE.

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C BASIC

BINARY SEARCH

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CONTENT

- Binary search
- Checking the existence (P.06.13.01)
- Pairs of numbers with a given sum (P.06.13.02)

BINARY SEARCH

- Given a sequence $a_1, a_2, \ldots, a_n$ in non-decreasing order. Given k, find i such that $a_i = k$.
- Binary search
  - Consider the mid element a_m with $m = (1+n)/2$
  - If $a_m = k$ then return m
  - If $a_m < k$ then do binary search in $a_{m+1}, a_{m+2}, \ldots, a_n$
  - Otherwise, do binary search in $a_1, a_2, \ldots, a_{m-1}$.

```
bSearch(a[1..n], L, R, k){
  if L > R then return -1; // not found
  if L = R then {
     if a[L] = k then return L; else return -1;
  }
  m = (L+R)/2;
  if a[m] = k then return m;
  if a[m] < k then return bSearch(a[1..n], m+1, R, k);
  else return bSearch(a[1..n], L, m-1, k);
}
```

CHECKING THE EXISTENCE (P.06.13.01)

- Given a sequence $a_1, a_2, \ldots, a_n$. Perform the queries with the form:
  - check k: return 1 if k appears in the given sequence, otherwise return 0
- Data
  - Line 1: a positive integer n ($1 <= n <= 100000$)
  - Line 2: $a_1, a_2, \ldots, a_n$ where ($1 <= a_i <= 1000000$)
  - Next lines, each line a query with the above form
  - Input data ends with a line "#"
- Result
  - Each line corresponds to a query in the input data

stdin	stdout
5 1 3 3 3 4 check 3 check 3 check 10 check 5 check 8 #	1 1 0 0 0

CHECKING THE EXISTENCE - PSEUDOCODE

- Algorithm
  - Sort $a_1, a_2, \ldots, a_n$ in non-decreasing order
  - For each query check k: do binary search for k in the sorted sequence.

```
Run() {
  read a[1..n] from the stdin;
  sort(a[1..n]) in a non-decreasing order;
  while true do {
     cmd = read a string from stdin;
     if cmd = "#" then break;
     if cmd = "check" then {
        k = read an integer from stdin;
        i = bSearch(a[1..n], 1, n, k);
        if i > -1 then write(1); else write(0);
     }
  }
}
```

PAIRS OF NUMBERS WITH A GIVEN SUM (P.06.13.02)

- Given a sequence $a_1, a_2, \ldots, a_n$ and a value Q. Counting the number M of pairs of indices (i, j) such that $1 <= i < j <= n$ vào $a_i + a_j = Q$.
- Data
  - Line 1: Two positive integers n and Q ($1 <= n, Q <= 1000000$)
  - Line 2: A sequence $a_1, a_2, \ldots, a_n$ where ($1 <= a_i <= 1000000$)
- Result
  - Write out M

stdin	stdout
5 8 4 6 5 3 2	2

PAIRS OF NUMBERS WITH A GIVEN SUM - PSEUDOCODE

- Algorithm
  - Sort the sequence $a_1, a_2, \ldots, a_n$ in non-decreasing order
  - Iterate the sequence from left to right, for each index i, do binary search for $Q - a_i$ in $a_{i+1}, a_{i+2}, \ldots, a_n$.

```
Run() {
  read a[1..n] and Q from the stdin;
  sort(a[1..n]) in a non-decreasing order;
  cnt = 0;
  for i = 1 to n-1 do {
    idx = bSearch(a[1..n], i+1, n, Q – a[i]);
    if idx > 0 then
      cnt = cnt + 1;
  }
  write(cnt);
}
```

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THANK YOU !