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## Indian National Olympiad in Informatics, 2003

### Solution to Question 1, Chambers in a Castle

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- **The idea**

Initially, all non wall squares are marked 0. As we visit rooms, we convert squares from 0 to 1. We maintain two variables, one to keep track of the number of chambers. and one to keep track of the size of the largest chamber.

Scan the floor plan of the castle from top to bottom, left to right. Each time you see a square marked 0, this is a new chamber. Increment the number of chambers. Recursively explore the neighbourhood of this chamber, determine its size and update the maximum size seen so far, if necessary.

- [A C program for this problem](#)
- Some test inputs ...
  - [Input 1](#)
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- [Input 4](#)
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- ... and corresponding outputs
  - [Output 1](#)
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```

#include<stdio.h>

void explore(int x, int y, int *size); /* Recursively explores rooms */

int castle[500][500]; /* Declare castle globally to avoid passing it
                        around */
int rows, cols;      /* Actual number of rows and columns in use */

int main(){
    int i, j;
    int chambers;    /* Number of chambers */
    int size, maxsize; /* Size of current chamber and maximum size of
                        chamber so far */

    /* Get input */

    /* Rows and columns */

    scanf("%d %d",&rows,&cols);

    /* Castle floor plan */

    for (i = 0; i < rows; i++){
        for (j = 0; j < cols; j++){
            scanf("%d",&castle[i][j]);
        }
    }

    /* Initialize number of chambers, size */

    chambers = 0;
    maxsize = 0;

    /* Scan castle floor plan */

    for (i = 0; i < rows; i++){
        for (j = 0; j < cols; j++){

            /* Each time we find an unexplored square ... */

            if (castle[i][j] == 0){
                chambers++; /* ... it is a new chamber ... */
            }
        }
    }
}

```

```

size = 0;
explore(i,j,&size); /* ... map it out and compute its size */
if (size > maxsize){
    maxsize = size; /* Update maximum size, if necessary */
}
}
}
}
}

```

```
/* Output */
```

```
printf("%d\n%d\n",chambers,maxsize);
}

```

```
/* Recursively explore rooms */
```

```
void explore(int x, int y, int *size){
```

```

if (castle[x][y] != 0){ /* A square marked 1 has already been */
    return; /* visited and counted earlier */
}

```

```
}
```

```

castle[x][y] = 1; /* Mark this square */
(*size)++; /* Increment the size of the chamber */

```

```
/* Recursively explore all four neighbours of this square. Check
for boundary conditions. */
```

```

if (x > 0){
    explore(x-1,y,size);
}

```

```

if (y < cols-1){
    explore(x,y+1,size);
}

```

```

if (x < rows-1){
    explore(x+1,y,size);
}

```

```

if (y > 0){
    explore(x,y-1,size);
}

```

}

}

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## Indian National Olympiad in Informatics, 2003

### Solution to Question 2, Nearest fraction

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- **The naive solution**

For each input fraction  $a/b$ , we keep track of the largest fraction below  $a/b$  and the smallest fraction above  $a/b$  that we have seen so far. Initially, these values are  $1/99$  and  $98/99$ .

In a loop, we generate all possible fractions  $i/j$ . If the fraction is proper, we check whether it lies above or below the current input  $a/b$ . If it beats the current nearest fraction in that direction, we update the value of the nearest fraction.

Notice that solution cycles through the entire set of fractions for each input.

- **A smarter solution**

We generate the entire set of proper fractions in the range given and sort them in ascending order.

For each input fraction, we use binary search on the sorted list to find the pair of fractions that are

nearest to it.

- **Some general tips**

The fractions should always be stored and compared in terms of their integer numerators and denominators, rather than being compared as floating point numbers, to avoid errors due to loss of precision.

- [A C program for the exhaustive solution to the problem](#)
- [A C program for the solution using sorting and searching](#)
- Some test inputs ...
  - [Input 1](#)
  - [Input 2](#)
  - [Input 3](#)
  - [Input 4](#)
  - [Input 5](#)
  - [Input 6](#)
  - [Input 7](#)
  - [Input 8](#)
  - [Input 9](#)
  - [Input 10](#)
- ... and corresponding outputs
  - [Output 1](#)
  - [Output 2](#)
  - [Output 3](#)
  - [Output 4](#)
  - [Output 5](#)
  - [Output 6](#)
  - [Output 7](#)
  - [Output 8](#)
  - [Output 9](#)
  - [Output 10](#)

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```

#include<stdio.h>

int gcd(int a, int b); /* Return gcd(a,b) */

int compare(int a, int b, int x, int y); /* Compare fractions a/b and x/y.
    Return -1 if a/b < x/y,
        0 if a/b == x/y,
        1 if a/b > x/y
    */

int main(){

    int i, j, k;
    int len, n, d;
    int result;
    int lowern, lowerd, uppern, upperd;

    /* Read length of input sequence */
    scanf("%d",&len);

    /* For each input fraction */
    for (k = 0; k < len; k++){
        scanf("%d %d",&n,&d);

        /* Set bracketing pair to 1/99 and 98/99 */

        lowern = 1;
        lowerd = 99;
        uppern = 98;
        upperd = 99;

        /* Generate all proper fractions 0 < n/d < 1 with 0 < d <= 99 and
            retain if it is better than one of the current bracketing
            pair */

        for (j = 1; j < 100; j++){
            for (i = 1; i < j; i++){
                if (gcd(i,j) == 1){
                    result = compare(n,d,i,j);
                }
            }
        }
    }
}

```

```

if (result < 0){ // New fraction lies above n/d
    result = compare(i,j,uppern,upperd);
    if (result < 0){ // If i/j < uppern/upperd
        uppern = i; // update uppern/upperd = i/j
        upperd = j;
    }
}else{
    if (result > 0){ // New fraction lies below n/d
        result = compare(lowern,lowerd,i,j);
        if (result < 0){ // If i/j > lowern/lowerd
            lowern = i; // update lowern/lowerd = i/j
            lowerd = j;
        }
    }
}
}
}
}

/* Print output */

printf("%d %d %d %d\n",lowern,lowerd,uppern,upperd);

}

}

/* Auxiliary functions defined below */

/* gcd */

int gcd(int a, int b){
    if (a == b){
        return a;
    }

    if (a < b){
        return gcd(a,b-a);
    }else{
        return gcd(b,a-b);
    }
}
}

```



```
/* comparing two fractions */
```

```
int compare(int a, int b, int x, int y){  
    if (a*y == b*x) { return 0; }  
    if (a*y < b*x) {return -1; }  
    return 1;  
}
```

```

#include<stdio.h>

int gcd(int a, int b); /* Return gcd(a,b) */

int compare(int a, int b, int x, int y); /* Compare fractions a/b and x/y.
    Return -1 if a/b < x/y,
        0 if a/b == x/y,
        1 if a/b > x/y
    */

void qsort(int *a, int *b,
    int lower, int upper); /* Interpret a as an array of
    numerators, b as an array of
    denominators. Use quicksort to order
    the resulting fractions in range
    lower <= index < upper in ascending order
    */

int bsearch(int *a, int *b,
    int lower, int upper,
    int n, int d); /* Binary search for n/d in the sorted
    arrays a and b of numerators
    and denominators */

int swap(int *a, int *b,
    int i, int j); /* Swap a[i],b[i] with a[j],b[j] */

int main(){

    int i, j, k;
    int num[10000],denom[10000];
    int len, n, d;
    int pos;

    k = 0;

    /* Generate all proper fractions 0 < n/d < 1 with 0 < d <= 99
    and store numerators/denominators in arrays num and denom */

    for (j = 1; j < 100; j++){
        for (i = 1; i < j; i++){
            if (gcd(i,j) == 1){

```

```
    num[k] = i;
    denom[k] = j;
    k++;
}
}
}

/* Sort the fractions using quicksort */
qsort(num,denom,0,k);

/* Read length of input sequence */
scanf("%d",&len);

/* For each input fraction */
for (i = 0; i < len; i++){
    scanf("%d %d",&n,&d);

    /* Find the bracketing pair using binary search and print it out */
    pos = bsearch(num,denom,0,k-1,n,d);
    printf("%d %d %d %d\n",num[pos],denom[pos],num[pos+1],denom[pos+1]);
}
}

/* Auxiliary functions defined below */

/* gcd */

int gcd(int a, int b){
    if (a == b){
        return a;
    }

    if (a < b){
        return gcd(a,b-a);
    }else{
        return gcd(b,a-b);
    }
}

/* comparing two fractions */
```

```
int compare(int a, int b, int x, int y){
    if (a*y == b*x) { return 0; }
    if (a*y < b*x) {return -1; }
    return 1;
}

/* swapping a pair of fractions */

int swap(int *a, int *b, int i, int j){

    int temp1, temp2;

    temp1 = a[i];
    temp2 = b[i];

    a[i] = a[j];
    b[i] = b[j];

    a[j] = temp1;
    b[j] = temp2;
}

/* Quick sort */

void qsort(int *a, int *b, int lower, int upper){
    int boundary = lower+1;
    int limit = lower+1;
    int result;

    if ((upper-lower) <= 1){
        return;
    }

    while(limit < upper){
        result = compare(a[limit],b[limit],a[lower],b[lower]);

        if (result < 0){
            swap(a,b,boundary,limit);
            boundary++;
            limit++;
        }else{
            limit++;
        }
    }
}
```

```
}
```

```
swap(a,b,lower,boundary-1);
```

```
qsort(a,b,lower,boundary-1);
```

```
qsort(a,b,boundary,upper);
```

```
}
```

```
/* Binary search */
```

```
int bsearch(int *a, int *b, int lower, int upper, int n, int d){
```

```
    int midpos;
```

```
    int result;
```

```
    if (upper < lower) {return upper;}
```

```
    midpos = (upper + lower)/2;
```

```
    result = compare(a[midpos],b[midpos],n,d);
```

```
    if (result == 0){
```

```
        return midpos;
```

```
    }
```

```
    if (result > 0){
```

```
        return bsearch(a,b,lower,midpos-1,n,d);
```

```
    }else{
```

```
        return bsearch(a,b,midpos+1,upper,n,d);
```

```
    }
```

```
}
```

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329801	457151
259151	372829
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265579	504307
232333	326063
321319	494749
365969	464467
315251	392131
229699	455237
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363967	474533
240853	458401
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360901	430499
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322229	488009
292693	502613

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357239	417317
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401329	473647
248879	450719
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300967	451709
356197	495589
310021	413087
240101	276779
384751	430783
391961	444113
380147	436181
294563	409397
335383	397549
264127	358859
270799	452539
281717	440171
325421	363901
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399491	458611
402593	447509

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