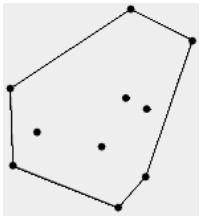
Problem 19: Convex Hull[1]



Source filename:	`convex.(cpp|java)`
Input filename:	`convex.in`
Output filename:	`convex.out`

A set of points on the plane is called **convex** if for any two points P and Q in the set, the entire line segment with the end points at P and Q belongs to the set. The **convex hull** of a set S of points in the plane is the smallest convex set containing S.

It can be shown that the convex hull of any set of $n > 2$ points (not all on the same line) is a convex polygon with the vertices at some of the points of S. (If all the points do lie on the same line, the polygon degenerates to a line segment but still with the end points at two points of S.)

The **convex-hull problem** is the problem of constructing the convex hull for a given set S of *n* points in the plane. To solve it, one needs to find the points that will serve as the vertices of the convex set. These vertices are called "extreme points". By definition, an **extreme point** of a convex set is a point of this set that is not a middle point of any line segment with end points in the set.

Given a set of *n* points (x & y-coordinates), find the extreme points of the convex hull.

The first line in the input file will contain an integer, $2 < n <= 10{,}000$. The next *n* lines will each contain 2 floating point values, *x* and *y* ($-1{,}000.0 <= x <= 1{,}000.0$ and $-1{,}000.0 <= y <= 1{,}000.0$), separated by a single space that represent the x-coordinate and y-coordinate of a point in the set S. Following the n^{th} point, the file may contain another set of points preceded by an integer, $2 < n <= 10{,}000$, which represents the number of points in the next set. The end-of-file is indicated by a value of 0 for *n*.

For each of points in the input file, the output file should list the extreme points of the convex hull. The output of the extreme points should be ordered with the left-most extreme point listed first. If more than one point has the same minimum x-coordinate, start with the one with the smallest y-coordinate. The rest of the extreme points should be listed in clockwise order.

Sample Input File

```
3
0.0 0.0
0.0 1.0
1.1 1.0
8
0.0 0.0
1.0 1.0
3.0 3.0
1.0 -4.0
0.0 3.0
-3.0 -3.0
-1.0 1.0
-3.0 2.0
0
```

Sample Output File

```
Set #1: (0.0,0.0) (0.0,1.0) (1.0,1.0)
Set #2: (-3.0,-3.0) (-3.0,2.0) (0.0,3.0) (3.0,3.0) (1.0,-4.0)
```

[1] The definitions and descriptions for this problem are found in chapters 3 and 4 of The Design & Analysis of Algorithms, by Anany Levitin.