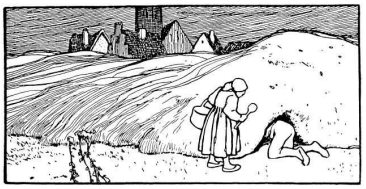
Problem D: Delicious Disaster

Time limit: 1 second

THE little girl Dana lives alone with her mother. They are not able to afford enough food, so the girl needs to go begging. An old woman gifts her a magic pot that starts cooking delicious, sweet porridge whenever the phrase "Cook, little pot, cook!" is uttered. All that is needed to end cooking is the phrase "Stop, little pot!".



Residents eat their way through the mound of porridge.
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Dana shows the pot to her mother, makes it start cooking using the magic phrase and leaves to go into town. However, she forgets to tell her mother the phrase needed to stop cooking, so now the pot keeps producing more and more porridge, and has enveloped the girl's home, as well as some of the surrounding homes.

The surroundings of Dana's home are modelled as an infinite grid of cells, with the girl's home located in cell $(0, 0)$. At any time, the porridge occupies all the cells that are at most r steps away from the girl's home when moving in the four cardinal directions.

Dana's mother has left the pot unattended for a while and now wants to figure out how far the porridge has spread. In other words, she wants to figure out r, the size of the porridge. She will shout out to people in the neighbourhood, asking them whether their houses are already surrounded by the porridge. Her shouting can only be heard in houses that are at most 1000 steps away, but she can find out the status of houses at a greater distance by arranging a relay of messages, where a group of people shout the message from one person to the next, with each two consecutive locations in the chain at most 1000 steps apart.

Formally, this means that her first question can be any location (x_1, y_1) such that $|x_1| + |y_1| \leq 1000$, her second question can be any location (x_2, y_2) such that $|x_2 - x_1| + |y_2 - y_1| \leq 1000$, her third question can be any location (x_3, y_3) such that $|x_3 - x_2| + |y_3 - y_2| \leq 1000$, and so on.

How can she coordinate the relays of messages in order to find out the size of the porridge while using at most 5000 questions? The current size r of the porridge is at most 10^6. However, the porridge keeps growing while questions are asked, and before every question, the porridge spreads by 1 step in every direction. An example of this process can be seen in Figure D.1.

Interaction

This is an interactive problem. Your submission will be run against an *interactor*, which reads from the standard output of your submission and writes to the standard input of your submission.

The interaction proceeds in rounds. In the kth round, you ask a query of the form "`?` x_k y_k", where (x_k, y_k) are the coordinates of the cell you want to ask about, subject to the rules described above. The interactor will respond with "`in`" if this cell is taken over by the porridge, and "`out`" otherwise. Formally, the porridge has an initial size of r_0 ($0 \leq r_0 \leq 10^6$) that is unknown to you, and the answer will be "`in`" if and only if $|x_k| + |y_k| \leq r_0 + k$.

Once you know the size of the porridge, you should output "`!` r", where r is the *current* size of the porridge. It is guaranteed that the size of the porridge does not change between your last '`?`' query and your '`!`' query. The interaction then ends and your program must exit.

You may send at most 5000 queries of type '`?`'.

After every request you should *flush* the standard output to ensure that the request is sent to the interactor. For example, you can use `fflush(stdout)` in C++, `System.out.flush()` in Java, `sys.stdout.flush()` in Python, and `hFlush stdout` in Haskell.

A testing tool is provided to help you develop your solution.

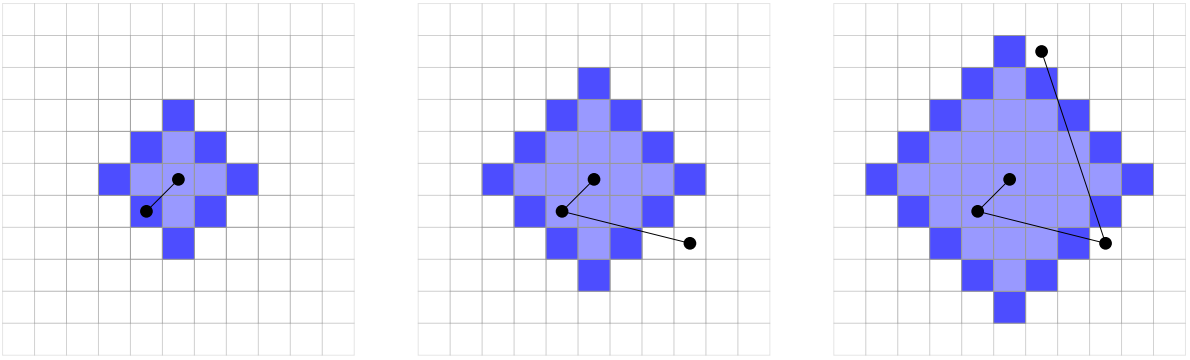

Figure D.1: Illustration of Sample Interaction 1. Initially, the size of the porridge is $r = 1$. Before the first query, this increases to $r = 2$, so the response to that query is "`in`", as can be seen in the left image. The other two images show the remaining two queries, where the light blue cells show the extent of the porridge before it grows, the dark blue cells are those that become swallowed as it grows, and the chain of connected dots corresponds to the relay of messages. The final size of the porridge is $r = 4$, which can be shown to be the only size consistent with the query responses.

Read	Sample Interaction 1	Write
	`? -1 -1`	
`in`		
	`? 3 -2`	
`out`		
	`? 1 4`	
`out`		
	`! 4`	

Read	Sample Interaction 2	Write
	`? 500 500`	
`in`		
	`? 1500 500`	
`in`		
	`? 2000 304`	
`out`		
	`? 2000 304`	
`in`		
	`! 2304`	