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The Song of Ducks and Dragons [2025]

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Quest 2: From Complex to Clarity

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Part I

> **Story section**
>
> You awaken on a bed of ash, still wrapped in the warmth of the dying embers.
>
> You don't know how long you have slept, nor why instinct has led you here. As dawn stirs the world to life, you sense another presence. A man stands in the doorway, watching you with a mix of surprise and caution. He is tall and broad-shouldered, his hands bearing the marks of years spent working with fire and steel. In one hand, he grips a hammer, unsure whether you are a friend or a foe.
>
> You lift your gaze, meeting his with coal-black eyes, glinting with flecks of gold like smouldering embers. A brief moment passes before a small smile forms on both your faces; a silent agreement of peace.
>
> "Friend?" The sound that escapes your beak surprises both you and the blacksmith. After a moment's pause, he nods.
>
> "Yes, friend. Looks like we both have many questions." He gestures toward a sturdy wooden table in the corner. "But first… breakfast, wouldn't you agree?"
>
> As you eat, the blacksmith explains he found you on his doorstep last night, left without any message or clue as to where you came from. He offers to help you find your home, but first, he must complete an urgent order for a knight who passed through the village a few days ago.
>
> You offer to help. The blacksmith smiles - after all, he has spent his whole life mastering his craft, while you have only just hatched from your egg. Still, he humours you and hands you a set of instructions by the knight.

The first page of the instructions describes a series of mathematical operations involving numbers called "complex". However, you don't find them complex at all. Interestingly, you grasp the formulas instantly, as if they were instinctive. Each "complex" number consists of a pair of integers, X and Y, written in square brackets as `[X,Y]`. These numbers can be added, multiplied, and divided, with the result always being another "complex" number.

To add two "complex" numbers, simply sum the X and Y values separately, following this formula:

```
[X1,Y1] + [X2,Y2] = [X1 + X2, Y1 + Y2]
```

A few examples of addition:
```
[1,1] + [2,2] = [1 + 2, 1 + 2] = [3,3]
[2,5] + [3,7] = [2 + 3, 5 + 7] = [5,12]
[-2,5] + [10,-1] = [-2 + 10, 5 + -1] = [8,4]
[-1,-2] + [-3,-4] = [-1 + -3, -2 + -4] = [-4,-6]
```

Multiplying two "complex" numbers follows a slightly more advanced formula:

```
[X1,Y1] * [X2,Y2] = [X1 * X2 - Y1 * Y2, X1 * Y2 + Y1 * X2]
```

Some examples of multiplication:
```
[1,1] * [2,2] = [1 * 2 - 1 * 2, 1 * 2 + 1 * 2] = [2 - 2, 2 + 2] = [0,4]
[2,5] * [3,7] = [2 * 3 - 5 * 7, 2 * 7 + 5 * 3] = [6 - 35, 14 + 15] = [-29,29]
[-2,5] * [10,-1] = [-2 * 10 - 5 * -1, -2 * -1 + 5 * 10] = [-20 + 5, 2 + 50] = [-15,52]
[-1,-2] * [-3,-4] = [-1 * -3 - -2 * -4, -1 * -4 + -2 * -3] = [3 - 8, 4 + 6] = [-5,10]
```

Dividing two "complex" numbers involves dividing both X and Y pairs while ignoring the division rest. This means that when performing the division, we focus solely on the integer parts of each number, ignoring (not rounding!) any fractional components that might arise.

```
[X1,Y1] / [X2,Y2] = [X1 / X2, Y1 / Y2]
```

Some examples of division:
```
[10,12] / [2,2] = [10 / 2, 12 / 2] = [5,6]
[11,12] / [3,5] = [11 / 3, 12 / 5] = [3,2]
[−10,−12] / [2,2] = [−10 / 2, −12 / 2] = [−5,−6]
[−11,−12] / [3,5] = [−11 / 3, −12 / 5] = [−3,−2]
```

To ensure you understand these calculations correctly, the instructions provide a sample number, referred to as: `A`
(your notes), along with a sequence of operations to perform on it.

Begin by setting the result to `[0,0]`. Then, complete three cycles of the following operations:

- Multiply the result by itself.
- Divide the result by `[10,10]`.
- Add `A` to the result.

After three cycles, the final result is your answer.

Example based on the following notes:
`A=[25,9]`

Here are the steps of the calculation, with the result stored as R:
```
R = [0,0]

Cycle I
R = R * R = [0,0]
R = R / [10,10] = [0,0]
R = R + A = [25,9]

Cycle II
R = R * R = [544,450]
R = R / [10,10] = [54,45]
R = R + A = [79,54]

Cycle III
R = R * R = [3325,8532]
R = R / [10,10] = [332,853]
R = R + A = [357,862]
```
The final result is: `[357,862]`.

What number will you get at the end of the process?
The answer is a "complex" number, written in square brackets as [X,Y] without any spaces.

Your notes for this part:

📋 Copy   🗗 Open   ⬇ Download

Part 1 solved with answer: [464987,999294]
⚙ Check your progress ⚙

Part II

The blacksmith is astonished by how effortlessly you calculate the correct result in your head, without the need for notes or working anything out on paper. His kind smile shifts into one of admiration for your remarkable talent.

The knight's request is to engrave a specific symbol onto his breastplate. The more precise the engraving, the greater the payment for the work, so it is worth experimenting with the engraving plan before beginning. However, the symbol is not given directly but as a series of calculations involving "complex" numbers. We interpret the X and Y values of these numbers as the coordinates of the points that will form the symbol on the breastplate.

The engraving should cover a square grid on the breastplate. The order includes a specific "complex" number `A` (your notes), which defines the coordinates of the first point (the top-left corner) of the grid. To determine the coordinates of the final point (the bottom-right corner), you simply add `[1000,1000]` to `A`. The remaining points depend on how finely the blacksmith decides to divide the grid, but they have to be at equal distances from each other both horizontally and vertically.

Each point on the breastplate may or may not be engraved. To determine whether a point should be engraved, follow this rules:
Initialise the check result as `[0,0]`. Then perform `100` cycles of the following steps:

- Multiply the result by itself.
- Divide the result by `[100000,100000]`.
- Add the coordinates of the point under examination.

If at the end of any of the 100 cycles the X or Y coordinate of the result exceeds `1000000` or falls below `-1000000`, that point will not be engraved. If we complete all 100 cycles without exceeding this range, we should engrave the point.

The blacksmith must decide how many points he can calculate and engrave while still completing the knight's order in time. His plan is to divide the area into a 101x101 grid, meaning he needs to check 10201 points. However, he has not yet finished all the calculations and is unsure whether the symbol will be distinct enough.

Numbers begin to swirl in your mind, and within moments, you see the planned symbol glowing faintly on the breastplate - just like the markings on your egg. You pick up a small piece of charcoal from the forge and sketch the 101x101 grid onto the breastplate, marking the cells where engraving will be needed.

Example based on the following notes:

`A=[35300,-64910]`

The first step is to calculate the coordinates of the opposite corner:

`A + [1000,1000] = [36300,-63910]`

The area is then divided into a 101x101 grid of equally distanced points.
The coordinates of the first five points in the first row are:

`[35300,-64910], [35310,-64910], [35320,-64910], [35330,-64910], [35340,-64910]`

The coordinates of the last five points in the last row are:

`[36260,-63910], [36270,-63910], [36280,-63910], [36290,-63910], [36300,-63910]`

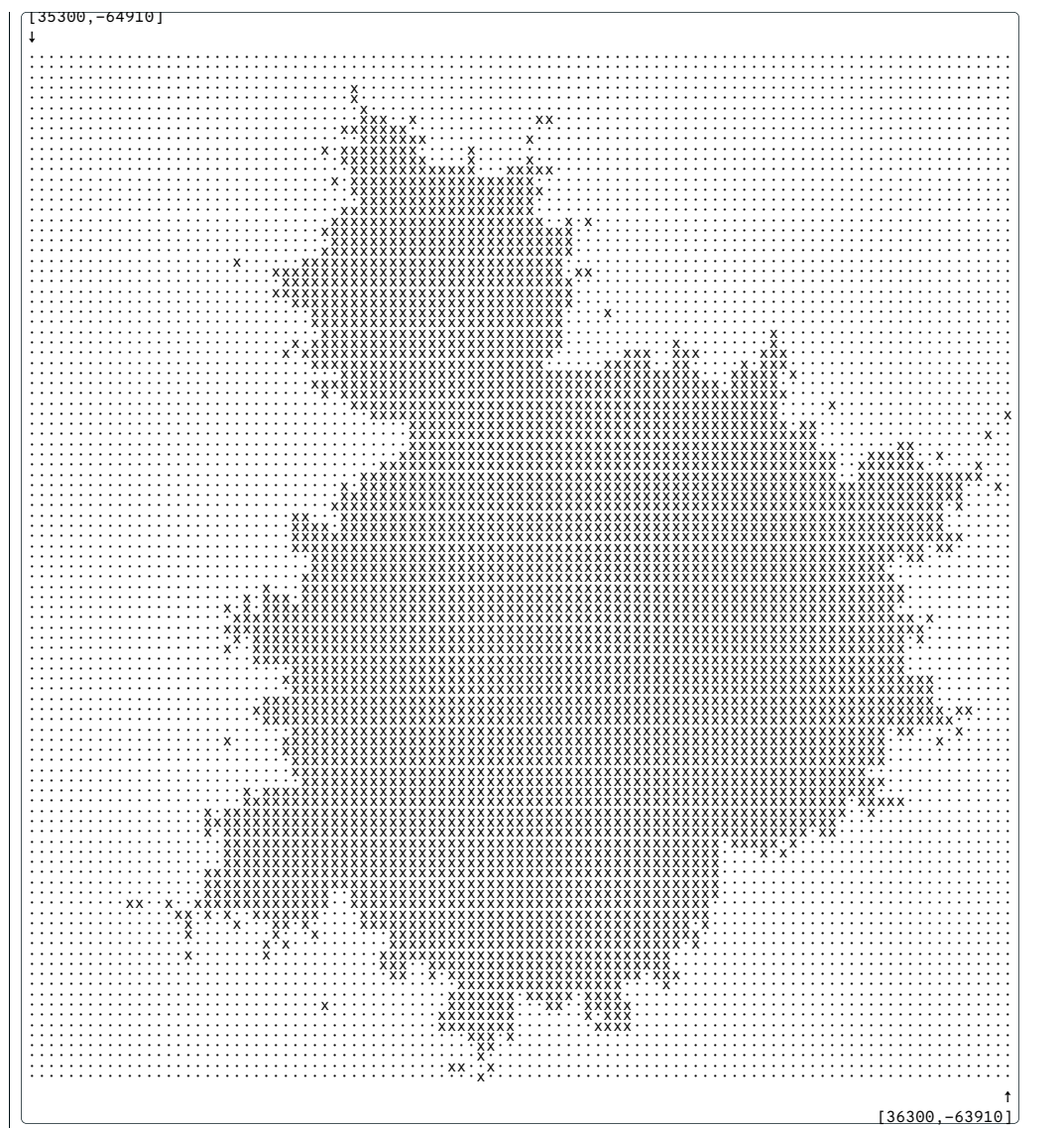Each point is then verified to determine if it should be engraved or not.
Below you can find a few examples of points `P` that should be engraved, along with their results `R` after completing all 100 calculation cycles:

```
P=[35630,-64880]    R=[-2520,-5355]
P=[35630,-64870]    R=[5021,6454]
P=[35640,-64860]    R=[-3291,-684]
P=[36230,-64270]    R=[-7266,3234]
P=[36250,-64270]    R=[162903,-679762]
```

A few examples of points `P` that are NOT be engraved, with their results `R` and the cycles `C` in which the limit `±1000000` was exceeded:

```
P=[35460, -64910]    R=[1265017, 932533]      C=27
P=[35470, -64910]    R=[-1724836, 19302]      C=28
P=[35480, -64910]    R=[-575306, 8705296]     C=30
P=[35680, -64850]    R=[-7919169, 5303832]    C=95
P=[35630, -64830]    R=[-6387697, -1621945]   C=100
```

For this example, the total number of engraved points is `4076` and the whole engraving is shown below. The first and the last points are additionally marked with arrows.

How many points will be engraved according to the blacksmith's plan?

Your notes for this part:

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Part 2 solved with answer: 1138

Check your progress

Part III

The symbol is too faint to be clearly visible, but you offer the blacksmith a solution. You can quickly calculate a far more detailed 1001x1001 grid and map it onto the breastplate. The smaller points will actually be easier to engrave, and with the time saved on calculations, the plan should work.

Just to be certain, the blacksmith asks you to determine exactly how many points will need engraving so he can assess whether he is capable of completing such a task.

Example based on the following notes:

    A=[35300,−64910]

After increasing the precision of the symbol to a 1001x1001 grid, the total number of engraved points for the same example as in Part II is ⌷ 406954 ⌷.

What is the number of points you plan to engrave?

Your notes for this part:

Copy   Open   Download

Part 3 solved with answer: 111136
Check your progress

Puzzle solved! Don't stop now!

Post your solution, compare ideas, and help others grow on Reddit