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The Song of Ducks and Dragons [2025]

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Quest 11: The Scout Duck Protocol

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Part I

> **Story section**
>
> As the winner of the Dragon Chess Tournament, you stand before the Grand Bytefather, the wisest of the sages at the Stacktrace Sanctuary. His long robes are adorned with golden patterns, and his gaze is full of wisdom and calm. When you speak of your lineage and recount your story, the Grand Bytefather pauses in thought.
>
> - Your skills are truly remarkable. You possess more than just talent. You have the determination and instinct that lead you to the truth.
>
> The Bytefather furrows his brow in concern.
>
> - For some time now, we have been receiving troubling reports. Nerdmasters from across the land of Algorithmia report that the dragonducks... have vanished. Overnight, entire families have disappeared without any trace. The Sanctuary cannot ignore this. We are sending scouts to search the entire kingdom.
>
> With these words, the Bytefather gestures toward the courtyard outside the window. You see ranks of ducks preparing to take flight. The rustle of their wings fills the square, and their formations are almost hypnotic.
>
> - I'll fly with them! - you declare with determination.
>
> - Your wings are not yet fully developed. If you wish to go, you must first learn to fly like a scout. These ducks fly in a special formation that helps conserve energy over long distances, but if you managed to conquer Dragon Chess, you'll surely grasp these rules quickly.

At the start of the flight, the ducks group randomly in columns. The number of scout ducks in the flock is always perfectly divisible by the number of columns. Each column, initially may contain a different number of ducks. Then, the entire flock performs a series of exchange rounds until every column has the same number of ducks. Their method is highly inefficient, but don't even try to explain that to them. Scout ducks value it as a time-honoured tradition that also entertains them during flight.

The whole procedure consists of two phases.

In the first phase, each column of ducks checks whether the next column has fewer birds. If so, one duck moves to the next column. In a single round of this phase, the first column checks the second, then the second checks the third, and so on. After the last pair of columns is checked, the next round begins with the first column comparing with the second again. This phase continues until no more ducks can move.

In the second phase, each column of ducks checks whether the next column has more birds. If so, one duck moves from the column with more birds to the one with fewer. This phase also continues until no more moves are possible, and it never goes back to the first phase.

Unbelievably, at the end of this process, the ducks are perfectly balanced across all columns.

It's best if I show you an example from the scout duck manual. It contains a setup with an initial count of ducks per column (your notes), and the flock's checksum after each round. The flock checksum is the sum of the number of ducks in each column, each multiplied by the column number, starting from 1. Try simulating the process and calculate the checksum of the flock after `10` rounds.

> Example based on the following notes:

```
9
1
1
4
9
6
```

The example above can be visualised as columns of ducks, numbered from 1 to 6. Each duck is represented as a [*].

```
1 2 3 4 5 6
* * * * * *
*     * * *
*     * * *
*     * * *
*       * *
*       * *
*       *
*       *
*       *
```

Below is a diagram of the first round of the first phase with square brackets [[]] showing which columns were compared. The moved duck is additionally marked as [(*)].

```
Step 1 [1,2]    Step 2 [2,3]    Step 3 [3,4]    Step 4 [4,5]    Step 5 [5,6]
 1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6
 * * * * * *     * * * * * *     * * * * * *     * * * * * *     * * * * * *
 *(*)  * * *     *  (*)* * *     *   * * * *     *   * * * *     *   * * * *
 *      * * *    *      * * *    *      * * *    *      * * *    *      * * *
 *      * * *    *      * * *    *      * * *    *      * * *    *      * * *
 *        * *    *        * *    *        * *    *        * *    *        * *
 *        * *    *        * *    *        * *    *        * *    *        * *
 *        *      *        *      *        *      *        *      *      *(*)
 *        *      *        *      *        *      *        *      *        *
          *               *               *               *
```

Not every step resulted in a duck moving. In steps 3 and 4, the target columns had more birds, so no movement happened. The number of birds at the end of this round (per column) is: [8 1 2 4 8 7].

Running simulations for all the rounds of the first phase gives:

```
Round     Birds in columns     Flock checksum
  0          9 1 1 4 9 6          111 = 1 * 9 + 2 * 1 + 3 * 1 + 4 * 4 + 5 * 9 + 6 * 6
  1          8 1 2 4 8 7          114 = 1 * 8 + 2 * 1 + 3 * 2 + 4 * 4 + 5 * 8 + 6 * 7
  2          7 2 2 4 7 8          116 = 1 * 7 + 2 * 2 + 3 * 2 + 4 * 4 + 5 * 7 + 6 * 8
  3          6 2 3 4 7 8          118 = 1 * 6 + 2 * 2 + 3 * 3 + 4 * 4 + 5 * 7 + 6 * 8
  4          5 3 3 4 7 8          119 = 1 * 5 + 2 * 3 + 3 * 3 + 4 * 4 + 5 * 7 + 6 * 8
  5          4 3 4 4 7 8          121 = 1 * 4 + 2 * 3 + 3 * 4 + 4 * 4 + 5 * 7 + 6 * 8
  6          3 4 4 4 7 8          122 = 1 * 3 + 2 * 4 + 3 * 4 + 4 * 4 + 5 * 7 + 6 * 8
```

After round [6], no more moves can be made so the second phase begins.

The first round of the second phase looks like this:

```
After round 6    Step 1 [1,2]    Step 2 [2,3]    Step 3 [3,4]    Step 4 [4,5]    Step 5 [5,6]
 1 2 3 4 5 6      1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6     1 2 3 4 5 6
 * * * * * *      * * * * * *     * * * * * *     * * * * * *     * * * * * *     * * * * * *
 * * * * * *      * * * * * *     * * * * * *     * * * * * *     * * * * * *     * * * * * *
 * * * * * *      * * * * * *     * * * * * *     * * * * * *     * * * * * *     * * * * * *
   * * * * *      (*)  * * * *    *(*)  * * *    * *(*)  * *    * * *(*)* *      * * * * * *
         * *             * *             * *             * *             * *             * *
         * *             * *             * *             * *             * *             * *
         * *             * *             * *             * *             *             (*)*
         *               *               *               *               *
```

At the end of this round, the number of ducks in each column is: [4 4 4 4 7 7].

Running simulations for all the rounds of the second phase gives:

```
Round     Birds in columns     Flock checksum
  6          3 4 4 4 7 8          122
  7          4 4 4 4 7 7          117
  8          4 4 4 5 7 6          115
  9          4 4 5 5 6 6          113
 10          4 5 5 5 6 5          109
 11          5 5 5 5 5 5          105
```

To calculate the flock checksum after [10] rounds, multiply the number of ducks in each column by the column number, then sum the results:

1 * 4 + 2 * 5 + 3 * 5 + 4 * 5 + 5 * 6 + 6 * 5 = [109]

What is the flock checksum after [10] rounds?

Your notes for this part:

📋 Copy   🗗 Open   ⭳ Download

Part 1 solved with answer: 249

⚙ Check your progress ⚙

Part II

To ensure everything is understood, let's review another example from the scout duck manual. For the given initial setup (your notes), find the number of rounds after which the flock is balanced.

Example based on the following notes:

```
9
1
1
4
9
6
```

For the Part I example, the flock is balanced after just [11] rounds.

```
805
706
179
48
158
150
232
885
598
524
423
```

For a slightly more complex example, the columns equalise after [1579] rounds.

The simulation for some of the rounds looks as follows:

Round	Birds in columns
0	805 706 179 48 158 150 232 885 598 524 423
1	804 706 179 49 157 151 232 884 598 524 424
10	795 706 179 58 154 154 232 875 598 524 433
20	785 706 179 68 154 154 232 865 598 524 443
30	775 706 179 78 154 154 232 855 598 524 453
40	765 706 179 88 154 154 232 845 598 524 463
50	755 706 179 98 154 154 232 835 598 524 473
60	745 706 179 108 154 154 232 825 598 524 483
70	735 706 179 118 154 154 232 815 598 524 493
80	725 706 179 128 154 154 232 805 598 524 503
90	715 706 179 138 154 154 232 795 598 524 513
100	706 705 179 148 154 154 232 785 598 524 523
200	656 655 183 184 184 184 232 685 598 573 574
300	606 605 208 209 209 209 232 607 607 608 608
400	556 555 233 233 233 234 234 607 607 608 608
500	506 505 253 253 253 254 254 607 607 608 608
600	456 455 273 273 273 274 274 607 607 608 608
700	406 405 293 293 293 294 294 607 607 608 608
800	356 355 313 313 313 314 314 607 607 608 608
900	331 331 331 331 331 331 331 598 598 598 597
1000	345 345 345 345 345 346 346 573 573 573 572
1100	359 359 359 360 360 360 360 548 548 548 547
1200	373 374 374 374 374 374 374 523 523 523 522
1300	388 388 388 388 388 388 389 498 498 498 497
1400	402 402 402 402 403 403 403 473 473 473 472
1500	416 416 417 417 417 417 417 448 448 448 447
1579	428 428 428 428 428 428 428 428 428 428 428

After how many rounds is the flock balanced across all columns?

Your notes for this part:

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Part 2 solved with answer: 3904455

Check your progress

Part III

You've managed to join the scouts and are flying with them, following all the rules. Along the way, you learn that the whole switching procedure isn't just for entertainment. Visibility during high-altitude flights can be limited, and it's easy to accidentally miss the travel destination.

The initial setup isn't random at all, as the Grand Bytefather had told you. Everything is arranged so that the journey lasts exactly as long as it takes to balance the number of birds in all columns. Thanks to this, no matter the visibility or altitude, the flock knows when it reaches its destination.

You look around the flock to count the current number of birds in each column (your notes). Luckily, you've practised simulating the whole process in Part II, so you can easily calculate the number of rounds left for the flock to be perfectly balanced.

After how many rounds is the flock balanced across all columns?

Your notes for this part:

Copy   Open   Download

Part 3 solved with answer: 131372033718239

Check your progress

Puzzle solved! Don't stop now!

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