

## Coding Fun: Rearranging All The Numbers

In issue 13 there were 8 problems involving sieves on the natural numbers; that is, schemes for extracting various sequences, similar to the Sieve of Eratosthenes for extracting the primes.

One of them was solved by Sanford Greenfarb and by David Ferguson in issue 19. That problem was "rediscovered" and appeared again as Problem 170 in issue 49, with general and specific solutions appearing in issue 51.

The following set of problems involve various ways of rearranging all the natural numbers. The cover diagram is for THROWBACK. For the unending stream of integers starting with 3, each number at the head of the stream (the leader) is to be moved back in the stream the number of places indicated by its value, as shown by the arrows. Eventually, every number will appear at the head of the list. For example, when 10 first appears, there will be this ordering:

10, 5, 3, 4, 7, 11, 6, 8, 12, 9, 13, 14, 15,...

and 14 numbers will have been moved back.

For THROWBACK, then, we have three sub-problems:

1. In order to continue the process until the number 100 first appears as the leader, how many numbers must be considered; that is, how much storage must be allocated for the solution?
2. What will be the ordering when the number 100 first appears as the leader?

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Contributing editors: Richard Andree  
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3. Extend the following table, which shows how many numbers have been moved when the number K first appears as the leader:

K	moves
4	1
5	2
6	3
7	5
8	7
9	10
10	14
11	19
12	26

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(A casual investigation of this function suggests that when K is 100, the number of moves will be around  $10^{12}$ )

Each of the REARRANGING problems forms an excellent exercise in computer coding. If carried to modest limits, each problem fits any computer and can be coded in any language.

In MULTIPLE THROWBACK, take the natural numbers starting with 3. Move the leading number back by its own number of places, as in THROWBACK. At the same time, move every multiple of the leading number back by the same number of places. This is to be done in the order of the multiples; that is, if the leading number is 3, then the numbers 3, 6, 9, 12, 15, ... are all to be moved back three places in that order. Print the new leading number and delete it from the stream. Produce the first 500 leading numbers, a list that begins:

4, 3, 8, 5, 9, 7, 6, 17, 14, 11, 15, 18, ...

After the first stage, the number 4 will be printed, and there will remain:

5, 3, 7, 8, 6, 10, 11, 9, 13, 14, 12, 16, ...

After the second stage, 4 and 3 will be printed, and there will remain:

7, 8, 6, 5, 11, 9, 13, 14, 10, 12, 16, 17, ...



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