**This Cryptography**

 As a young child, you learned important techniques of cryptanalysis. These techniques are so intuitive to you now that they may seem too trivial to be significant. That is typically the case with important discoveries; it often takes a specific stimulus to awaken dormant knowledge learned in a different context than the domain of the problem under study. Have you experienced such "aha!" moments? They usually occur after struggling with a problem for a period of time, and then, seemingly out of nowhere, a flash of insight allows you to connect the dots to reveal a solution.

Can you remember when you developed a perception of time, associating the position of the hands on an analog clock with specific daily events and the passage of time? Suddenly, bed time, play time, snack time, nap time, story time, bath time, etc., were no longer qualitative events; they became fixed to specific times of day. And, slowly, you grasped the quantitative nature of time: lunch at noon, bath at 7:00, story time at 7:30, and lights out at 8:00. These daily benchmarks led to an awareness of elapsed time. Your favorite children's show lasted for an hour, the ride to and from the grocery store was about half an hour, and time out was probably about 15 minutes (at least on the good days). In time, the fun and games were over.

You had to learn to tell time for yourself and do clock arithmetic, which sowed the seeds of the cryptanalytic skills you are about to rediscover. *Eureka!* You have applied modulus math for many years. See, finding the remainder of a division problem can indeed be very helpful!

### Part 1

Finding Time

Example 1: In the clock shown here, the little hand points to 9 and the big hand points to 12. What time is it? What time will it be two hours later? That is not difficult, but select "check prediction" to check your answer.

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### Thinking Outside the Box - Clock Display

A clock starting with the little hand pointing to 9 and the big hand pointing to 12 and ending with the little hand pointing to 11 and the big hand pointing to 12.

Clock arithmetic is straightforward until the big hand goes past 12 in either direction. Adding and subtracting time can be tricky at times.

Example 2: The time shown on this clock is 10 o'clock. What time will it be five hours later? Select "check prediction" to check your answer. How did you arrive at the new time?

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### Thinking Outside the Box - Clock Display

A clock starting with the little hand pointing to 10 and the big hand pointing to 12 and ending with the little hand pointing to 3 and the big hand pointing to 12.

Here are some possible strategies:

* Some people will point to each number on the face of the clock and count five hours past 10 o’clock.
* Others will add 10 and 5, get 15, and recall that 15 o’clock in 24-hour time is 3 o’clock regular time.
* Still others will add 10 and 5, get 15, and know to subtract 12 to give the new time of 3 o’clock in the afternoon.

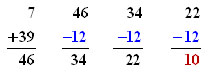
Which technique did you use? Any one will work unless you add (or subtract) more than 12 hours. Then what do you do?

Example 3: This clock shows the time as 7 o'clock. What time will it be 39 hours later? Select "check prediction" to check your answer. What is the most efficient way to arrive at the new time?

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### Thinking Outside the Box - Clock Display

A clock starting with the little hand pointing to 7 and the big hand pointing to 12 and ending with the little hand pointing to 10 and the big hand pointing to 12.

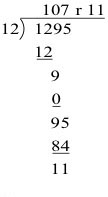


Do you recognize an implied loop in this clock arithmetic algorithm? If the future time is greater than 12, it appears that the clock time can be determined by repeatedly subtracting 12.

Example 4: Let's try a challenge! What time would it be 1,293 hours after 2 o’clock? Before you dull your pencil repeatedly subtracting twelve over and over, think about a way to simplify this problem!

What if you replace repeatedly subtracting with the modulus operator to find the remainder? Then you could find the result of the quantity 2 plus 1293 modulus 12 and have your solution!

To perform the calculation by hand, set up a long division problem.



As the arithmetic is performed, you'll discover the remainder is 11. Remember, there are no decimal points in integer arithmetic.

Using modulus to find the remainder can be very helpful. Try it on the previous examples and see if your results match.

Pretty amazing! The remainders from the arithmetic represent the new time on the clock. You may have just experienced one of those connect the dots, "Eureka!" moments of insight.