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Chinese Remainder Theorem for CAT





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Chinese remainder theorem is useful when the divisor of any number is composite.

Let M be a number which is divided by a divisor N . The theorem states that if N is the divisor which can be expressed as $N = a \cdot b$ where a and b are co-prime

Then,

$$M \bmod N = ar_2x + br_1y$$

$$\text{Here } r_1 = M \bmod a$$

$$\text{And } r_2 = M \bmod b$$

$$\text{Here, } ax + by = 1$$

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Euler's Theorem

Find the remainder when 344^{237} is divided by 119.

In the first look it looks difficult but if one knows the Chinese remainder theorem then question can be solved very easily.

$119 = 17 * 7$, So here $a = 17$ and $b = 7$

$$344^{237} \bmod 17 = 4^{237} \bmod 17 = (4 * 16^{116}) \bmod 17 = 4 * 1 = 4$$

Hence, we get $r_1 = 4$

Now, $344^{237} \bmod 7 = 1^{237} \bmod 7 = 1$, Hence, $r_2 = 1$

We know that $M \bmod N = ar_2x + br_1y$

$$\text{Therefore, } 344^{237} \bmod 119 = 17 * 1x + 7 * 4y = 17x + 28y \quad (1)$$

We know that $17x + 7y = 1$

\Rightarrow We can see that $x = 5$ and $y = -12$ satisfies the above equation.

Hence, putting the values of x and y in equation 1, we get

$$344^{237} \bmod 119 = 17 * 5 - 28 * 12 = 85 - 336 = -251$$

Converting this into positive remainder we get $357 - 251 = 106$

Hence, the required remainder is 106.

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Let's consider another example to understand it better
Find the remainder when 495^{2517} is divided by 78.

In this question also, the divisor is 78 which can be written as 13×6 . So, we can use the Chinese remainder theorem in this question as well.

Let's take $a = 13$ and $b = 6$

$$\begin{aligned} \text{So we can write } 495^{2517} \bmod 78 &= 13r_2x + 6r_1y \\ \Rightarrow r_1 &= 495^{2517} \bmod 13 = 1^{2517} \bmod 13 = 1 \\ \Rightarrow r_2 &= 495^{2517} \bmod 6 = 3^{2517} \bmod 6 = (3^{2516} \bmod 2) \times 3 = 1 \times 3 = 3 \end{aligned}$$

We also know that $13x + 6y = 1$
 $x = 1$ and $y = -2$ satisfies the above equation.

Hence, we can obtain the remainder as
 $495^{2517} \bmod 78 = 13r_2x + 6r_1y = 13 \times 3 \times 1 = 6 \times 1 \times -2 = 39 - 12 = 27$
Hence, the required answer is 27

Thus, we can see that if we are aware of the Chinese remainder theorem then the seemingly difficult questions can be solved with ease. You can practice more such questions from our [CAT Study room](#) to master the topic.

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