Chinese Remainder Theorem Encyclopedia Article

Chinese Remainder Theorem

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Chinese Remainder Theorem

We have an unknown number of things from which, when we count them by threes, we have two left over. If we count them by fives, we have three left over. If we count them by sevens, we have two left over. How many things are there?

The above problem is found in the "Sun Tzu Suan Ching," an early Chinese textbook on **arithmetic** dating from about the third century A.D. The book goes on to solve this particular problem and to give a general recipe to solve problems of this kind, which later acquired the name "Chinese remainder problems." Similar problems and solutions are also found in ancient Indian and Byzantine texts. These problems originated in astronomical questions, in which one is asked to predict the simultaneous occurrence of a number of periodic events with different periods.

More precisely, if one is given two or more **integers** as divisors, which are relatively prime in pairs (such as 3, 5, and 7 in the example from the "Sun Tzu Suan Ching"), and also remainders corresponding to each divisor (such as 2, 3, 2 in the example from the "Sun Tzu Suan Ching"), then the Chinese remainder **theorem** guarantees the existence of an integer which, when divided by the given divisors, leaves the corresponding remainders. Moreover, any two solutions to the problem will differ by a multiple of the product of all the divisors. In the example from the "Sun Tzu Suan Ching," one solution is 23, and any other solution differs from 23 by a multiple of 105.

The traditional way to find the solution is to express the question as a linear diophantine equation which can then be solved by the Euclidean **algorithm**. After J. C. F. Gauss introduced the notion of congruences, or **modular arithmetic**, the Chinese remainder theorem has often been stated as a theorem guaranteeing the existence of a solution to a system of congruences modulo pairwise relatively prime integers.