

## The use of the brute-force method for solving the money-exchanging problem

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**Abstract.** In this paper we propose the brute-force method as a suitable method for solving the money-exchanging problem in high schools and colleges.

**Keywords:** brute-force method, money-exchanging problem

Given a set of  $n$  positive integers  $a_1, a_2, \dots, a_n$ , called the *denominations* and an integer  $A$ . We call an *exchange* a sequence of  $n$  positive integers  $(x_1, x_2, \dots, x_n)$  such that  $A = x_1 a_1 + x_2 a_2 + \dots + x_n a_n$ . The money-exchanging problem is as follows. Find the number of all exchanges. If in addition we have to list all exchanges, we call the problem the *extended* money-exchanging problem.

The brute-force solution of the money-exchanging problem is as follows. We list all exchanges and calculate their number.

Since the brute-force method is simple, it allows a simple implementation. I have created a simple computer program by using the programming language PHP. The computer program is used in the examples given below.

In the examples given below, the computer program displays the answer without any delay. Hence, we could use the brute-force method as a suitable method for solving the money-exchanging problem in high schools and colleges. Also, for the extended money exchanging problem we obtain the answer without delay. The university students have to study more fast and sophisticated methods, but in the high schools and colleges, we could prefer the brute-force method, since it is simple and the students could easily understand and use it.

**Example 1.** How many ways are there to make change for a 1 dollar? Solve also the extended money-exchange problem.

**Solution.** The denominations are 1,5,10,25,50 cents. The output of the computer program is available for download as supplementary material.

**Example 2.** How many ways are there to make change for 2 dollars? Solve also the extended money-exchange problem.

**Solution.** We consider as denominations 1,5,10,25,50 cents. (We do not use 1 dollar = 100 cents as a denomination in this example). The output of the computer program is available for download as supplementary material.

**Example 3.** How many ways are there to make change for 50 cents? Solve also the extended money-exchange problem.

**Solution.** The denominations are 1,5,10,25 cents. The output of the computer program is available for download as supplementary material.

**Example 4.** How many ways are there to make change for 25 cents? Solve also the extended money-exchange problem.

**Solution.** The denominations are 1,5,10 cents. The output of the computer program is available for download as supplementary material.

**Example 5.** How many ways are there to make change for a 1 lev? Solve also the extended money-exchange problem.

**Solution.** The denominations are 1,2,5,10,20,50 stotinki. The output of the computer program is available for download as supplementary material.

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