

Fall 1999, CMPT-101, Assignment 1

Doing Your Algebra Homework in C++

You probably spent many (happy?) hours in high school solving word problems:

Georgina spent \$40 buying movie tickets for a group of 5 people, some adults and some children. If adult's tickets cost \$10, and children's tickets cost \$5, how many adult tickets did Georgina buy?

What we want to do in this assignment is to write a C++ program that will help you solve problems like this.

First, how can we solve this problem without using a computer? It's an algebra problem, so we'll try setting up some variables and equations. Let X be the number of adults, and Y the number of children. Since there are 5 people in total, $X + Y = 5$ (we also know that both X and Y are positive because the problem implies there's at least one child and one adult in the group). The total amount spent on tickets is the amount spent on adult tickets ($10X$), plus the amount spent on kids tickets ($5Y$), so $10X + 5Y = 40$. We now have two equations and two unknowns.

To determine the number of adults and children, we need to solve for X and Y in this system of equations:

$$\begin{array}{rcl} X & + & Y = 5 \\ 10X & + & 5Y = 40 \end{array} \tag{1}$$

You should be able to calculate (or at least guess, through a bit of trial and error!) the one and only solution: $X = 3$ and $Y = 2$. Thus, Georgina bought 3 adult tickets.

Linear Equations with 2 Variables

To solve this kind of problem with a computer, we need a general method for solving linear systems of equations with 2 variables. In other words, we need to find the values of X and Y in problems like this:

$$\begin{aligned} aX + bY &= c \\ dX + eY &= f \end{aligned} \tag{2}$$

We assume that a , b , c , d , e , and f are given (by the user).

To solve (2), we'll use these formulas:¹

$$\begin{aligned} X &= \frac{ce - bf}{ae - bd} \\ Y &= \frac{cd - af}{bd - ae} \end{aligned} \tag{3}$$

You can verify that they're correct by substituting them back into the equations in (2).

To solve the ticket-buying example, just identify the values of a , b , c , d , e , and f , and plug them into the equations in (3):

$$a = 1, b = 1, c = 5, d = 10, e = 5, f = 40$$

$$X = \frac{ce - bf}{ae - bd} = \frac{5 \cdot 5 - 1 \cdot 40}{1 \cdot 5 - 1 \cdot 10} = \frac{-15}{-5} = 3$$

$$Y = \frac{cd - af}{bd - ae} = \frac{5 \cdot 10 - 1 \cdot 40}{1 \cdot 10 - 1 \cdot 5} = \frac{10}{5} = 2$$

Your Program

Write a C++ program that solves a system of two linear equations with two unknowns. It should perform the following steps:

Step 1 Read in 6 `double` values from the keyboard: a , b , c , d , e , and f ;

Step 2 Display a nicely formatted pair of equations, as in (1). This is feedback for the user so that they can make sure they've typed in the right numbers. It turns out to be difficult to print out nicely formatted equations, so for this assignment it's okay to print something like this:

¹You can derive these formulas by solving for X and Y in the above equations, using the same techniques you would use to solve them if a , b , c , d , e , and f were numbers instead of variables.

$$\begin{array}{rclcl} 1x & + & -4.2y & = & 9 \\ 0x & + & -1y & = & -144.22 \end{array}$$

Step 3 Using the formulas in (3), print out the values of X and Y

Be careful: not all values of a , b , c , d , e , and f result in unique solutions! For example, if $ae = bd$, then the denominator of X and Y in (3) is 0, and dividing by 0 is undefined and can cause strange errors. Make sure to check for this possibility in step 3 of your program; if X and Y do not have unique numeric values, then print a message to the screen saying that the equations don't have a unique solution.

Examples to Try

Test your program on at least these examples, and make sure to hand them in for the markers to see (see below):

Example 1 $a = 1, b = 1, c = 5, d = 10, e = 5, f = 40$

Example 2 $a = 1.43, b = -41, c = 50034, d = 120, e = 0.335, f = 40$

Example 3 $a = 22, b = 0, c = 4.07, d = 120, e = 0.335, f = 81$

Example 4 $a = 0, b = 0, c = 0, d = 0, e = 0, f = 0$ (does not have a unique solution)

Example 5 $a = 3, b = 9, c = 4, d = 2, e = 6, f = 34$ (does not have a unique solution)

What To Hand In

On the CMPT-101 home pages is a document that explains everything you need to hand in. Follow those instructions for this assignment.