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**Systems of equations in Engineering: The Penny Project**

**Abstract:**

By the execution of The Penny Project, our goal was to prove that the number of pennies that were in the jars, actually matched the number in the calculations. In order to measure the pennies number, we had to count them without opening the jar and weight each one. Each jar contained pennies from different years, they went from the time before 1982 and after this year. The results were gotten from three different methods: The substitution method, Matrix Inverse and by Cramer’s Rule.

By measuring each jar, we got the following values. For the actual mass of the pennies, we got 2.5 grams, and for the prior-mass 3,11 grams. Each jar contained about twenty pennies each one; therefore, by knowing these values, we can start by creating the system of equations. It consisted on a system of equations 2x2, where the variables used were x1 and x2. It is important to highlight that the value after the “=” sign for the second equation, depends on the subtraction of the value in grams that is found for each cup and the mass of the empty jar. The chart should look like this.

1. x1+x2= 20
2. 3.11x1+2.5x2= mass-mass of the empty jar

|  |  |  |
| --- | --- | --- |
| **Number of Jars** | **Mass of the jar** | **Final Mass** |
| Jar 7 | 78.93 g | 52.98 g |
| Jar 5 | 78.31 g | 52.36 g |
| Jar 8 | 79.39 g | 53.44 g |
| Empty Jar | 25.95 g | ---- |

**Equation 5:**

X1+X2=20

3.11X1+2.5X2=52.36

**Equation 7:**

X1+X2=20

3.11X1+2.5X2=52.98

**Equation 8:**

X1+X2=20

3.11X1+2.5X2=53.44

Now we followed the procedure to solve it for the number of each type of penny:

For the first method, it does not matter which variable is substituted, it should get to the same answer, after isolating x1 or x2, the value is later on place on the other equation and solve for the opposite variable. By doing this, we should have the values for each variable. These could be used as reference for proving the following methods. For the next method, the Matrix Algebra one, we should order and write three matrixes. In this case we used A for the values of the equations, also known as coefficients, then for the X matrix, we should write the variables that are being solved in the system of equations, x1 and x2. Finally for the Y matrix, we write the values after the “=” sign.

By having these matrixes written, we calculate the determinant by cross multiplying the values of the matrix A. Later on, we divide the inverse of A by the determinant and got the values for the A’. Finally, we multiply the inverse matrix times the Y one, this being the path for our final answer x1 and x2.

For the last method, we use Crammer’s Rule, in it we basically write the same matrixes, A, X, Y , get the determinant and later on we substitute the values of Y in the original A matrix, the substitution must be for each column, it means that only one column will maintain the original values while the other one changes, they are alternated. After this, we divide the values by the determinant and this is how we get x1 and x2.