EGR 101
LABORATORY 4
Systems of Equations in Engineering: The Two-Loop Circuit
Wright State University

OBJECTIVE: The objective of this laboratory is to learn the basics of systems of equations and matrices and its application in engineering.

EDUCATIONAL OBJECTIVES:

After performing this experiment, students should be able to:

1. Write loop equations.
2. Solve the unknowns by finding the inverse of the matrix and Cramer's Rule.
3. Solve the equations and find the unknowns by the substitution method.

BACKGROUND:

- **Writing the Loop equations:**

  Using the Kirchoff's voltage law, write the loop equations for the circuit shown in *Figure 1.*

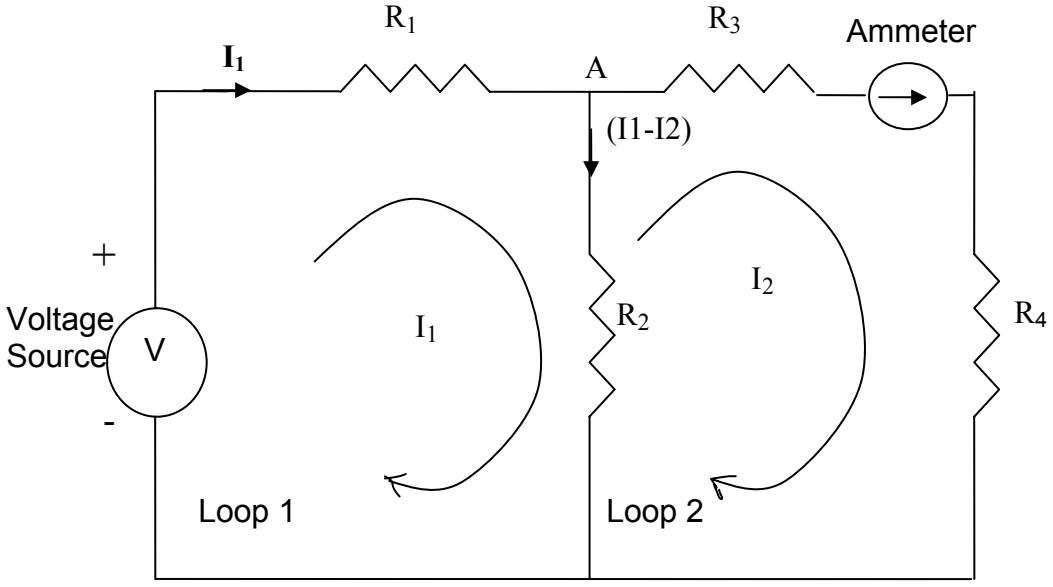

Figure 1: Electrical Circuit to calculate the current in the two loops.

Hence the loop equations are:

Loop 1: $R_1 * I_1 + R_2 * (I_1 - I_2) = V$ (1)

Loop 2: $R_3 * I_2 + R_4 * I_2 - R_2 * (I_1 - I_2) = 0$ (2)

The currents $\mathbf{I_1}$ and $\mathbf{I_2}$ in equations (1) and (2) can be solved using the following three methods:

a) Substitution method.
b) Matrix Algebra method.
c) Cramer's rule.

Notes*: Review the lecture notes to learn these methods.*

PROCEDURE:

Connect the circuit shown in Figure 1. Use $R_1 = R_2 = 100\ \Omega$ and $R_3 = R_4 = 200\ \Omega$

1. Adjust the value of the voltage source as shown in the *Table 1.*
2. Measure and record current $\mathbf{I_1}$, which is the current reading from the supply.
3. Measure and record current $\mathbf{I_2}$, which is the current in Loop 2, using the ammeter as shown in the *Figure 1*.

***Table 1*:** To verify the value of the measured and calculated currents.

No.	Voltage Source [V_s] (V)	Measured current [I_1] (A)	Measured current [I_2] (A)	Calculated current [I_1] (A)	Calculated current [I_2] (A)
1.	5				
2.	7				

4. Substitute the values of the resistances and the voltage in the loop equations (1) and (2).
5. Writing the equations in the matrix form as shown below,

$$\begin{bmatrix} (R1 + R_2) & -R_2 \\ -R_2 & (R_2 + R_3 + R_4) \end{bmatrix} \cdot \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V \\ 0 \end{bmatrix}$$

6. The value of the currents can be found using the formula:

$$I = R^{-1} v$$

where I = $\begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$ is current vector, R = $\begin{bmatrix} (R1 + R_2) & -R_2 \\ -R_2 & (R_2 + R_3 + R_4) \end{bmatrix}$ is the resistance matrix and v = $\begin{bmatrix} V \\ 0 \end{bmatrix}$ is voltage vector.

7. Find the value of $\mathbf{I_1}$ and $\mathbf{I_2}$ from the three different methods and record these values in Table I.
8. Compare the values of the calculated currents with the measured currents.

9. Write an m-file to find the values of the currents I_1 and I_2 by using the Matrix Algebra method.

LAB NOTEBOOK:

1. Show the completed Table 1.
2. Show calculations to solve the currents I_1 and I_2 using the three methods described earlier.

APPENDIX

MATLAB Program:

```
clear all
clc

% to input the value of voltage source
V=input('Input the value of Voltage : ');

% to input the value of the resistances
r1=input('Input the value of R1 : ');
r2=input('Input the value of R2 : ');
r3=input('Input the value of R3 : ');
r4=input('Input the value of R4 : ');

% matrix V
v=[V 0]'

% matrix R (from the equations)
R=[-(r1+r2) r2; -r2 (-r3-r4+r2)]

% to calculate current using the inverse function
I=inv(R)*v
```