

ELEC 2110

Electric Circuit Analysis

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Section 002

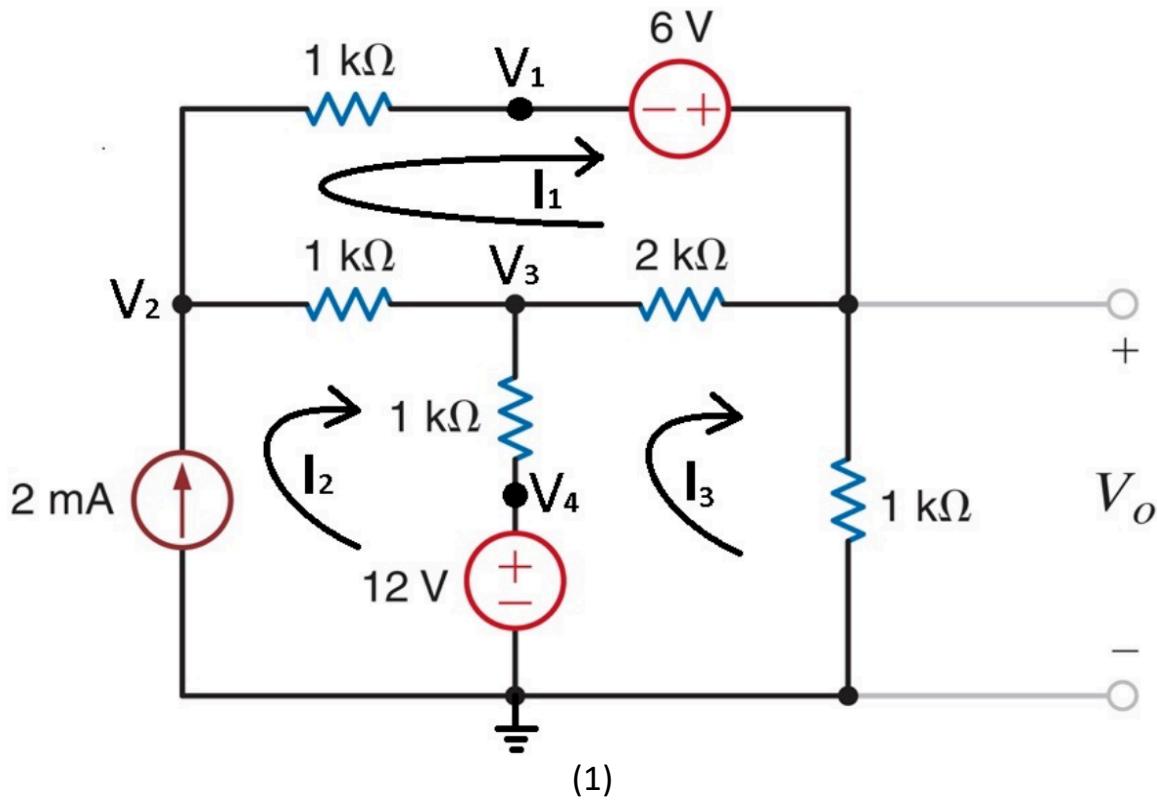
DC Mesh and Nodal Analysis

Introduction

This lab tasks the student with using Nodal and Mesh analysis to solve multiple circuits. The student will be given a circuit and told to use Nodal and Mesh analysis on each one. Also, use MATLAB to solve the matrix equations.

Exercise 1

Analyze the circuit given using Nodal and Mesh analysis.



Circuit 1

Exercise 1

$$V_0 = 6$$

$$V_4 = 12 \text{ V}$$

$$V_0 - V_1 = 6 \text{ V}$$

$$\frac{V_2 - V_3}{1 \text{ k}\Omega} + \frac{V_2 - V_1}{1 \text{ k}\Omega} = 2 \text{ mA}$$

$$\frac{V_3 - V_2}{1 \text{ k}\Omega} + \frac{V_3 - V_0}{2 \text{ k}\Omega} + \frac{V_3 - V_4}{1 \text{ k}\Omega} = 0$$

$$\frac{V_0 - V_3}{2 \text{ k}\Omega} + \frac{V_0 - V_1}{1 \text{ k}\Omega} + \frac{V_1 - V_2}{1 \text{ k}\Omega} = 0$$

(2)

Nodal Analysis equations

```

>> A
A =
0 0 0 1.0000 0
-1.0000 0 0 0 1.0000
-1.0000 2.0000 -1.0000 0 0
0 -1.0000 2.5000 -1.0000 -0.5000
1.0000 -1.0000 -0.5000 0 1.5000

>> b= [12;6;2;0;0]
b =
12
6
2
0
0

>> A\b
ans =
0
5
8
12
6
fz >>

```

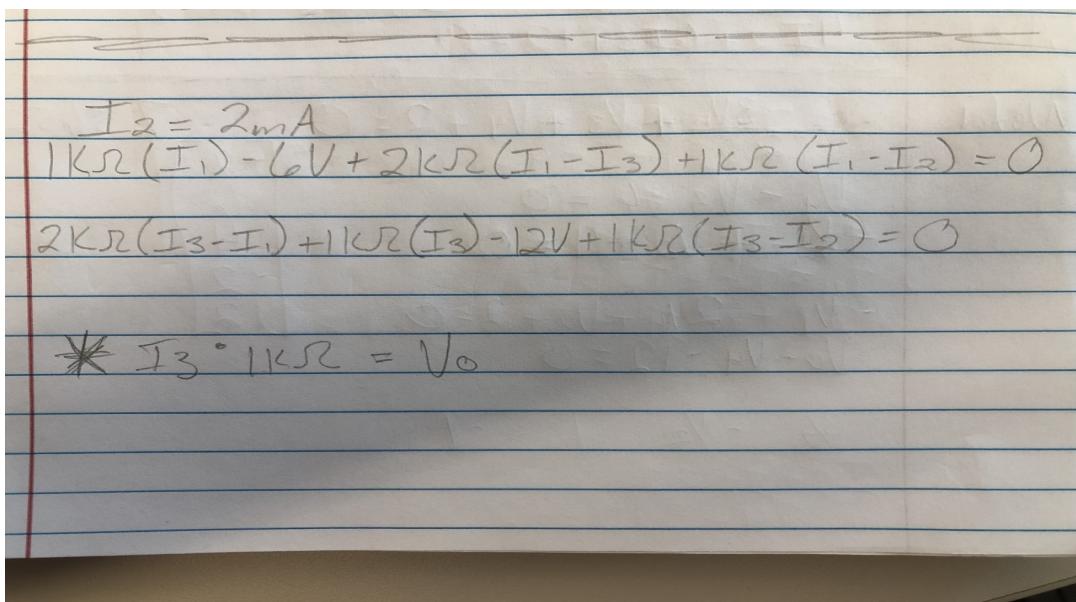
(3)

Matrix Code and Answer

Nodal Summary Table

V1	0V
V2	5V
V3	8V
V4	12V
Vo	6V

Mesh Analysis



The image shows handwritten mesh analysis equations on a sheet of lined paper. The equations are:

$$I_2 = 2mA$$

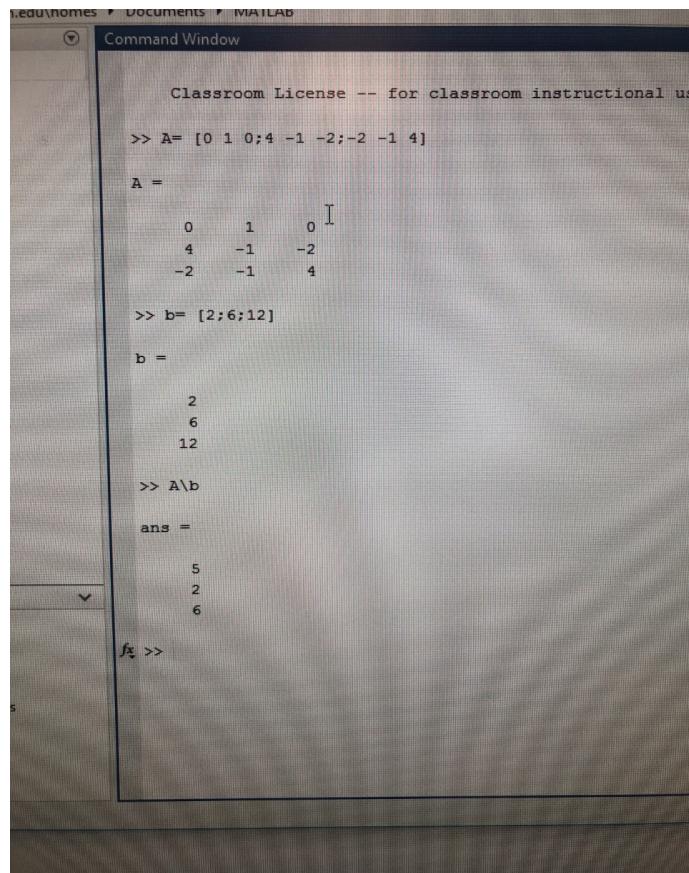
$$1k\Omega(I_1) - 6V + 2k\Omega(I_1 - I_3) + 1k\Omega(I_1 - I_2) = 0$$

$$2k\Omega(I_3 - I_1) + 1k\Omega(I_3) - 12V + 1k\Omega(I_3 - I_2) = 0$$

$$\star I_3 \cdot 1k\Omega = V_o$$

(4)

Mesh Analysis equations



The screenshot shows the MATLAB Command Window with the following code and output:

```
Classroom License -- for classroom instructional use  
>> A= [0 1 0;4 -1 -2;-2 -1 4]  
A =  
0 1 0  
4 -1 -2  
-2 -1 4  
  
>> b= [2;6;12]  
b =  
2  
6  
12  
  
>> A\b  
ans =  
5  
2  
6
```

(5)

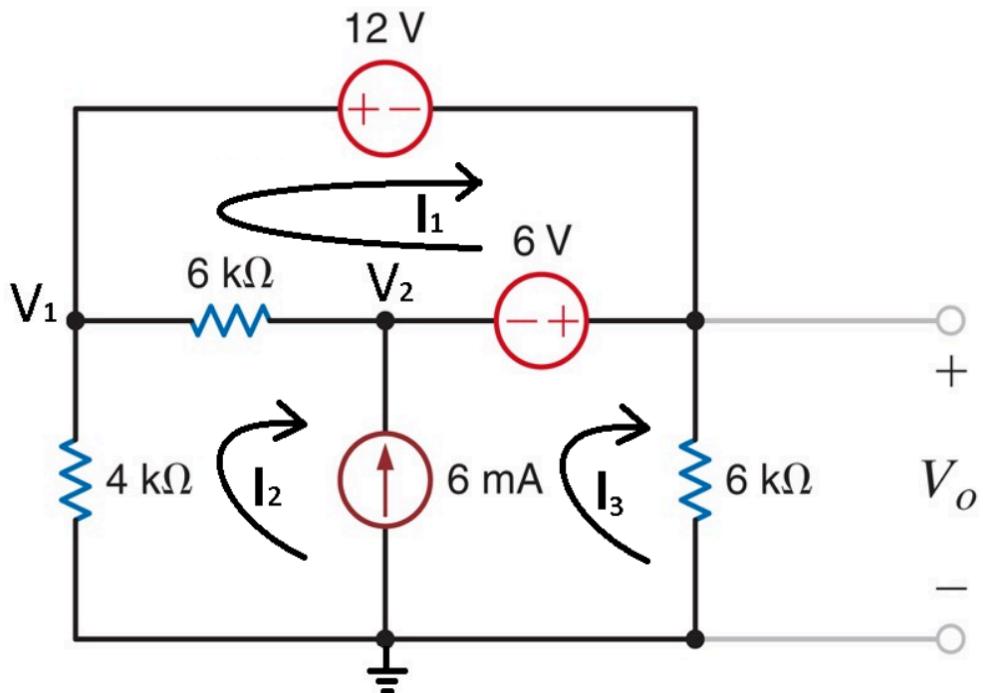
Matrix Code and Answer

Mesh Summary Table

I1	5mA
I2	2mA
I3	6mA
$I_3 \cdot 1\text{KOhms} = V_o$	$= 6 \cdot 1 = 6\text{V}$

Exercise 2

Given a new circuit, use Nodal and Mesh analysis to find voltage and current.



(6)

Circuit 2

* Multiply $I_3 \cdot 1\text{ k}\Omega$ for V_o

Lab 4

$V_o = 7.2$

$$\frac{V_1}{4} + \frac{V_o}{6} = 6$$

$$12 = V_1 - V_o$$

$$6 = V_o - V_2$$

(7)

Nodal Analysis equations

```

>> A= [1/4 0 1/6;1 0 -1;0 -1 1]

A =

    0.2500      0      0.1667
    1.0000      0     -1.0000
    0     -1.0000      1.0000

>> b= [6;12;6]

b =

    6
    12
    6

>> A\b

ans =

    19.2000
    1.2000
    7.2000

```

(8)

Matrix Code and Answer

Nodal Summary Table

V1	19.2V
V2	1.2V
Vo	7.2V

Mesh Analysis

6	-6	0	-18	I_1
	-1	1	6	I_2
0	4	6	-12	I_3

$$6I_1 - 6I_2 = -18 \rightarrow 6I_1 - 6I_2 + 18 = 0$$

$$-I_2 + I_3 = 6 \rightarrow I_3 - I_2 - 6 = 0$$

$$4I_2 + 6I_3 + 12 = 0$$

(9)

Mesh Analysis equations

```

>> A= [6 -6 0;0 -1 1;0 4 6]
A =
    6     -6      0
    0     -1      1
    0      4      6

>> b= [-18;6;-12]
b =
    -18
      6
    -12

>> A\b
ans =
    1
   -7.8000
   -4.8000
    1.2000

```

for the circuit in Figure 6 and solve for V_o .
Include code or screenshot of MATLAB script

(10)

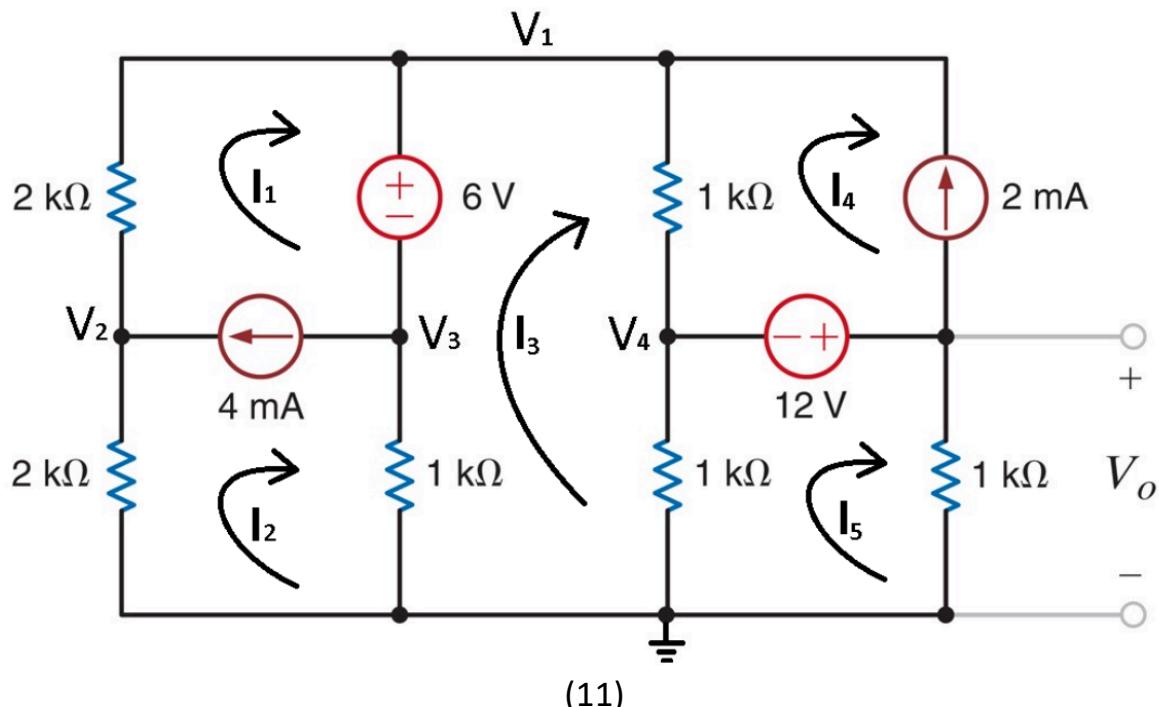
Matrix Code and Answer

Mesh Summary Table

I1	-7.8mA
I2	-4.8mA
I3	1.2mA
(I3*1)+6 = Vo	= (1.2*1)+6 = 7.2V

Exercise 3

Given a new circuit, use Nodal and Mesh analysis to find voltage and current.



Circuit 3

$$\begin{array}{l}
 V_2 - 3V_1 + V_3 - V_4 + 2 = 0 \quad | \cdot 2 \\
 V_1 - V_3 - 6 = 0 \\
 -\frac{V_1}{2} + V_2 - 4 = 0 \\
 -V_1 + 2V_4 + V_0 + 2 = 0 \\
 V_0 - V_4 - 12 = 0
 \end{array}
 \quad
 \begin{bmatrix}
 -2 \\
 6 \\
 4 \\
 -2 \\
 12
 \end{bmatrix}$$

(12)

Nodal Analysis equation

```

>> A= [3/2 -1/2 1 -1 0;1 0 -1 0 0;-1/2 1 0 0 0;-1 0 0 2 1;0 0 0 -1 1]

A =

1.5000   -0.5000    1.0000   -1.0000    0
1.0000     0   -1.0000     0       0
-0.5000    1.0000     0       0       0
-1.0000     0       0   2.0000   1.0000
  0       0       0   -1.0000   1.0000

>> b

b =

-2
6
4
-2
12

>> A\b

ans =

0.6957
4.3478
-5.3043
-4.4348
  7.5652
  ]

```

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Matrix Code and Answer

Nodal Summary Table

V1	0.6957V
V2	4.3478V
V3	-5.3043V
V4	-4.4348V
Vo	7.5652V

Mesh Analysis

Handwritten notes for Mesh Analysis:

* $V_o = I_5 \cdot 1k\Omega = 7.5652V$

Lab 4

sh	$I_1 - I_2 - 4 = 0$	I_1
	$2I_1 + 3I_2 - I_3 + 6 = 0$	-6
	$-I_2 + 3I_3 - I_4 - I_5 - 6 = 0$	I_3
	$-I_4 - 2 = 0$	I_4
	$2I_5 - I_3 - I_2 = 0$	I_2

(14)

Mesh Analysis equations

```

>> A= [1 -1 0 0 0;2 3 -1 0 0;0 -1 3 -1 -1;0 0 0 -1 0;0 0 -1 0 2]

A =

    1   -1     0     0     0
    2     3   -1     0     0
    0   -1     3   -1   -1
    0     0     0   -1     0
    0     0   -1     0     2

>> b= [4;-6;6;2;12]

b =

    4
   -6
    6
    2
   12

>> A\b

ans =

    1.8261
   -2.1739
    3.1304
   -2.0000
    7.5652

```

(15)

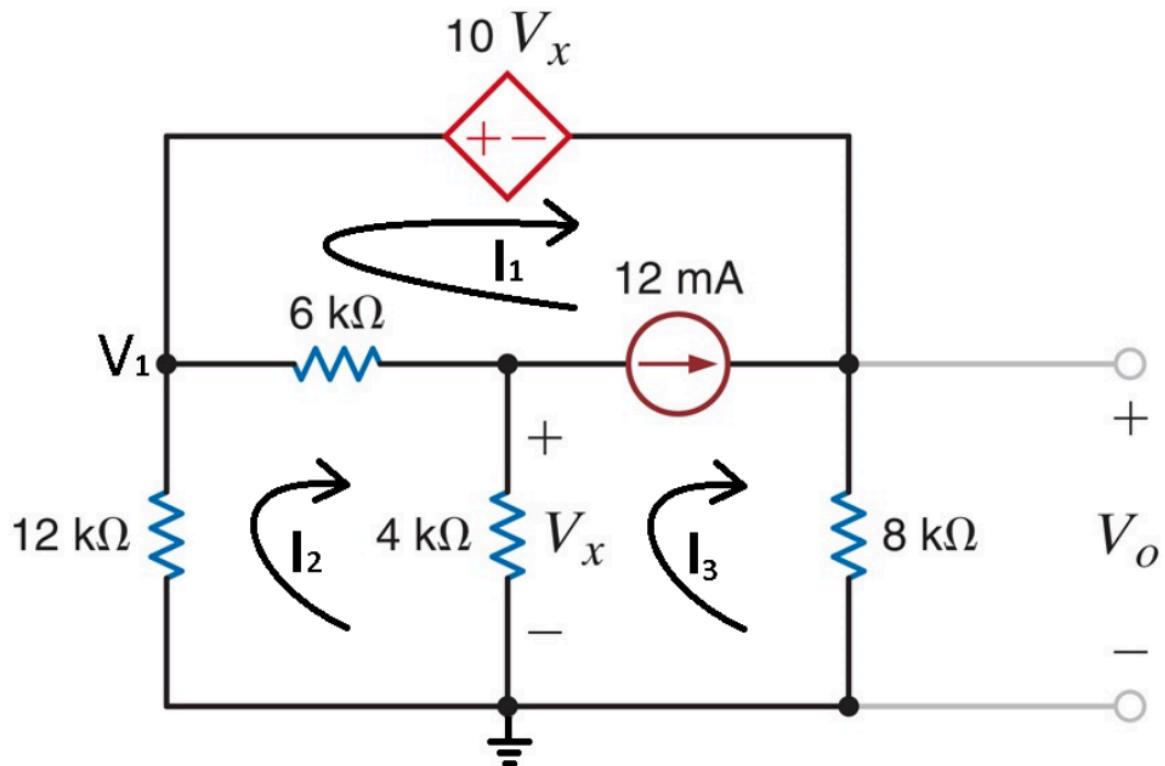
Matrix Code and Answer

Mesh Summary Table

I1	1.8261mA
I2	-2.1739mA
I3	3.1304mA
I4	-2.0mA
I5	7.5652mA
Vo = I5*1KOhm	= 7.5652*1 = 7.5652V

Exercise 4

Given a new circuit, use Nodal and Mesh analysis to find voltage and current.



(16)

Circuit 4

$$\begin{aligned}
 & \frac{18V_1 - V_2 + V_3 - 12}{72} = 0 \quad | \begin{matrix} 12 \\ 0 \\ -12 \end{matrix} \\
 & V_1 - 10V_2 - V_3 = 0 \\
 & -\frac{V_1}{6} + \frac{10V_2}{24} + 12 = 0
 \end{aligned}$$

(17)

Nodal Analysis equations

```

>> A= [18/72 -1/6 1/8;1 -10 -1;-1/6 10/24 0]

A =

    0.2500   -0.1667    0.1250
    1.0000   -10.0000   -1.0000
   -0.1667    0.4167      0

>> b= [12;0;-12]

b =

    12
     0
    -12

>> A\b
ans =
    150.2609
    31.3043
   -162.7826

```

(18)

Matrix Code and Answer

Nodal Summary Table

V1	150.2609V
Vx	31.3043V
Vo	-162.7826V

Mesh Analysis

Handwritten mesh analysis equations:

$$\begin{aligned} -I_3 - I_1 - 12 &= 0 \\ 12I_2 + 8I_3 + 10V_x &= 0 \\ 4I_2 - 4I_3 - V_x &= 0 \\ -6I_1 + 22I_2 - 4I_3 &= 0 \end{aligned}$$

~~$I_3 \cdot 8K$~~

(19)

Mesh Analysis equations

Command Window

```

>> A= [-1 0 1 0;0 12 8 10;0 4 -4 -1;-6 22 -4 0]

A =
    -1     0     1     0
     0    12     8    10
     0     4    -4    -1
    -6    22    -4     0

>> b= [12;0;0;0]

b =
    12
     0
     0
     0
    -1

>> A\b

ans =
    -32.3478
    -12.5217
    -20.3478
    31.3043
  
```

(20)

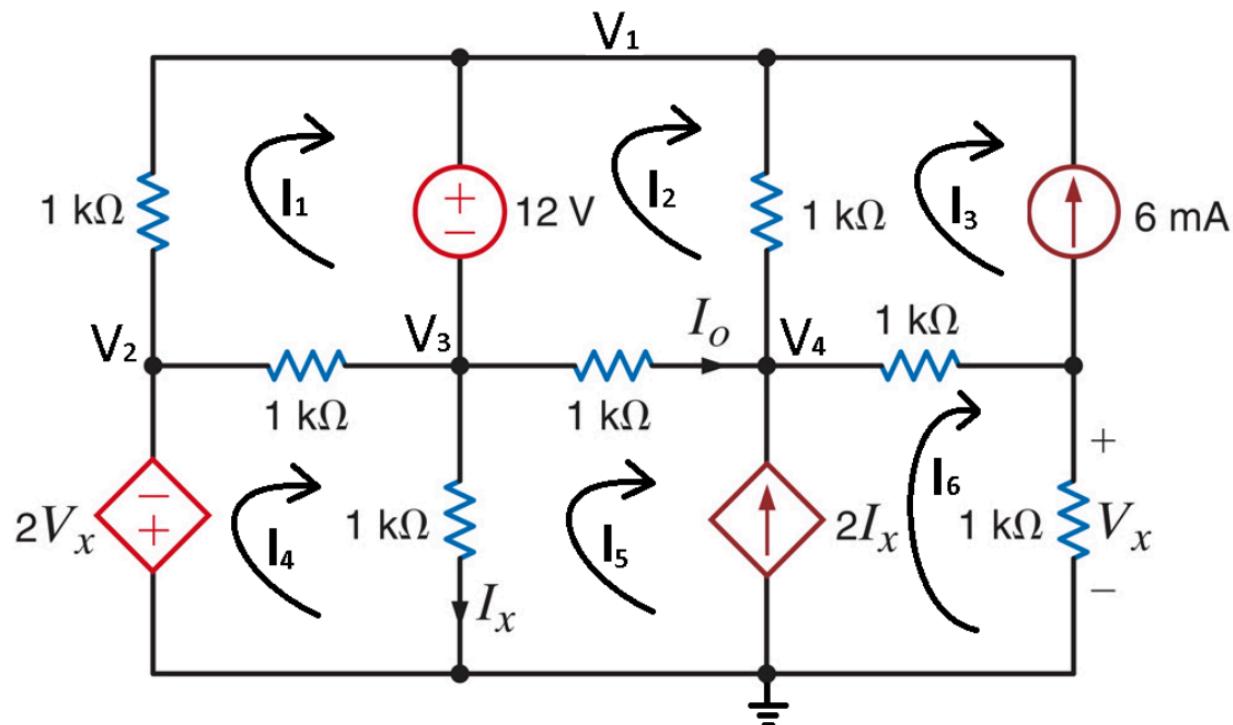
Matrix Code and Answer

Mesh Summary Table

I1	-32.3478mA
I2	-12.5217mA
I3	-20.3478mA
Vx	31.3043V
$V_o = (I3 * 8k)$	= -20.3478 * 8k = -162.7826V

Exercise 5

Given a new circuit, use Nodal and Mesh analysis to find voltage and current.



(21)

Circuit 5

$I_0 = \frac{V_3 - V_4}{1} = -1.2 - 1.680 = -2.88$
 Lab 4
 Nodal
 $2V_1 - 2V_2 + 3V_3 - 2V_4 - 6 = 0$ | 7
 $V_1 - V_3 - 12 = 0$ | 12
 $V_2 + 2V_x = 0$ | 6
 $-V_1 - V_3 + 3V_4 - V_x - 2K_{Tx} = 0$ | 3
 $V_3 - 1K_{Tx} = 0$ | 8
 $-V_4 + 2V_x + 6 = 0$ | -6

$$\begin{bmatrix} 2 & -2 & 3 & -2 & 0 & 0 \\ 1 & 0 & -1 & 0 & 8 & 8 \\ 0 & 1 & 0 & 0 & 2 & 0 \\ -1 & 0 & -1 & 3 & -1 & -2 \\ 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & -1 & 2 & 0 \end{bmatrix}$$

(22)

Nodal Analysis equations

```

Command Window

>> A= [2 -2 3 -2 0 0;1 0 -1 0 0 0;0 1 0 0 2 0;-1 0 -1 3 -1 -2;0 0 1 0 0 -1;0 0 0 -1 2 0]

A =
2   -2    3   -2    0    0
1    0   -1    0    0    0
0    1    0    0    2    0
-1   0   -1    3   -1   -2
0    0    1    0    0   -1
0    0    0   -1    2    0

>> b

b =
6
12
0
0
0
-6

>> A\b

ans =
10.8000
4.3200
-1.2000
1.6800
-2.1600
-1.2000

```

(23)

Matrix Code and Answer

Nodal Summary Table

V1	10.8V
V2	4.32V
V3	-1.2V
V4	1.68V
Vx	-2.16V
Ix	-1.2mA
$I_o = (V_3 - V_4)/1k$	$= (-1.2 - 1.68)/1 = -2.88mA$

Mesh Analysis

Mesh

$$\begin{aligned} & \checkmark 2I_1 - I_4 + 12m = 0 && -12m \\ & \checkmark 2I_2 - I_3 - I_5 - 12m = 0 && 12m \\ & \checkmark I_3 + 6m = 0 && -6m \\ & \checkmark -I_1 + 2I_4 - I_5 + 2mV_x = 0 && 0 \\ & \checkmark I_6 - 1mV_x = 0 && 0 \\ & I_4 - I_5 - 2I_x = 0 && 0 \\ & I_4 - I_5 - I_x = 0 && 0 \\ & 2I_5 + 2I_6 - I_2 - I_3 - I_4 = 0 && 0 \end{aligned}$$

~~X~~

$$I_5 - I_2 = I_o$$

$$-24 - 3.12 = -2.88$$

(24)

Mesh Analysis equations

```

-2.1600
-1.2000

>> A= [2 0 0 -1 0 0 0 0;0 2 -1 0 -1 0 0 0;0 0 1 0 0 0 0 0;-1 0 0 2 -1 0 2 0;0 0 0 0 0 1 -1 0;0 0 0 0 -1 1 0 -2;0 0 0 1 -1 0 0 -1;0 -1 -1 2 2 0 0]

A =
2 0 0 -1 0 0 0 0
0 2 -1 0 -1 0 0 0
0 0 1 0 0 0 0 0
-1 0 0 2 -1 0 2 0
0 0 0 0 1 -1 0
0 0 0 0 -1 1 0 -2
0 0 0 1 -1 0 0 -1
0 -1 -1 -1 2 2 0 0

>> b=[-12;12;-6;0;0;0;0]

b =
-12
12
-6
0
0
0
0

>> A\b

ans =

```

File

> f5 >>

(25)

Matrix Code and Answer

Mesh Summary Table

I1	-6.48mA
I2	3.12mA
I3	-6.00mA
I4	-0.96mA
I5	0.24mA
I6	-2.16mA
Vx	-2.16V
Ix	-1.2mA
Io = I5 - I2	= 0.24 - 3.12 = -2.88mA

Bibliography

1. Circuit 1 given to analyze for exercise 1
2. Hand-written Nodal Analysis equations for exercise 1
3. Multisim matrix of answer for Nodal analysis exercise 1
4. Hand-written Mesh Analysis equations for exercise 1
5. Multisim matrix of answer for Mesh analysis exercise 1
6. Circuit 2 given to analyze for exercise 2
7. Hand-written Nodal Analysis equations for exercise 2
8. Multisim matrix of answer for Nodal analysis exercise 2
9. Hand-written Mesh Analysis equations for exercise 2
10. Multisim matrix of answer for Mesh analysis exercise 2
11. Circuit 3 given to analyze for exercise 3
12. Hand-written Nodal Analysis equations for exercise 3
13. Multisim matrix of answer for Nodal analysis exercise 3
14. Hand-written Mesh Analysis equations for exercise 3
15. Multisim matrix of answer for Mesh analysis exercise 3
16. Circuit 4 given to analyze for exercise 4
17. Hand-written Nodal Analysis equations for exercise 4
18. Multisim matrix of answer for Nodal analysis exercise 4
19. Hand-written Mesh Analysis equations for exercise 4
20. Multisim matrix of answer for Mesh analysis exercise 4
21. Circuit 5 given to analyze for exercise 5
22. Hand-written Nodal Analysis equations for exercise 5
23. Multisim matrix of answer for Nodal analysis exercise 5
24. Hand-written Mesh Analysis equations for exercise 5
25. Multisim matrix of answer for Mesh analysis exercise 5