Stephen J. R. Smith Faculty of Engineering & Applied Science

ELEC-372: Numerical Methods and Optimization

LAB-02: MATLAB Based Circuit Simulator v2.0

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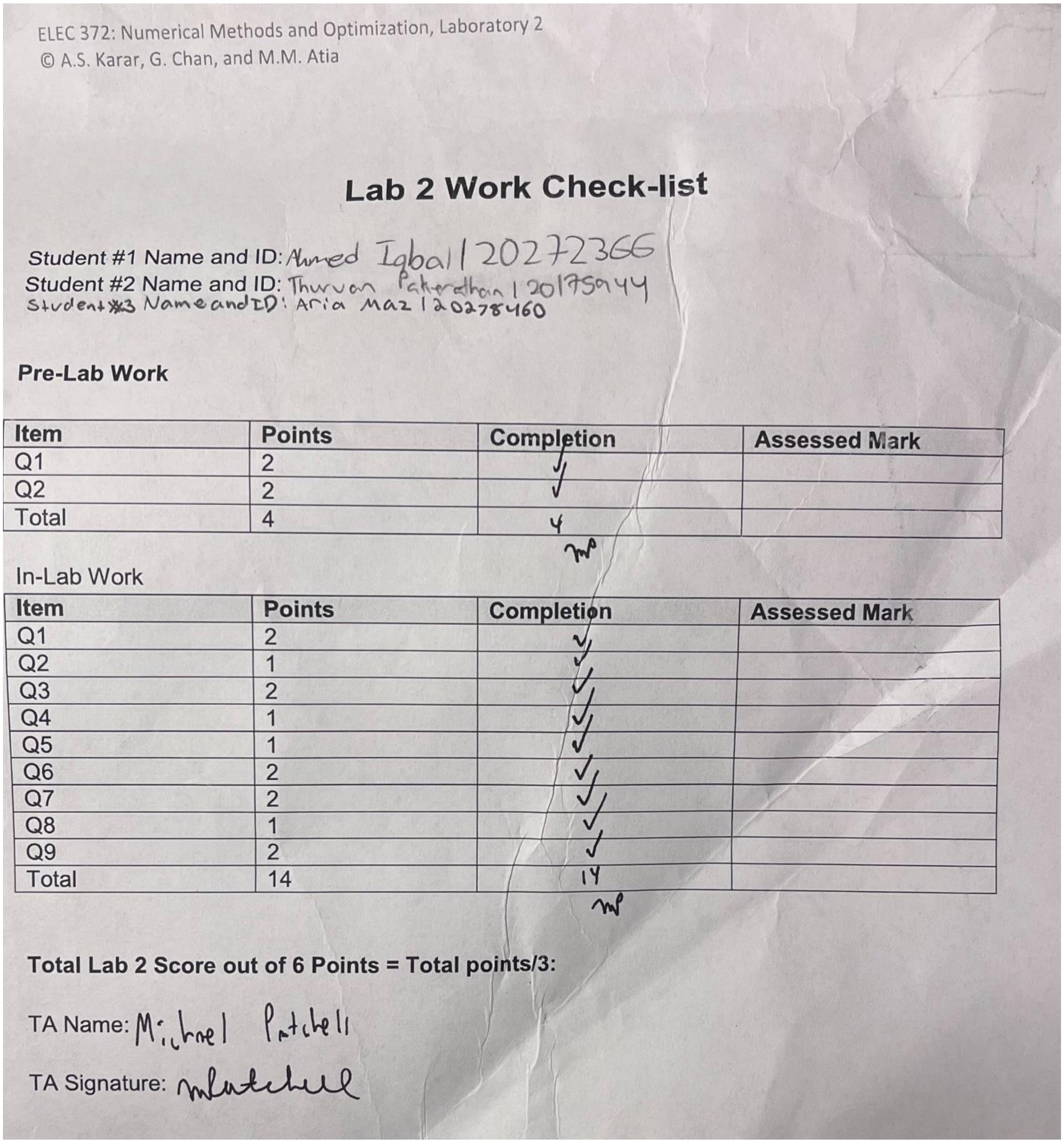
February 22, 2024

Please find the Lab 2 Work Checklist in Figure 1.



ELEC 372: Numerical Methods and Optimization, Laboratory 2
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Lab 2 Work Check-list

Student #1 Name and ID: Ahmed Iqbal | 20272366
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Student #3 Name and ID: Aria Maz | 20278460

Pre-Lab Work

Item	Points	Completion	Assessed Mark
Q1	2	✓	
Q2	2	✓	
Total	4	4	

mp

In-Lab Work

Item	Points	Completion	Assessed Mark
Q1	2	✓	
Q2	1	✓	
Q3	2	✓	
Q4	1	✓	
Q5	1	✓	
Q6	2	✓	
Q7	2	✓	
Q8	1	✓	
Q9	2	✓	
Total	14	14	

mp

Total Lab 2 Score out of 6 Points = Total points/3:

TA Name: Michael Patchell

TA Signature: MPatchell

Figure 1: Checked off and signed lab 2 Work Checklist.

Prelab)

Question 1)

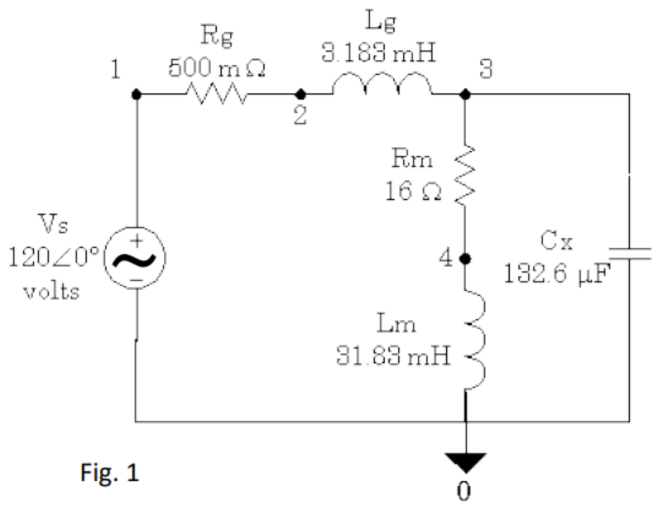

Fig. 1

Rg	1	2	500e-3
Lg	3	2	3.183e-3
Rm	3	4	16
Lm	0	4	31.83e-3
Cx	3	0	132.6e-6
Vs	0	1	120

$$A = \begin{bmatrix} \frac{1}{R_g} & -\frac{1}{R_g} & 0 & 0 & 0 & 0 & 1 \\ -\frac{1}{R_g} & \frac{1}{R_g} & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & sC_x + \frac{1}{R_m} & -\frac{1}{R_m} & -1 & 0 & 0 \\ 0 & 0 & -\frac{1}{R_m} & \frac{1}{R_m} & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 & -sL_g & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & -sL_m & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad x = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ I_g \\ I_m \\ I_v \end{bmatrix} \quad b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 120 \end{bmatrix}$$

Figure 2: Provided circuit, netlist, and component values for Fig. 1 circuit of lab manual.

a)

$$A=\left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ -2 & 2 & 0 & 0 & 1 & 0 & 0 & 0\\ 0 & 0 & 0.0625 & -0.0625 & -1 & 0 & 0 & 0\\ 0 & 0 & -0.0625 & 0.0625 & 0 & 1 & 0 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 120 \end{array}\right] \xrightarrow{R_2 \leftarrow R_2-\left(\frac{-2}{2}\right)R_1} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0.0625 & -0.0625 & -1 & 0 & 0 & 0\\ 0 & 0 & -0.0625 & 0.0625 & 0 & 1 & 0 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 120 \end{array}\right]$$

$$\xrightarrow{R_7 \leftarrow R_7-\left(\frac{1}{2}\right)R_1} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & \frac{1}{16} & -\frac{1}{16} & -1 & 0 & 0 & 0\\ 0 & 0 & -\frac{1}{16} & \frac{1}{16} & 0 & 1 & 0 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 1 & 0 & 0 & 0 & 0 & -\frac{1}{2} & 120 \end{array}\right] \xrightarrow{R_2 \leftrightarrow R_5} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & \frac{1}{16} & -\frac{1}{16} & -1 & 0 & 0 & 0\\ 0 & 0 & -\frac{1}{16} & \frac{1}{16} & 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 1 & 0 & 0 & 0 & 0 & -\frac{1}{2} & 120 \end{array}\right]$$

$$\xrightarrow{R_7 \leftarrow R_7-\left(\frac{1}{1}\right)R_2} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & \frac{1}{16} & -\frac{1}{16} & -1 & 0 & 0 & 0\\ 0 & 0 & -\frac{1}{16} & \frac{1}{16} & 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120 \end{array}\right] \xrightarrow{R_7 \leftrightarrow R_3} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120\\ 0 & 0 & -\frac{1}{16} & \frac{1}{16} & 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & \frac{1}{16} & -\frac{1}{16} & -1 & 0 & 0 & 0 \end{array}\right]$$

$$\xrightarrow[R_7 \leftarrow R_7-\left(\frac{1/16}{1}\right)R_3]{R_4 \leftarrow R_4-\left(\frac{-1/16}{1}\right)R_3} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120\\ 0 & 0 & 0 & \frac{1}{16} & 0 & 1 & -\frac{1}{32} & \frac{15}{2}\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & -\frac{1}{16} & -1 & 0 & \frac{1}{32} & -\frac{15}{2} \end{array}\right] \xrightarrow{R_6 \leftrightarrow R_4} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & \frac{1}{16} & 0 & 1 & -\frac{1}{32} & \frac{15}{2}\\ 0 & 0 & 0 & -\frac{1}{16} & -1 & 0 & \frac{1}{32} & -\frac{15}{2} \end{array}\right]$$

$$\xrightarrow[R_7 \leftarrow R_7-\left(-\frac{1}{16}\right)R_4]{R_6 \leftarrow R_6-\left(\frac{1}{16}\right)R_4} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 0 & 0 & 1 & -\frac{1}{32} & \frac{15}{2}\\ 0 & 0 & 0 & 0 & -1 & 0 & \frac{1}{32} & -\frac{15}{2} \end{array}\right] \xrightarrow{R_7 \leftarrow R_7-(-1)R_5} \left[\begin{array}{ccccccc|c} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0\\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 120\\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0\\ 0 & 0 & 0 & 0 & 0 & 1 & -\frac{1}{32} & \frac{15}{2}\\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{33}{32} & -\frac{15}{2} \end{array}\right]$$

Figure 3: Manual Computation of node voltages and current of Figure 2, using Gaussian Elimination with partial pivoting.

$$\frac{33}{32} I_V = \frac{-15}{2}$$

$$I_V = \frac{-80}{11} A \approx -7.27 A$$

$$I_g + \left(\frac{-80}{11}\right) = 0$$

$$I_g = \frac{80}{11} A \approx 7.27 A$$

$$V_3 - \frac{1}{2}\left(\frac{-80}{11}\right) = 120$$

$$V_3 = \frac{-1280}{11} V \approx 116.36 V$$

$$I_m + \frac{-1}{32}\left(-\frac{80}{11}\right) = \frac{15}{2}$$

$$I_m = \frac{80}{11} A \approx 7.27 A$$

$$V_4 = 0V$$

$$V_2 - \left(\frac{1280}{11}\right) = 0$$

$$V_2 = \frac{1280}{11} V \approx 116.36 V$$

$$2V_1 - 2\left(\frac{1280}{11}\right) - \frac{80}{11} = 0$$

$$V_1 = 120V$$

$$x = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ I_g \\ I_m \\ I_V \end{bmatrix}$$

$$x = \begin{bmatrix} 120 \\ \frac{1280}{11} \\ -\frac{1280}{11} \\ 0 \\ -\frac{80}{11} \\ \frac{80}{11} \\ -\frac{80}{11} \end{bmatrix}$$

$$V_1 = 120V$$

$$V_2 = \frac{1280}{11} V \approx 116.36V$$

$$V_3 = \frac{-1280}{11} V \approx -116.36V$$

$$V_4 = 0V$$

$$I_g = \frac{-80}{11} \approx -7.27 A$$

$$I_m = \frac{80}{11} A \approx 7.27 A$$

$$I_V = \frac{-80}{11} A \approx -7.27 A$$

Figure 4: Node voltage and current Results of Figure 3.

b)

$$U=\begin{bmatrix}2&-2&0&0&0&0&1\\0&1&-1&0&0&0&0\\0&0&1&0&0&0&-\frac{1}{2}\\0&0&0&1&0&0&0\\0&0&0&0&1&0&1\\0&0&0&0&0&1&-\frac{1}{32}\\0&0&0&0&0&0&\frac{33}{32}\end{bmatrix}\quad L=\begin{bmatrix}1&0&0&0&0&0&0\\0&1&0&0&0&0&0\\0&1&1&0&0&0&0\\0&0&0&1&0&0&0\\-1&0&0&0&1&0&0\\0&0&-\frac{1}{16}&\frac{1}{16}&0&1&0\\\frac{1}{2}&0&\frac{1}{16}&-\frac{1}{16}&-1&0&1\end{bmatrix}\quad P=\begin{bmatrix}1&0&0&0&0&0&0\\0&0&0&0&1&0&0\\0&0&0&0&0&0&1\\0&0&0&0&0&1&0\\0&1&0&0&0&0&0\\0&0&0&1&0&0&0\\0&0&1&0&0&0&0\end{bmatrix}$$

$Ly=Pb$

$$Ly=\begin{bmatrix}1&0&0&0&0&0&0\\0&1&0&0&0&0&0\\0&1&1&0&0&0&0\\0&0&0&1&0&0&0\\-1&0&0&0&1&0&0\\0&0&-\frac{1}{16}&\frac{1}{16}&0&1&0\\\frac{1}{2}&0&\frac{1}{16}&-\frac{1}{16}&-1&0&1\end{bmatrix}\begin{bmatrix}y_1\\y_2\\y_3\\y_4\\y_5\\y_6\\y_7\end{bmatrix}\qquad Pb=\begin{bmatrix}1&0&0&0&0&0&0\\0&0&0&0&1&0&0\\0&0&0&0&0&0&1\\0&0&0&0&0&1&0\\0&1&0&0&0&0&0\\0&0&0&1&0&0&0\\0&0&1&0&0&0&0\end{bmatrix}\begin{bmatrix}0\\0\\0\\0\\0\\0\\120\end{bmatrix}=\begin{bmatrix}0\\0\\120\\0\\0\\0\\0\end{bmatrix}$$

$Ly=Pb$

$$\begin{bmatrix}1&0&0&0&0&0&0\\0&1&0&0&0&0&0\\0&1&1&0&0&0&0\\0&0&0&1&0&0&0\\-1&0&0&0&1&0&0\\0&0&-\frac{1}{16}&\frac{1}{16}&0&1&0\\\frac{1}{2}&0&\frac{1}{16}&-\frac{1}{16}&-1&0&1\end{bmatrix}\begin{bmatrix}y_1\\y_2\\y_3\\y_4\\y_5\\y_6\\y_7\end{bmatrix}=\begin{bmatrix}0\\0\\120\\0\\0\\0\\0\end{bmatrix}$$

$y_1=0\quad y_2=0\quad y_3=120\quad y_4=0\quad y_5=0$

$-\frac{1}{16}(120)+y_6=0\qquad \frac{1}{16}(120)+y_7=0$

$y_6=\frac{15}{2}\qquad y_7=\frac{-15}{2}$

$Ux=y$

$$\begin{bmatrix}2&-2&0&0&0&0&1\\0&1&-1&0&0&0&0\\0&0&1&0&0&0&-\frac{1}{2}\\0&0&0&1&0&0&0\\0&0&0&0&1&0&1\\0&0&0&0&0&1&-\frac{1}{32}\\0&0&0&0&0&0&\frac{33}{32}\end{bmatrix}\begin{bmatrix}v_1\\v_2\\v_3\\v_4\\I_g\\I_m\\I_v\end{bmatrix}=\begin{bmatrix}0\\0\\120\\0\\0\\\frac{15}{2}\\\frac{-15}{2}\end{bmatrix}$$

$I_v=\frac{-80}{11}A\quad I_m=\frac{80}{11}A\quad I_g=\frac{80}{11}A$

$v_4=0V\quad v_3=\frac{-1280}{11}V\quad v_2=\frac{1280}{11}V$

$v_1=120V$

$v_1=120V$
$v_2=\frac{1280}{11}V\approx 116.36V$
$v_3=\frac{-1280}{11}V\approx -116.36V$
$v_4=0V$
$I_g=\frac{-80}{11}\approx -7.27A$
$I_m=\frac{80}{11}A\approx 7.27A$
$I_v=\frac{-80}{11}A\approx -7.27A$

Figure 5: Manual computation of node voltages and currents of Figure 2, using PLU Decomposition.

Question 2)

$$\begin{bmatrix} 2 & -2 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & -\frac{1}{2} & 60 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & -\frac{1}{32} & \frac{15}{4} \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{33}{32} & -\frac{15}{4} \end{bmatrix}$$

$$\frac{33}{32} I_V = \frac{-15}{4}$$

$$I_V = \frac{-40}{11} A$$

$$I_m + \frac{-1}{32}\left(-\frac{40}{11}\right) = \frac{15}{4}$$

$$I_m = \frac{40}{11} A$$

$$I_g + \left(\frac{-40}{11}\right) = 0$$

$$I_g = \frac{-40}{11} A$$

$$V_4 = 0V$$

$$v_2 - \left(\frac{640}{11}\right) = 0$$

$$v_2 = \frac{640}{11} V$$

$$v_3 - \frac{1}{2}\left(-\frac{40}{11}\right) = 60$$

$$v_3 = -\frac{640}{11} V$$

$$2v_1 - 2\left(\frac{640}{11}\right) - \frac{40}{11} = 0$$

$$v_1 = 60 V$$

$$\boxed{\begin{aligned} V_1 &= 60V \\ V_2 &= \tfrac{640}{11} V \approx 58.18V \\ V_3 &= -\tfrac{640}{11} V \approx -58.18V \\ V_4 &= 0 V \\ I_g &= \tfrac{-40}{11} A \approx -3.64 A \\ I_m &= \tfrac{40}{11} A \approx 3.64 A \\ I_V &= \tfrac{-40}{11} A \approx -3.64 A \end{aligned}}$$

Figure 6: Repeat of question 1 using v_s = 60V.

When using gaussian elimination with partial decomposition, the source voltage in the rightmost column is switched out with 60V. Compared to PLU decomposition, Gaussian Elimination would be better for sweeping voltages.

MATLAB Output)

Question 2)

```
Question 2:
Matrix A:
    2.0000   -2.0000         0         0         0         0    1.0000
   -2.0000    2.0000         0         0    1.0000         0         0
         0         0    0.0625   -0.0625   -1.0000         0         0
         0         0   -0.0625    0.0625         0    1.0000         0
         0    1.0000   -1.0000         0         0         0         0
         0         0         0    1.0000         0         0         0
    1.0000         0         0         0         0         0         0

Vector b:
     0
     0
     0
     0
     0
     0
   120
```

Figure 7: MAPNETLIST output Matrix A and vector B of Figure 2. The results are the same as the provided calculations.

Question 4)

```
Q4a - 0 Hz Results:
Gaussian Partial Pivot Solution:
120.0000V
116.3636V
116.3636V
0.0000V
7.2727V
7.2727V
-7.2727V
PLU Decomposition Solution:
120.0000V
116.3636V
116.3636V
0.0000V
7.2727V
7.2727V
-7.2727V
Note: the phasor angle is 0° as there is no imaginary component.
```

Figure 8: Gaussian with partial pivoting and PLU decomposition solution of Figure 2, at 0Hz. Since the circuit is DC only, there is no phasor angle for any of the nodes. Note that the results are the same.

```
Q4b - 60 Hz Results:
Gaussian Partial Pivot Solution:
120.0000V ∠117.5334°
120.2765V ∠72.1645°
5.3784V ∠6.0139°
5.3784V ∠-0.0000°
-0.5169V ∠-3.3324°
49.7986V ∠23.2199°
-40.2014V ∠-156.7801°

PLU Decomposition Solution:
120.0000V ∠117.5334°
120.2765V ∠72.1645°
5.3784V ∠6.0139°
5.3784V ∠-0.0000°
-0.5169V ∠-3.3324°
49.7986V ∠23.2199°
-40.2014V ∠-156.7801°
```

Figure 9: Gaussian with partial pivoting and PLU decomposition solution of Figure 2, at 60Hz. Note that the results are the same.

Comparing Gaussian elimination with partial pivoting and PLU decomposition with forward/backward substitution result in the same solution. Hence either method should provide the same level of accuracy.

Question 5)

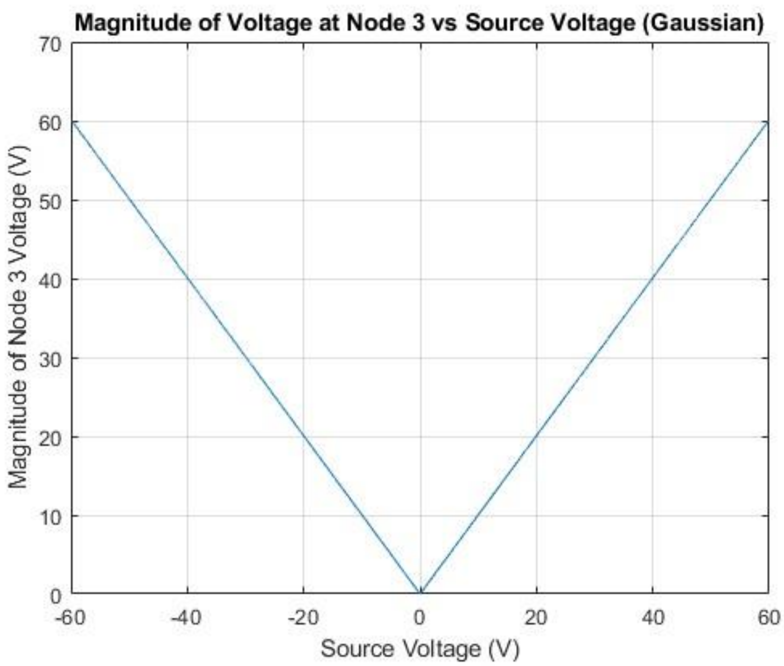

Figure 10: Magnitude of node three voltage as the source voltage is swept from -60V to 60V with 0.01V steps, at 60Hz. The plot takes the form of an absolute function.

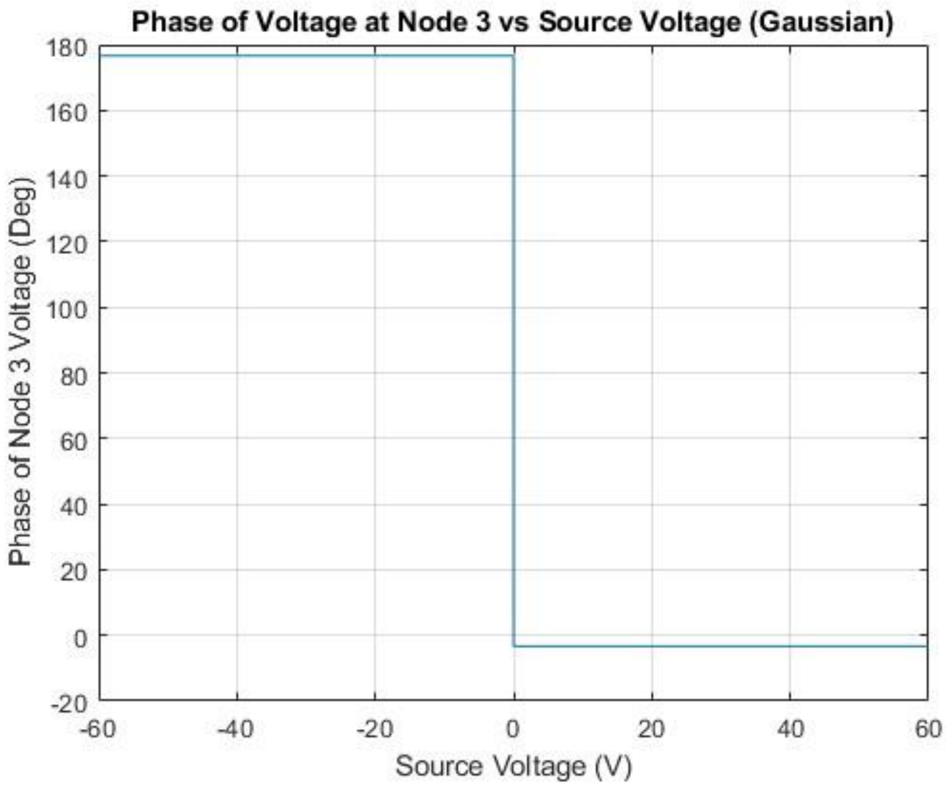

Figure 11: Phase of node three as the source voltage is swept.

Question 6)

```
>> q5toq6
PLU CPU Time: 5.88 seconds
Gaussian CPU Time:5.41 seconds
```

Figure 12: Estimated execution time of PLU and Gaussian calculations.

As seen by Figure 12, Gaussian elimination with partial pivoting is faster by approximately 8 percent.

Question 7)

a)

The netlists for Fig. 2 and Fig. 3 from the lab two manual can be found in the MATLAB code appendix.

b)

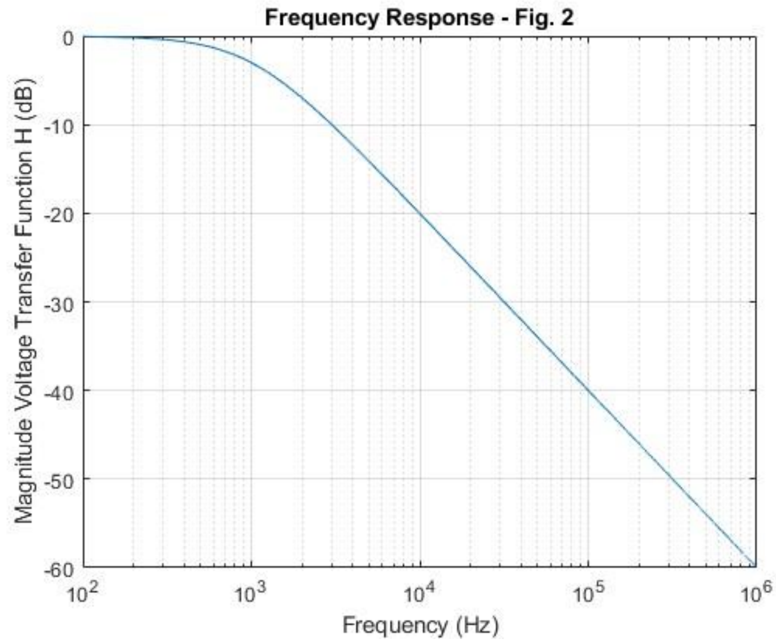

Figure 13: Frequency response plot of Fig. 2 from the lab manual. Frequency range is from 0 Hz to 1 MHz, with 100 Hz step sizes.

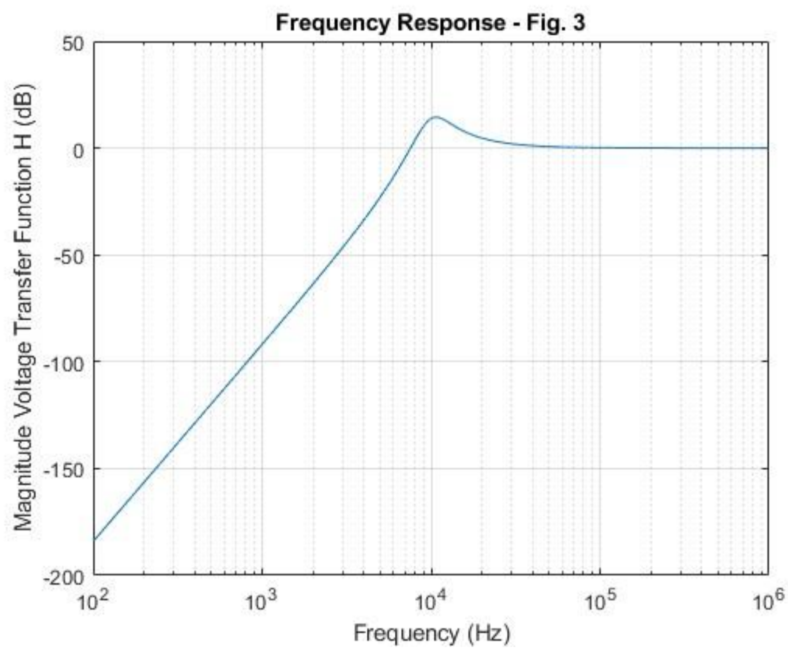

Figure 14: Frequency response plot of Fig. 3 from the lab manual. Frequency range is from 0 Hz to 1 MHz, with 100 Hz step sizes.

Question 8)

The frequency response curves of Fig. 2 and Fig. 3 are that of a low-pass and high-pass filter, respectively. The Fig. 2 circuit would filter out high frequency noise, while Fig. 3 would filter out low frequency noise. Note that on the frequency response curve in Figure 14, there is a "bump" at around 10 kHz, which is the resonant frequency of the circuit.

Question 9)

```
>> q7toq9
The -3dB corner frequency for the circuit in fig. 2 is: 998.60 Hz
```

Figure 15: -3dB corner frequency of Figure 13 is 998.6 Hz.

Conclusion

In conclusion, this lab expanded our knowledge on circuit analysis and simulation, specifically with analyzing DC and AC sources. We learned how to perform a voltage sweep analysis along with a simple frequency transfer function characterization. In addition to this as a team, we modelled voltage sources, capacitors, and inductors. In this lab we used several numerical methods like Gaussian elimination, PLU decomposition and interpolation. Moreover, the utilization of advanced numerical methods such as Gaussian elimination, PLU decomposition, and interpolation further enriched our learning experience, equipping us with the analytical tools necessary to tackle complex circuit analysis problems with confidence and precision. Collaboratively, as a team, we meticulously modeled various essential components including voltage sources, capacitors, and inductors, a task that not only solidified our theoretical knowledge but also honed our practical skills in circuit design and simulation.

MATLAB Code)

Question 1)

```
function [A, b] = mappNETLIST(filename, f)
    % Open the file
    fid = fopen(filename, 'r');

    % Initialize a counter for the maximum node number
    maxNode = 0;
    extraRow = 0;
    counter = 0;

    %initalize s for inductor and capacitor
    s = (2*pi*f)*1i;
    % First pass to determine the size of matrices A and b
    while ~feof(fid)
        line = fgetl(fid);
        tokens = strsplit(line);
        type = tokens{1}(1);
        % Check node numbers and update maxNode if necessary
        n1 = str2double(tokens{2});
        n2 = str2double(tokens{3});
        if type == 'V' || type == 'L'
            extraRow = extraRow + 1;
        end
        if n1 > maxNode
            maxNode = max(maxNode, n1);
        end
        if n2 > maxNode
            maxNode = max(maxNode, n2);
        end
    end

    % Close and reopen the file to reset the read position to the beginning
    fclose(fid);
    fid = fopen(filename, 'r');

    % Initialize matrix A and vector b with the correct size
    A = zeros(maxNode + extraRow);
    b = zeros(maxNode + extraRow, 1);

    % Read the file line by line and update A and b
    while ~feof(fid)
        line = fgetl(fid);
        tokens = strsplit(line);

        % Determine the type of component (Resistor or Current Source)
        type = tokens{1}(1);
```

```
n1 = str2double(tokens{2});
n2 = str2double(tokens{3});
value = str2double(tokens{4});

% Update the matrices A and b based on the component type
if type == 'R'
   % For resistors, update A matrix
   G = 1 / value; % Conductance is the inverse of resistance
   if n1 ~= 0
      A(n1, n1) = A(n1, n1) + G;
   end
   if n2 ~= 0
      A(n2, n2) = A(n2, n2) + G;
   end
   if n1 ~= 0 && n2 ~= 0
      A(n1, n2) = A(n1, n2) - G;
      A(n2, n1) = A(n2, n1) - G;
   end

elseif type == 'I'
   % For current sources, update b vector
   if n1 ~= 0
      b(n1) = b(n1) - value; % Current entering node n1, assumed negative
   end
   if n2 ~= 0
      b(n2) = b(n2) + value; % Current leaving node n2, assumed positive
   end
elseif type == 'V'
   counter = counter + 1;
   if n1 ~= 0 && n2 ~= 0
      A(n1, maxNode + counter) = A(n1, maxNode + counter) - 1;
      A(maxNode + counter, n1) = A(maxNode + counter, n1) - 1;
      A(n2, maxNode + counter) = A(n2, maxNode + counter) + 1;
      A(maxNode + counter, n2) = A(maxNode + counter, n2) + 1;

   elseif n1 ~= 0 && n2 == 0
      A(n1, maxNode + counter) = A(n1, maxNode + counter) - 1;
      A(maxNode + counter, n1) = A(maxNode + counter, n1) - 1;
   elseif n1 == 0 && n2 ~= 0
      A(n2, maxNode + counter) = A(n2, maxNode + counter) + 1;
      A(maxNode + counter, n2) = A(maxNode + counter, n2) + 1;
   end
   b(maxNode + counter) = value;
elseif type == 'L'
   counter = counter + 1;
   if n1 ~= 0 && n2 ~= 0
      A(n1, maxNode + counter) = A(n1, maxNode + counter) - 1;
```

```
            A(maxNode + counter, n1) = A(maxNode + counter, n1) - 1;
            A(n2, maxNode + counter) = A(n2, maxNode + counter) + 1;
            A(maxNode + counter, n2) = A(maxNode + counter, n2) + 1;
            A(maxNode + counter, maxNode + counter) = A(maxNode + counter, maxNode + counter) -
s*value;

         elseif n1 ~= 0 && n2 == 0
            A(n1, maxNode + counter) = A(n1, maxNode + counter) - 1;
            A(maxNode + counter, n1) = A(maxNode + counter, n1) - 1;
            A(maxNode + counter, maxNode + counter) = A(maxNode + counter, maxNode + counter) -
s*value;
         elseif n1 == 0 && n2 ~= 0
            A(n2, maxNode + counter) = A(n2, maxNode + counter) + 1;
            A(maxNode + counter, n2) = A(maxNode + counter, n2) + 1;
            A(maxNode + counter, maxNode + counter) = A(maxNode + counter, maxNode + counter) -
s*value;
         end
      elseif type == 'C'
         if n1 ~= 0 && n2 ~= 0
            A(n1, n1) = A(n1, n1) + s*value;
            A(n1, n2) = A(n1, n2) - s*value;
            A(n2, n1) = A(n2, n1) - s*value;
            A(n2, n2) = A(n2, n2) + s*value;
         elseif n1 ~= 0 && n2 == 0
            A(n1, n1) = A(n1, n1) + s*value;
         elseif n1 == 0 && n2 ~= 0
            A(n2, n2) = A(n2, n2) + s*value;
         end
      end
   end

   % Close the file
   fclose(fid);
end
```

Question 2 & 4)

```
%q2, find netlist from figure 1 with mappNETLIST
[A_Fig1, b_Fig1] = mappNETLIST('Figure_1.txt', 0);

disp('Question 2:');
disp('Matrix A:');
disp(A_Fig1);
disp('Vector b:');
disp(b_Fig1);

%%Q4a - 0 Hz
x_fig1_gauss = GaussElimPivot(A_Fig1, b_Fig1);
```

```
x_fig1_PLU = PLUSolver(A_Fig1, b_Fig1);

disp('Q4a - 0 Hz Results:');
disp('Gaussian Partial Pivot Solution:');
fprintf('');
fprintf("%0.4fV\n", x_fig1_gauss);
disp('PLU Decomposition Solution:');
fprintf("%0.4fV\n", x_fig1_PLU);
disp("Note: the phasor angle is 0° as there is no imaginary component.")


%%Q4b - 60Hz
%Gaussian solution
disp('Q4b - 60 Hz Results:')
[A_Fig1, b_Fig1] = mappNETLIST('Figure_1.txt', 60);

disp('Gaussian Partial Pivot Solution:');

x_fig1_gauss = GaussElimPivot(A_Fig1, b_Fig1);

for i = x_fig1_gauss
   x_fig1_gauss_mag = abs(i);
   x_fig1_gauss_phase = angle(i);
   x_fig1_gauss_phase_deg = rad2deg(x_fig1_gauss_phase);
   fprintf("%0.4fV ∠%0.4f° \n", x_fig1_gauss_mag, x_fig1_gauss_phase_deg);
end
fprintf("\n");

%%PLU solution
disp('PLU Decomposition Solution:');
x_fig1_PLU = PLUSolver(A_Fig1, b_Fig1);

for i = x_fig1_PLU
   x_fig1_PLU_mag = abs(i);
   x_fig1_PLU_phase = angle(i);
   x_fig1_PLU_phase_deg = rad2deg(x_fig1_PLU_phase);
   fprintf("%0.4fV ∠%0.4f° \n", x_fig1_gauss_mag, x_fig1_gauss_phase_deg);
end
fprintf("\n");
```

Question 3a)

```
function [x] = GaussElimPivot(A,b)
% GaussPivot: Gauss elimination pivoting
% x = GaussPivot(A,b): Gauss elimination with pivoting.
% input:
% A = coefficient matrix
% b = right hand side vector
```

```
% output:
% x = solution vector
[m,n]=size(A);
if m~=n, error('Matrix A must be square'); end
nb=n+1;
Aug=[A b];
% forward elimination
for k = 1:n-1
% partial pivoting
[big,i]=max(abs(Aug(k:n,k)));
ipr=i+k-1;
if ipr~=k
Aug([k,ipr],:)=Aug([ipr,k],:);
end
for i = k+1:n
factor=Aug(i,k)/Aug(k,k);
Aug(i,k:nb)=Aug(i,k:nb)-factor*Aug(k,k:nb);
end
end
% back substitution
x=zeros(n,1);
x(n)=Aug(n,nb)/Aug(n,n);
for i = n-1:-1:1
x(i)=(Aug(i,nb)-Aug(i,i+1:n)*x(i+1:n))/Aug(i,i);
end
```

Question 3 b)

```
function [x] = PLUSolver(A, b)
   [L, U, P] = PLU(A);
   y = L\(P*b);
   x = U\y;
end
```

Question 5 & 6)

```
%q5
close all;

vSourceMin=-60;
VSourceMax=60;
vSource_Sampling = vSourceMin:0.01:VSourceMax;

v3_Magnitude = [];
v3_Phase = [];
v3_Mag = [];
v3_Ph = [];
```

```
v3_Magnitude_Gauss = [];
v3_Phase_Gauss = [];
v3_Mag_Gauss = [];
v3_Ph_Gauss = [];

t_Gaussian = 0;
t_PLU = 0;


%%PLU
for i = vSource_Sampling
    tic;
    [A_Fig1, b] = mappNETLIST('Figure_1.txt', 60);
    b(length(b)) = i;
    [x_fig1_PLU] = PLUSolver(A_Fig1, b);
    v3_Magnitude=abs(x_fig1_PLU(3));
    v3_Phase = angle(x_fig1_PLU(3))*(180/pi);

    v3_Mag = [v3_Mag, v3_Magnitude];
    v3_Ph = [v3_Ph, v3_Phase];
    t_PLU = t_PLU + toc;

end
fprintf('PLU CPU Time: %0.2f seconds\n', t_PLU);

figure;
plot(vSource_Sampling, v3_Mag);
xlabel('Source Voltage (V)');
ylabel('Magnitude of Node 3 Voltage (V)');
title('Magnitude of Voltage at Node 3 vs Source Voltage (PLU)');
grid on;

figure;
plot(vSource_Sampling, v3_Ph);
xlabel('Source Voltage (V)');
ylabel('Phase of Node 3 Voltage (Deg)');
title('Phase of Voltage at Node 3 vs Source Voltage (PLU)');
grid on;



%%Gaussian calculation
for i = vSource_Sampling
    tic;
    [A_Fig1_Gauss, b_Gauss] = mappNETLIST('Figure_1.txt', 60);
    b_Gauss(length(b_Gauss)) = i;
```

```
    [x_fig1_Gauss] = GaussElimPivot(A_Fig1_Gauss,b_Gauss);
    v3_Magnitude_Gauss=abs(x_fig1_Gauss(3));
    v3_Phase_Gauss = angle(x_fig1_Gauss(3))*(180/pi);
    v3_Mag_Gauss = [v3_Mag_Gauss, v3_Magnitude_Gauss];
    v3_Ph_Gauss = [v3_Ph_Gauss, v3_Phase_Gauss];

    t_Gaussian = t_Gaussian + toc;
end
fprintf('Gaussian CPU Time:%0.2f seconds\n', t_Gaussian);
figure;
plot(vSource_Sampling, v3_Mag_Gauss);
xlabel('Source Voltage (V)');
ylabel('Magnitude of Node 3 Voltage (V)');
title('Magnitude of Voltage at Node 3 vs Source Voltage (Gaussian)');
grid on;

figure;
plot(vSource_Sampling, v3_Ph_Gauss);
xlabel('Source Voltage (V)');
ylabel('Phase of Node 3 Voltage (Deg)');
title('Phase of Voltage at Node 3 vs Source Voltage (Gaussian)');
grid on;
```

Question 7 & 9)

```
%%Write a MATLAB script to call the mappNETLIST function and solve for the output voltage
% over a frequency range from 0 Hz to 1 MHz with a 100 Hz step size. The script should
% produce a plot of the magnitude voltage transfer function H (in dB) as a function of the frequency f.

%frequency range & sampling rate
f_min = 0;
f_max = 1e6;
f_Sample = f_min:100:f_max;

%-3dB corner frequency
corner_gain = -3;

%allocate space for voltage gains
voltage_gain_fig2 = zeros(1,10001);
voltage_gain_fig3 = zeros(1,10001);

counter = 0;

%Figure 2
for i = f_Sample
    counter = counter + 1 ;
    [A, b] = mappNETLIST('figure_2.txt', i);
```

```
    x_fig2 = PLUSolver(A,b);
    voltage_gain_fig2(counter) = 20*log10(abs(x_fig2(2)/1));
end

figure;
semilogx(f_Sample, voltage_gain_fig2);
xlabel('Frequency (Hz)');
ylabel('Magnitude Voltage Transfer Function H (dB)');
title('Frequency Response - Fig. 2');
grid on;

%q9, use interp1 function to find -3dB corner frequency
corner_freq = interp1(voltage_gain_fig2, f_Sample, corner_gain);
fprintf('The -3dB corner frequency for the circuit in fig. 2 is: %0.2f Hz\n', corner_freq);


%Figure 3
counter = 0;
for i = f_Sample
    counter = counter + 1;
    [A, b] = mappNETLIST('figure_3.txt', i);
    x_fig3 = PLUSolver(A,b);
    voltage_gain_fig3(counter) = 20*log(abs(x_fig3(3)/10));
end

figure;
semilogx(f_Sample, voltage_gain_fig3);
xlabel('Frequency (Hz)');
ylabel('Magnitude Voltage Transfer Function H (dB)');
title('Frequency Response - Fig. 3');
grid on;
```

Figure 1 Netlist)

```
Rg 1 2 500e-3
Lg 3 2 3.183e-3
Rm 3 4 16
Lm 0 4 31.83e-3
Cx 3 0 132.6e-6
Vs 0 1 120
```

Figure 2 Netlist)

```
R1 1 2 1.59
C1 2 0 100e-6
Vin 0 1 1
```

Figure 3 Netlist)

```
Rf 1 2 4
Cf 2 3 2e-6
Lf 3 0 127e-6
Vin 0 1 10
```