

BE 601 HW #1

1/10/2023 p1

Problem #1

A. Find  $|A|$

$$A = \begin{bmatrix} 1 & -1 & 0 & 1 \\ 2 & 0 & 2 & 0 \\ -1 & -1 & 2 & -1 \end{bmatrix}$$

$$|A| = -20$$

How?: Well let's do it w/ Laplace Expansion

Choose the column or row with the most 0s

In this case row 2, so  $i=2$

$$\sum_{ij=1}^n (-1)^{i+j} a_{ij} M_{ij}$$

~~$|A| = \sum_{j=1}^4 (-1)^{2+j} a_{2j} M_{2j}$~~

$$= (-1)^{2+1} a_{21} M_{21} + (-1)^{2+2} \cancel{a_{22} M_{22}} + (-1)^{2+3} \cancel{a_{23} M_{23}} + (-1)^{2+4} \cancel{a_{24} M_{24}}$$

$$= -2 M_{21}$$

$$M_{21} = \begin{bmatrix} -1 & 0 & 1 \\ 2 & 3 & 0 \\ -1 & 2 & -1 \end{bmatrix} = (-1 \cdot 3 \cdot -1 + 0 \cdot 0 \cdot -1 + 1 \cdot 2 \cdot 2) - (-1 \cdot 3 \cdot 1 + 2 \cdot 0 \cdot -1 + -1 \cdot 2 \cdot 0)$$

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

$$= +10$$

$$\text{Thus, } |A| = -2(10) = -20$$

Find cofactor matrix

$$(1) C_{ij} = (-1)^{i+j} M_{ij}$$

$$C_{11} = +1 \begin{vmatrix} 0 & 0 & 0 \\ 2 & 3 & 0 \\ -1 & 2 & -1 \end{vmatrix} = 0 \quad \text{top row is 0}$$

$$C_{12} = -1 \begin{vmatrix} 2 & 0 & 0 \\ 0 & 3 & 0 \\ -1 & 2 & -1 \end{vmatrix} = -1 [((2 \cdot 3 \cdot -1) + (0 \cdot 0 \cdot -1) + (0 \cdot 0 \cdot 2)) - ((-1 \cdot 3 \cdot 0) + (2 \cdot 0 \cdot 2) + (-1 \cdot 0 \cdot 0))] = 6$$

cont.

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Problem 1

Part B (cont.)

$$C_{13} = 1 \begin{vmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ -1 & -1 & -1 \end{vmatrix} = (2 \cdot 2 \cdot -1 + 0 \cdot 0 \cdot -1 + 0 \cdot 0 \cdot -1) - (-1 \cdot 2 \cdot 0 + -1 \cdot 0 \cdot 2 + -1 \cdot 0 \cdot -1) = 4$$

$$C_{14} = -1 \begin{vmatrix} 2 & 0 & 0 \\ 0 & 2 & 3 \\ -1 & -1 & 2 \end{vmatrix} = [2 \cdot 2 \cdot 2 + 0 \cdot 3 \cdot -1 + 0 \cdot 0 \cdot -1] - [-1 \cdot 2 \cdot 0 + -1 \cdot 3 \cdot 2 + 2 \cdot 0 \cdot 0] = -14$$

$$C_{21} = -1 \begin{vmatrix} -1 & 0 & 1 \\ 2 & 3 & 0 \\ -1 & 2 & -1 \end{vmatrix} = -1 \left[ (-1 \cdot 3 \cdot 1 + 0 \cdot 0 \cdot -1 + 1 \cdot 2 \cdot 2) - (-1 \cdot 3 \cdot 1 + 2 \cdot 0 \cdot -1 + 1 \cdot 2 \cdot 0) \right] = -10$$

$$C_{22} = -1 \begin{vmatrix} 1 & 0 & 1 \\ 0 & 3 & 0 \\ -1 & 2 & -1 \end{vmatrix} = (1 \cdot 2 \cdot -1 + 0 \cdot 0 \cdot -1 + 1 \cdot 0 \cdot -1) - (-1 \cdot 2 \cdot 1 + 0 \cdot 0 \cdot 1 + -1 \cdot 0 \cdot -1) = 0$$

$$C_{23} = -1 \begin{vmatrix} 1 & -1 & 1 \\ 0 & 2 & 0 \\ -1 & -1 & -1 \end{vmatrix} = 0 \quad \text{same as above}$$

$$C_{24} = 1 \begin{vmatrix} 1 & -1 & 0 \\ 0 & 2 & 3 \\ -1 & -1 & 2 \end{vmatrix} = (1 \cdot 2 \cdot -1 + 3 \cdot -1 + 0) - (0 + -1 \cdot 1 + 0) = 10$$

$$C_{31} = 1 \begin{vmatrix} -1 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 2 & -1 \end{vmatrix} = 0$$

$$C_{32} = -1 \begin{vmatrix} 1 & 0 & 1 \\ 2 & 0 & 0 \\ -1 & 2 & -1 \end{vmatrix} = (0 + 0 + 1 \cdot 2 \cdot -1) - (0 + 0 + -1 \cdot 2 \cdot 1) = -4$$

$$C_{33} = 1 \begin{vmatrix} 1 & -1 & 1 \\ 2 & 0 & 0 \\ -1 & -1 & -1 \end{vmatrix} = (0 + 0 + 1 \cdot 2 \cdot -1) - (0 + 0 + -1 \cdot 2 \cdot -1) = -4$$

$$C_{34} = -1 \begin{vmatrix} 1 & -1 & 0 \\ 2 & 0 & 0 \\ -1 & -1 & 2 \end{vmatrix} = (0 + 0 + 0) - (0 + 0 + 2 \cdot 2 \cdot -1) = 0 - 4 = -4$$

$$C_{41} = -1 \begin{vmatrix} -1 & 0 & 1 \\ 0 & 0 & 0 \\ 2 & 3 & 0 \end{vmatrix} = (0 + 0 + 0) - (0 + 0 + 0) = 0$$

$$C_{42} = +1 \begin{vmatrix} 1 & 0 & 1 \\ 2 & 0 & 6 \\ 0 & 3 & 0 \end{vmatrix} = (0 + 0 + 1 \cdot 2 \cdot 3) - (0 + 0 + 0) = 6$$

## Problem 1

Part B (cont.)

$$C_{43} = -1 \begin{vmatrix} 1 & -1 & 1 \\ 2 & 0 & 0 \\ 0 & 2 & 0 \end{vmatrix} = (0 + 0 + 12) - (0 + 0 + 0) = -4$$

$$C_{44} = 1 \begin{vmatrix} 1 & -1 & 0 \\ 2 & 0 & 0 \\ 0 & 2 & 3 \end{vmatrix} = (0 + 0 + 0) - (0 + 0 + 32 - 1) = -6$$

So  $C = \begin{bmatrix} 0 & 6 & -4 & -14 \\ -10 & 0 & 0 & 10 \\ 0 & -4 & -4 & -4 \\ 0 & 6 & -4 & 6 \end{bmatrix}$   $C^T = \begin{bmatrix} 0 & -10 & 0 & 0 \\ 6 & 0 & -4 & 6 \\ -4 & 0 & -4 & -4 \\ -14 & 10 & -4 & 6 \end{bmatrix}$

Then  $A^{-1} = C^T / |A|$   $A^{-1} = \begin{bmatrix} 0 & 0.5 & 0 & 0 \\ -0.3 & 0 & 0.2 & -0.3 \\ 0.2 & 0 & 0.2 & 0.2 \\ 0.7 & -0.5 & 0.2 & -0.3 \end{bmatrix}$   
 $C^T / -20$

## Contents

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- Part A
- Part B

### Part A

```
echo on
%Part A
T1_mA = [ 6 6 1; 4 4 1; 5 2 1];
Area_T1 = 0.5 * det(T1_mA)

T2_mA = [ 6 6 1; 1 4 1; 4 4 1];
Area_T2 = 0.5 * det(T2_mA)

T3_mA = [ 4 4 1; 1 4 1; 5 2 1];
Area_T3 = 0.5 * det(T3_mA)
```

```
%Part A
T1_mA = [ 6 6 1; 4 4 1; 5 2 1];
Area_T1 = 0.5 * det(T1_mA)

Area_T1 =
```

3.0000

```
T2_mA = [ 6 6 1; 1 4 1; 4 4 1];
Area_T2 = 0.5 * det(T2_mA)

Area_T2 =
```

3

```
T3_mA = [ 4 4 1; 1 4 1; 5 2 1];
Area_T3 = 0.5 * det(T3_mA)

Area_T3 =
```

3.0000

### Part B

```
PB_T1_mA = [ 6 6 1; 4.5 3 1; 5 2 1];
PB_Area_T1 = 0.5 * det(PB_T1_mA)

PB_T2_mA = [ 6 6 1; 1 4 1; 4.5 3 1];
PB_Area_T2 = 0.5 * det(PB_T2_mA)

PB_T3_mA = [ 4.5 3 1; 1 4 1; 5 2 1];
PB_Area_T3 = 0.5 * det(PB_T3_mA)

Cyan_pArea = PB_Area_T1/9
Magenta pArea = PB Area T2/9
```

```
Yellow_pArea = PB_Area_T3/9  
echo off
```

%% Part B

```
PB_T1_mA = [ 6 6 1; 4.5 3 1; 5 2 1];  
PB_Area_T1 = 0.5 * det(PB_T1_mA)
```

```
PB_Area_T1 =
```

```
1.5000
```

```
PB_T2_mA = [ 6 6 1; 1 4 1; 4.5 3 1];  
PB_Area_T2 = 0.5 * det(PB_T2_mA)
```

```
PB_Area_T2 =
```

```
6.0000
```

```
PB_T3_mA = [ 4.5 3 1; 1 4 1; 5 2 1];  
PB_Area_T3 = 0.5 * det(PB_T3_mA)
```

```
PB_Area_T3 =
```

```
1.5000
```

```
Cyan_pArea = PB_Area_T1/9
```

```
Cyan_pArea =
```

```
0.1667
```

```
Magenta_pArea = PB_Area_T2/9
```

```
Magenta_pArea =
```

```
0.6667
```

```
Yellow_pArea = PB_Area_T3/9
```

```
Yellow_pArea =
```

```
0.1667
```

```
echo off
```

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Problem # 3

Part 1

$$A = \begin{bmatrix} 1 & -2 & 1 \\ 2 & 4 & 1 \\ 2 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -2 \\ 11 \\ 5 \end{bmatrix}$$

$$L = \begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 2 & 0 & 1 \end{bmatrix} \quad p.4$$

Find  $P, L, U$  Essentially I solve for  $U$  by eliminating  $A_{1,2}, A_{1,3}, A_{2,3}$

$$\begin{array}{ccc} 1 & -2 & 1 & -(2R_1) + R_2 \\ 2 & 4 & 1 & \xrightarrow{\quad} 0 & 8 & -1 & -2R_1 + R_3 \\ 2 & 1 & 1 & \downarrow & 2 & 1 & 1 & \downarrow \\ & & & & & & & \end{array} \begin{array}{ccc} 1 & -2 & 1 & -2R_1 + R_3 \\ 0 & 8 & -1 & \xrightarrow{\quad} 0 & 8 & -1 & -\frac{5}{8}R_1 + R_3 \\ 2 & 1 & 1 & \downarrow & 0 & 5 & -1 & \downarrow \\ & & & & & & & \end{array}$$

From here we  
can get  $L_{2,1} = 2$

thus  $L_{3,1} = 2$

$L_{3,2} = 5/8$

$$\begin{bmatrix} 1 & -2 & 1 \\ 0 & 8 & -1 \\ 0 & 0 & -0.375 \end{bmatrix} \leftarrow \text{Well this is } U \quad L = \begin{bmatrix} 1 & 0 & 0 \\ 2 & 1 & 0 \\ 2 & 0.625 & 1 \end{bmatrix}$$

I think through this  $P$  remains unchanged and is still

This doesn't match  $\text{lu}(A)$ ... but if we consider  $\text{lu}(\text{sparse}(A))$   
it matches...

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Part 2

$b_{\text{new}}$  Find  $x$        $b_{\text{new}}$  is just  $b$  since  $Pb$  is just  $b$

$$L\tilde{c} = b \rightarrow c_1 = -2$$

$$2c_1 + c_2 = 11 \rightarrow c_2 = 15$$

$$2c_1 + 0.625c_2 + c_3 = 5 \rightarrow c_3 = -0.375$$

$$\tilde{c} = \begin{bmatrix} -2 \\ 15 \\ -0.375 \end{bmatrix}$$

$$U\tilde{x} = \tilde{c} \rightarrow \begin{aligned} x_1 - 2x_2 + x_3 &= -2 & x_1 &= 1 \\ 8x_2 - x_3 &= 15 & x_2 &= 2 \\ -0.375x_3 &= -0.375 & x_3 &= 1 \end{aligned}$$

$$\tilde{x} = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix}$$

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Problem #3 cont.

Part 3

$$\ln(A) *$$

$$P = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

$$A = \begin{bmatrix} -1 & 3 & 5 \\ 1 & 1 & -1 \\ 2 & 2 & -2 \end{bmatrix}$$

$$L = \begin{bmatrix} 1 & 0 & 0 \\ -0.5 & 1 & 0 \\ 0.5 & 0 & 1 \end{bmatrix}$$

$$U = \begin{bmatrix} 2 & 2 & -2 \\ 0 & 4 & 4 \\ 0 & 0 & 0 \end{bmatrix}$$

Well linear independence is easily found

I think we can determine that by

Well we know that  $L$  and  $U$  are linearly dependent, but  $P$  is independent. Since  $L$  and  $U$  are just decompositions we can determine that  $a_1, a_2, a_3$  are dependent.

$$\begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

What is the equation involving 9 sides of right I

((A) simple relation will be found ... (A) is done + result will be obtained)

Sum of d 9 sides of right is zero

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$x = 0 \quad \text{or } d = 0$$

$$21 = 0 \quad 11 = 0 \quad 21 = 0 \\ 286.0 = 0 \quad 286.0 = 0 \quad 286.0 = 0$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$1 \cdot X + 0 \cdot Y + 0 \cdot Z = X + 0 \cdot Y + 0 \cdot Z \\ 1 \cdot X = X \quad 0 \cdot Y = 0 \cdot Y \\ 1 \cdot X = 286.0 \quad 0 \cdot Y = 286.0$$

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~~Part A~~ Problem #4

Part A Node 1

$$\begin{aligned} 1 & G_o(V_1 - 12) + G_o(V_1 - 0) + G_o(V_1 - V_2) + G_o(V_1 - V_6) = 0 \\ 2 & G_o(V_2 - V_1) + G_o(V_2 - 0) + G_o(V_2 - V_3) + G_o(V_2 - V_7) = 0 \\ 3 & G_o(V_3 - V_2) + G_o(V_3 - 0) + G_o(V_3 - V_4) + G_o(V_3 - V_8) = 0 \\ 4 & G_o[(V_4 - V_3) + (V_4 - 0) + (V_4 - V_5) + (V_4 - V_9)] = 0 \\ 5 & (V_5 - V_4) + (V_5 - 0) + (V_5 - V_0) + (V_5 - V_{10}) = 0 \\ 6 & (V_6 - 12) + (V_6 - V_1) + (V_6 - V_7) + (V_6 - V_{11}) = 0 \\ 7 & (V_7 - V_6) + (V_7 - V_2) + (V_7 - V_8) + (V_7 - V_{12}) = 0 \\ 8 & (V_8 - V_7) + (V_8 - V_3) + (V_8 - V_{13}) + (V_8 - V_9) = 0 \\ 9 & (V_9 - V_8) + (V_9 - V_4) + (V_9 - V_{10}) + (V_9 - V_{14}) = 0 \\ 10 & (V_{10} - V_{11}) + (V_{10} - V_5) + (V_{10} - 0) + (V_{10} - V_{15}) = 0 \\ 11 & (V_{11} - 12) + (V_{11} - V_6) + (V_{11} - V_{12}) + (V_{11} - 0) = 0 \\ 12 & (V_{12} - V_{11}) + (V_{12} - V_2) + (V_{12} - V_{13}) + (V_{12} - 0) = 0 \\ 13 & (V_{13} - V_{12}) + (V_{13} - V_8) + (V_{13} - V_{14}) + (V_{13} - 0) = 0 \\ 14 & (V_{14} - V_{13}) + (V_{14} - V_9) + (V_{14} - V_{15}) + (V_{14} - 0) = 0 \\ 15 & (V_{15} - V_{14}) + (V_{15} - V_{10}) + (V_{15} - 0) + (V_{15} - 0) = 0 \end{aligned}$$

Node 1: 4 neighbors [12]

2

$$\begin{aligned} 1 & 4G_oV_1 - G_oV_2 - G_oV_6 = +12G_o \\ 2 & 4G_oV_2 - G_oV_1 - G_oV_3 - G_oV_7 = 0 \\ 3 & 4G_oV_3 - G_oV_2 - G_oV_4 - G_oV_8 = 0 \\ 4 & 4G_oV_4 - G_oV_3 - G_oV_5 - G_oV_9 = 0 \\ 5 & 4G_oV_5 - G_oV_4 - G_oV_{10} = -10G_o \\ 6 & 4G_oV_6 - G_oV_1 - G_oV_7 - G_oV_{11} = +12G_o \\ 7 & 4G_oV_7 - G_oV_6 - G_oV_2 - G_oV_8 - G_oV_{12} = 0 \\ 8 & 4G_oV_8 - G_oV_7 - G_oV_3 - G_oV_{13} - G_oV_9 = 0 \\ 9 & 4G_oV_9 - G_oV_8 - G_oV_4 - G_oV_{10} - G_oV_{14} = 0 \\ 10 & 4G_oV_{10} - G_oV_9 - G_oV_5 - G_oV_{15} = 0 \\ 11 & 4G_oV_{11} - G_oV_6 - G_oV_{12} = +12G_o \\ 12 & 4G_oV_{12} - G_oV_{11} - G_oV_7 - G_oV_{13} = 0 \\ 13 & 4G_oV_{13} - G_oV_{12} - G_oV_8 - G_oV_{14} = 0 \\ 14 & 4G_oV_{14} - G_oV_{13} - G_oV_9 - G_oV_{15} = 0 \\ 15 & 4G_oV_{15} - G_oV_{14} - G_oV_{10} = 0 \end{aligned}$$

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Problem # 4 cont.

Part A cont.

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# 7 last solution

$$G = \begin{bmatrix} 4V - 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 4V - 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4V - 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$b = \begin{bmatrix} 12 \\ 0 \\ 0 \\ 0 \\ 0 \\ 12 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Block Matrix  $G$ :

$$G = \begin{bmatrix} 0 & -I & D \\ -I & D & -I \\ -I & -D & D \end{bmatrix}$$

add rows 1+2+3

$$D = \begin{bmatrix} 4 & 0 & 0 & 0 & 0 \\ 0 & 4 & 0 & 0 & 0 \\ 0 & 0 & 6 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 0 & 4 \end{bmatrix}$$

$$D = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 \\ -1 & 4 & -1 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 \\ 0 & 0 & -1 & 4 & -1 \\ 0 & 0 & 0 & -1 & 4 \end{bmatrix}$$

$$I = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

## Problem # 4 cont.

Part A cont.

6. 5. Yes, LU factorization will always preserve bandwidth.

6. The width of the matrix (~~including the diagonal~~), / circuit / the nodes between the source and grounds

7. You could theoretically avoid it by not actually using pivots and simply do good old gaussian elimination.

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Problem # 4 cont.

Part B  
 Nodes 1-5 are the same, and 6, 8, 10 (in terms of ports V<sub>cont</sub> xns).  
 Node 7, 9 and 11-15 change others change as well from 4 → 3 or 2

$$G_{\text{new}} = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 4 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & -1 & 3 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 & -1 & 4 & -1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & -1 & 3 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & -1 & 4 & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 3 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & -1 & 3 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 2 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & -1 & 3 & 0 \end{bmatrix}$$

$b = \begin{bmatrix} 12 \\ 7 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$

b has not changed as the only node to affect that would be 11, however not having a ground should not change it.

$$D_1 = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 \\ -1 & 4 & -1 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 \\ 0 & 0 & -1 & 4 & -1 \\ 0 & 0 & 0 & -1 & 4 \end{bmatrix} \quad D_1 = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 \\ -1 & 4 & -1 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 \\ 0 & 0 & -1 & 4 & -1 \\ 0 & 0 & 0 & -1 & 4 \end{bmatrix} \quad D_2 = \begin{bmatrix} 4 & -1 & 0 & 0 & 0 \\ -1 & 3 & -1 & 0 & 0 \\ 0 & -1 & 4 & -1 & 0 \\ 0 & 0 & -1 & 3 & -1 \\ 0 & 0 & 0 & -1 & 4 \end{bmatrix}$$

$$D_3 = \begin{bmatrix} 3 & -1 & 0 & 0 \\ -1 & 2 & -1 & 0 \\ 0 & -1 & 3 & -1 \\ 0 & 0 & -1 & 2 \\ 0 & 0 & 0 & -1 \end{bmatrix} \quad E = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

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Problem # 4 cont.

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5. No, I believe I slightly make an error somewhere: certain nodes and their surroundings were unchanged by the removal of resistors, so their voltage should not have changed.

## Contents

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- Part A
- Part B

### Part A

---

```

clc
clear all
close all

G = [4,-1,0,0,0,-1,0,0,0,0,0,0,0,0,0;
      -1,4,-1,0,0,0,-1,0,0,0,0,0,0,0,0;
      0,-1,4,-1,0,0,0,-1,0,0,0,0,0,0,0;
      0,0,-1,4,-1,0,0,0,-1,0,0,0,0,0,0;
      0,0,0,-1,4,0,0,0,-1,0,0,0,0,0,0;
      -1,0,0,0,0,4,-1,0,0,0,-1,0,0,0,0;
      0,-1,0,0,0,-1,4,-1,0,0,0,-1,0,0,0;
      0,0,-1,0,0,0,-1,4,-1,0,0,0,-1,0,0;
      0,0,0,-1,0,0,0,-1,4,-1,0,0,0,-1,0;
      0,0,0,0,-1,0,0,0,-1,4,0,0,0,0,-1;
      0,0,0,0,-1,0,0,0,0,4,-1,0,0,0;
      0,0,0,0,0,-1,0,0,0,-1,4,-1,0,0;
      0,0,0,0,0,0,-1,0,0,0,-1,4,-1,0;
      0,0,0,0,0,0,0,-1,0,0,0,-1,4,-1;
      0,0,0,0,0,0,0,-1,0,0,0,-1,4];
b = [12 0 0 0 0 12 0 0 0 0 12 0 0 0 0];

f0 = figure('Name', 'Spy(G)');
t = title('Spy(G)'); %not sure why this isn't working
spy(G)

[L, U, P] = lu(G);

f1 = figure('Name', 'Spy(L)');
title('Spy(L)')
spy(L)

f2 = figure('Name', 'Spy(U)');
title('Spy(U)')
spy(U)

f3 = figure('Name', 'Spy(P)');
title('Spy(P)')
spy(P)

f5 = figure('Name', 'Subplot Comparison');
subplot(2, 2, 1);
spy(G)
subplot(2, 2, 2);
spy(L)
subplot(2, 2, 3);
spy(U)
subplot(2, 2, 4);
spy(P)

v = G\b

```

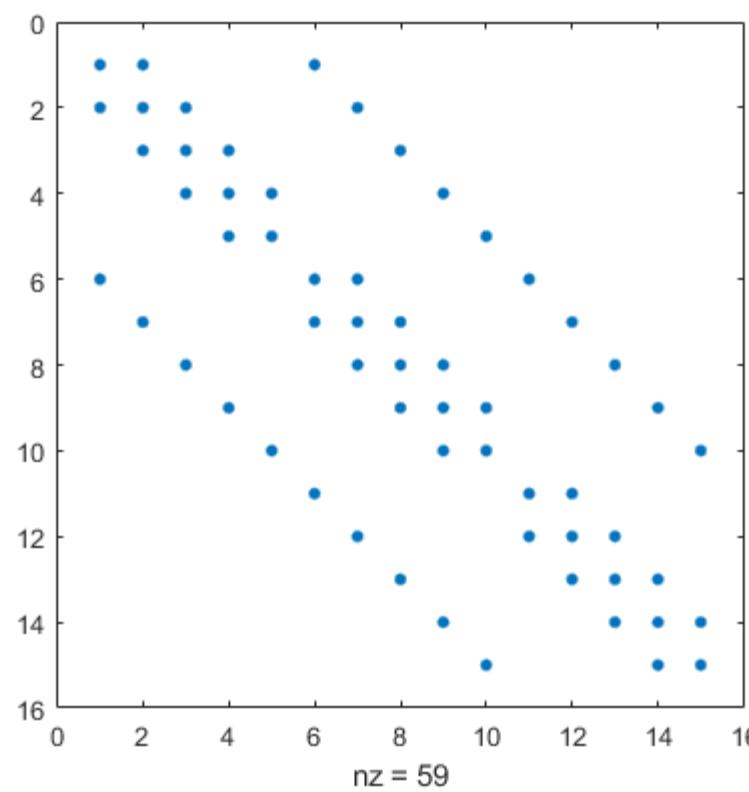
```
v_report = reshape(v, [5, 3]).'
```

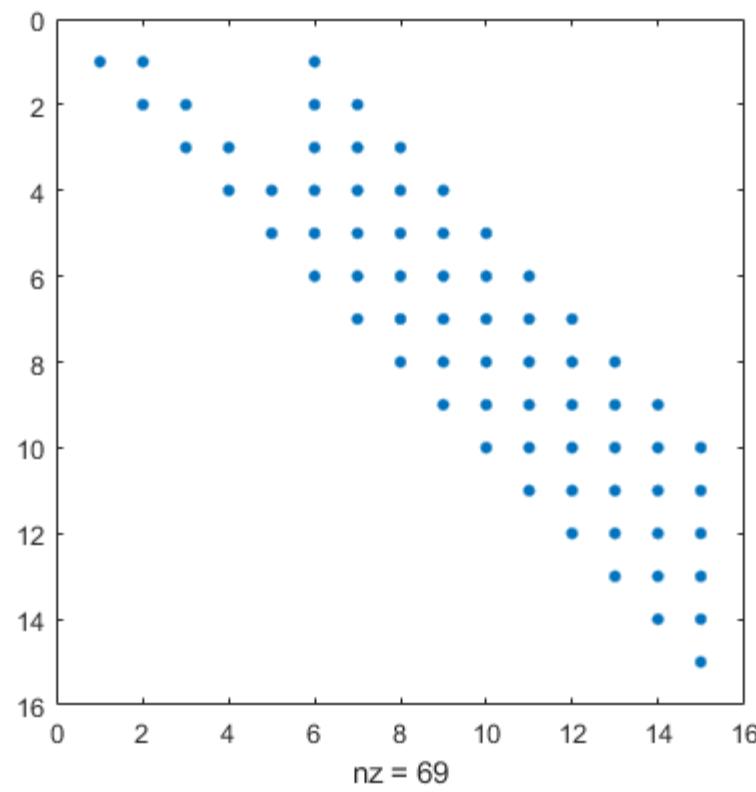
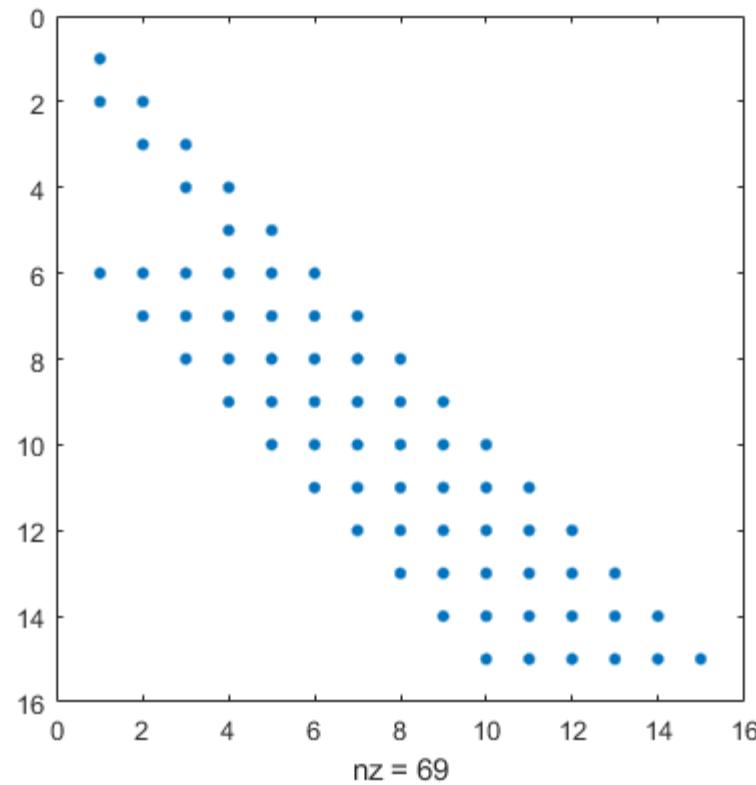
v =

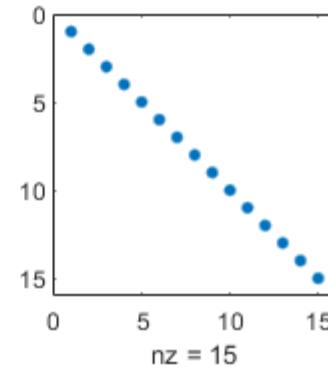
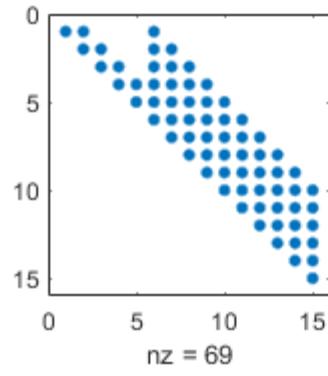
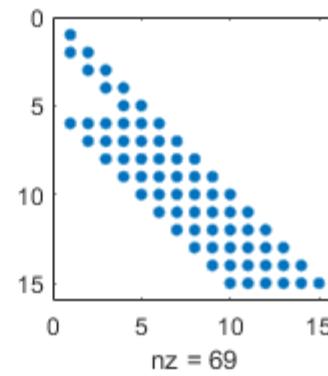
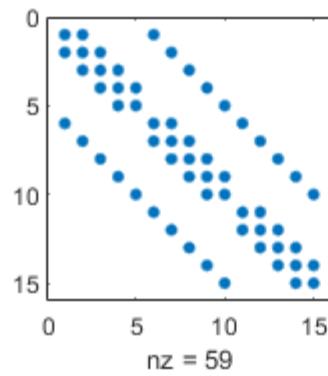
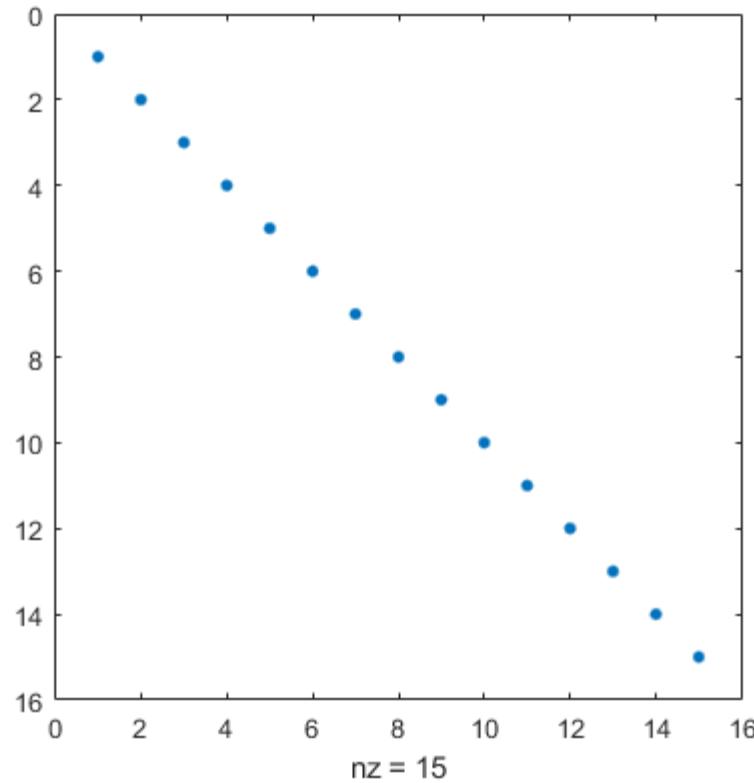
```
5.1832  
2.3544  
1.0869  
0.4910  
0.1894  
6.3784  
3.1473  
1.5022  
0.6877  
0.2666  
5.1832  
2.3544  
1.0869  
0.4910  
0.1894
```

v\_report =

```
5.1832    2.3544    1.0869    0.4910    0.1894  
6.3784    3.1473    1.5022    0.6877    0.2666  
5.1832    2.3544    1.0869    0.4910    0.1894
```







## Part B

```
partB_G = [4,-1,0,0,0,-1,0,0,0,0,0,0,0,0,0;  
-1,4,-1,0,0,0,-1,0,0,0,0,0,0,0,0;  
0,-1,4,-1,0,0,0,-1,0,0,0,0,0,0,0,0;
```

```

0,0,-1,4,-1,0,0,0,-1,0,0,0,0,0,0;
0,0,0,-1,4,0,0,0,-1,0,0,0,0,0;
-1,0,0,0,0,4,-1,0,0,0,-1,0,0,0,0;
0,-1,0,0,0,-1,3,-1,0,0,0,0,0,0,0;
0,0,-1,0,0,0,-1,4,-1,0,0,0,-1,0,0;
0,0,0,-1,0,0,0,-1,3,-1,0,0,0,0,0;
0,0,0,-1,0,0,0,-1,4,0,0,0,0,-1;
0,0,0,0,-1,0,0,0,0,3,-1,0,0,0;
0,0,0,0,0,0,0,0,0,-1,2,-1,0,0;
0,0,0,0,0,0,0,-1,0,0,0,-1,3,-1,0;
0,0,0,0,0,0,0,0,0,0,0,0,-1,2,-1;
0,0,0,0,0,0,0,0,0,-1,0,0,0,-1,3];
b = [12 0 0 0 0 12 0 0 0 0 12 0 0 0 0]';

v_new = partB_G\b

v_report_new = reshape(v_new, [5, 3]).'

```

```

v_new =
5.6746
2.9785
1.7014
0.9116
0.4171
7.7199
4.5380
2.9156
1.5280
0.7567
8.6669
6.2809
3.8949
2.4883
1.0817

```

```

v_report_new =
5.6746    2.9785    1.7014    0.9116    0.4171
7.7199    4.5380    2.9156    1.5280    0.7567
8.6669    6.2809    3.8949    2.4883    1.0817

```