CMR
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Internal Assesment Test - I

Sub:	Power System Analysis II							Code:	18EE71
Date:	20/10/2022	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE
Answer Any FIVE FULL Questions. Each question carry 10 marks									

		Marks	OBE CO	OBE RBT
1a	Derive an expression for obtaining the Y_{bus} using singular transformation method	[5]	CO1	L2
1b	Explain briefly about the primitive network. Obtain the impedance and admittance form of primitive network.	[5]	CO2	L2
2	With the help of singular transformation method, determine the bus admittance matrix Y_{bus} for the power system whose oriented graph is shown in fig.1 Element no and self impedance of the elements in pu are marked on the diagram. Neglect mutual coupling .Verify the same using direct inspection method.	[10]	CO1	L3

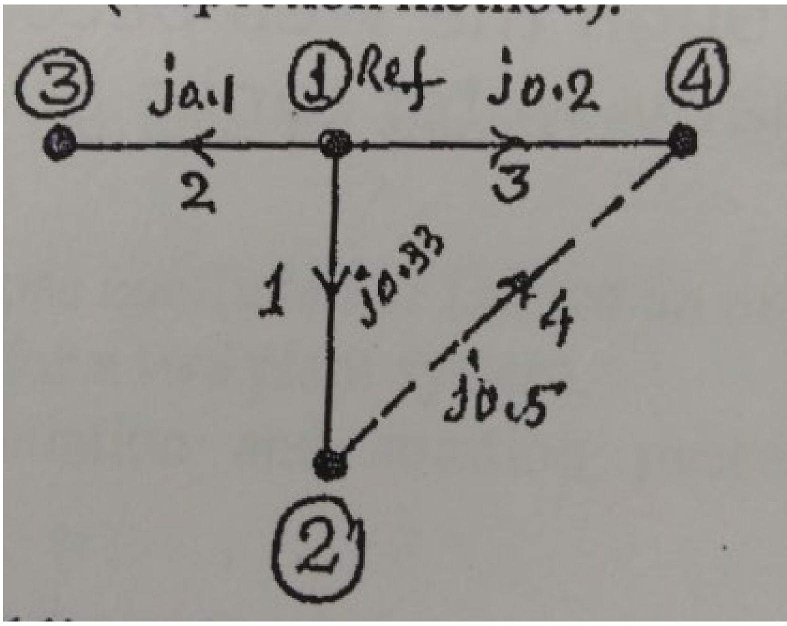


Fig.1

		Marks	CO	RBT
3a	The bus incidence matrix A for a network of 8 elements and 5 nodes is as given below. Reconstruct the oriented graph. Hence obtain the one line diagram of the system indicating the generator positions.	[5+5]	CO1	L3

A=

Elements ▶ Nodes ▼	1	2	3	4	5	6	7	8
1	1	0	0	0	-1	0	-1	0
2	0	1	0	0	1	-1	0	-1
3	0	0	1	-1	0	1	0	0
4	0	0	0	1	0	0	1	1

3b Consider three passive elements whose data is given in table below. Form the primitive admittance matrix | CO1 | L3

Element No		
	Self Impedance in pu	Mutual impedance in pu
1	j 0.6	
2	j 0.5	j0.2(element 1)
3	j 0.7	

4 For the power system shown in fig.2, Obtain Y_{bus} using singular transformation method. Verify the obtained Y_{bus} by inspection method. Line impedance and shunt admittance values are marked in the diagram. [10] | CO1 | L3

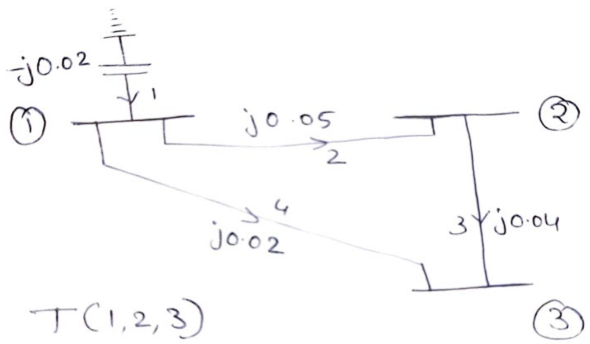


Fig.2

5 Obtain the oriented graph for the system shown in fig.3. Select T(1,2,3,4) as the tree. Show that $B_l = A_l.K^t$ [10] | CO1 | L4

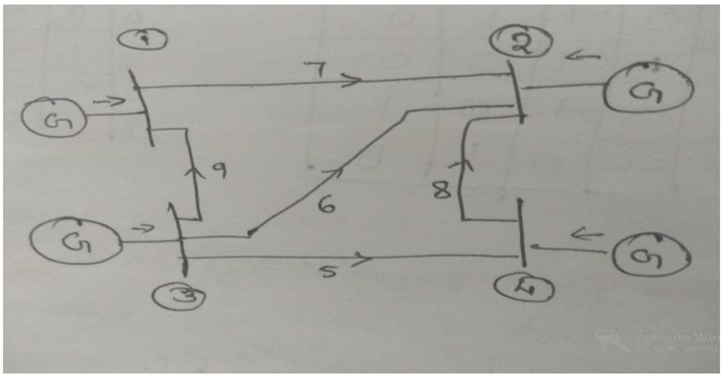


Fig.3

6 For the power system shown in fig.4 ,choose node 1 as reference & T(1,2,3) as tree and verify the following relations : 1) A_bK^t=U 2) $B_l = A_lK^t$ [10] | CO1 | L4

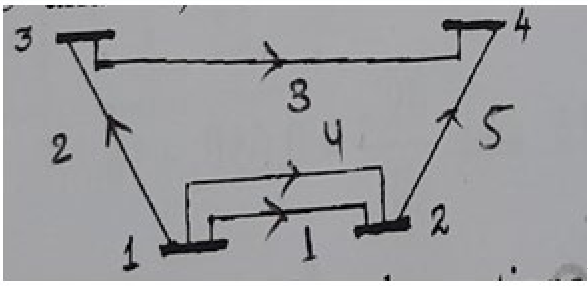


Fig.4

Solutions

1a

Singular Transformation method

The performance equation of the primitive network

$$\bar{i} + \bar{j} = [y]\bar{v}$$

Xly by A^t

$$A^t\bar{i} + A^t\bar{j} = A^t \cdot [y]\bar{v}$$

According to Kirchoff's law the algebric sum of the current at a bus is zero then

$$A^t\bar{i} = 0$$

$A^t j$ is the algebraic sum of the source current at each bus and equals the vector of impressed bus currents

$$I_{bus} = A^t j \quad \text{—— (1)}$$

$$I_{bus} = A^t[y]\bar{v} \quad \text{—— (3)}$$

We know that $(I_{bus}^{*})^{t} E_{bus}$ is the power into the network.

Sum of the powers in the primitive network (w.r.t I_{bus}) ... should be equal

$$(I_{bus}^{*})^{t} E_{bus} = (j^{*})^{t} \bar{v} \quad \text{———} \quad (2)$$

Taking the conjugate transpose of (1)

$$(I_{bus}^{*})^{t} = (j^{*})^{t} \cdot A^{*}$$

Since A is a real matrix $A^{*} = A$

i.e) $(I_{bus}^{*})^{t} = (j^{*})^{t} \cdot A$

i.e) $(I_{bus}^{*})^{t} = (j^{*})^{t} \cdot A$

Substituting this in (2)

$$(j^*)^t A \cdot E_{bus} = (j^*)^t \cdot \bar{v}$$

i.e) $\bar{v} = A \cdot E_{bus}$.

Substituting in (3)

i.e) $\bar{I}_{bus} = A^t \cdot [y] \cdot v$

$$\bar{I}_{bus} = A^t \cdot [y] \cdot A \cdot E_{bus}.$$

i.e) $\bar{I}_{bus} = Y_{bus} \cdot E_{bus}$.

i.e) $Y_{bus} = A^t \cdot [y] \cdot A$

i.e) $A^t \cdot [y] A$ is the singalar transformation of $[y]$

1b

Primitive network

Network components represented both in impedance form and in admittance form.

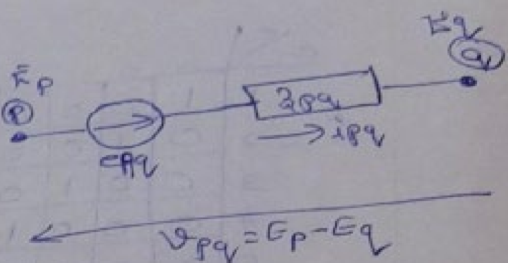
v_{pq} is the voltage across the element p-q
e_{pq} is the source voltage in series with pq
i_{pq} is the current through element pq.
j_{pq} is the source current in parallel with element pq
z_{pq} is the self impedance of element p-q
y_{pq} is the self admittance of element p-q.

Performance equation of an element in impedance form:

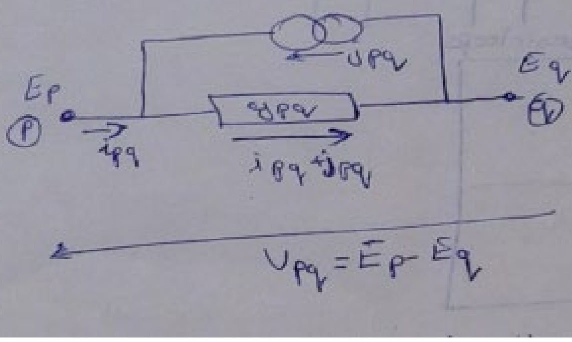
$$v_{pq} + e_{pq} = z_{pq} i_{pq}$$

admittance form is

$$i_{pq} + j_{pq} = y_{pq} v_{pq}$$



Impedance form.



$$i_{pq}+j_{pq}=y_{pq}v_{pq}$$

$$v_{pq}+e_{pq}=z_{pq}i_{pq}$$

$$\frac{i_{pq}+j_{pq}}{y_{pq}}+e_{pq}=z_{pq}i_{pq}$$

$$i_{pq}+j_{pq}+e_{pq}y_{pq}=i_{pq} \quad \Big| \quad z_{pq}y_{pq}=1$$

$$\boxed{j_{pq}=-y_{pq}e_{pq}}$$

Parallel source current in admittance form is related to series source voltage in impedance form by

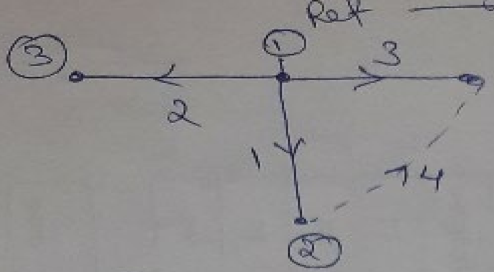
$$j_{pq}=-y_{pq}e_{pq}$$

A set of unconnected elements is defined as primitive network. The performance equa in impedance form is $\cancel{[v]+[e]=[z]i}$ $\bar{v}+\bar{e}=[z]\bar{i}$

Admittance form $\bar{i}+\bar{j}=[y]\bar{v}$

2b

Singular Transformation method.



$Y_{bus} = A^T [y] A$

$$A = \begin{array}{c|ccc} e \backslash b & 2 & 3 & 4 \\ \hline 1 & -1 & 0 & 0 \\ 2 & 0 & -1 & 0 \\ 3 & 0 & 0 & -1 \\ 4 & 1 & 0 & -1 \end{array}$$

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

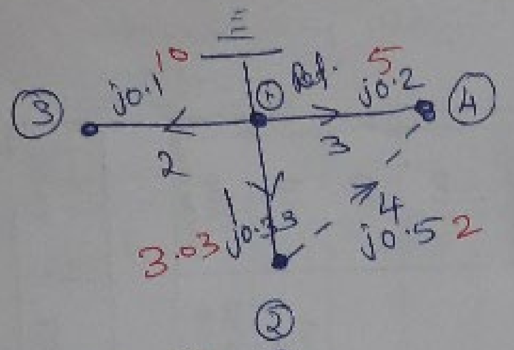
$$[y] = \begin{array}{c|cccc} e \backslash e & 1 & 2 & 3 & 4 \\ \hline 1 & \overset{-3.03}{\cancel{j0.33}} & 0 & 0 & 0 \\ 2 & 0 & \overset{-10}{\cancel{j0.1}} & 0 & 0 \\ 3 & 0 & 0 & \overset{-5}{\cancel{j0.2}} & 0 \\ 4 & 0 & 0 & 0 & \overset{j2}{\cancel{j0.5}} \end{array}$$

$Y_{bus} = A^T [y] A$

$$= \begin{bmatrix} -1 & 0 & 0 & 1 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & -1 \end{bmatrix} \begin{bmatrix} \frac{1}{j0.33} & 0 & 0 & 0 \\ 0 & \frac{1}{j0.1} & 0 & 0 \\ 0 & 0 & \frac{1}{j0.2} & 0 \\ 0 & 0 & 0 & \frac{1}{j0.5} \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$$

$$= \cancel{\begin{bmatrix} j0.85 & 0 & -j0.5 \\ 0 & j0.1 & 0 \\ -j0.5 & 0 & j0.7 \end{bmatrix}} = \begin{bmatrix} -j5.03 & 0 & j2 \\ 0 & -j10 & 0 \\ j2 & 0 & -j7 \end{bmatrix}$$

Veriy using Inspection method



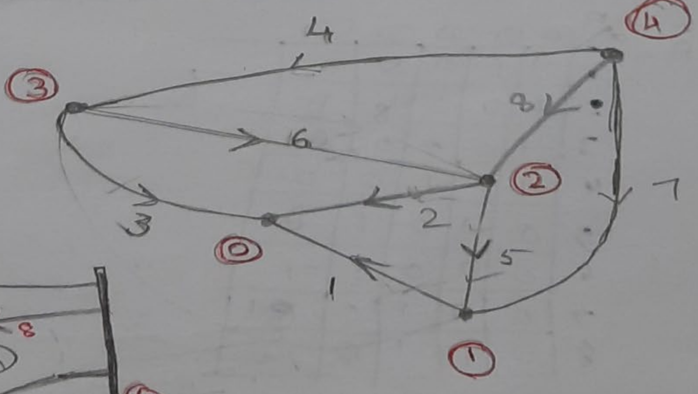
$$Y_{bus} = \begin{array}{c|ccc} & 2 & 3 & 4 \\ \hline 2 & j0.83 & 0 & -j0.5 \\ 3 & 0 & j0.1 & 0 \\ 4 & -j0.5 & 0 & j0.7 \end{array} = \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{bmatrix} -j5.03 & 0 & +j2 \\ 0 & -j10 & 0 \\ +j2 & 0 & -j7 \end{bmatrix} \end{array}$$

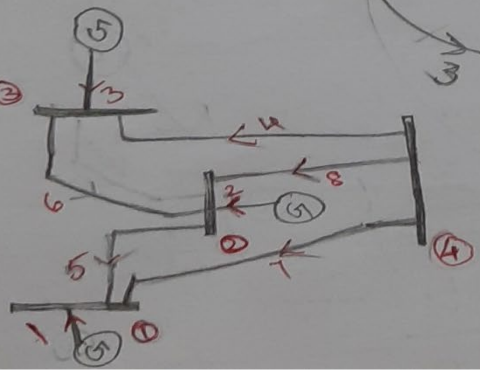
3a

The bus incidence matrix. A sample network of 8-ele
and 5 nodes (4-buses) is as given below. Reconstruct
the oriented graph. Hence obtain the one line
diagram of the system indicating the generator
positions.

A = ↓ Nodes

	1	2	3	4	5	6	7	8
1	1	0	0	0	-1	0	-1	0
2	0	1	0	0	1	-1	0	-1
3	0	0	1	-1	0	1	0	0
4	0	0	0	1	0	0	1	1





3b

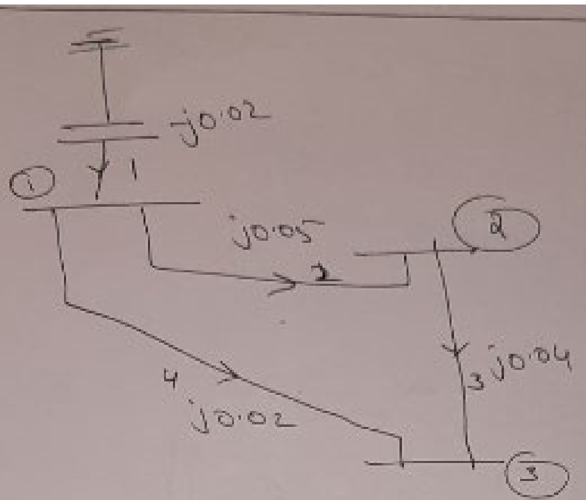
Consider three passive elements whose data is given on table 2.1. Form the primitive impedance matrix.

element	Z_{ii} (pu)	mutual impedance
1	j0.6	
2	j0.5	j0.2 (element 1)
3	j0.7	

$$[Z] = \begin{bmatrix} j0.6 & j0.2 & 0 \\ j0.2 & j0.5 & 0 \\ 0 & 0 & j0.7 \end{bmatrix}$$

$$y = [Z]^{-1} = \begin{bmatrix} -j1.923 & j0.7692 & 0 \\ j0.7692 & -j2.3077 & 0 \\ 0 & 0 & -j1.4286 \end{bmatrix}$$

Alotted



② $\frac{1}{j0.05} = -j20$

③ $\frac{1}{j0.04} = -j25$

④ $\frac{1}{j0.02} = -j50$

$$\begin{pmatrix} -j70.02 & j20 & +j50 \\ j20 & -j45 & +j25 \\ j50 & j25 & -j75 \end{pmatrix}$$

$$A = \begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & -1 & 0 & 0 \\ 2 & 1 & -1 & 0 \\ 3 & 0 & 1 & -1 \\ 4 & 1 & 0 & -1 \end{array}$$

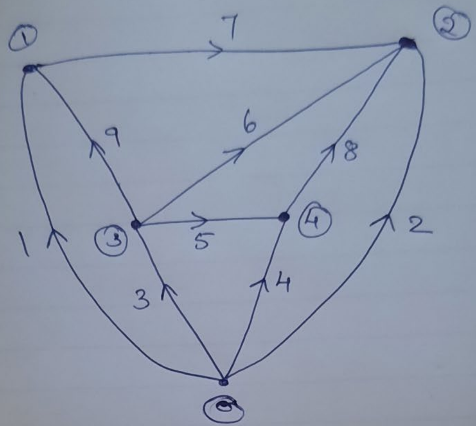
$$[Y] = \begin{pmatrix} -j0.02 & 0 & 0 & 0 \\ 0 & -j20 & 0 & 0 \\ 0 & 0 & -j25 & 0 \\ 0 & 0 & 0 & -j50 \end{pmatrix}$$

$$\begin{bmatrix} -1 & 1 & 0 & 1 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & -1 & -1 \end{bmatrix} \cancel{\begin{bmatrix} -1 & 0 & 0 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 0 & -1 \end{bmatrix}} \begin{bmatrix} -j0.02 & 0 & 0 & 0 \\ 0 & -j20 & 0 & 0 \\ 0 & 0 & -j25 & 0 \\ 0 & 0 & 0 & -j50 \end{bmatrix}$$

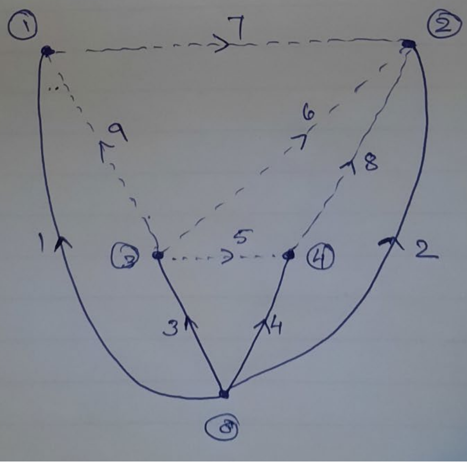
$$\begin{bmatrix} j0.02 & -j20 & 0 & -j50 \\ 0 & j20 & -j25 & 0 \\ 0 & 0 & j25 & j50 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 0 & -1 \end{bmatrix}$$

$$\begin{bmatrix} -j70.02 & +j20 & j50 \\ j20 & -j45 & j25 \\ j50 & j25 & -j75 \end{bmatrix}$$

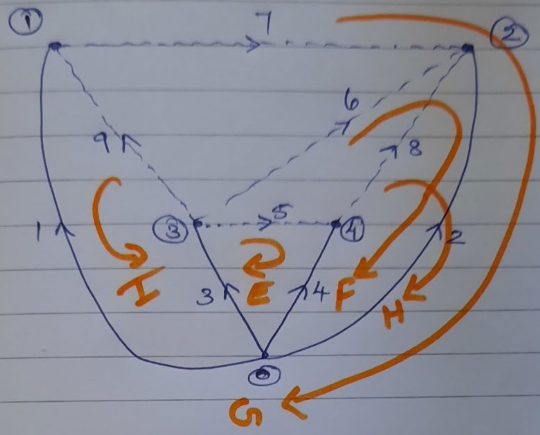
Oriented graph



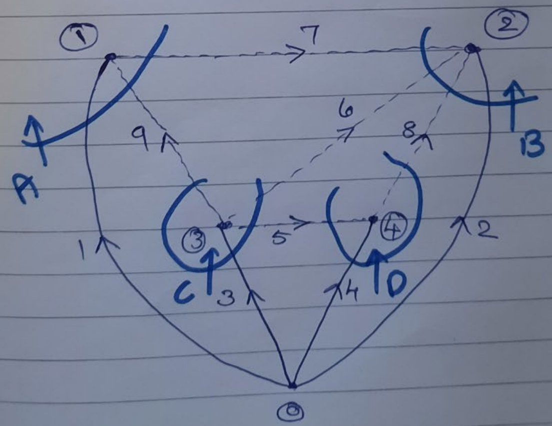
Tree : T(1,2,3,4)



Basic loops



Basic cutsets



$\hat{A} =$

e \ n	0	1	2	3	4
1	1	-1	0	0	0
2	1	0	-1	0	0
3	1	0	-0	-1	0
4	1	0	0	0	-1
5	0	0	0	1	-1
6	0	0	-1	1	0
7	0	1	-1	0	0
8	0	0	-1	0	1
9	0	-1	0	1	0

$A =$

e \ bus	1	2	3	4
1	-1	0	0	0
2	0	-1	0	0
3	0	0	-1	0
4	0	0	0	-1
5	0	0	1	-1
6	0	-1	1	0
7	1	-1	0	0
8	0	-1	0	1
9	-1	0	1	0

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

$\cancel{0 \quad 0 \quad 1 \quad 1}$

$\cancel{0 \quad 1 \quad 1 \quad 0}$

K =

	1	2	3	4
1	-1	0	0	0
2	0	-1	0	0
3	0	0	-1	0
4	0	0	0	-1

$$A_b K^t = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \underline{\underline{U}}$$

B =

	A	B	C	D	
1	1	0	0	0	
2	0	1	0	0	
3	0	0	1	0	U_b
4	0	0	0	1	
5	0	0	-1	1	
6	0	1	-1	0	
7	-1	1	0	0	B_l.
8	0	1	0	-1	
9	1	0	-1	0	

$$B_l = A_l \cdot K^t = \begin{bmatrix} 0 & 0 & 1 & -1 \\ 0 & -1 & 1 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & -1 & 0 & 1 \\ -1 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

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

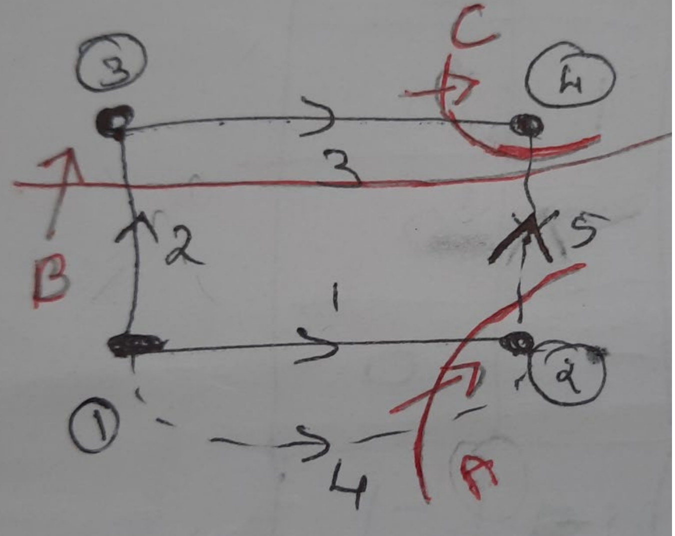
6

$$A = \begin{array}{c|c|c|c|l} & ② & ③ & ④ & \\ \hline 1 & -1 & 0 & 0 & \\ 2 & 0 & -1 & 0 & A_b \\ 3 & 0 & 1 & -1 & \\ \hline 4 & -1 & 0 & 0 & A_l \\ 5 & +1 & 0 & -1 & \end{array}$$

$K =$

b \ Path	2	3	4
1	-1	0	0
2	0	-1	-1
3	0	0	-1

Tree



$$A_l K^t = \begin{bmatrix} -1 & 0 & 0 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & -1 \end{bmatrix}$$

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

$$B = \begin{array}{c|ccc} e \backslash b & A & B & C \\ \hline 1 & 1 & 0 & 0 \\ 2 & 0 & 1 & 0 \\ 3 & 0 & 0 & 1 \\ 4 & 1 & 0 & 0 \\ 5 & -1 & 1 & 1 \end{array} \qquad \left.\begin{array}{l} \text{rows } 4, 5 \end{array}\right\} \rightarrow B_l$$

$$B = \boxed{\begin{matrix} U_b \\ B_l \end{matrix}}$$

$$B_l = A_l K^t$$

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