CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test - I

Sub:	Power System Analysis II							Code:	18EE71/17EE71
Date:	11/11/2021	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE
Answer Any FIVE FULL Questions									

		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

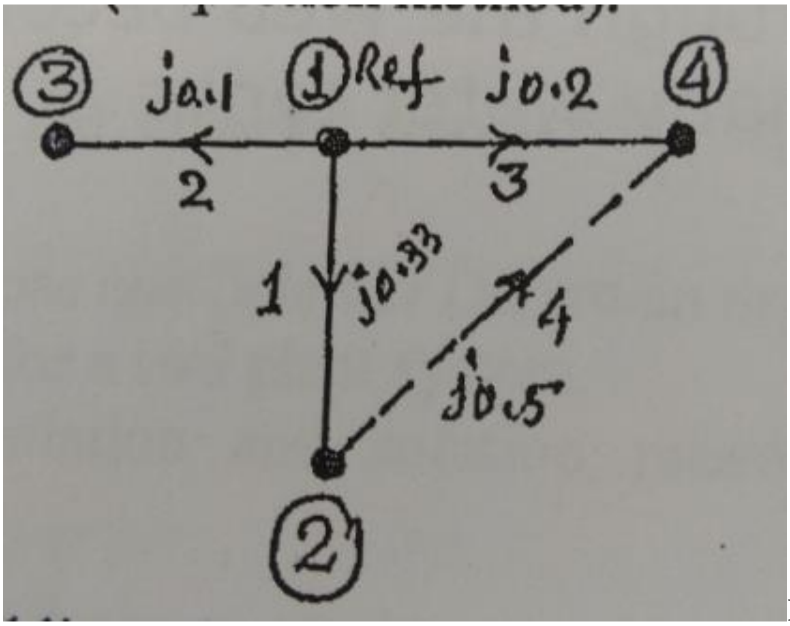


Fig.1

		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]	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 Impedence(Zpq-pq)		Mutual Impedance(Zpq-rs)	
	Buscode(pq)	Impedance in pu	Bus code (rs)	Impedance in pu
1	1-2	j 0.452		
2	2-3	j 0.387	1-2(element 1)	j 0.165
3	1-3	j 0.619	1-2(element 1)	j 0.234

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

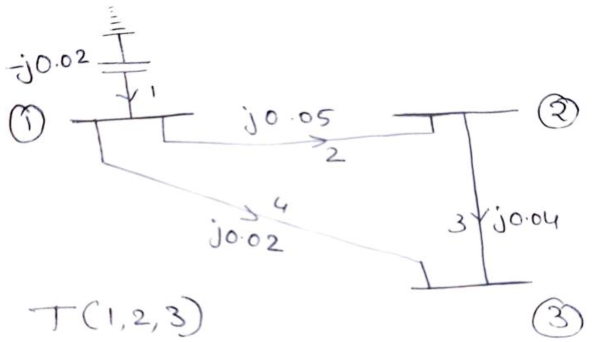


Fig.2

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

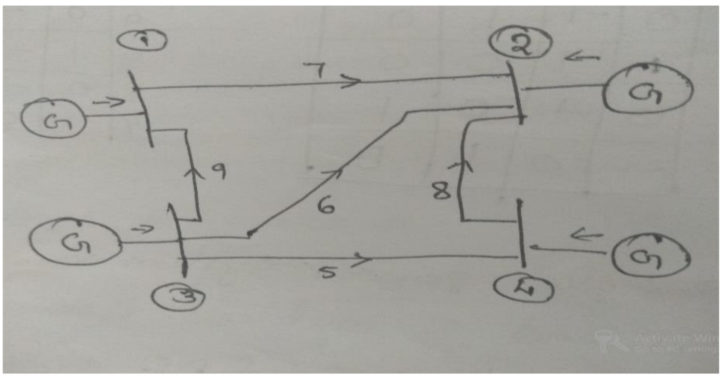


Fig.3

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) $B_l = A_lK^t$ — CO1 L4

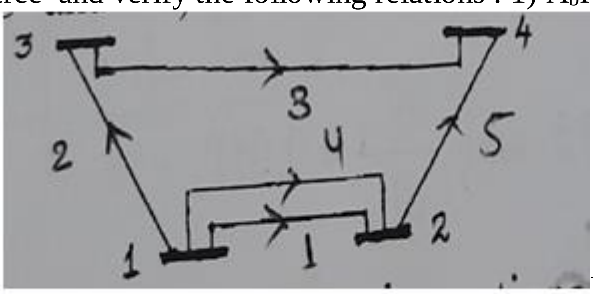


Fig.4

1a)

Singular Transformation method

The performance equation of the primitive network

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

X^{ly} 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 is $(j^{*})^{t}\, v$. They should be equal.

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

Taking the conjugate transpose of (1)

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

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

ie) $(I_{bus}^{*})^{t} = (j^{*})^{t} . A$

Substituting this in (I)

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

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

Substituting in (3)

ie) $I_{bus} = A^t \cdot [y] \cdot v$

$$I_{bus} = A^t \cdot [y] \cdot A \cdot E_{bus}.$$

ie) $I_{bus} = Y_{bus} \cdot E_{bus}$.

ie) $\underline{Y_{bus} = A^t \cdot [y] \cdot A}$

ie) $A^t \cdot [y] A$ is the singalar transformation of $[y]$

1b)

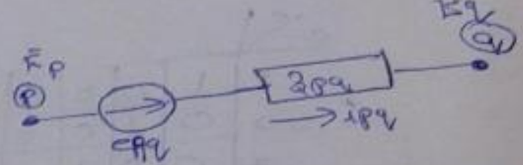
Primitive network

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's

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

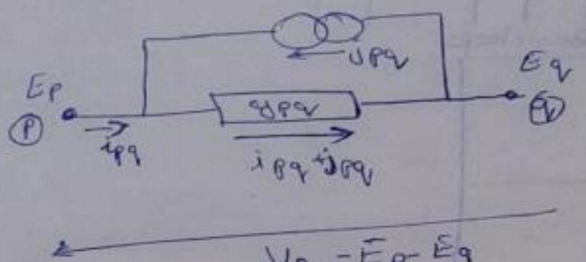


admittance form is

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

$v_{pq} = E_p - E_q$

Impedance form.



$V_{pq} = E_p - E_q$

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

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

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

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

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

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 interconnected elements is defined as primitive network. The performance equation in impedance form is ~~$[v]+[e]=[z]i$~~ $\bar{v}+\bar{e}=[z]\bar{i}$

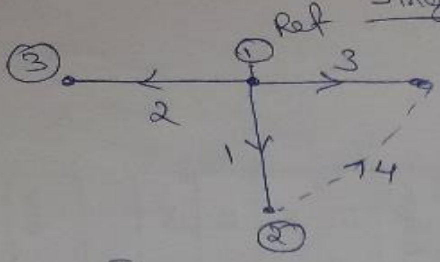
Admittance form $\bar{i}+\bar{j}=[y]\bar{v}$

2)

(b)

2b

Singular Transformation method.



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

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

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

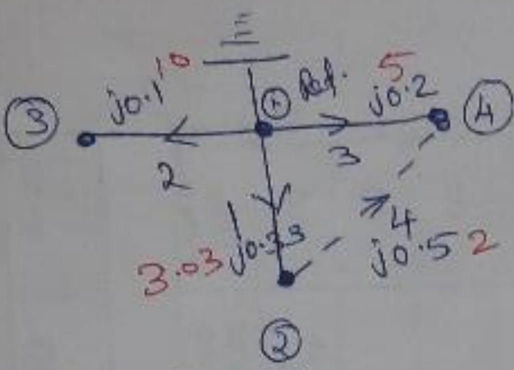
$$[y] = \begin{array}{c|cccc} e \backslash e & 1 & 2 & 3 & 4 \\ \hline 1 & -j3.03\ \cancel{j0.33} & 0 & 0 & 0 \\ 2 & 0 & -j10\ \cancel{j0.1} & 0 & 0 \\ 3 & 0 & 0 & -j5\ \cancel{j0.2} & 0 \\ 4 & 0 & 0 & 0 & -j2\ \cancel{j0.5} \end{array}$$

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

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

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

Veriy using Inspection method



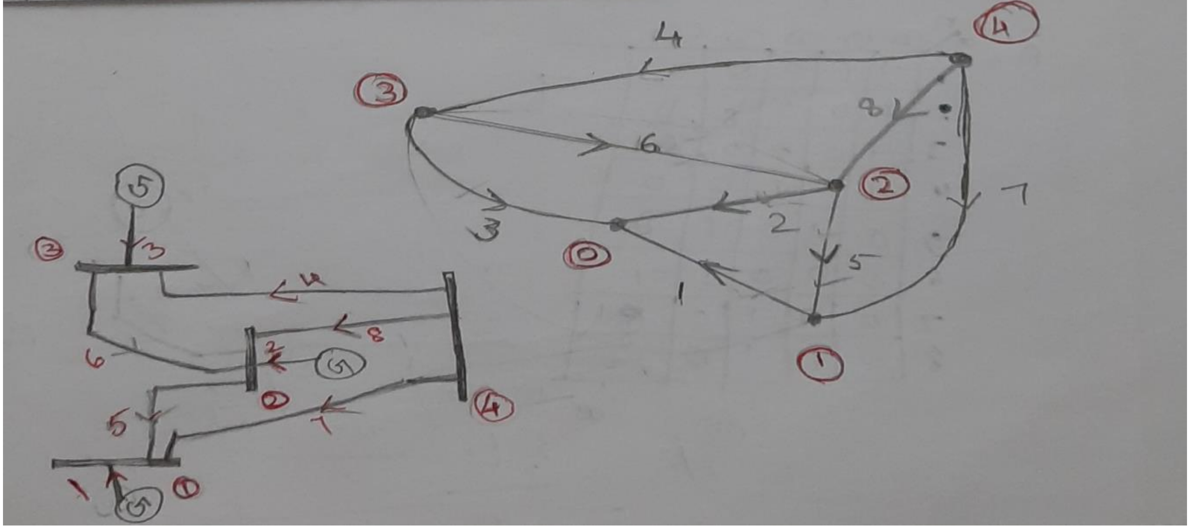
$$Y_{bus} = \begin{array}{c|ccc} & 2 & 3 & 4 \\ \hline 2 & \cancel{j0.83} & \cancel{0} & \cancel{-j0.5} \\ 3 & \cancel{0} & \cancel{j0.1} & \cancel{0} \\ 4 & \cancel{-j0.5} & \cancel{0} & \cancel{j0.7} \end{array} = \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{bmatrix} -j5.03 &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

3a)

The bus incidence matrix. A 8-xpa network of 8-ele and 5 nodes (4-buses) is as given below. Re construct 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



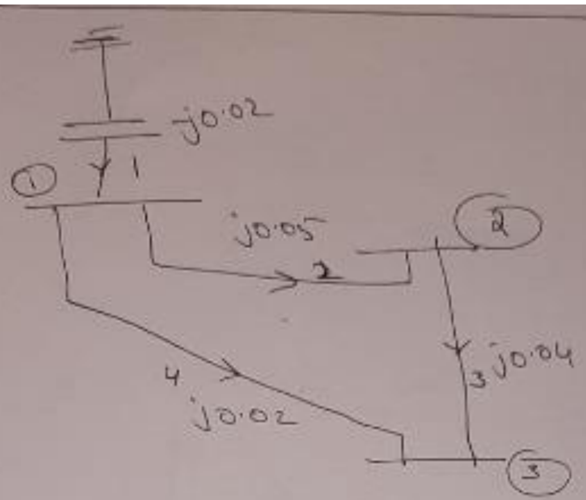
3b)

$$[Z] = \begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & \multicolumn{3}{c}{\begin{bmatrix} j0.452 & j0.165 & j0.234 \\ j0.165 & j0.387 & 0 \\ j0.234 & 0 & j0.619 \end{bmatrix}} \\ 2 & & & \\ 3 & & & \end{array}$$

$$[Y] = \frac{1}{[Z]}$$

4)

Alotted



$$② \ \frac{1}{j0.05} = -j20$$

$$③ \ \frac{1}{j0.04} = -j25$$

$$④ \ \frac{1}{j0.02} = -j50$$

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

A =

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

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

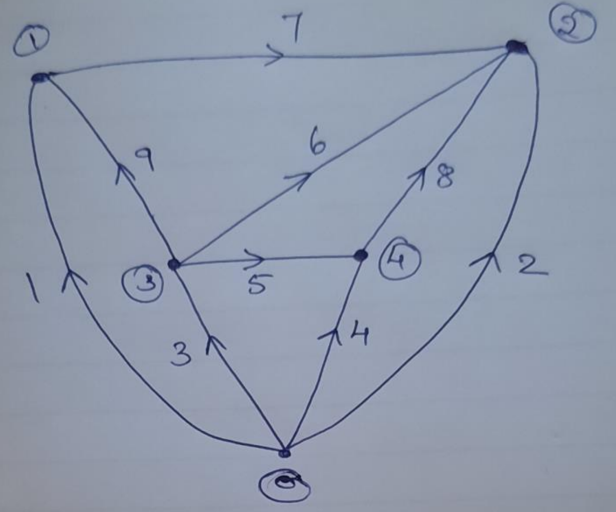
$$\begin{bmatrix} -1 & 1 & 0 & 1 \\ 0 & -1 & 1 & 0 \\ 0 & 0 & -1 & -1 \end{bmatrix} \cancel{\begin{bmatrix} -1 & 0 & 0 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 0 & -1 \end{bmatrix}} \begin{bmatrix} -j0.02 & 0 & 0 & 0 \\ 0 & -j20 & 0 & 0 \\ 0 & 0 & -j25 & 0 \\ 0 & 0 & 0 & -j50 \end{bmatrix}$$

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

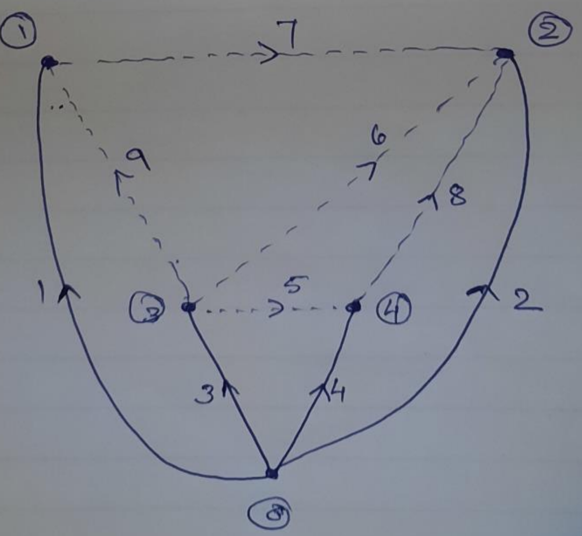
$$\begin{bmatrix} -j70.02 & +j20 & j50 \\ j20 & -j45 & j25 \\ j50 & j25 & -j75 \end{bmatrix}$$

5)

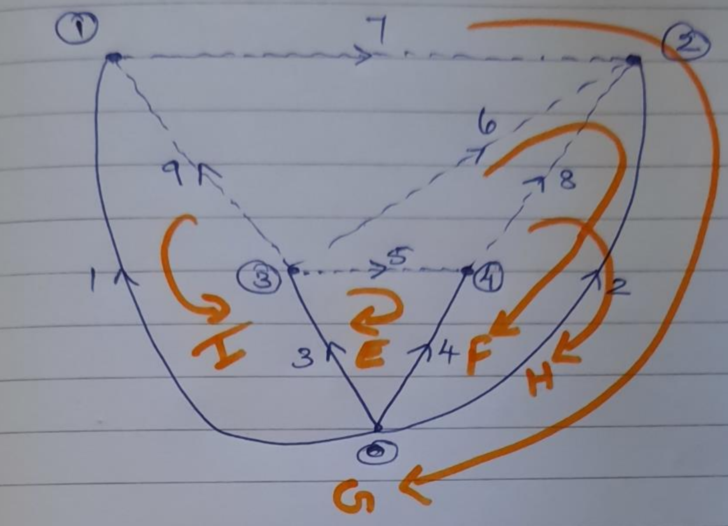
Oriented graph



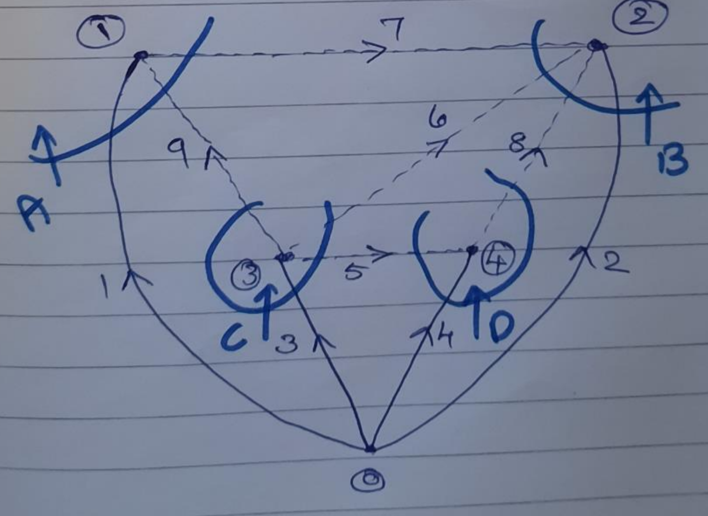
Tree : T(1,2,3,4)



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	D

$A =$

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

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

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

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

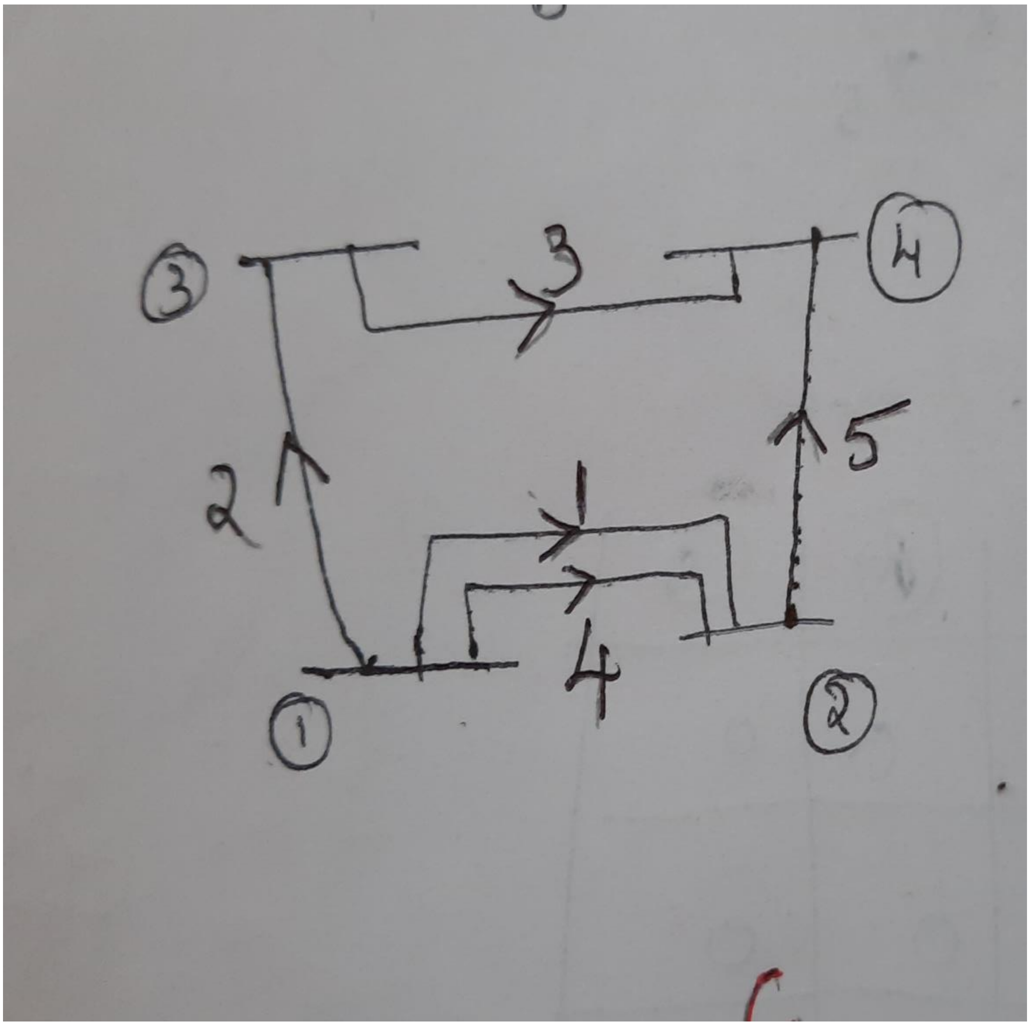
$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \underline{\underline{U}}$$

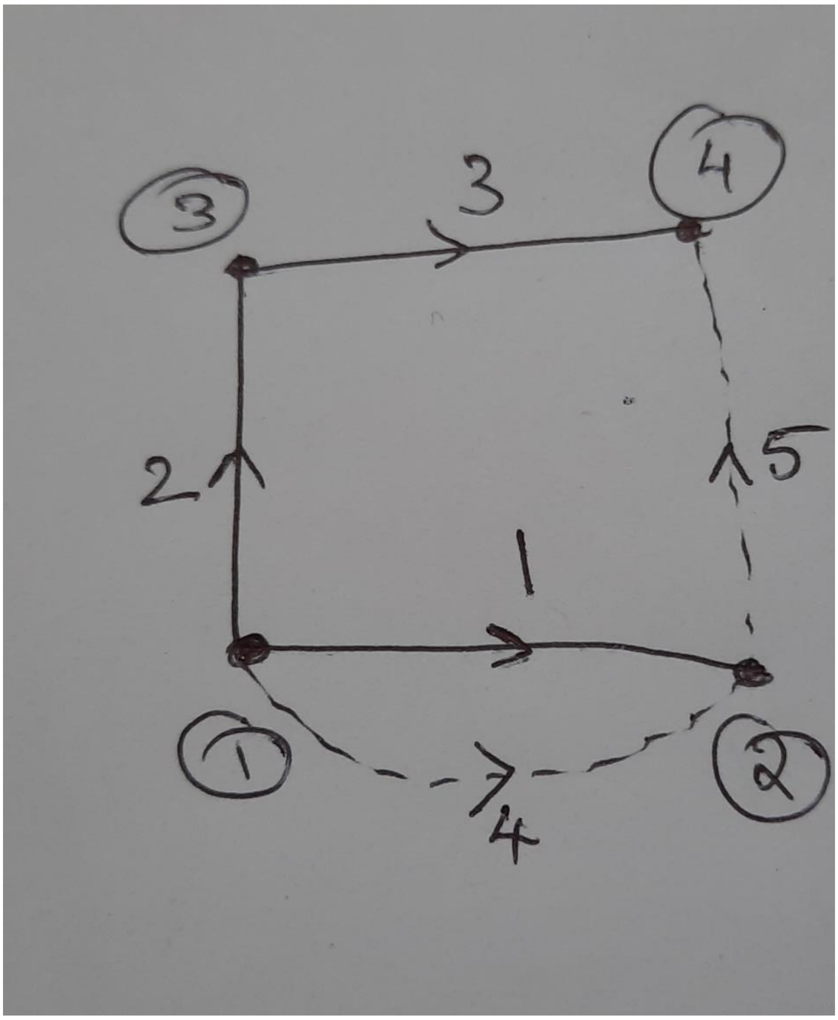
$$B = \begin{array}{c|cccc|c}
 & A & B & C & D & \\
\hline
1 & 1 & 0 & 0 & 0 & \\
2 & 0 & 1 & 0 & 0 & \\
3 & 0 & 0 & 1 & 0 & U_b \\
4 & 0 & 0 & 0 & 1 & \\
\hline
5 & 0 & 0 & -1 & 1 & \\
6 & 0 & 1 & -1 & 0 & \\
7 & -1 & 1 & 0 & 0 & B_l. \\
8 & 0 & 1 & 0 & -1 & \\
9 & 1 & 0 & -1 & 0 &
\end{array}$$

$$B_\ell = A_\ell \cdot K^t = \begin{bmatrix} 0 & 0 & 1 & -1 \\ 0 & -1 & 1 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & -1 & 0 & 1 \\ -1 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

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

6)


3
3
4
2
5
1
4
1
2


3
4
3
2
5
1
1
2
4

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

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

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

$B =$

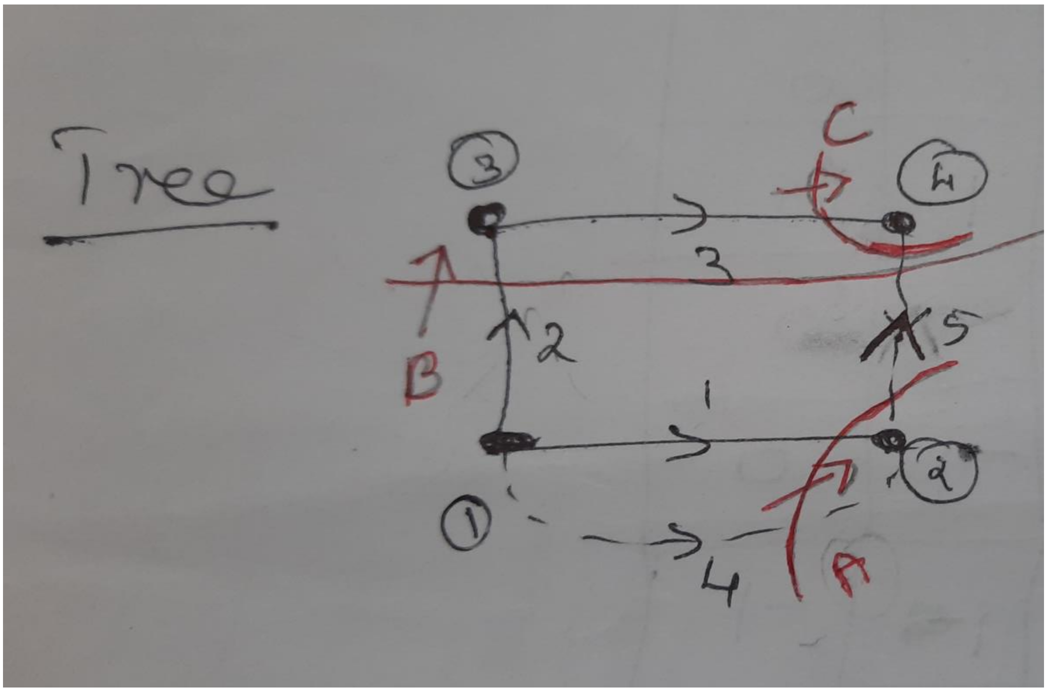
e \ b	A	B	C
1	1	0	0
2	0	1	0
3	0	0	1
4	1	0	0
5	-1	1	1

$B_{=}$

$B_l =$

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

$$= \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} //$$


Tree
3
4
2
1
1
2
3
4
5
A
B
C

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

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

$B =$

e \ b	A	B	C
1	1	0	0
2	0	1	0
3	0	0	1
4	1	0	0
5	-1	1	1

$B = \begin{bmatrix} U_b \\ B_l \end{bmatrix}$

$\left.\begin{matrix} 4 \\ 5 \end{matrix}\right\} \rightarrow B_l$

$B_l = A_l K^t$

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