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SUBJECT:

Control System

Q1:- Convert into Normal form.

$$\begin{bmatrix} 2 & 3 & 4 & 5 \\ 3 & 4 & 5 & 6 \\ 4 & 5 & 6 & 7 \\ 9 & 10 & 11 & 12 \end{bmatrix}$$

divide R_1 by 2.

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 3 & 4 & 5 & 6 \\ 4 & 5 & 6 & 7 \\ 9 & 10 & 11 & 12 \end{bmatrix}$$

$3R_1 - R_2$ \therefore operation on R_2

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 0.5 & 1 & 1.5 \\ 4 & 5 & 6 & 7 \\ 9 & 10 & 11 & 12 \end{bmatrix}$$

$4R_1 - R_3$ \therefore operation on R_3

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 0.5 & 1 & 1.5 \\ 0 & 1 & 2 & 3 \\ 9 & 10 & 11 & 12 \end{bmatrix}$$

$9R_1 - R_4$ \therefore operation on R_4

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 0.5 & 1 & 1.5 \\ 0 & 1 & 2 & 3 \\ 0 & 3.5 & 7 & 10.5 \end{bmatrix}$$

Multiply R_2 by 2 & ~~R_4~~ divide R_4 by 3.5

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 1 & 2 & 3 \\ 0 & 1 & 2 & 3 \\ 0 & 1 & 2 & 3 \end{bmatrix}$$

$R_2 - R_3$ \therefore operation on R_3

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 2 & 3 \end{bmatrix}$$

$R_2 - R_4$ \therefore operation on R_4

$$\begin{bmatrix} 1 & 1.5 & 2 & 2.5 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

or

$$\begin{bmatrix} 1 & 3/2 & 2 & 5/2 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

This is reduced-row echelon form
& the rank is 2.

$C_2 - 3/2 C_1$ \therefore operation of C_2

$$\begin{bmatrix} 1 & 0 & 2 & 5/2 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$C_3 - 2C_1$ \therefore operation of on C_3

$$\begin{bmatrix} 1 & 0 & 0 & 5/2 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$C_4 - 5/2 C_1$ \therefore operation of C_4

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

$C_3 - 2C_2$ \therefore operation on C_3

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

$C_4 - 3C_2$ \therefore operation on C_4

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

$$\begin{bmatrix} 2 & -2 & 0 & 6 \\ 4 & 2 & 0 & 2 \\ 1 & -1 & 0 & 3 \\ 1 & -2 & 1 & 2 \end{bmatrix}$$

$$R_1 \leftrightarrow R_4$$

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 4 & 2 & 0 & 2 \\ 1 & -1 & 0 & 3 \\ 2 & -2 & 0 & 6 \end{bmatrix}$$

$$R_2 - 4R_1 \quad \therefore \text{operation on } R_2$$

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 10 & -4 & -6 \\ 1 & -1 & 0 & 3 \\ 2 & -2 & 0 & 6 \end{bmatrix}$$

$$R_3 - R_1 \quad \therefore \text{operation on } R_3$$

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 10 & -4 & -6 \\ 0 & 1 & -1 & 1 \\ 2 & -2 & 0 & 6 \end{bmatrix}$$

$$R_4 - 2R_1 \quad \therefore \text{operation on } R_4$$

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 10 & -4 & -6 \\ 0 & 1 & -1 & 1 \\ 0 & 2 & -2 & 2 \end{bmatrix}$$

$$R_3 \Leftrightarrow R_2$$

$$1 \quad -2 \quad 1 \quad 2$$

$$0 \quad 6 \quad -4 \quad -6$$

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 1 & -1 & 1 \\ 0 & 6 & -4 & -6 \\ 0 & 2 & -2 & 2 \end{bmatrix}$$

$R_3 - 6R_2$ \therefore operation on R_3

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 1 & -1 & 1 \\ 0 & 0 & 6 & -16 \\ 0 & 2 & -2 & 2 \end{bmatrix}$$

$R_4 - 2R_2$ \therefore operation on R_4

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 1 & -1 & 1 \\ 0 & 0 & 6 & -16 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

divide R_3 by 6

$$\begin{bmatrix} 1 & -2 & 1 & 2 \\ 0 & 1 & -1 & 1 \\ 0 & 0 & 1 & -16/6 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

This is the reduced Row echelon form.