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Holiday Assignment

Q1
soln → $A = \begin{pmatrix} 1 & 2 & 3 & 0 \\ 2 & 4 & 3 & 2 \\ 3 & 2 & 1 & 3 \\ 6 & 8 & 7 & 5 \end{pmatrix}$ → $R_2 \to R_2 - 2R_1$
$R_3 \to R_3 - 3R_1$
$R_4 \to R_4 - 6R_1$

$A = \begin{pmatrix} 1 & 2 & 3 & 0 \\ 0 & 0 & -3 & 2 \\ 0 & -4 & -8 & 3 \\ 0 & -4 & -11 & 5 \end{pmatrix}$ $R_2 \leftrightarrow R_3$
$R_2 \to -\frac{R_2}{4}$
$R_1 = R_1 - 2R_2$

$A = \begin{pmatrix} 1 & 0 & -1 & 3/2 \\ 0 & 1 & 2 & -3/4 \\ 0 & 0 & -3 & 2 \\ 0 & -4 & -11 & 5 \end{pmatrix}$ $R_4 = R_4 + 4R_2$
$R_3 = -\frac{R_3}{3}$
$R_1 = R_1 + R_3$

$A = \begin{bmatrix} 1 & 0 & 0 & 5/6 \\ 0 & 1 & 2 & -3/4 \\ 0 & 0 & 1 & -2/3 \\ 0 & 0 & -3 & 2 \end{bmatrix}$ $R_2 = R_2 - 2R_3$
$R_4 = R_4 + 3R_3$

$A = \begin{bmatrix} 1 & 0 & 0 & 5/6 \\ 0 & 1 & 0 & 7/12 \\ 0 & 0 & 1 & -2/3 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

Rank = '3'

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Q2
Solⁿ→ the max degree of polynomial $T=2$, so $\dim(P_2) \Rightarrow 3$

Kernel
So a subset of Kernel T is $T(P)=0$

$$(a-b)+(b-c)x+(c-a)x^2 \Rightarrow 0$$

$$\hookrightarrow \boxed{a=b=c=t \text{ (let)}}$$

Kero matrix

$$\begin{pmatrix} t & t \\ t & d \end{pmatrix}$$

dimension of Kernel is 1, because there is only one independent parameter as 't'.

Acc. to rank nullity Thⁿ →

$$\text{rank}(T)+\text{nullity}(T) \Rightarrow \dim(W)$$

$$\text{rank}(T)+1=4$$

So, rank of T is 3, nullity is 1

Q3
Solⁿ→

$$A-\lambda I=0$$

det

$$|A-\lambda I| = \begin{vmatrix} 2-\lambda & -1 \\ -1 & 2-\lambda \end{vmatrix} = 0$$

$$(2-\lambda)^2-1=0$$

$$\lambda=1,3$$

for $\lambda=1$

$$\begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}=\begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

$$x=y$$

let $x=t$
$y=t$

eigen vector $v_1 = t\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ Ans

for $\lambda=3$

$$\begin{pmatrix} -1 & -1 \\ -1 & -1 \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}=\begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

$$-x-y=0$$

$$x=-y$$

let $x=t \Rightarrow y=t$

eigen vector $v_2=t\begin{pmatrix} -1 \\ 1 \end{pmatrix}$

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for A^{-1} →

eigan values are ⇒ $1, \frac{1}{3}$

for $A+4I$ →

$5, 7$

eigen vector are same for all as v_1 and v_2

Q4 Ans →

$$3x - 0.1y - 0.2z = 7.85$$
$$0.1x - 7y - 0.3z = +19.3$$
$$0.3x - 0.2y + 10z = 71.4$$

with initial values $x(0) = 0$, $y(0) = 0$, $z(0) = 0$

eq^n → $x^{k+1} = \frac{7.85 + 0.1y^{k} + 0.2z^{k}}{3}$

$$y^{k+1} = \frac{-19.3 - 0.1x^{k+1} - 0.3z^{k}}{-7}$$

$$z^{k+1} \Rightarrow \frac{71.4 - 0.3x^{k+1} + 0.2y^{k+1}}{10}$$

we know $x(0) = 0$, $y(0) = 0$, $z(0) = 0$

iteration-1 →

$x(1) \Rightarrow \frac{7.85 + 0.1(0) + 0.2(0)}{3} \Rightarrow 2.6167$

$y(1) \Rightarrow \frac{-19.3 - 0.1(2.6167) - 0.3(0)}{-7} = 2.7956$

$z(1) = \frac{71.4 - 0.3(2.6167) - 0.2(3.7956)}{10} \Rightarrow 7.1373$

iter-2 →

$x(2) = 3$
$y(2) = 3$
$z(2) = 8$

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ite 3 →

$x(3) = 3$

$y(3) = 3$

$z(3) = 3$

After three iteratⁿ $x, y, z \approx 3$

so value of $x = 3, y = 3$ and $z = 3$

Q5

Ans →

Consistent
(atleast one solⁿ)

Dependent
(infinite solⁿ)

Independent
(unique solⁿ)

Inconsistent
(No solⁿ)

$$A = \left(\begin{array}{ccc|c} 1 & 3 & 2 & 0 \\ 2 & -1 & 3 & 0 \\ 3 & -5 & 4 & 0 \\ 1 & 17 & 4 & 0 \end{array}\right)$$

$R_2 \to R_2 - 2R_1$

$R_3 \to R_3 - 3R_1$

$R_4 \to R_4 - R_1$

$$\Rightarrow \begin{pmatrix} 1 & 3 & 2 & 0 \\ 0 & -7 & -1 & 0 \\ 0 & -14 & -2 & 0 \\ 0 & 14 & 2 & 0 \end{pmatrix}$$

$R_3 \to R_3 - 2R_2$

$R_4 \to R_4 + 2R_2$

$$\left[\begin{array}{ccc|c} 1 & 3 & 2 & 0 \\ 0 & -7 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{array}\right]$$

$\rho(A) = 2$, $\rho(A:B) = 2$, $n = 3$

$\rho(A) = \rho(A:B) \neq n$

Consistent, but infinite solⁿ

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Q6

Ans → 1) Additive

$$T(u+v) = T(u) + T(v)$$

$$u = a_1 + b_1 x + c_1 x^2$$

$$v = a_2 + b_2 x + c_2 x^2$$

$$T(u+v) = T((a_1+a_2) + (b_1+b_2)x + (c_1+c_2)x^2)$$

$$\Rightarrow (a_1+a_2+1) + (b_1+b_2+1)x + (c_1+c_2+1)x^2$$

$$\Rightarrow (a_1+1) + (b_1+1) + (c_1+1)x^2 + (a_2+1) + (b_2+1)x + (c_2+1)x^2$$

$$\Rightarrow T(u) + T(v)$$

Hence Proved

2) Homogenity

$$T(ku) \Rightarrow kT(u)$$

$$T(k(a+bx+cx^2))$$

$$T(ka + kbx + kcx^2)$$

$$\rightarrow (ka+kb+kc+1) + (ka+kb+kc+1)x + (ka+kb+kc+1)x^2$$

$$\Rightarrow k(a+1) + k(b+1) + k(c+1)x^2$$

$$\rightarrow kT(u)$$

Hence Proved

Hence it is a linear Transformation

Q7

Soln →

$$a(1,2,3) + b(3,1,0) + c(-2,1,3) = (0,0,0)$$

$$a + 3b - 2c = 0$$

$$2a + b + c = 0 \qquad \Rightarrow \qquad c = -a, \; b = -a$$

$$3a + 3c = 0$$

only one solⁿ is possible $a = b = c = 0$, so linearly independent since dimⁿ of $V_3(R)$ is 3 and S also contains 3 vector and $S \rightarrow LI$ then it spans $V_3(R)$ making it a basis for $V_3(R)$.

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Q8)
Solⁿ →

$x_0 = 1, y_0 = 1, z_0 = 1$

for 1st eqⁿ $x = \frac{1}{3}(23 + 6y - 2z)$
2nd eqⁿ → $y = (-15 + 4x + z)$
3rd eqⁿ → $z = \frac{1}{7}(16 - x + 3y)$
$x(0) = 1, \; y(0) = 1, \; z(0) = 1$

iterⁿ → 1
$x(1) \rightarrow \frac{(23 + 6 - 2)}{2} = 9$
$y(1) = (-15 + 4 + 1) \Rightarrow -10$
$z(1) \Rightarrow \frac{16 - 1 + 3}{7} \Rightarrow \frac{18}{7}$

Q9
Ans

$$\begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

→ rotatⁿ of image by θ
to rotate it around centre

1) Translate to origin
Translate the image so that it centre allign with origin
2) Rotatⁿ
Apply rotatⁿ matrix
3) Translation Back

Q10
Ans

Linear Transformation for rotⁿ 2D images involves applying a rotatⁿ matrix to each pixel coordinate. This matrix rotates points counter clockwise by an angle θ around the origin. It preserves geometric properties like parallism and distance. Rotation is essential in tasks like image allignment and object detection in ~~complete~~ computer vision.

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Assignment-1

(i) $2x+3y+7z=5$, $3x+y-3z=13$, $2x+19y-47z=32$

Augmented Matrix :-

$$(A:B) = \begin{pmatrix} 2 & -3 & 7 & 5 \\ 3 & 1 & -3 & 13 \\ 2 & 19 & -47 & 32 \end{pmatrix} \qquad \begin{matrix} (R_2 \to R_2 - 3/2 R_1) \\ R_3 \to R_3 - R_1 \end{matrix}$$

$$= \begin{pmatrix} 2 & -3 & 7 & 5 \\ 0 & 11/2 & -27/2 & 11/2 \\ 0 & 22 & -54 & 27 \end{pmatrix} \qquad R_3 \to R_3 - 4R_2$$

$$= \begin{pmatrix} 2 & -3 & 7 & 5 \\ 0 & 11/2 & -27/2 & 11/2 \\ 0 & 0 & 0 & 5 \end{pmatrix}$$

$\rho(A:B) \neq \rho(A) \to$ No sol^n

(iii) $4x-y=12$, $-x+5y-2z=0$, $-2x+4z=-8$

Augmented Matrix :-

$$A:B = \begin{pmatrix} 4 & -1 & 0 & 12 \\ -1 & 5 & -2 & 0 \\ -2 & 0 & 4 & -8 \end{pmatrix} \qquad \begin{matrix} R_2 \to 4R_2 + R_1 \\ R_3 \to 2R_3 + R_1 \end{matrix}$$

$$A:B = \begin{pmatrix} 4 & -1 & 0 & 12 \\ 0 & 19 & -8 & 12 \\ -2 & 0 & 4 & -8 \end{pmatrix} \qquad R_3 \to 19R_3 + R_2$$

$$= \begin{pmatrix} 4 & -1 & 0 & 12 \\ 0 & 19 & -8 & 12 \\ 0 & 0 & 144 & -64 \end{pmatrix}$$

$\rho(A:B) = \rho(A) = 3 \to$ so consistent $\to$ unique

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(b) $x+y+z=6$, $x+2y+3z=10$, $x+2y+\lambda z=4$

(i) $A:B = \begin{pmatrix} 1 & 1 & 1 & 6 \\ 1 & 2 & 3 & 10 \\ 1 & 2 & \lambda & 4 \end{pmatrix}$ Given no solⁿ $\rho(A:B) \neq \rho(A)$

$R_2 \to R_2 - R_1 \to \begin{pmatrix} 1 & 1 & 1 & 6 \\ 0 & 1 & 2 & 4 \\ 1 & 2 & \lambda & 4 \end{pmatrix}$ $R_3 \to R_3 - R_1$ $R_3 \to R_3 - R_2$

$= \begin{pmatrix} 1 & 1 & 1 & 6 \\ 0 & 1 & 2 & 4 \\ 0 & 0 & \lambda-3 & 4-10 \end{pmatrix}$

$\rho(A-B) = \rho(A)$

$\lambda - 3 = 0 \to \boxed{\lambda = 3}$

$\mu - 10 \neq 0 \boxed{\to \mu \neq 10}$

(ii) for unique solⁿ $\rho(A:B) = \rho(A) = 3$

$\lambda \neq 3$, $\mu \neq 10$

(iii) for infinitely many solⁿ

$\lambda = 3$, $\mu = 10$

Q.

(d) $A = \begin{pmatrix} 1 & 3 & -2 \\ 2 & -1 & 4 \\ 1 & -11 & 14 \end{pmatrix}$ $R_2 \to R_2 - 2R_1$ $R_3 \to R_3 - R_1$

$A = \begin{pmatrix} 1 & 3 & -2 \\ 0 & -7 & 8 \\ 0 & -14 & 16 \end{pmatrix}$ $R_3 \to R_3 - 2R_2$

$A = \begin{pmatrix} 1 & 3 & -2 \\ 0 & -7 & 8 \\ 0 & 0 & 0 \end{pmatrix}$

since in echlon form no. of eqⁿ > no. of variable , so z is freevariable

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$x+3y-2z=0$
$-7y+8z=0$
set $\boxed{z=7}$, then $\boxed{y=8} \to \boxed{x=-10}$

(c)
$$A = \begin{pmatrix} 3 & 1 & -\lambda \\ 4 & -2 & -3 \\ 2\lambda & 4 & \lambda \end{pmatrix} \qquad R_2 \to 3R_2 - 4R_1$$

$$A = \begin{pmatrix} 3 & 1 & -\lambda \\ 0 & -10 & 4\lambda-9 \\ 2\lambda & 4 & \lambda \end{pmatrix}$$

case (i), $\boxed{\lambda=0}$ then $A = \begin{pmatrix} 3 & 1 & 0 \\ 0 & -10 & -9 \\ 0 & 4 & 0 \end{pmatrix} \to$ it is not satisfying
$\boxed{\lambda \neq 0}$

for finding sol^n
$$|A| = \begin{vmatrix} 3 & 1 & -\lambda \\ 4 & -2 & -3 \\ 2\lambda & 4 & \lambda \end{vmatrix} = \begin{vmatrix} 3+2\lambda & 5 & 0 \\ 4 & -2 & -3 \\ 2\lambda & 4 & \lambda \end{vmatrix}$$

$$\lambda = \frac{-1 \pm \sqrt{1-4(7)(22)}}{4(2)}$$

since $D<0$, so no real sol^n exist

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Assignment - II

Q1 $A = \begin{pmatrix} 1 & 2 & 3 & 0 \\ 2 & 4 & 3 & 2 \\ 3 & 2 & 1 & 3 \\ 6 & 8 & 7 & 5 \end{pmatrix}$ $R_4 \to R_4 - 2R_3$, $R_3 \to R_3 - 3R_1$, $R_2 \to R_2 - 2R_1$

$\Rightarrow \begin{pmatrix} 1 & 2 & 3 & 0 \\ 0 & 0 & -3 & 2 \\ 0 & -4 & -8 & 3 \\ 0 & 4 & 5 & -1 \end{pmatrix}$ $R_4 \to R_4 + R_3$, $R_2 \leftrightarrow R_3$, $R_4 \to R_4 - R_3$

$\Rightarrow \begin{pmatrix} 1 & 2 & 3 & 0 \\ 0 & -4 & -8 & 3 \\ 0 & 0 & -3 & 2 \\ 0 & 0 & 0 & 0 \end{pmatrix}$ $\boxed{\text{Rank} = \rho(A) = 3}$

Q2 (1) $A = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{pmatrix}$ rank = 3
infinite solⁿ and vectors are L.I

(2) $\vec{B} = 6\vec{A}$, so both are linearly dependent

(3) $A = \begin{pmatrix} -1 & 16 & -64 \\ 5 & 8 & 56 \\ 6 & -3 & 9 \end{pmatrix} \xrightarrow{\text{echelon form}} \begin{pmatrix} 1 & 0 & 16 \\ 0 & 1 & -3 \\ 0 & 0 & 0 \end{pmatrix}$

So, the vectors are linearly dependent

(4) $(2,-4), (1,5), (3,5)$
→ linearly dependent

(5) (6)

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(6) $A = \begin{pmatrix} 3 & 5 & -6 & 2 \\ -2 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 4 & 1 & 1 & 3 \end{pmatrix}$

echelon form $\rightarrow$ $= \begin{pmatrix} 3 & 5 & -6 & 2 \\ 0 & -17 & 21 & 1 \\ 0 & 1 & 3 & 3 \\ 0 & 0 & 0 & 0 \end{pmatrix}$

LD

7) [6 0 3 1 4 2], (0 -1 2 7 0 5), (1 2 3 0 -13 8 -11]

$A = \begin{pmatrix} 6 & 0 & 12 & 0 & 0 & 0 \\ 0 & -1 & 3 & 0 & 0 & 0 \\ 3 & 2 & 0 & 0 & 0 & 0 \\ 1 & 7 & -13 & 0 & 0 & 0 \\ 4 & 0 & 8 & 0 & 0 & 0 \\ 2 & 5 & -11 & 0 & 0 & 0 \end{pmatrix} \rightarrow A = \begin{pmatrix} 1 & 0 & 2 & 0 & 0 & 0 \\ 0 & 1 & -3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$

so vectors are LD

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Assignment - 3

Q1 (1) $A = \begin{bmatrix} -2 & 2 & 3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$ $|A - \lambda I| = 0$

$$\begin{vmatrix} -2-\lambda & 2 & 3 \\ 2 & 1-\lambda & -6 \\ -1 & -2 & -\lambda \end{vmatrix} = 0$$

$(-2-\lambda)((1-\lambda)(-\lambda) - 12) = 0$

$\lambda = 3, \quad \lambda = 1 \pm \sqrt{10}$

for $\lambda = -3$

$A = \begin{pmatrix} 1 & 2 & 3 \\ 2 & 4 & -6 \\ -1 & -2 & 3 \end{pmatrix}$

making echelon form $\rightarrow$ $A = \begin{pmatrix} 1 & 2 & 3 \\ 0 & 6 & -12 \\ 0 & 0 & 0 \end{pmatrix}$

$\boxed{z = 0}$, $x + 2y = 0$

let $x = k$, $y = -\frac{k}{2}$, $z = 0$

eigen vector $\rightarrow$ $k\begin{pmatrix} -2 \\ 1 \\ 0 \end{pmatrix}$

for $\lambda = 1 - \sqrt{10}$ $\rightarrow$

eigen vector is $k\begin{pmatrix} -3+\sqrt{10} \\ -2 \\ 1 \end{pmatrix}$

for $\lambda = 1 + \sqrt{10}$ $\rightarrow$

$= k\begin{pmatrix} 3-\sqrt{10} \\ -2 \\ 1 \end{pmatrix}$

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(Q7) $A = \begin{pmatrix} 4 & 0 & 1 \\ -2 & 1 & 0 \\ -2 & 0 & 1 \end{pmatrix}$

$|A - \lambda I| = 0$

$\Rightarrow \begin{vmatrix} 4-\lambda & 0 & 1 \\ -2 & 1-\lambda & 0 \\ -2 & 0 & 1-\lambda \end{vmatrix} = 0$

eigen values are $\boxed{\lambda = 1, 3, 2}$

for $\lambda = 1$

$A - \lambda I = \begin{pmatrix} 3 & 0 & 1 \\ -2 & 0 & 0 \\ -2 & 0 & 0 \end{pmatrix} \rightarrow \begin{pmatrix} 3 & 0 & 1 \\ -2 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$

$-2x = 0$, $3x + z = 0$, $y = k$

eigen vector $\rightarrow k \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

for $\lambda = 2$

$(A - \lambda I)$

$\begin{pmatrix} 2 & 0 & 1 \\ -2 & -1 & 0 \\ -2 & 0 & -1 \end{pmatrix} \rightarrow \begin{pmatrix} 2 & 0 & 1 \\ 0 & -1 & 1 \\ 0 & 0 & 0 \end{pmatrix}$

eigen vector $\rightarrow k \begin{pmatrix} 1 \\ -2 \\ -2 \end{pmatrix}$

for $\lambda = 3$

eigen vector $= k \begin{pmatrix} -1 \\ 1 \\ 1 \end{pmatrix}$

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(3) $A = \begin{pmatrix} 5 & 0 & 0 \\ 0 & 0 & 0 \\ -1 & 0 & 3 \end{pmatrix}$

$(A - \lambda I) = \begin{pmatrix} 5-\lambda & 0 & 0 \\ 0 & -\lambda & 0 \\ -1 & 0 & 3-\lambda \end{pmatrix}$

$|A - \lambda I| = 0$

After solving determinant
eigen values are $\boxed{\lambda = 5, 3, 0}$

for $\lambda = 5$
eigen vector $\rightarrow K \begin{pmatrix} -2 \\ 0 \\ 1 \end{pmatrix}$.

for $\lambda = 3$
eigen vector $= K \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$

for $\lambda = 0$
eigen vector $= K \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

4) $A = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 3 & 4 \\ 0 & 0 & -2 \end{pmatrix}$ $(A - \lambda I) = \begin{pmatrix} -\lambda & 0 & 0 \\ 0 & 3-\lambda & 4 \\ 0 & 0 & -2-\lambda \end{pmatrix}$

eigenvalues after solving $|A - \lambda I| = 0$
are $\boxed{\lambda = 0, -2, 3}$

for $\lambda = 0$ $(A - 0I) = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 3 & 4 \\ 0 & 0 & -2 \end{pmatrix}$

$3x + 4z = 0, \; -2z = 0, \; y = 0$

so $\vec{x} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

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for $\lambda = -2$

$$A = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 5 & 4 \\ 0 & 0 & 0 \end{pmatrix}$$

$$\vec{x} = k\begin{pmatrix} 0 \\ 1 \\ -5/4 \end{pmatrix}$$

for $\lambda = 3$

$$A = \begin{pmatrix} -3 & 0 & 0 \\ 0 & 0 & 4 \\ 0 & 0 & -5 \end{pmatrix}$$

$$\vec{x} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

5)

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix} \qquad tr(A) = 6, \; \det(A) = 0$$

because rows and columns are same

Now $\lambda_1 \lambda_2 \lambda_3 = 0$ and $\lambda_1 + \lambda_2 + \lambda_3 = 6$

λ_1 from this $\lambda_1 = 0 \rightarrow$ $\lambda_2 + \lambda_3 = 6$

$\boxed{\lambda_3 = 6}$

Hence by the property of eigen value

$\boxed{\lambda = 0, \lambda = 0, \lambda = 6}$