



$$= a^2 b^2 c^2 (-1) \begin{vmatrix} 0 & 2 \\ 2 & 0 \end{vmatrix}$$

$$= -a^2 b^2 c^2 (0 - 4) = 4a^2 b^2 c^2$$

**Question 8:**

By using properties of determinants, show that:

$$(i) \begin{vmatrix} 1 & a & a^2 \\ 1 & b & b^2 \\ 1 & c & c^2 \end{vmatrix} = (a-b)(b-c)(c-a)$$

$$(ii) \begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^3 & b^3 & c^3 \end{vmatrix} = (a-b)(b-c)(c-a)(a+b+c)$$

**Answer**

$$(i) \text{ Let } \Delta = \begin{vmatrix} 1 & a & a^2 \\ 1 & b & b^2 \\ 1 & c & c^2 \end{vmatrix}$$

Applying  $R_1 \rightarrow R_1 - R_3$  and  $R_2 \rightarrow R_2 - R_3$ , we have:

$$\Delta = \begin{vmatrix} 0 & a-c & a^2-c^2 \\ 0 & b-c & b^2-c^2 \\ 1 & c & c^2 \end{vmatrix}$$

$$= (c-a)(b-c) \begin{vmatrix} 0 & -1 & -a-c \\ 0 & 1 & b+c \\ 1 & c & c^2 \end{vmatrix}$$

Applying  $R_1 \rightarrow R_1 + R_2$ , we have:

$$\Delta = (b-c)(c-a) \begin{vmatrix} 0 & 0 & -a+b \\ 0 & 1 & b+c \\ 1 & c & c^2 \end{vmatrix}$$

$$= (a-b)(b-c)(c-a) \begin{vmatrix} 0 & 0 & -1 \\ 0 & 1 & b+c \\ 1 & c & c^2 \end{vmatrix}$$

Expanding along  $C_1$ , we have:

$$\Delta = (a-b)(b-c)(c-a) \begin{vmatrix} 0 & -1 \\ 1 & b+c \end{vmatrix} = (a-b)(b-c)(c-a)$$

Hence, the given result is proved.

$$(ii) \text{ Let } \Delta = \begin{vmatrix} 1 & 1 & 1 \\ a & b & c \\ a^3 & b^3 & c^3 \end{vmatrix}$$

Applying  $C_1 \rightarrow C_1 - C_3$  and  $C_2 \rightarrow C_2 - C_3$ , we have:

$$\Delta = \begin{vmatrix} 0 & 0 & 1 \\ a-c & b-c & c \\ a^3-c^3 & b^3-c^3 & c^3 \end{vmatrix}$$

$$= \begin{vmatrix} 0 & 0 & 1 \\ a-c & b-c & c \\ (a-c)(a^2+ac+c^2) & (b-c)(b^2+bc+c^2) & c^3 \end{vmatrix}$$

$$= (c-a)(b-c) \begin{vmatrix} 0 & 0 & 1 \\ -1 & 1 & c \\ -(a^2+ac+c^2) & (b^2+bc+c^2) & c^3 \end{vmatrix}$$

Applying  $C_1 \rightarrow C_1 + C_2$ , we have:

$$\Delta = (c-a)(b-c) \begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & c \\ (b^2-a^2)+(bc-ac) & (b^2+bc+c^2) & c^3 \end{vmatrix}$$

$$= (b-c)(c-a)(a-b) \begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & c \\ -(a+b+c) & (b^2+bc+c^2) & c^3 \end{vmatrix}$$

$$= (a-b)(b-c)(c-a)(a+b+c) \begin{vmatrix} 0 & 0 & 1 \\ 0 & 1 & c \end{vmatrix}$$

$$\begin{vmatrix} 1 & 1 & 1 \\ -1 & (b^2 + bc + c^2) & c^3 \end{vmatrix}$$

Expanding along  $C_1$ , we have:

$$\begin{aligned} \Delta &= (a-b)(b-c)(c-a)(a+b+c)(-1) \begin{vmatrix} 0 & 1 \\ 1 & c \end{vmatrix} \\ &= (a-b)(b-c)(c-a)(a+b+c) \end{aligned}$$

Hence, the given result is proved.

#### Question 9:

By using properties of determinants, show that:

$$\begin{vmatrix} x & x^2 & yz \\ y & y^2 & zx \\ z & z^2 & xy \end{vmatrix} = (x-y)(y-z)(z-x)(xy+yz+zx)$$

Answer

$$\text{Let } \Delta = \begin{vmatrix} x & x^2 & yz \\ y & y^2 & zx \\ z & z^2 & xy \end{vmatrix}$$

Applying  $R_2 \rightarrow R_2 - R_1$  and  $R_3 \rightarrow R_3 - R_1$ , we have:

$$\begin{aligned} \Delta &= \begin{vmatrix} x & x^2 & yz \\ y-x & y^2-x^2 & zx-yz \\ z-x & z^2-x^2 & xy-yz \end{vmatrix} \\ &= \begin{vmatrix} x & x^2 & yz \\ -(x-y) & -(x-y)(x+y) & z(x-y) \\ (z-x) & (z-x)(z+x) & -y(z-x) \end{vmatrix} \\ &= (x-y)(z-x) \begin{vmatrix} x & x^2 & yz \\ -1 & -x-y & z \\ 1 & z+x & -y \end{vmatrix} \end{aligned}$$

Applying  $R_3 \rightarrow R_3 + R_2$ , we have:

$$\begin{aligned} \Delta &= (x-y)(z-x) \begin{vmatrix} x & x^2 & yz \\ -1 & -x-y & z \\ 0 & z-y & z-y \end{vmatrix} \\ &= (x-y)(z-x)(z-y) \begin{vmatrix} x & x^2 & yz \\ -1 & -x-y & z \\ 0 & 1 & 1 \end{vmatrix} \end{aligned}$$

Expanding along  $R_3$ , we have:

$$\begin{aligned} \Delta &= [(x-y)(z-x)(z-y)] \left[ (-1) \begin{vmatrix} x & yz \\ -1 & z \end{vmatrix} + 1 \begin{vmatrix} x & x^2 \\ -1 & -x-y \end{vmatrix} \right] \\ &= (x-y)(z-x)(z-y) [(-xz-yz) + (-x^2-xy+x^2)] \\ &= -(x-y)(z-x)(z-y)(xy+yz+zx) \\ &= (x-y)(y-z)(z-x)(xy+yz+zx) \end{aligned}$$

Hence, the given result is proved.

#### Question 10:

By using properties of determinants, show that:

$$(i) \begin{vmatrix} x+4 & 2x & 2x \\ 2x & x+4 & 2x \\ 2x & 2x & x+4 \end{vmatrix} = (5x+4)(4-x)^2$$

$$(ii) \begin{vmatrix} y+k & y & y \\ y & y+k & y \\ y & y & y+k \end{vmatrix} = k^2(3y+k)$$

Answer

$$(i) \Delta = \begin{vmatrix} x+4 & 2x & 2x \\ 2x & x+4 & 2x \\ 2x & 2x & x+4 \end{vmatrix}$$

Applying  $R_1 \rightarrow R_1 + R_2 + R_3$ , we have:

$$\begin{aligned} \Delta &= \begin{vmatrix} 5x+4 & 5x+4 & 5x+4 \\ 2x & x+4 & 2x \\ 2x & 2x & x+4 \end{vmatrix} \\ &= (5x+4) \begin{vmatrix} 1 & 1 & 1 \\ 2x & x+4 & 2x \\ 2x & 2x & x+4 \end{vmatrix} \end{aligned}$$

Applying  $C_2 \rightarrow C_2 - C_1$ ,  $C_3 \rightarrow C_3 - C_1$ , we have:

$$\begin{aligned} \Delta &= (5x+4) \begin{vmatrix} 1 & 0 & 0 \\ 2x & -x+4 & 0 \\ 2x & 0 & -x+4 \end{vmatrix} \\ &= (5x+4)(4-x) \begin{vmatrix} 1 & 0 & 0 \\ 2x & 1 & 0 \\ 2x & 0 & 1 \end{vmatrix} \end{aligned}$$

Expanding along  $C_3$ , we have:

$$\Delta = (5x+4)(4-x)^2 \begin{vmatrix} 1 & 0 \\ 2x & 1 \end{vmatrix}$$

$$= (5x+4)(4-x)^2$$

Hence, the given result is proved.

$$(ii) \quad \Delta = \begin{vmatrix} y+k & y & y \\ y & y+k & y \\ y & y & y+k \end{vmatrix}$$

Applying  $R_1 \rightarrow R_1 + R_2 + R_3$ , we have:

$$\Delta = \begin{vmatrix} 3y+k & 3y+k & 3y+k \\ y & y+k & y \\ y & y & y+k \end{vmatrix}$$

$$= (3y+k) \begin{vmatrix} 1 & 1 & 1 \\ y & y+k & y \\ y & y & y+k \end{vmatrix}$$

Applying  $C_2 \rightarrow C_2 - C_1$  and  $C_3 \rightarrow C_3 - C_1$ , we have:

$$\Delta = (3y+k) \begin{vmatrix} 1 & 0 & 0 \\ y & k & 0 \\ y & 0 & k \end{vmatrix}$$

$$= k^2 (3y+k) \begin{vmatrix} 1 & 0 & 0 \\ y & 1 & 0 \\ y & 0 & 1 \end{vmatrix}$$

Expanding along  $C_3$ , we have:

$$\Delta = k^2 (3y+k) \begin{vmatrix} 1 & 0 \\ y & 1 \end{vmatrix} = k^2 (3y+k)$$

Hence, the given result is proved.

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