

2.9.26

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Question

If $f(\alpha) = \begin{pmatrix} \cos \alpha & -\sin \alpha & 0 \\ \sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 1 \end{pmatrix}$, prove that $f(\alpha)f(-\beta) = f(\alpha - \beta)$.

Solution

We have

$$f(\theta) = \begin{pmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (1)$$

$$f(\alpha) = \begin{pmatrix} \cos \alpha & -\sin \alpha & 0 \\ \sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (2)$$

$$f(-\beta) = \begin{pmatrix} \cos \beta & \sin \beta & 0 \\ -\sin \beta & \cos \beta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (3)$$

$$f(\alpha)f(-\beta) = \begin{pmatrix} \cos \alpha & -\sin \alpha & 0 \\ \sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos \beta & \sin \beta & 0 \\ -\sin \beta & \cos \beta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (4)$$

$$= \begin{pmatrix} \cos \alpha \cos \beta + \sin \alpha \sin \beta & \cos \alpha \sin \beta - \sin \alpha \cos \beta & 0 \\ \sin \alpha \cos \beta - \cos \alpha \sin \beta & \sin \alpha \sin \beta + \cos \alpha \cos \beta & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (5)$$

$$= \begin{pmatrix} \cos(\alpha - \beta) & -\sin(\alpha - \beta) & 0 \\ \sin(\alpha - \beta) & \cos(\alpha - \beta) & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad (6)$$

$$= f(\alpha - \beta). \quad (7)$$

Thus proved.