

$$\begin{aligned}
 1 - e^{i\theta} &= 1 - \cos \theta - i \sin \theta \\
 &= 2 \sin^2 \frac{\theta}{2} - 2 i \sin \frac{\theta}{2} \cos \frac{\theta}{2} \\
 &= 2 \sin \frac{\theta}{2} \left(\sin \frac{\theta}{2} - i \cos \frac{\theta}{2} \right) \\
 &= 2 \sin \frac{\theta}{2} \left(-i^2 \sin \frac{\theta}{2} - i \cos \frac{\theta}{2} \right) \\
 &= -2 i \sin \frac{\theta}{2} \cdot \left(\cos \frac{\theta}{2} + i \sin \frac{\theta}{2} \right)
 \end{aligned} \tag{1}$$

$$\boxed{\forall \theta \in \mathbb{R} \quad 1 - e^{i\theta} = -2 i \sin \frac{\theta}{2} \cdot e^{i \frac{\theta}{2}}} \quad \text{إذن}$$

$$\begin{aligned}
 z_1 &= 1 - e^{i \frac{\pi}{6}} \\
 &= -2 i \sin \frac{\pi}{12} \cdot e^{i \frac{\pi}{12}} \\
 &= 2 \sin \frac{\pi}{12} \cdot e^{i \left(-\frac{\pi}{2} + \frac{\pi}{12} \right)}
 \end{aligned} \quad * \tag{2}$$

$$\boxed{z_1 = \left[2 \sin \frac{\pi}{12}, -\frac{5 \pi}{12} \right]} \quad \text{إذن}$$

$$\begin{aligned}
 z_2 &= 1 - e^{-i \frac{\pi}{8}} \\
 &= -2 i \sin \left(-\frac{\pi}{16} \right) e^{-i \frac{\pi}{16}}
 \end{aligned} \quad *$$

$$= 2i \sin\left(\frac{\pi}{16}\right) e^{-i\frac{\pi}{16}}$$

$$z_2 = \left[2 \sin\left(\frac{\pi}{16}\right), \frac{\pi}{2} - \frac{\pi}{16} \right] \quad \text{إذن}$$

$$z_2 = \left[2 \sin \frac{\pi}{16}, \frac{7\pi}{16} \right] \quad \text{أي :}$$

$$z_3 = \frac{2 - \sqrt{3} + i}{2} \quad *$$

$$= 1 - \left(\frac{\sqrt{3}}{2} - \frac{1}{2}i \right)$$

$$= 1 - e^{-i\frac{\pi}{6}}$$

$$= -2i \sin\left(-\frac{\pi}{12}\right) e^{-i\frac{\pi}{12}}$$

$$= 2i \sin\left(\frac{\pi}{12}\right) \cdot e^{-i\frac{\pi}{12}}$$

$$z_3 = \left[2 \sin\left(\frac{\pi}{12}\right), \frac{\pi}{2} - \frac{\pi}{12} \right] \quad \text{إذن}$$

$$z_3 = \left[2 \sin\left(\frac{\pi}{12}\right), \frac{5\pi}{12} \right] \quad \text{أي :}$$

$$z_4 = \frac{2 - \sqrt{2} - i\sqrt{2}}{2} \quad *$$

$$= 1 - \left(\frac{\pi}{2} + i\frac{\sqrt{2}}{2} \right)$$

$$= 1 - e^{i\frac{\pi}{4}}$$

$$= -2i \sin\left(\frac{\pi}{8}\right) e^{i\frac{\pi}{8}}$$

$$= 2 \sin \frac{\pi}{8} \cdot e^{i\left(\frac{\pi}{8} - \frac{\pi}{2}\right)}$$

$$z_4 = \left[2 \sin \frac{\pi}{8}, -\frac{3\pi}{8} \right] \quad \text{إذن}$$

إعداد الأستاذ : سعيد الهاني