

STEP II, 2005, Q7

7 The position vectors, relative to an origin O , at time t of the particles P and Q are

$$\cos t \mathbf{i} + \sin t \mathbf{j} + 0 \mathbf{k} \quad \text{and} \quad \cos\left(t + \frac{1}{4}\pi\right) \left[\frac{3}{2}\mathbf{i} + \frac{3\sqrt{3}}{2}\mathbf{k}\right] + 3 \sin\left(t + \frac{1}{4}\pi\right) \mathbf{j},$$

respectively, where $0 \leq t \leq 2\pi$.

- (i) Give a geometrical description of the motion of P and Q .
- (ii) Let θ be the angle POQ at time t that satisfies $0 \leq \theta \leq \pi$. Show that

$$\cos \theta = \frac{3\sqrt{2}}{8} - \frac{1}{4} \cos\left(2t + \frac{1}{4}\pi\right).$$

- (iii) Show that the total time for which $\theta \geq \frac{1}{4}\pi$ is $\frac{3}{2}\pi$.



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