3.19 Vector field $\mathbf{E}$ is given by

$$\mathbf{E} = \hat{\mathbf{R}}\, 5R\cos\theta - \hat{\boldsymbol{\theta}}\frac{12}{R}\sin\theta\cos\phi + \hat{\boldsymbol{\phi}}3\sin\phi.$$

Determine the component of $\mathbf{E}$ tangential to the spherical surface $R = 2$ at point $P = (2, 30^\circ, 60^\circ)$.

Solution: At P, $\mathbf{E}$ is given by

$$\begin{aligned}\mathbf{E} &= \hat{\mathbf{R}}\, 5\times 2\cos 30^\circ - \hat{\boldsymbol{\theta}}\frac{12}{2}\sin 30^\circ\cos 60^\circ + \hat{\boldsymbol{\phi}}3\sin 60^\circ \\ &= \hat{\mathbf{R}}\, 8.67 - \hat{\boldsymbol{\theta}}1.5 + \hat{\boldsymbol{\phi}}2.6.\end{aligned}$$

The $\hat{\mathbf{R}}$ component is normal to the spherical surface while the other two are tangential. Hence,

$$\mathbf{E}_{\rm t} = -\hat{\boldsymbol{\theta}}1.5 + \hat{\boldsymbol{\phi}}2.6.$$