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Problem 34.10 (RHK)

An electron has initial velocity $\left(12.0\hat{j}+15.0\hat{k}\right)$ km s^{-1} *and a constant acceleration of* $\left(2.00\times10^{12}\ \text{m s}^{-2}\right)\hat{i}$ *in a region in which uniform electric and magnetic fields are present. If* $\vec{B}=400\hat{i}\ \mu\text{T}$*, we have to find the electric field* $\vec{E}$.

Solution:

Lorentz force on an electron moving with velocity $\vec{v}$ in electric field $\vec{E}$ and magnetic field $\vec{B}$ is

$$\vec{F}=e\vec{E}+e\vec{v}\times\vec{B},$$

where,

charge of electron, $e=-1.6\times10^{-19}$ C,

mass of electron, $m_e=9.11\times10^{-31}$ kg,

velocity of electron, $\vec{v}=\left(12.0\hat{j}+15.0\hat{k}\right)$ km s^{-1},

and magnetic field , $\vec{B}=400\hat{i}\ \mu\text{T}$.

Electron in the uniform electric and magnetic fields is moving with acceleration

$$\vec{a} = \left(2.00\times10^{12}\ \text{m s}^{-2}\right)\hat{i}.$$

Therefore, force on the electron will be

$$\vec{F} = m_e\vec{a} = 9.11\times10^{-31}\times\left(2.00\times10^{12}\ \text{m s}^{-2}\right)\hat{i}\ \text{N}$$

$$= 1.822\times10^{-18}\hat{i}\ \text{N}.$$

From the Lorentz force equation, we write

$$1.822\times10^{-18}\hat{i}\ \text{N} = -1.6\times10^{-19}\left(\vec{E} + \left(12.0\hat{j} + 15.0\hat{k}\right)\times 4\times10^{-1}\hat{i}\ \text{m s}^{-1}\ \text{T}\right)\text{C}$$

$$= -1.6\times10^{-19}\left(\vec{E} + \left(-4.8\hat{k} + 6.0\hat{j}\right)\ \text{m s}^{-1}\ \text{T}\right)\ \text{C}.$$

Or

$$\vec{E} = \left(-\frac{1.822\times10^{-18}}{1.6\times10^{-19}}\hat{i} + 4.8\hat{k} - 6.0\hat{j}\right)\ \text{V m}^{-1}$$

$$= \left(-11.38\hat{i} - 6.0\hat{j} + 4.8\hat{k}\right)\ \text{V m}^{-1}.$$