

A proton ($e=1.6 \times 10^{-19}$ C) moves in the x-y plane with a velocity, $\vec{v} = (2 \times 10^6 \hat{i} + 3 \times 10^6 \hat{j}) \frac{m}{s}$ in a region of space where the magnetic field is $\vec{B} = (5 \hat{i} + 5 \hat{k}) T$. What is the force on the proton?

$$\begin{aligned}
 \vec{F} &= q \vec{v} \times \vec{B} \\
 &= 1.6 \times 10^{-19} \text{ C} \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 \times 10^6 & 3 \times 10^6 & 0 \\ 5 & 0 & 5 \end{vmatrix} \\
 &= 1.6 \times 10^{-19} \text{ C} \left(15 \times 10^6 \text{ T} \frac{m}{s} \hat{i} - 10 \times 10^6 \text{ T} \frac{m}{s} \hat{j} - 15 \times 10^6 \text{ T} \frac{m}{s} \hat{k} \right) \\
 &= (1.6)(5)(10^{-13}) \text{ N} \left(3 \hat{i} - 2 \hat{j} - 3 \hat{k} \right) \\
 &= 8 \times 10^{-13} \text{ N} \left(3 \hat{i} - 2 \hat{j} - 3 \hat{k} \right)
 \end{aligned}$$