Q 4. A charged particle enters an environment of a strong and non-uniform magnetic field varying from point to point both in magnitude and direction and comes out of it following a complicated trajectory. Would its final speed equal the initial speed if it suffered no collisions with the environment?

Sol. When a charged particle q moves with a velocity v in a magnetic field B, enters a magnetic field it experiences a force known as Magnetic Lorentz Force which is given by $\overrightarrow{F} = q(\overrightarrow{v} \times \overrightarrow{B})$

$|\overrightarrow{F}| = (q|\overrightarrow{v}||\overrightarrow{B}| \sin\theta)\hat{w}$

Now, due to magnetic Lorentz force, the particle accelerates so the velocity of particle changes, Magnetic field changes in both magnitude and direction so the Magnitude of Force on particle also keeps on changing, hence the velocity of the particle also changes.

In this Case force on the particle is always perpendicular to its velocity, which only changes the direction of the particle and its speed remains same, i.e. velocity of particle changes due to change in direction of particle and magnitude of velocity or speed same as it entered.

The following figure depicts the direction of the force on the particle at any instant: