QUES 03:-

Five long wires A, B, C, D and E, each carrying current I are arranged to form edges of a pentagonal prism as shown in Fig. Each carries current out of the plane of paper.

a. What will be magnetic induction at a point on the axis O? Axis is at a distance R from each wire.
b. What will be the field if current in one of the wires (say A) is switched off?
c. What if current in one of the wire (say) A is reversed?

Sol.

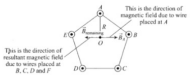
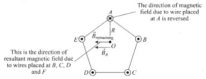
a. Suppose the five wires A, B, C, D and E be perpendicular to the plane of paper at locations as shown in figure.
Thus, magnetic field induction due to five wires will be represented by various sides of closed pentagon in one order lying in the plane of paper. So, its value is zero.

b. Total Magnetic field induction at O due to currents through the wires A, B, C, D and E is equal and opposite to the magnetic field induction at O due to current through wire A. since, the vector sum of magnetic field produced by each wire at O is equal to 0. Therefore, magnetic induction produced by one current carrying wire is equal magnitude of resultant of four wires and opposite in direction.

$\vec{B}_A + \vec{B}_{\text{remaining}} = 0$

$\frac{\mu_0 I}{2\pi R}\hat{i} + \vec{B}_{\text{remaining}} = 0 \Rightarrow \vec{B}_{\text{remaining}} = -\frac{\mu_0 I}{2\pi R}\hat{i}$

Therefore, the field if current in one of the wires (say A) is switched off is $\frac{\mu_0}{2\pi}\frac{I}{R}$ perpendicular to AO towards left.



c. If current in wire A is reversed, then
Total magnetic field induction at O
= Magnetic field induction due to wire A + Magnetic field induction due to wires B, C, D, and E
$= -\frac{\mu_0}{2\pi}\frac{I}{R}$ (acting perpendicular to AO towards left) $+\frac{\mu_0}{2\pi}\frac{3I}{R}$ (acting perpendicular AO towards left)$=\frac{\mu_0}{\pi}\frac{I}{R}$ acting perpendicular AO towards left