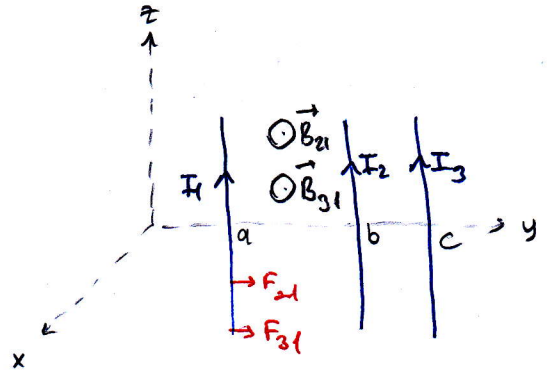
Q2 Three infinitely long parallel conducting wires are carrying I_1, I_2 and I_3 direct current in the same direction as shown in figure. Determine the force per unit length of wire I.



A2

$$dF_m = I\, d\vec{l} \times \vec{B} \quad \Rightarrow F_M = I \oint d\vec{l} \times \vec{B} \quad [N]$$

Magnetic flux of infinitely long wire is $\vec{B} = \frac{NI}{2\pi\rho}\vec{e_\phi}$

$$\vec{F} = \vec{F_{21}} + \vec{F_{31}}$$

$$\vec{F_{21}} = I_1 \int_{z=0}^{dz} (dz\,\vec{e_z}) \cdot \left(\frac{NI_2}{2\pi(b-a)}\vec{e_x}\right) = \frac{NI_1I_2}{2\pi(b-a)}\, dz \,/ dz \quad \text{(per unit length)}$$

$$\vec{F_{21}} = \frac{NI_1I_2}{2\pi(b-a)}\vec{e_y} \quad [N/m]$$

$$\vec{F_{31}} = I_1 \oint (dz\,\vec{e_z}) \cdot \left(\frac{NI_3}{2\pi(c-a)}\vec{e_x}\right) =$$

$$\vec{F_{31}} = \frac{NI_1I_3}{2\pi(c-a)}\vec{e_y} \quad [N/m]$$

$$\vec{F} = \frac{NI_1}{2\pi}\left[\frac{I_2}{b-a} + \frac{I_3}{c-a}\right]\vec{e_y} \quad [N/m]$$