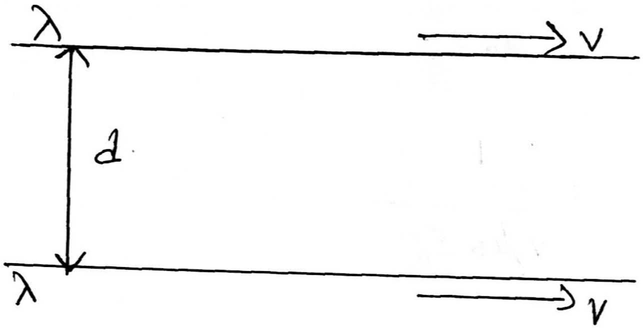
Suppose you have two infinite straight-line charges λ, a distance d apart, moving along at a constant speed v. How great would v have to be in order for the magnetic attraction to balance the electrical repulsion? Work out the actual number

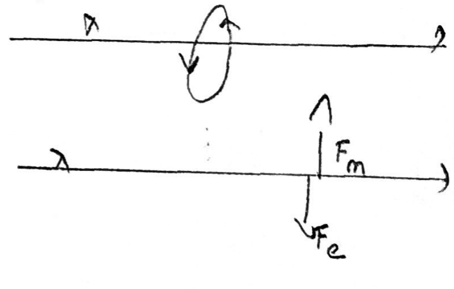


Magnetic field, $B = \dfrac{\mu_0 I}{2\pi d}$

Electric field, $E = \dfrac{1}{2\pi \varepsilon_0} \dfrac{\lambda}{d}$

Since both the wires are positively charged, they repel each other.

If the magnetic and electric force are going to balance each other out



Then,

$$F_m = F_e$$

F_m = Magnetic force, F_e = Electric force

$$q(v \times B) = qE$$

$$\Rightarrow v \times B = E$$

$$\Rightarrow \frac{v \mu_0 I}{2\pi d} = \frac{1}{2\pi \varepsilon_0} \frac{\lambda}{d}$$

$$\Rightarrow v\mu_0(\cancel{\lambda}v) = \frac{\cancel{\lambda}}{\varepsilon_0} \qquad (\because I = \lambda v)$$

$$\Rightarrow v^2\mu_0 = \frac{1}{\varepsilon_0}$$

$$\Rightarrow v^2 = \frac{1}{\mu_0\varepsilon_0}$$

$$v = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$$

$$= \frac{1}{\sqrt{4\pi\times10^{-7}\times8.854\times10^{-12}}}$$

$$= 2.998\times10^{8}\ m/s$$