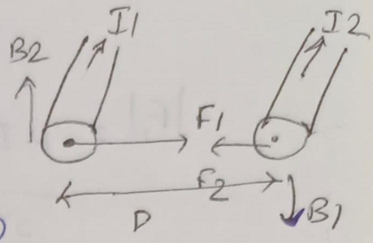
Force between differential current elements

(two parallel conductors)

Field due to the conductor (1) on the other conductor

$$B_1 = \frac{\mu I_1}{2\pi D}(-a_z)$$



Force on conductor (2) due to conductor (1)

$$F_2 = I_2(l \times B_1)$$

$$= I_2 [\, l(-a_x) \times B_1(-a_z)]$$

$$= l\, I_2\, B_1\, (-a_y)$$

$$= l\, I_2\, \frac{\mu I_1}{2\pi D}(-a_y)$$

$$|F_2| = \frac{\mu l\, I_1 I_2}{2\pi D}$$

This is an attractive force

Force of attraction b/w two infinitely long parallel conductors per metre length is

$$|F| = \frac{\mu I_1 I_2}{2\pi D}$$

Similarly, field at conductor (1) due to conductor (2)

$$B_2 = \frac{\mu I_2}{2\pi D}(a_z)$$

Force on conductor (1) due to B_2.

$$F_1 = I_1(l \times B_2)$$

$$= I_1 [\, l(-a_x) \times B_2(a_z)]$$

$= I l B_2 a_y$

Two current flow in same direction
→ attractive force

$\therefore F_1 = l I_1 \frac{\mu I_2}{2\pi D} a_y$

Opposite direction
→ repulsive force

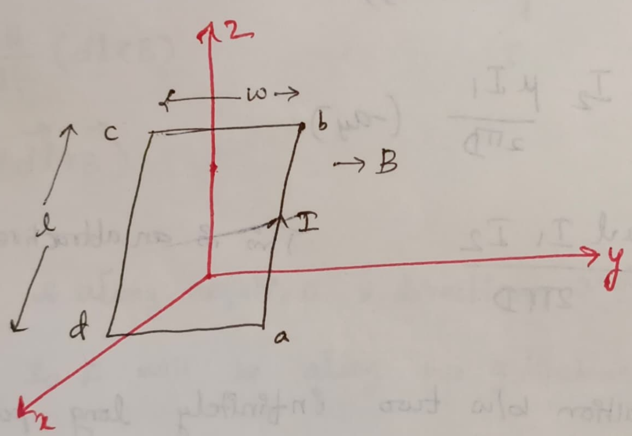
$$|F_1| = \frac{\mu I_1 I_2 l}{2\pi D}$$

F is along +ve y direction. This is also an attractive force

$|F_1| = |F_2|$

Torque on a loop carrying current I

force that tends to cause rotation (rotation force / twisting force)



Force = BIl (on the sides ab & cd)

Force = 0 (on the sides da & bc) since I & B are parallel to each other.

Torque is the tangential force multiplied by the radial distance at which the force acts.

Total torque on the loop abcd

= 2 × Torque on each side

= 2 × Force × Distance from axis of rotation

$= 2 \times BIl \times w/2$