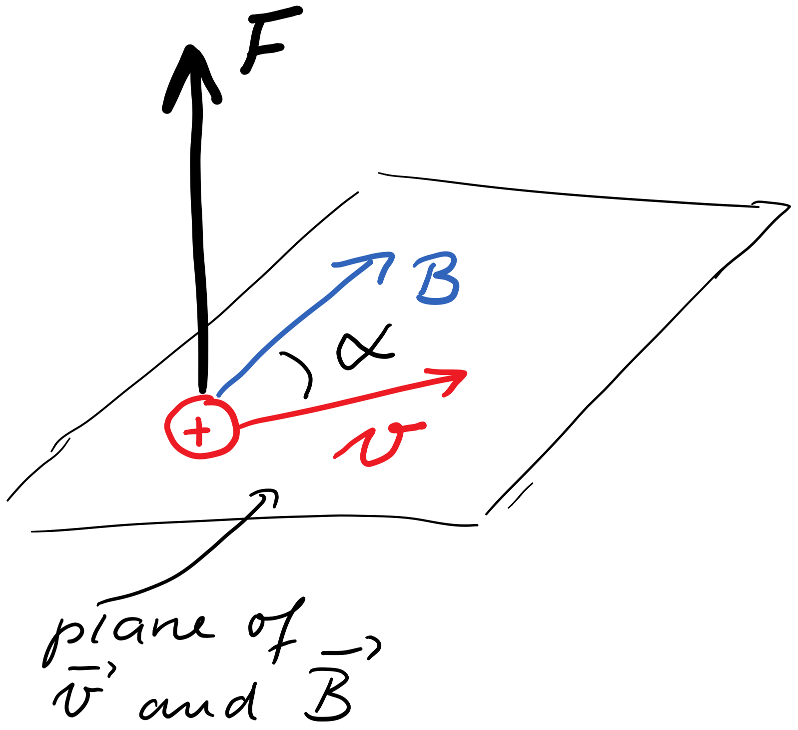
Lecture 26: Magnetic force ctd

- Force on straight current
- Force and torque on current loop

Force on moving charges

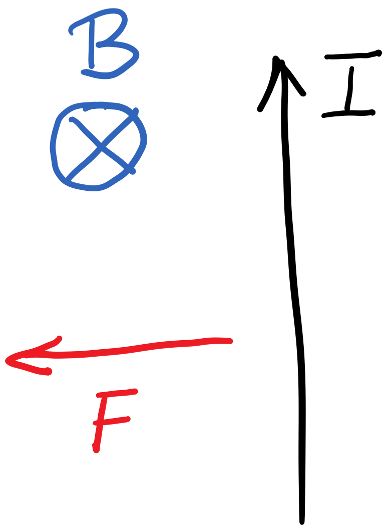
$$F = |q| v B \sin\alpha$$



If $\vec{v} \perp \vec{B}$:

$$F = |q| v B$$

Force on straight current



Current = moving charges

If magnetic field exerts force on moving charges, it exerts a force on a current

Length *L* of wire, current *I*

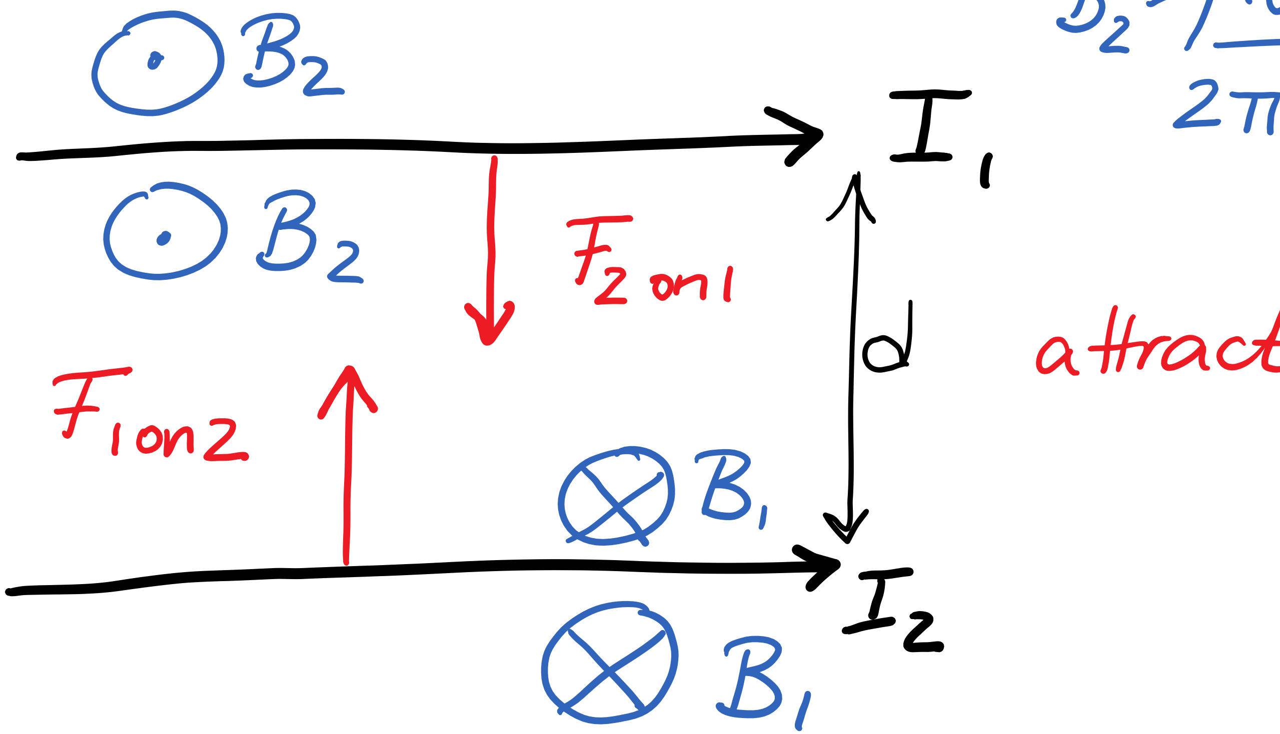
$\vec{I} \perp \vec{B}$ external magnetic field, not the current's own!

$$F = ILB$$

If wire is at angle to field: $F = ILB \sin \alpha$

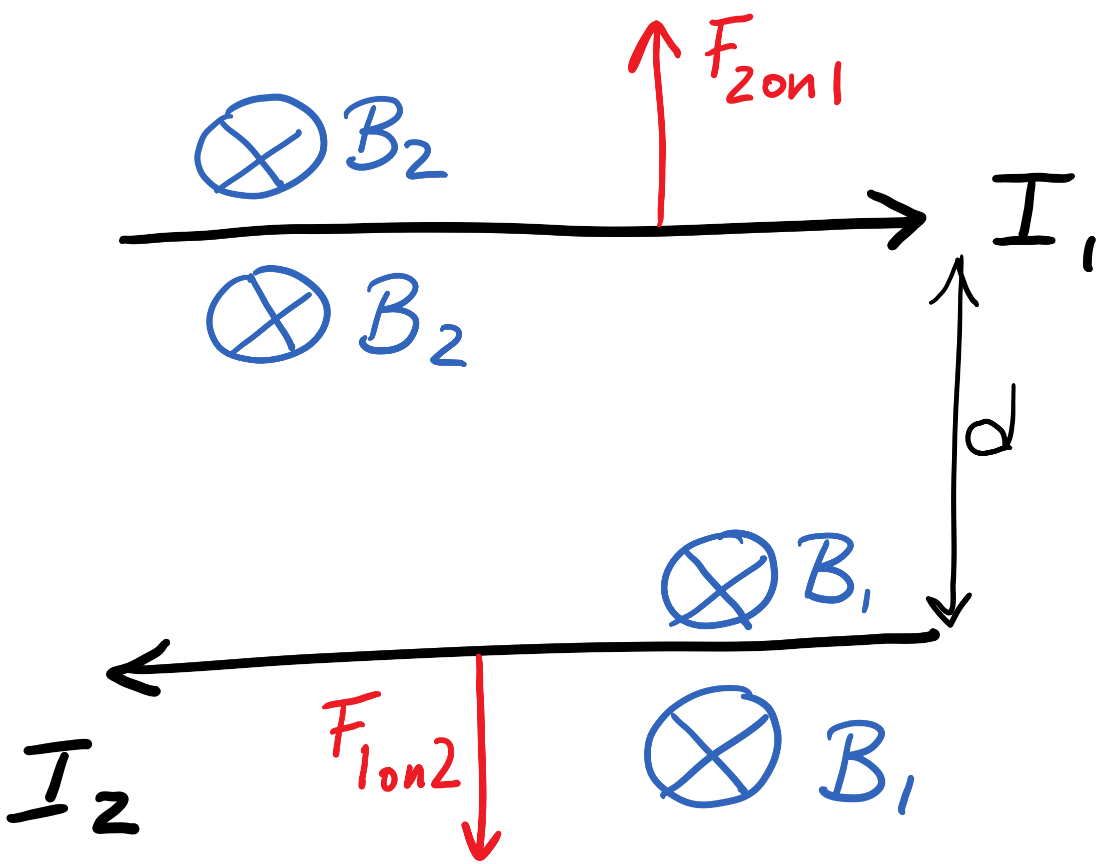
Forces between currents

$$B_2 = \frac{\mu_0 I_2}{2\pi d}$$



$$F_{2\,on\,1} = I_1 L B_2 = \frac{\mu_0 I_1 I_2 L}{2\pi d}$$

Forces between currents: opposite direction

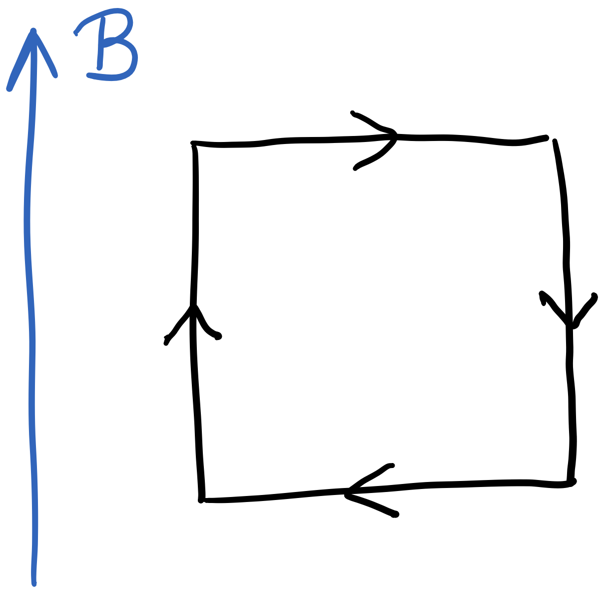


$$B_2 = \frac{\mu_0 I_2}{2\pi d}$$

repel

$$F_{2 on 1} = I_1 L B_2 = \frac{\mu_0 I_1 I_2 L}{2\pi d}$$

Example: Square current loop



$I = 10\,A$

$l = 20\,cm$

$B = 0.1\,T$

Force and torque on current loop

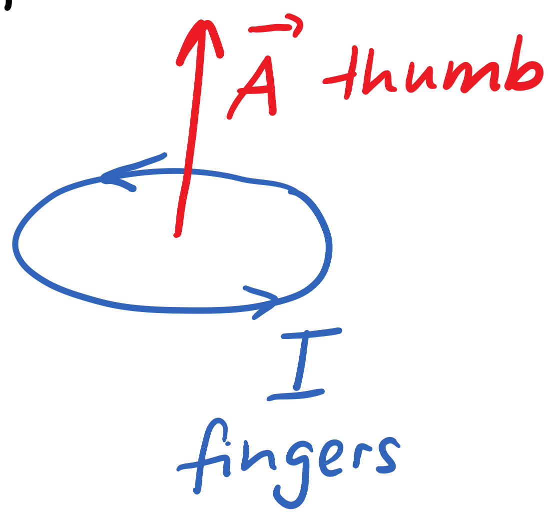
In uniform magnetic field:

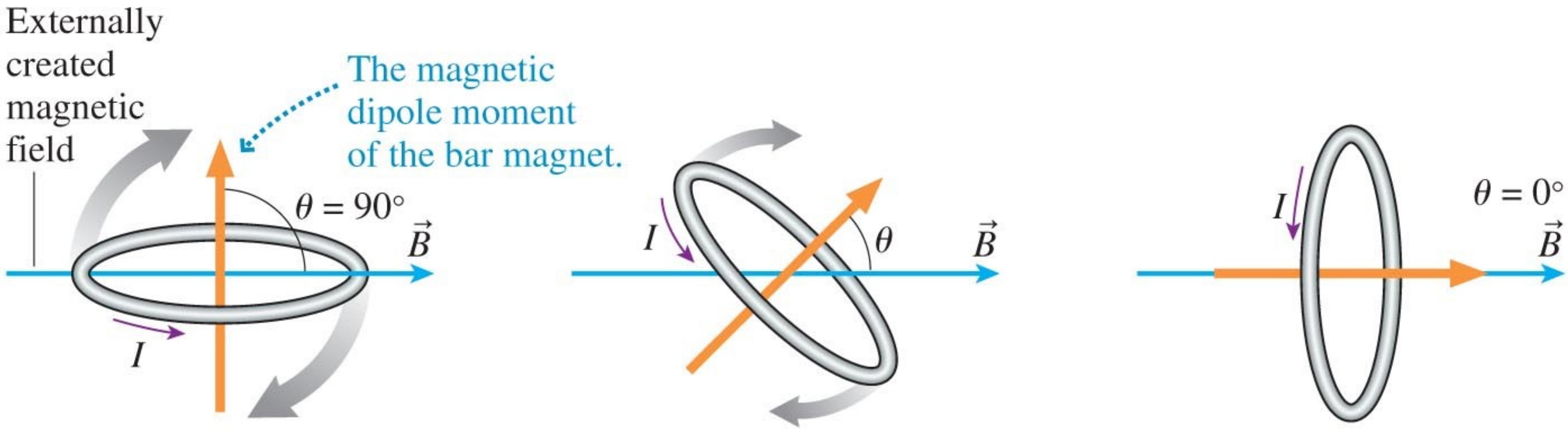
$$F_{net} = 0$$

$$\tau_{net} = IAB\sin\alpha$$

IA magnetic dipole moment

$I\vec{A}$





At an angle of 90°, the torque is maximum. A dipole free to rotate will do so.

The dipole will continue to rotate; as the angle θ decreases, the torque decreases.

The torque is zero once the dipole is lined up so that the angle θ is zero.

$\vec{A} \perp \vec{B}$

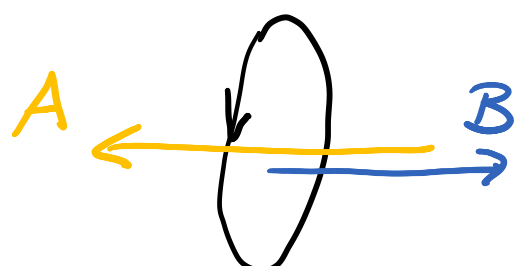
$\theta = 90°$

τ max

$\vec{A} \parallel \vec{B}$

$\theta = 0$

$\tau = 0$



$\theta = 180°$

$\tau = 0$

but unstable, higher energy