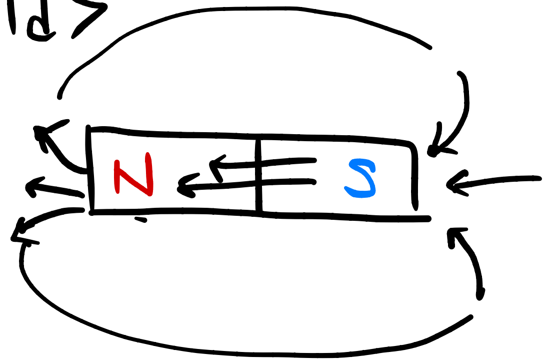
W10

- Magnetic field
- Magnetic force
- Faraday's law & Lenz's law
-

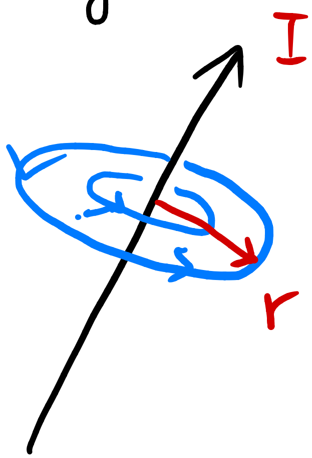
< Magnetic field >

- Dipole



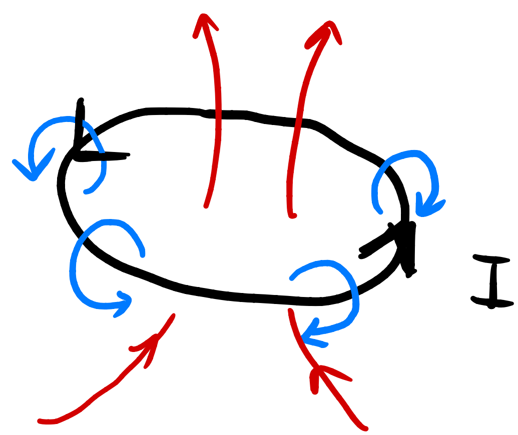
- Single moving charge

- Single wire



$$B = \frac{\mu_0 I}{2\pi r}$$

- Loop wire



$$B = \frac{\mu_0 I}{2r}$$

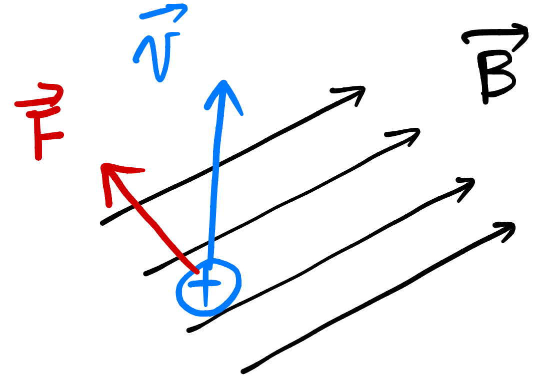
< Magnetic force >

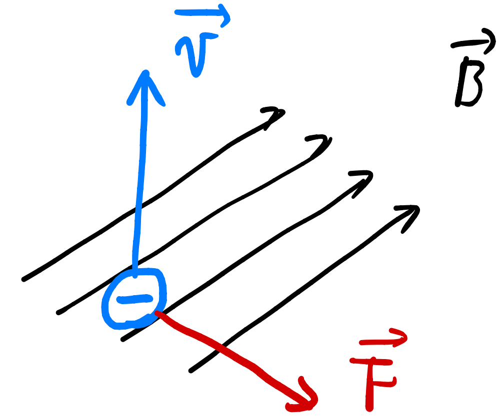
$$\vec{F} = q\vec{v} \times \vec{B}$$

watch out sign

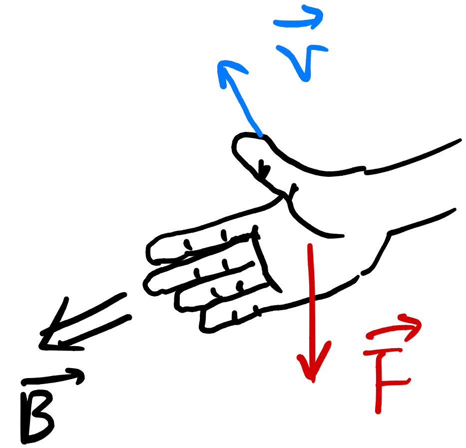
$$q\left(\frac{L}{t}\right)$$

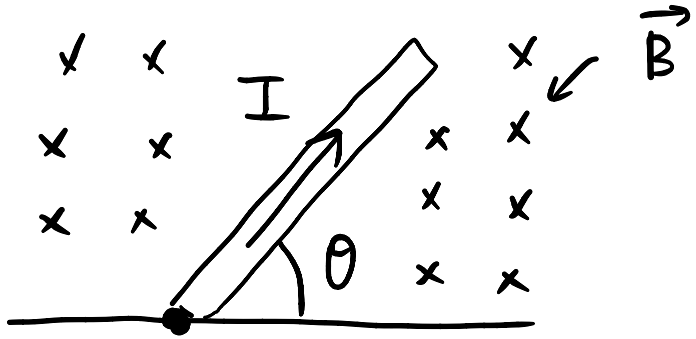
$$= L\cdot\frac{q}{t} = L\cdot I$$



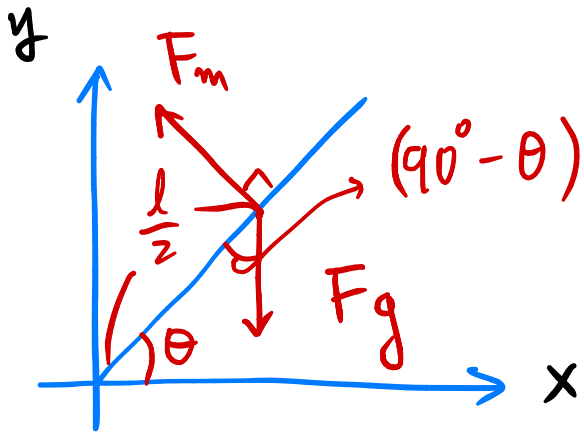


⇒ $\vec{F} = L\vec{I}\times\vec{B}$ (right hand rule) →





Mass of rod is 0.094 kg.
Length of rod is 0.45 m.
$I = 4.1\,A$. $B = 0.36\,T$.
Find θ where the rod does not rotate either direction.



$\rightarrow \Sigma \tau = 0$

$$F_m \cdot \left(\frac{l}{2}\right) \sin 90^\circ - F_g \cdot \left(\frac{l}{2}\right) \sin(90 - \theta) = 0$$

$$F_m = B \cdot l \cdot I \sin 90^\circ = BIl$$

$$F_g = mg$$

$$\sin(90 - \theta) = \cos\theta$$

$$\Rightarrow BIl\left(\frac{l}{2}\right) - mg\left(\frac{l}{2}\right)\cos\theta = 0$$

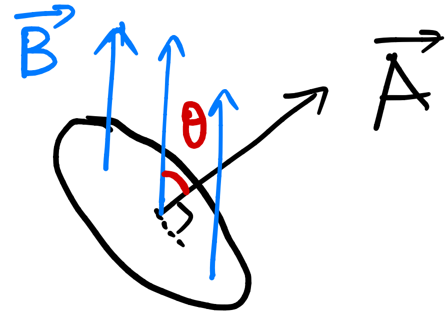
$$\cos\theta = \frac{BIl}{mg}$$

$$\theta = \cos^{-1}\left(\frac{BIl}{mg}\right) = \underline{\underline{44^\circ}}$$

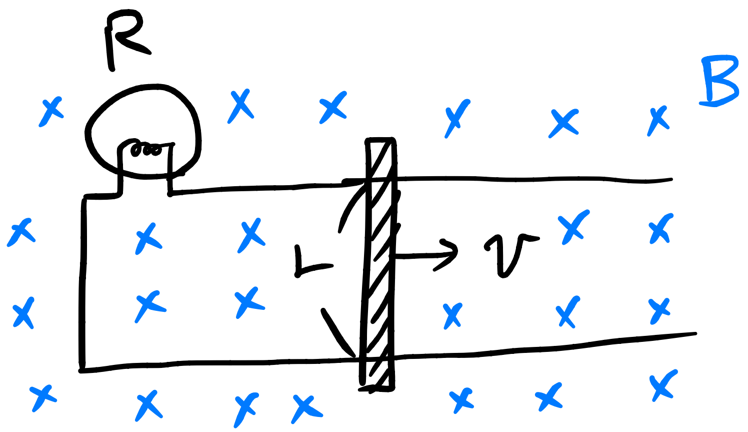
⟨ Faraday's law & Lenz's law ⟩

$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

N: the number of loops



$$\Phi = AB\cos\theta$$



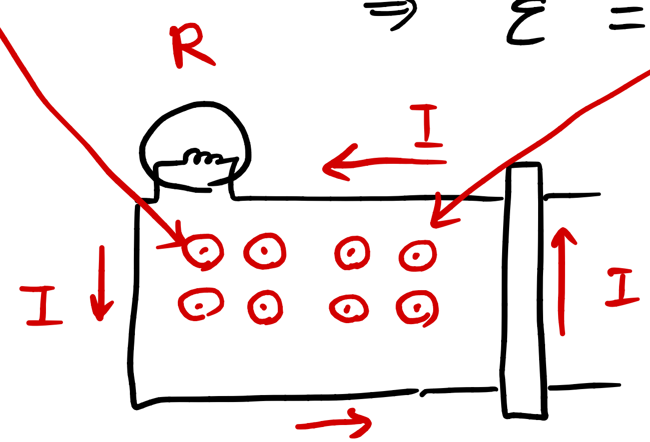
$$\Rightarrow \Phi = A \cdot B \cdot \cos 0^\circ = AB$$

$$\Rightarrow \mathcal{E} = -\frac{\Delta \Phi}{\Delta t} = -B\frac{\Delta A}{\Delta t}$$

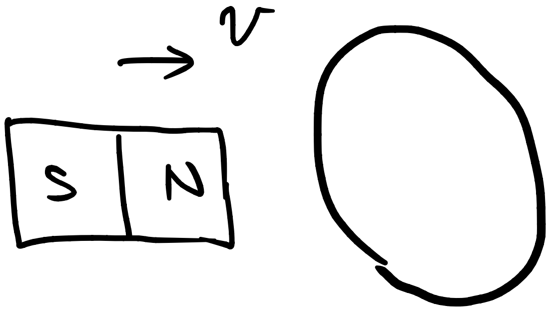
$$\Delta A = L \cdot v \cdot \Delta t$$

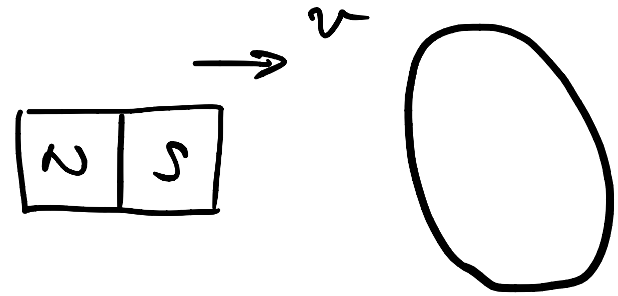
$$\Rightarrow \mathcal{E} = -BLv$$

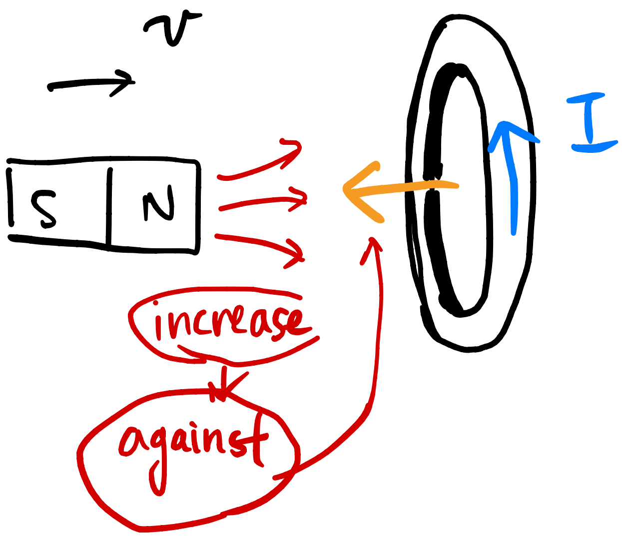
opposite direction to changes of magnetic field.

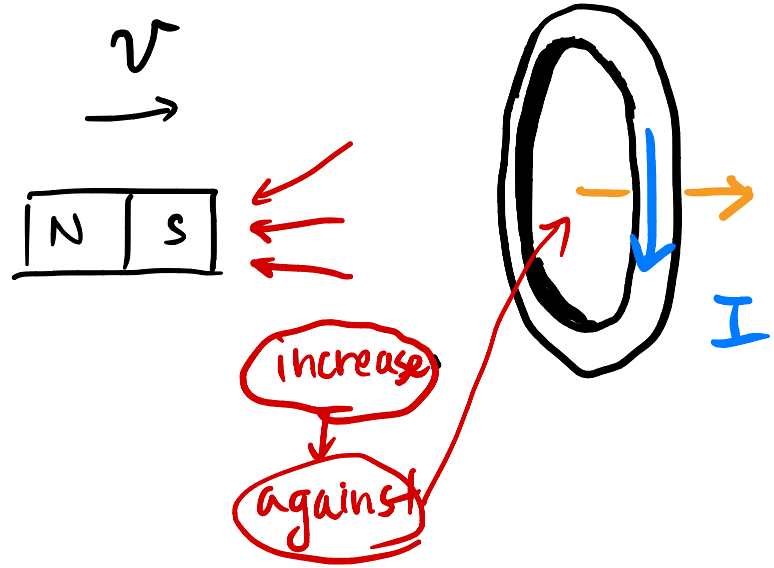


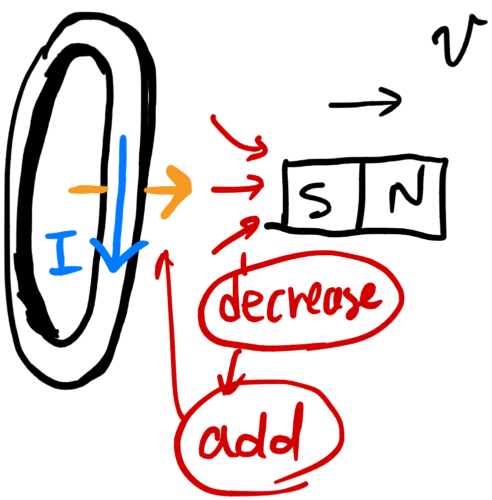
$$I = \frac{\mathcal{E}}{R}$$

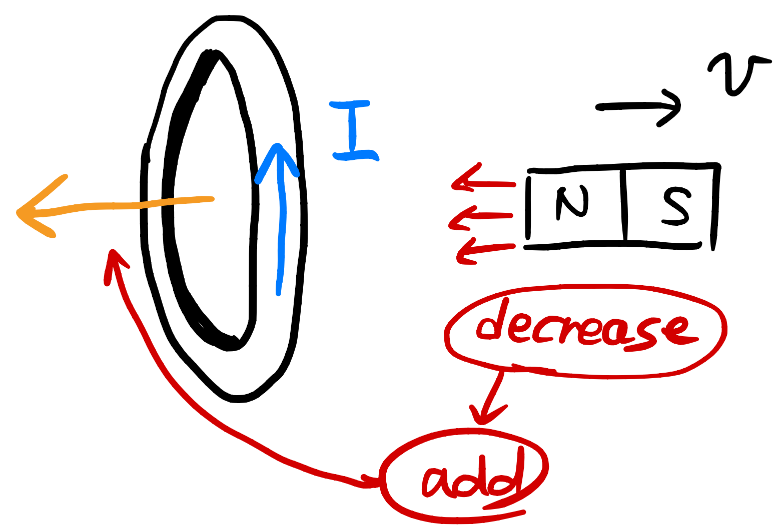

v
S
N

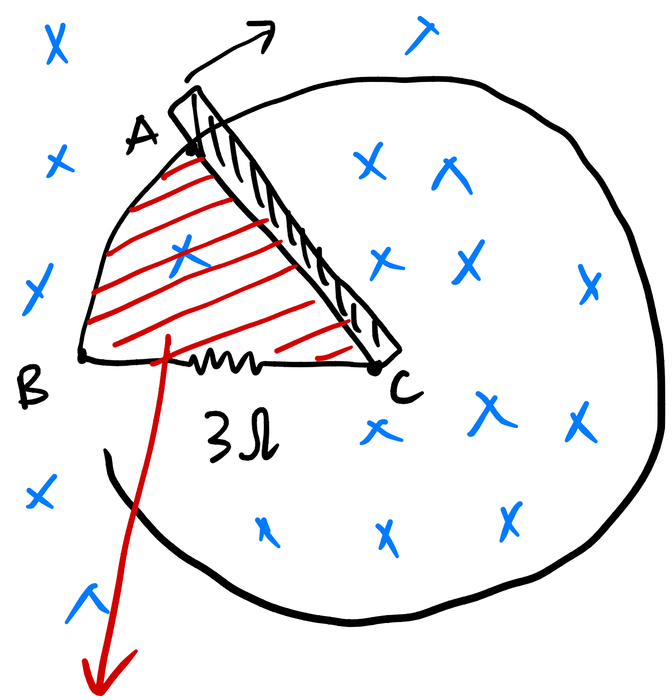

v
N
S


v
S
N
I
increase
against


v
N
S
I
increase
against


v
S
N
I
decrease
add


I
v
N
S
decrease
add



$r = 0.5\ m$

$\omega = 15\ rad/s$

$B = 3.8 \times 10^{-3}\ T$

Find the magnitude and direction of the current in the loop ABC.

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

$$\Phi = BA\cdot\cos\theta = BA$$

$$= \frac{Br^2}{2}\cdot\theta$$

$$A = \left(\frac{\theta}{2\pi}\right)\cdot\pi r^2$$

$$= \frac{\theta}{2}r^2$$

$$\Rightarrow \quad \mathcal{E} = -\underbrace{\frac{Br^2}{2}}_{\text{constant}}\frac{\Delta\theta}{\Delta t} = -\frac{Br^2}{2}\omega$$

$$I = \frac{|\mathcal{E}|}{R} = \frac{Br^2}{2R}\omega = 2.4\ mA,$$

c.c.w