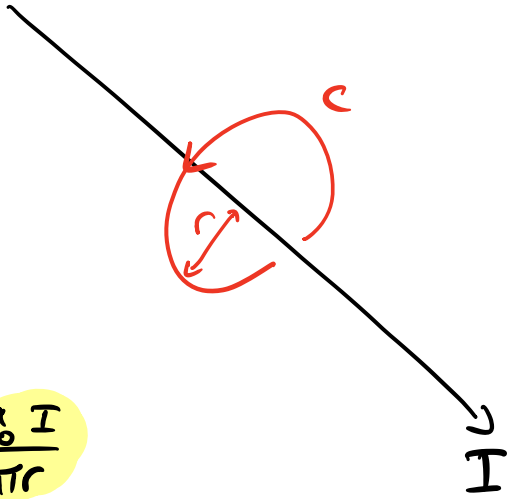
Examples of Ampere's law

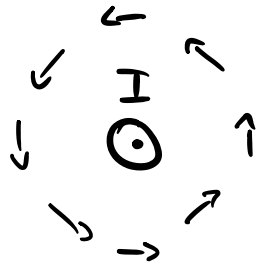
Example A long straight wire



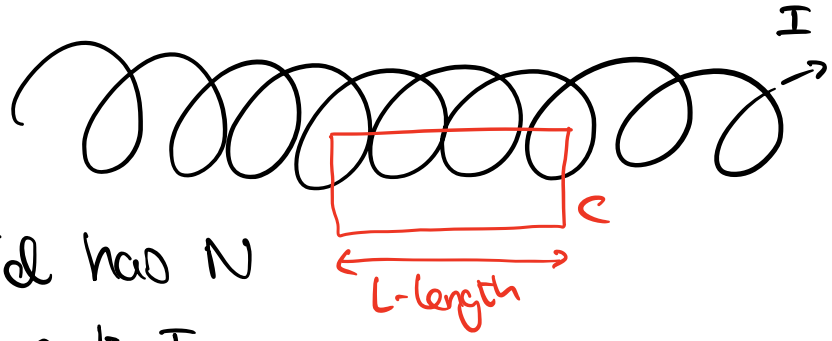
$$\oint_C \underline{B}\cdot d\underline{l} = \mu_0 I$$

But, $\oint_C \underline{B}\cdot d\underline{l} = 2\pi r B$ $\therefore$ $B = \frac{\mu_0 I}{2\pi r}$

$\underline{B}$ is in the $\hat{\phi}$ direction (right-hand rule). N.B. $\nabla\cdot\underline{B}=0$ means there is no radial component.



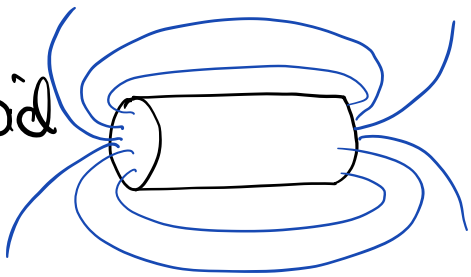
Example Solenoid



A long straight solenoid has N terms per metre and current I.

The current in the loop will be INL.

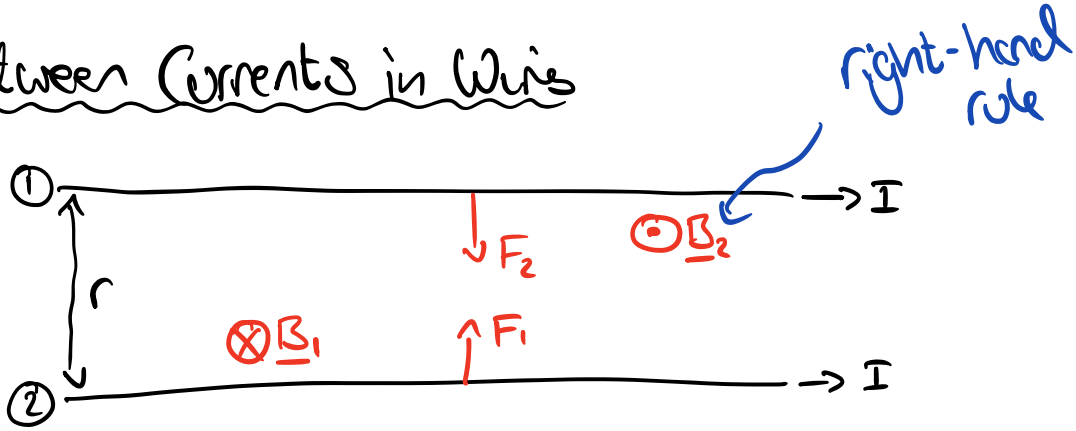
$$\oint \underline{B}\cdot d\underline{l} = \mu_0 INL = BL \Rightarrow B = \mu_0 IN$$



The field points along the solenoid and is uniform inside but zero outside.

This is an idealised situation.

Forces between Currents in Wire



Wire ① creates a magnetic field on wire ②.

$$B_1 = \frac{\mu_0 I}{2\pi r} \text{ into page}$$

Wire ② creates a magnetic field on wire ①.

$$B_2 = \frac{\mu_0 I}{2\pi r} \text{ out of page.}$$

Both wire feel a force towards each other

$$\underline{F}_1 = I\int_0^L d\underline{l} \times \underline{B} = B_1 I L$$

∴ the force per unit length is

$$\underline{F}_1 = \frac{\mu_0 I^2}{2\pi r}$$

The other wire feels an equal & opposite force.

Parallel currents: Attractive force
Opposite currents: Repulsive force