AMPERE'S CIRCUIT LAW

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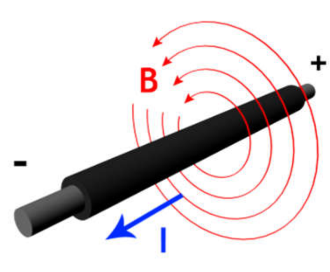
Ampere's Circuit Law

André-Marie Ampère,
1775-1836

$$\oint \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} = I_{\mathrm{enc}}$$



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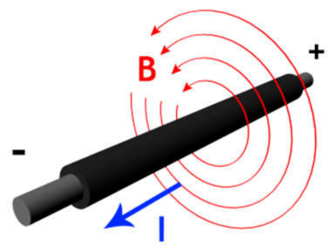
Ampere's Circuit Law

$$\oint \vec{H} \cdot d\vec{l} = I_{enc}$$

- Ampere's law is only useful for calculation in certain specific situations, involving highly symmetric currents.
- Only holds for constant fields. We will need to introduce another term when the electric field is changing with time.



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Applications of Ampere's Law

1. Identify region in which to calculate magnetic field.
2. Choose Amperian path using symmetry: magnetic field is zero or constant of the loop.
3. Calculate $\oint \vec{H} \cdot d\vec{l}$.
4. Calculate current enclosed by loop I_{enc}.
5. Apply Ampere's law to solve for magnetic field

$$\oint \vec{H} \cdot d\vec{l} = I_{enc}$$

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Infinite Line Current

Draw Amperian path

Choose a concentric path.

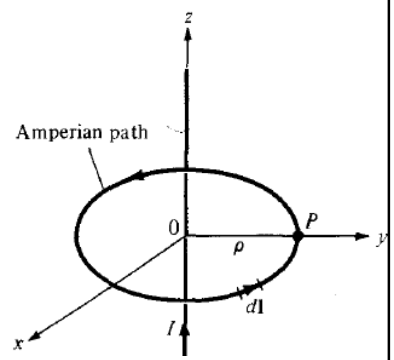
Apply Ampere's law

$$\oint \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} = I_{\mathrm{enc}}$$

$$\int H_\phi \, \hat{\mathrm{a}}_\phi \cdot \rho \, d\phi \, \hat{\mathrm{a}}_\phi = H_\phi \int_0^{2\pi} \rho \, d\phi = I$$

$$H_\phi \cdot 2\pi\rho = I$$

$$\vec{\mathrm{H}} = \frac{I}{2\pi\rho} \hat{\mathrm{a}}_\phi$$



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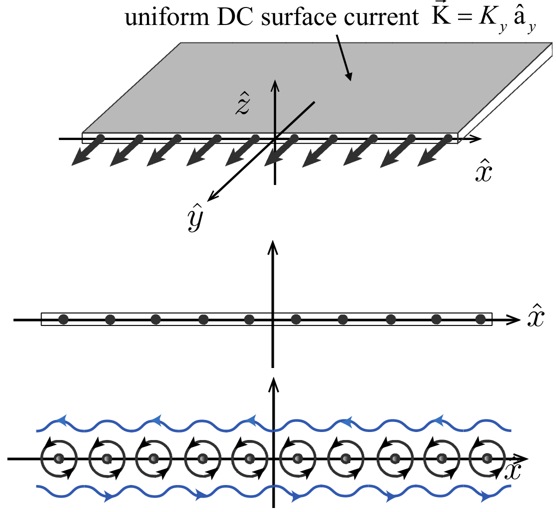
Sheet of Current

uniform DC surface current $\vec{\mathrm{K}} = K_y \, \hat{\mathrm{a}}_y$



In between the wires the fields cancel

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Infinite Sheet of Current

The current density $\vec{K} = K_y \hat{a}_y$ A/m

Draw Amperian path

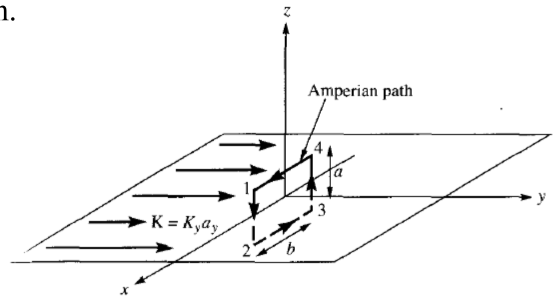
Choose a rectangular path.

Apply Ampere's law

$\vec{H}$ on either side are in opposite direction.

$$\vec{H} = \begin{cases} H_0 \hat{a}_x, & z>0 \\ -H_0 \hat{a}_x, & z<0 \end{cases}$$

$$\oint \vec{H} \cdot d\vec{l} = I_{enc} = K_y b$$



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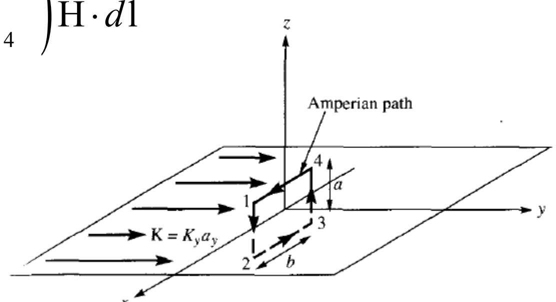
Infinite Sheet of Current

$$\oint \vec{H} \cdot d\vec{l} = I_{enc} = K_y b$$

$$\oint \vec{H} \cdot d\vec{l} = \left(\int_1^2 + \int_2^3 + \int_3^4 + \int_4^1 \right) \vec{H} \cdot d\vec{l}$$

$$= 2H_0 b$$

$$\vec{H} = \begin{cases} \frac{1}{2} K_y \hat{a}_x, & z>0 \\ -\frac{1}{2} K_y \hat{a}_x, & z<0 \end{cases}$$



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