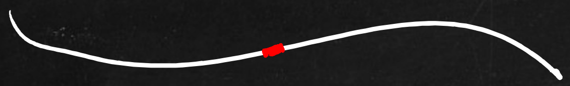
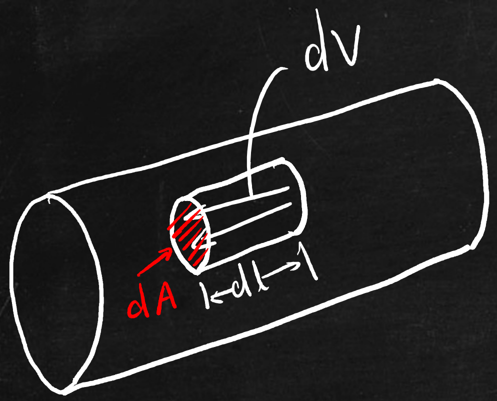
$I\,d\vec{l}$





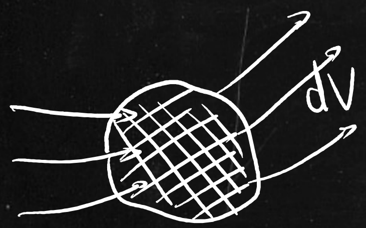
current density

ρ — charge density

$$I = J \cdot dV = J \cdot dA\,dl$$

$$dq = \rho\, dV \qquad I = \frac{dq}{dt} = \frac{\rho\, dV}{dt} = \frac{\rho \cdot dA \cdot dl}{dt} = \rho v\, dA$$

$$\underline{I\,d\vec{l}} = \rho v\, dA \cdot dl = \rho \cdot dV \cdot v = dq \cdot v$$



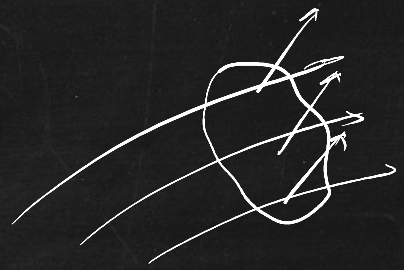
$$\vec{p} = dm\,\vec{v} \qquad \frac{dq}{dt} = \rho \frac{dV}{dt} = I = J \cdot dV$$

$$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{j} = 0$$

$\rho(x, y, z, t)$

Electromagnetic Induction

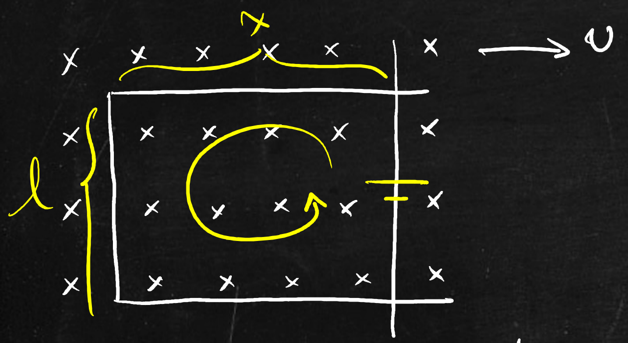
Flux $\varphi = \iint \vec{B} \cdot d\vec{A}$



$$\mathcal{E} = -N \cdot \frac{d\varphi}{dt}$$

$\operatorname{curl} \vec{A} = \vec{\nabla} \times \vec{A}$

$\operatorname{div} \vec{A} = \vec{\nabla} \cdot \vec{A}$



$$\varphi = B \cdot x \cdot l$$

$$\mathcal{E} = -\frac{d\varphi}{dt} = -\frac{d}{dt}(Bxl) = -Bl\frac{dx}{dt} = -Blv$$

$$\mathcal{E} = \oint \vec{E} \cdot d\vec{r} = -\frac{d\varphi}{dt} = -\frac{d}{dt}\left(\iint \vec{B} \cdot d\vec{A}\right) = -\frac{d\varphi}{dt}$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial B}{\partial t}$$

$$\oint \vec{A} \cdot d\vec{r} = \iint (\vec{\nabla} \times \vec{A}) \cdot d\vec{A}$$

$$\operatorname{curl} \vec{E} = -\frac{dB}{dt}$$

① $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$

② $\vec{\nabla} \cdot B = 0$

③ $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

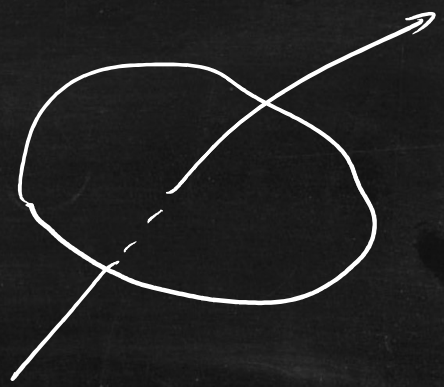
④ $\vec{\nabla} \times \vec{B} = \mu_0 \varepsilon_0 \cdot \frac{\partial \vec{E}}{\partial t} + \mu_0 \vec{J}$

Maxwell Equation

$$\iiint \vec{\nabla} \cdot \vec{E} \, dV = \iiint \frac{\rho \, dV}{\varepsilon_0} = \frac{q_{net}}{\varepsilon_0}$$

$$\Updownarrow$$

$$\oiint \vec{E} \cdot dA = \frac{q_{net}}{\varepsilon_0} = \iiint \frac{\rho \, dV}{\varepsilon_0}$$



Electromagnetic Wave:

$$\vec{E} = E_0 \sin(y - vt)\,\hat{z}$$

$$\vec{B} = B_0 \sin(y - vt)\,\hat{x}$$

$$v = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = c \qquad E_0 = c B_0$$