#### **Electrostatics**

$$\vec{F} = \frac{q}{4\pi\varepsilon} \cdot \sum_{i=1}^{N} \frac{q_i \cdot (\vec{r} - \vec{r_i})}{|\vec{r} - \vec{r_i}|^3}$$

$$\vec{F}=q\vec{E}$$

$$\vec{F} = \frac{q}{4\pi\varepsilon} \cdot \sum_{i=1}^{N} \frac{q_i \cdot (\vec{r} - \vec{r_i})}{|\vec{r} - \vec{r_i}|^3} \qquad \vec{F} = q\vec{E} \qquad \int_{P_1}^{P_2} \vec{E} d\vec{r} \text{ is path-independent} \qquad \text{rot } \vec{E} = 0$$

$$\operatorname{rot} \vec{E} = 0$$

## Magnetostatics

$$\mathrm{ad}\Phi$$

$$\Phi(\vec{r}) = \frac{1}{4\pi\varepsilon} \cdot \sum_{i=1}^{N} \frac{q_i}{|\vec{r} - \vec{r_i}|} \qquad \text{div}\left(\varepsilon \operatorname{grad}\Phi\right) = -\varrho \qquad \vec{E} = -\operatorname{grad}\Phi$$

$$\operatorname{div}\left(\varepsilon\operatorname{grad}\Phi\right)=-\varrho$$

$$\vec{E} = -\text{grad}\Phi$$

$$U_{12} = \Phi(P_1) - \Phi(P_2) = \int_1^2 \vec{E} d\vec{r}$$
  $\vec{D} \cdot \vec{N} = \sigma$   $C = \frac{Q}{U}$ 

$$\vec{D} \cdot \vec{N} = \sigma$$

$$C = \frac{Q}{U}$$

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$$W_{12} = \int_{C} \vec{F} d\vec{r} = q \cdot U_{12}$$
  $w_{\text{el}} = \frac{1}{2} \cdot \vec{E} \cdot \vec{D}$   $W_{\text{el}} = \frac{1}{2} \cdot C \cdot U^{2}$ 

$$w_{
m el} = rac{1}{2} \cdot ec{E} \cdot ec{D}$$

 $I_A = \frac{dQ}{dt} \bigg|_{A} \qquad \qquad \vec{j} = \sum_{i}^{n} q_i \cdot n_i \cdot \vec{v}_i \bigg|_{A}$ 

 $ec{v} = \mathrm{sgn}(q) \cdot \mu \cdot ec{E} \qquad U = R \cdot I \qquad p_{\mathrm{el}} = ec{j} \cdot ec{E} \qquad P = U \cdot I$ 

$$W_{ ext{el}} = rac{1}{2} \cdot C \cdot U^2$$

### Maxwell's Equations

$$\int_{\partial V} \vec{D} d\vec{a} = Q(V) = \int_{V} \varrho \, d^{3}r$$

$$\int_{\partial V} \vec{B} d\vec{a} = 0$$

$$\int_{\partial V} \vec{B} d\vec{a} = 0 \qquad \qquad \int_{\partial A} \vec{H} d\vec{r} = \int_{A} \left( \vec{j} + \frac{\partial \vec{D}}{\partial t} \right) d\vec{a}$$

$$\operatorname{div} \vec{D} = \varrho$$

$$\operatorname{div} \vec{D} = \varrho \qquad \operatorname{rot} \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$$

$$\operatorname{div} \vec{B} = 0$$

$$\operatorname{div} \vec{B} = 0 \qquad \operatorname{rot} \vec{H} = \vec{j} + \frac{\partial \vec{D}}{\partial t}$$

### Constitutive laws

$$\vec{D} = \varepsilon \vec{E}$$

$$\vec{R} = \mu I$$

$$\vec{D} = \varepsilon \vec{E}$$
  $\vec{B} = \mu \vec{H}$   $\vec{j} = \sigma \vec{E}$ 

## Electromagnetic force

$$ec{F}_{ ext{ iny em}} = q \cdot (ec{E} + ec{v} imes ec{B})$$

## $\vec{F}_{\mathrm{L}} = q \cdot (\vec{v} \times \vec{B})$

$$ec{f}_{ ext{ iny L}} = ec{j} imes ec{B}$$

$$d\vec{F}_{\rm L} = I \cdot d\vec{s} \times \vec{B}$$

$$\operatorname{rot} \vec{H} = \vec{j}$$

$$\vec{B} = \mu I$$

$$\vec{F}_{\text{em}} = q \cdot (\vec{E} + \vec{v} \times \vec{B})$$

#### Electromagnetic Induction

$$U_{\rm ind} = -\frac{d\Phi_{\rm mag}}{dt}$$

$$\Phi_{
m mag} = \int_A ec{B} dec{a}$$

# Integral theorems

$$\int_{\partial V} \vec{D} d\vec{a} = \int_{V} \operatorname{div} \vec{D} d^{3}r \qquad \int_{\partial A} \vec{H} d\vec{r} = \int_{A} \operatorname{rot} \vec{H} d\vec{a}$$

 $\int_{\partial V} \vec{j} d\vec{a} = -\frac{dQ(V)}{dt} \qquad \text{div} \vec{j} + \frac{\partial \varrho}{\partial t} = 0$ 

**Stationary Currents** 

$$\int_{A}^{A} H = I = \int_{A}^{A} \int_{A}^{A} P = \frac{Q}{A}$$

$$\overline{f}(r) = \overline{A}$$

$$\left( \begin{array}{ccc} & & \\ & \searrow & \\ & & \\ & & \\ & & \\ \end{array} \right) \stackrel{\mathcal{D}}{=} \frac{ \mathbb{Q}}{V} \qquad \qquad U_{\mathrm{ind}} = - \int_{A(t)} \frac{\partial \vec{B}}{\partial t} d\vec{a} + \int_{\partial A(t)} \left( \vec{v} \times \vec{B} \right) d\vec{r}$$

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