Electricity and Magnetism

Definitions

Fundamental Quantity: q [Coulombs]

Densities	$\rho = \frac{dq}{dV}$	The **charge density** ρ in a volume dV enclosing charge dq.
	$\vec{j} = \rho \vec{v}$	The **current density J** due to a charge density ρ moving with velocity **v**.
Fields & Potentials	$\nabla \cdot \vec{E} = \rho / \varepsilon_0$ $\nabla \cdot \vec{B} = 0$ $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\nabla \times \vec{B} = \mu_0 \vec{j} + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$	The **electric field E** and **magnetic field B** due to a charge density ρ and a current density **J**.
	$\vec{E} = -\nabla V - \frac{\partial \vec{A}}{\partial t}$ $\vec{B} = \nabla \times \vec{A}$	The **scalar potential V** and **vector potential A** giving rise to electric and magnetic fields **E** and **B**.
Circuits	$R = \frac{\Delta V}{I}$	The **resistance R** of an object with a potential difference ΔV between its two ends and carrying a current I.
	$C = \frac{Q}{\Delta V}$	The **capacitance C** of an object with a potential difference ΔV between its two ends, which hold net charges Q.
	$L = \frac{-\Delta V}{dI/dt}$	The **inductance L** of an object with a potential difference ΔV between its two ends and carrying a current I.
	$\rho_R = \frac{Ra}{l}$	The **resistivity** ρ_R of an object with resistance R, cross-sectional area a, and length l.
Energy	$w = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2\mu_0} B^2$	The **energy density w** stored in the fields **E** and **B**.
	$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$	The **Poynting vector S** due to the fields **E** and **B**.
	$\vec{p} = \frac{1}{c^2} \vec{S}$	The **momentum density p** carried by the fields **E** and **B**.

Observations

An object of charge q moving with velocity **v** in an electric field **E** and magnetic field **B** feels a force $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$

For some objects (“resistors”), R does not depend upon how much current I is flowing through it.

For some materials (“conductors”), ρ_R is very small.

For some materials (“insulators”), ρ_R is very large.

For some physical systems, we can neglect all other forces.