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Electrostatics Formulae for Quiz #1

Conservative Field: $\int_C \vec{F} \cdot d\vec{r} = 0$ for any closed path C, $W_{ab,C} = W_{ab,C'}$ for any C, C' connecting a *and* b, $\vec{F} = -\vec{\nabla} U$, $\vec{\nabla} \times \vec{F} = 0$

Coulomb Law: $\vec{F}_{21} = \frac{q_1 q_2}{r^2} \hat{r}_{21}$ for two point charges at distance r. $\vec{F}_{12} = -\vec{F}_{21}$, and for charges dq_1 and dq_2 that make part of continuous charge distributions 1 and 2, $d\vec{F}_{21} = \frac{dq_1 dq_2}{r^2} \hat{r}_{21}$

Electric Field: *at point 2* due to q_1 $\vec{E}_1 = \frac{q_1}{r^2} \hat{r}_{21}$. If q_1 is not a point charge but part of a continuous distribution, $d\vec{E} = \frac{dq}{r^2} \hat{r}$

Principle of Superposition: Two or more electric fields acting at a given point P add vectorially: $\vec{E}_P = \vec{E}_1 + \vec{E}_2 + ... + \vec{E}_n$

Electrostatic Field is Conservative: $\vec{\nabla} \times \vec{E} = 0$ and thus there exists scalar function ϕ such that $\vec{E} = -\vec{\nabla}\phi$ where $d\phi = \frac{dq}{r}$

Electrostatic potential: The potential at $\vec{x}$ with respect to a *ref* point is $\phi(\vec{x}) - \phi(ref) = -\int_{ref}^{\vec{x}} \vec{E} \cdot d\vec{r} = -\frac{W_{ref \to \vec{x}}}{q}$

Gauss Law: $\int_S \vec{E} \cdot d\vec{a} = 4\pi \int_V \rho dV$ where S is a closed surface and V is its corresponding volume (integral form) or $\vec{\nabla} \cdot \vec{E} = 4\pi\rho$ (differential form).

Poisson Eqn: $\nabla^2 \phi = -4\pi\rho$, Laplace Eqn: $\nabla^2 \phi = 0$

Energy: $U = \frac{1}{2} \int_V dV \int_{V'} dV' \frac{\rho(\vec{x})\rho(\vec{x}')}{|\vec{x} - \vec{x}'|} = \frac{1}{2} \int_V \rho\phi dV = \frac{1}{8\pi} \int_V E^2 dV$

Electric Force on Conductors: $\frac{dF}{da} = 2\pi\sigma^2 = \frac{E^2}{8\pi}$ Current Density: $\vec{J}(\vec{x}) = \rho(\vec{x})\vec{v}(\vec{x})$, Conservation Law/Continuity: $\vec{\nabla} \cdot \vec{J} = -\frac{\partial \rho}{\partial t}$ Capacitance: $Q = CV$, $U = \frac{1}{2} CV^2$