Electromagnetic Fields – Main Results

Symbols

MISCELLANEOUS

c	$\mathrm{ms^{-1}}$	Velocity of light in free space	$\mathrm{d}V$	$\mathrm{m^3}$	Differential volume element
$\mathbf{r}$	m	Position vector	ε_0	$\mathrm{Fm^{-1}}$	Permittivity of free space
d^3r'	$\mathrm{m^3}$	Differential volume element	μ_0	$\mathrm{Hm^{-1}}$	Permeability of free space

PROPERTIES OF AN ENTITY OR SYSTEM

C	F	Capacitance	t	s	Time
I	A	Electric current	U	J	Potential energy of a system
L	H	Inductance	ε_r		Relative permittivity
$\mathbf{m}$	$\mathrm{Am^2}$	Magnetic dipole moment	μ_r		Relative permeability
$\mathbf{p}$	Cm	Electric dipole moment	χ		Susceptibility
q	C	Electric charge			

FIELDS

$\mathbf{A}$	Tm	Magnetic vector potential	$\mathbf{j}$	$\mathrm{Am^{-2}}$	Current density
$\mathbf{B}$	T	Magnetic induction field, (aka magnetic flux density)	$\mathbf{j}_\mathrm{c}$	$\mathrm{Am^{-2}}$	Conduction current density
			$\mathbf{j}_\mathrm{M}$	$\mathrm{Am^{-2}}$	Magnetisation current density
$\mathbf{D}$	$\mathrm{Cm^{-2}}$	Electric displacement field	ρ	$\mathrm{Cm^{-3}}$	Electric charge density
$\mathbf{E}$	$\mathrm{Vm^{-1}}$	Electric field	ρ_f	$\mathrm{Cm^{-3}}$	Free charge density
$\mathbf{F}$	N	Force	ρ_b	$\mathrm{Cm^{-3}}$	Bound charge density
$\mathbf{H}$	$\mathrm{Am^{-1}}$	Magnetic field intensity	σ	$\mathrm{Cm^{-2}}$	Surface charge density
$\mathbf{M}$	$\mathrm{JT^{-1}m^{-3}}$	Magnetisation field	ϕ	V	Electric potential
$\mathbf{P}$	$\mathrm{Cm^{-2}}$	Electric polarisation field			

Fundamental Results

Static Systems	**General Systems**
$\mathbf{F}_{12} = \dfrac{q_1 q_2}{4\pi\varepsilon_0} \dfrac{(\mathbf{r}-\mathbf{r}')}{\lvert\mathbf{r}-\mathbf{r}'\rvert^3}$	$\mathbf{F} = q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$
$\mathbf{E}(\mathbf{r}) = \displaystyle\int \dfrac{\rho(\mathbf{r}').(\mathbf{r}-\mathbf{r}')\,\mathrm{d}^3 r'}{4\pi\varepsilon_0 \lvert\mathbf{r}-\mathbf{r}'\rvert^3}$	$\boxed{(\nabla\cdot\mathbf{E}) = \dfrac{\rho}{\varepsilon_0}}$
$\mathbf{E} = -\nabla\phi$	$\mathbf{E} = -\nabla\phi - \dfrac{\partial\mathbf{A}}{\partial t}$
$\nabla\times\mathbf{E} = 0$	$\boxed{\nabla\times\mathbf{E} = -\dfrac{\partial\mathbf{B}}{\partial t}}$
	$(\nabla\cdot\mathbf{j}) + \dfrac{\partial\rho}{\partial t} = 0$
$(\nabla\times\mathbf{B}) = \mu_0\mathbf{j}$	$\boxed{(\nabla\times\mathbf{B}) = \mu_0\mathbf{j} + \dfrac{1}{c^2}\dfrac{\partial\mathbf{E}}{\partial t}}$
$\mathbf{B}(\mathbf{r}) = \dfrac{\mu_0}{4\pi}\displaystyle\int \dfrac{\mathbf{j}(\mathbf{r}')\times(\mathbf{r}-\mathbf{r}')\,\mathrm{d}^3 r'}{\lvert\mathbf{r}-\mathbf{r}'\rvert^3}$	$\boxed{(\nabla\cdot\mathbf{B}) = 0}$
	$\nabla\times\mathbf{A} = \mathbf{B}$
$\nabla^2\phi = -\dfrac{\rho}{\varepsilon_0}$	$\nabla^2\phi - \dfrac{1}{c^2}\dfrac{\partial^2\phi}{\partial t^2} = -\dfrac{\rho}{\varepsilon_0}$
$\nabla^2\mathbf{A} = -\mu_0\mathbf{j}$	$\nabla^2\mathbf{A} - \dfrac{1}{c^2}\dfrac{\partial^2\mathbf{A}}{\partial t^2} = -\mu_0\mathbf{j}$
$(\nabla\cdot\mathbf{A}) = 0$	$\nabla\cdot\mathbf{A} + \dfrac{1}{c^2}\dfrac{\partial^2\phi}{\partial t^2} = 0$
$U = \frac{1}{2}\displaystyle\int(\rho\phi + \mathbf{j}\cdot\mathbf{A})\,\mathrm{d}^3 r$	$U = \frac{1}{2}\displaystyle\int\left(\varepsilon_0 E^2 + B^2/\mu_0\right)\mathrm{d}^3 r$