Harold's Maxwell's Equations
Cheat Sheet
15 January 2026

Maxwell's Equations

Gauss's Law for Electricity

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

$$\int E \cdot dA = \frac{Q_{inside}}{\varepsilon_0}$$

Gauss's Law for Magnetism

$$\nabla \cdot B = 0$$

$$\int B \cdot dA = \frac{d\Phi_B}{dt}$$

Faraday's Law of Induction

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

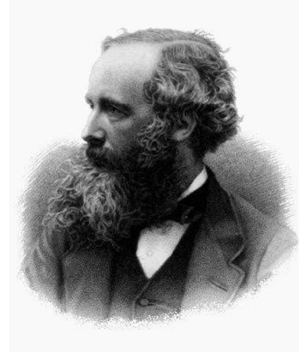
$$\int E \cdot dl = -\frac{d\Phi_B}{dt}$$

Ampère-Maxwell Law

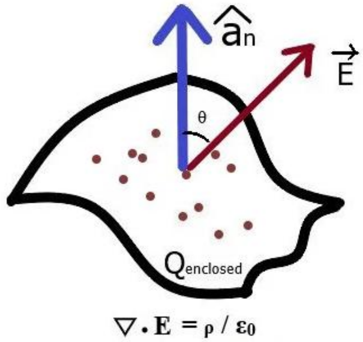
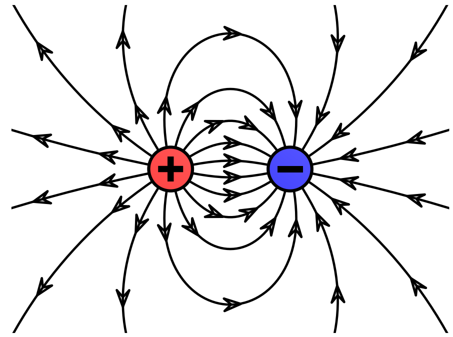
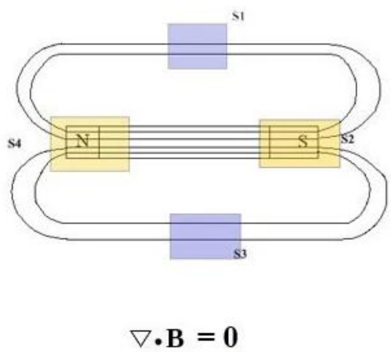
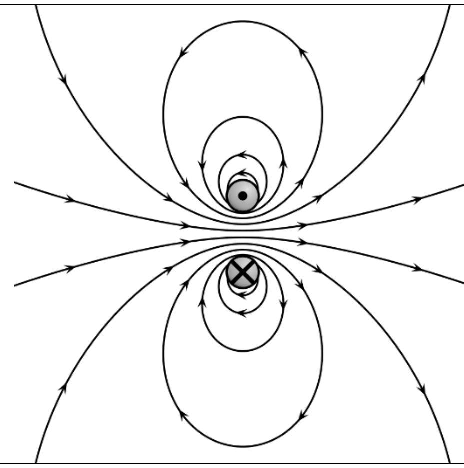
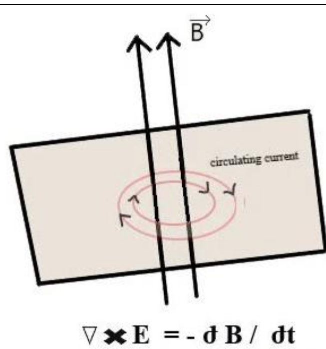
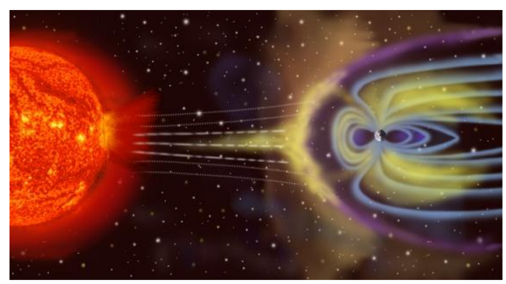
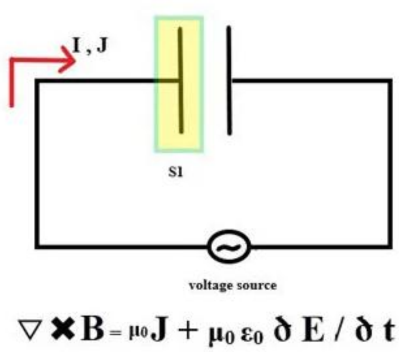
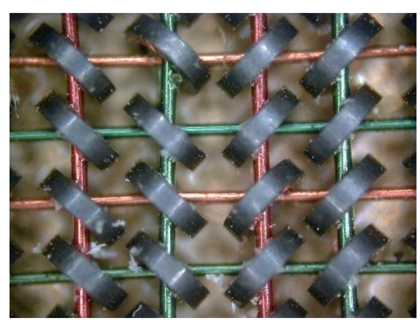
$$\nabla \times B = \mu_0 J + \mu_0 \frac{\partial E}{\partial t}$$

$$\int B \cdot dl = \mu_0 I + \frac{d\Phi_E}{dt}$$

Maxwell's Equations

Name	Differential Form	Integral Form
Maxwell's Equations in Electromagnetism	A set of four pivotal laws that describe the interactions between electric charges, magnetic fields, and electric currents.	 James Clerk Maxwell
1. Gauss' Law for Electricity	$\nabla \cdot \boldsymbol{E} = \frac{\rho}{\epsilon_0}$ $\nabla \cdot \boldsymbol{D} = \rho_{\boldsymbol{f}}$	$\Phi_E = \oiint \boldsymbol{E} \cdot d\boldsymbol{S} = \frac{Q(V)}{\epsilon_0}$ $= \frac{1}{\epsilon_0} \iiint_\Omega \rho \, dV$ $\Phi_E = \oiint \boldsymbol{D} \cdot d\boldsymbol{S} = Q_f(V)$
2. Gauss' Law for Magnetism	$\nabla \cdot \boldsymbol{B} = \boldsymbol{0}$	$\Phi_B = \oiint \boldsymbol{B} \cdot d\boldsymbol{S} = 0$
3. Faraday's Law of Induction (Maxwell-Faraday Equation)	$\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}$	$\oint \boldsymbol{E} \cdot d\boldsymbol{\ell} = -\iint \frac{\partial \boldsymbol{B}}{\partial t} \cdot d\boldsymbol{S}$ $= -\frac{d}{dx} \iint \boldsymbol{B} \cdot d\boldsymbol{S}$ $= -\frac{\Delta\Phi_B}{\Delta t}$
4. Ampère-Maxwell Law	$\nabla \times \boldsymbol{B} = \mu_0 \left(\epsilon_0 \frac{\partial \boldsymbol{E}}{\partial t} + \boldsymbol{J} \right)$ $\nabla \times \boldsymbol{H} = \frac{\partial \boldsymbol{D}}{\partial t} + \boldsymbol{J_f}$	$\oint \boldsymbol{B} \cdot d\boldsymbol{\ell} = \mu_o I + \mu_0 \varepsilon_0 \iint \frac{\partial \boldsymbol{E}}{\partial t} \cdot d\boldsymbol{S}$ $= \mu_o \iint_\Sigma \boldsymbol{J} \cdot d\boldsymbol{S} + \mu_0 \varepsilon_0 \frac{d}{dx} \iint \boldsymbol{E} \cdot d\boldsymbol{S}$ $= \mu_o I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$ $\oint \boldsymbol{H} \cdot d\boldsymbol{\ell} = I_f + \mu_0 \varepsilon_0 \iint \frac{\partial \boldsymbol{E}}{\partial t} \cdot d\boldsymbol{S}$ $= \mu_o I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

Maxwell's Equations Diagrams

Name	Application	Diagram
1. Gauss' Law of Electricity		
2. Gauss' Law of Magnetism		
3. Faraday's Law of Induction (Maxwell-Faraday Equation)		
4. Ampère-Maxwell Law		

Symbols and Terms

Term Name	Variable	Value
Vector	<**bold**>	*Magnitude and direction*
Scalar	<*italics*>	Magnitude only
Electric Field	$\boldsymbol{E}$	
Magnetic Field	$\boldsymbol{B}$	
Displacement Field	$\boldsymbol{D}$	
Magnetization Field	$\boldsymbol{H}$	
Electric Charge Density	ρ	Total charge per unit volume
Electric Current Density	$\boldsymbol{J}$	Total current per unit area
Permittivity of free space	ϵ_0	
Permeability of free space	μ_0	
Speed of Light	c	$c = (\epsilon_0\, \mu_0)^{-\frac{1}{2}}$
Nabia Symbol	∇	Three-dimensional gradient operator, del.
Divergence Operator	$\nabla \cdot$	del dot
Curl Operator	$\nabla \times$	del cross
Surface Integral	$\oiint$	With a loop indicating the surface is closed
Volume Integral	$\iiint$	
Line Integral	$\oint$	With a loop indicating the curve is closed
Surface Integral	$\iint$	
Net Electric Flux	Φ_E	$\Phi_E = \oiint \boldsymbol{B} \cdot d\boldsymbol{S}$
Net Magnetic Flux	Φ_B	$\Phi_B = \oiint \boldsymbol{B} \cdot d\boldsymbol{S}$
Net Electric Current	I	$I = \iint_{\Sigma} \boldsymbol{J} \cdot d\boldsymbol{S}$
Surface Area	$d\boldsymbol{S}$	Differential vector element of surface area S, normal to surface Σ.
Time	t	seconds
Length	$\boldsymbol{\ell}$	meters
Free Charge	Q_f	Volts
Free Current	I_f	Amperes

Sources

- BlogSpot.com (17 February 2013). Laws of Electric/Electrical Engineering, Maxwell's Equations. https://electrical-laws.blogspot.com/2013/02/maxwells-equations.html
- Wikipedia (11 January 2026). Maxwell's Equations. https://en.wikipedia.org/wiki/Maxwell's_equations