Equation Sheet
EE1813
Electricity & Magnetism

This equation sheet covers the entire course and is good for the mid-terms and final exam.

Physical Constants

Table 1:
Protons and Electrons

Particle	Mass (kg)	Relative Mass	Charge	Charge (C)
Proton	1.67×10^{-27}	1833	+e	$+1.60 \times 10^{-19}$
Electron	9.11×10^{-31}	1	−e	-1.60×10^{-19}

Table 2:
Physical Constants and Properties of Materials

Constant or Term	Symbol	Value (Units)
Electrostatic Constant	k	8.99×10^{9} (N m^2/ C^2)
Permittivity Constant	ε_o	8.85×10^{-12} (C^2/N m^2)
Permeability Constant	μ_o	$4\pi \times 10^{-7}$ (Tm/A)
Conductivity	σ	see Table 3
Resistivity	ρ	see Table 3
Gravitational acceleration on earth	g	9.8 m / s^2
Gravitational Constant	G	6.67×10^{-11} (Nm^2/kg^2)
Avagadro's Number	N_A	6.023×10^{23} (particles/mole)

Table 3:
Resistivity and Conductivity

Material	Resistivity (Ω m)	Conductivity (Ω^{-1} m^{-1})
Aluminum	2.8×10^{-8}	3.5×10^{7}
Copper	1.7×10^{-8}	6.0×10^{7}
Gold	2.4×10^{-8}	4.1×10^{7}
Iron	9.7×10^{-8}	1.0×10^{7}
Silver	1.6×10^{-8}	6.2×10^{7}
Tungsten	5.6×10^{-8}	1.8×10^{7}
Nichrome* (nickel-chromium alloy)	1.5×10^{-6}	6.7×10^{5}
Carbon	3.5×10^{-5}	2.9×10^{4}

Table 4:
Conduction-electron Density in Metals

Metal	Electron Density (m^{-3}) or (electrons/m^3)
Aluminum	6.0×10^{28}
Copper	8.5×10^{28}
Iron	8.5×10^{28}

Table 4:
Conduction-electron Density in Metals

Metal	Electron Density (m^{-3}) or (electrons/m^3)
Gold	5.9×10^{28}
Silver	5.8×10^{28}

$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r} \qquad \vec{E} = k\frac{q}{r^2}\hat{r} \qquad U = k\frac{q_1 q_2}{r} \qquad V = k\frac{q}{r}$$

For Point Charges

$$\vec{E} = k\frac{2\lambda}{r}\hat{r}$$

For Line of Charge

$$\vec{E} = \frac{\eta}{2\varepsilon_o}\hat{z}$$

For Plane of Charge

$$\vec{E} = \frac{\eta}{\varepsilon_o}$$

For Parallel Plate Capacitor

$$k = \frac{1}{4\pi\varepsilon_o}$$

$$\vec{J} = \sigma\vec{E} \qquad \vec{F} = q\vec{E} \qquad \Delta U = q\Delta V$$

$$\Delta V = (-E)\Delta s$$

For constant E field

$$W = \int_{s_i}^{s_f} \vec{F} \cdot d\vec{s}$$

= F ΔS (constant force)

$$U_f + K_f = U_i + K_i \qquad E = -\frac{dV}{ds}$$

$$\Delta V = -\int_{s_i}^{s_f} \vec{E} \cdot d\vec{s}$$

For arbitrary E = f(x,y,z)

$$R = \rho\frac{L}{A} \qquad \sigma = \frac{1}{\rho} \qquad I = \frac{\Delta V}{R} \qquad P = I\Delta V = I^2 R = \frac{\Delta V^2}{R}$$

$$C = \frac{Q}{V} = \frac{\varepsilon_r \varepsilon_o A}{d}$$

$$U_c = \frac{1}{2}C(\Delta V_c)^2$$

Stored Energy

$$U_E = \frac{\varepsilon_r \varepsilon_o}{2}E^2$$

Energy Density

$$I = -\frac{dQ}{dt}$$

= – (slope)

RC circuits (charging)

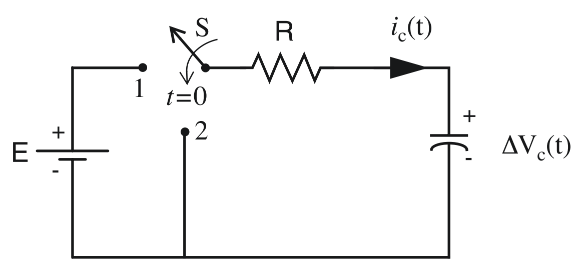
$$I_c(t) = I_o e^{-t/RC}$$

$$\Delta V_c(t) = E(1 - e^{-t/RC})$$

RC circuits (discharging)

$$I_c(t) = \frac{-\Delta V_{c_o}}{R} e^{-t/RC}$$

$$\Delta V_c(t) = \Delta V_{c_o} e^{-t/RC}$$



$$R_{eq} = R_1 + R_2 + ... + R_n$$

Series Resistors

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$$

Parallel Resistors

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}$$

Series Capacitors

$$C_{eq} = C_1 + C_2 + ... + C_n$$

Parallel Capacitors

$$L_{eq} = L_1 + L_2 + ... + L_n$$

Series Inductors

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + ... + \frac{1}{L_n}$$

Parallel Inductors

$$\vec{B} = \frac{\mu_o}{4\pi}\frac{q\,\vec{v}\times\hat{r}}{r^2}$$

(see cross product)
Moving Point Charges

$$\vec{B} = \frac{\mu_o}{2}\frac{NI}{R}$$

Centre of multi-turn loop or coil, z=0

$$\vec{B} = \frac{\mu_o}{4\pi}\frac{2AI}{z^3}$$

Loop, B on z axis

$$\vec{B} = \frac{\mu_o}{4\pi}\frac{2\vec{\mu}}{z^3}$$

dipole, where μ = AI

$$\oint \vec{B}\cdot d\vec{s} = \mu_o I_{through}$$

$$B_{solenoid} = \frac{\mu_o NI}{l}$$

$$\vec{F} = q\,\vec{v}\times\vec{B}$$

|F| = qVB sinθ

$$F = IlB$$

Wire in field

$$\vec{B} = \frac{\mu_o I}{2\pi d}$$

straight wire

$$\tau = \vec{\mu}\times\vec{B}$$

magnetic dipole

$$\mathcal{E} = vlB$$

motional EMF

$$\Phi = \vec{A}\cdot\vec{B}$$

= |A| |B| cosθ

$$\Phi_m = \int \vec{B}\cdot d\vec{A}$$

= B A sinθ (const B)
Loop

$$\mathcal{E} = \left|\frac{d\Phi_m}{dt}\right| = N\left|\frac{d\Phi_{perturn}}{dt}\right| = \left|\vec{B}\cdot\frac{d}{dt}\vec{A} + \vec{A}\cdot\frac{d}{dt}\vec{B}\right|$$

$$v_{em} = c = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$

speed of light

$$L = \frac{\Phi_m}{I}$$

Inductance

$$\Delta V_L = -L\frac{dI}{dt}$$

= – L (slope)

$$U_L = \frac{1}{2}LI^2$$

$$\Delta U = q\Delta V$$

$$\tau = \frac{L}{R}$$

$$L_{solenoid} = \frac{\mu_o N^2 A}{l}$$

$$\vec{A}\times\vec{B} = |A||B|\sin\theta$$

Cross product

$$\vec{A}\cdot\vec{B} = |A||B|\cos\theta$$

Dot product

LR circuits (energizing)

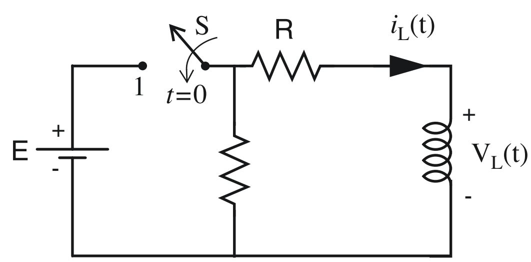
$$I_L(t) = I_o(1 - e^{-t/L/R})$$

$$\Delta V_L(t) = V_o e^{-t/L/R}$$

LR circuits (de-energizing)

$$I_L(t) = I_o e^{-t/L/R}$$

$$\Delta V_L(t) = V_o e^{-t/L/R}$$



Mechanics

$$KE = \frac{1}{2}mv^2$$

$$P = mv$$

$$S = S_0 + V_0 t + \frac{1}{2}at^2$$