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P112 Final Equations

Coulomb's Law

$$F = k \frac{|q_1|\,|q_2|}{r^2}, \qquad k = 8.99 \times 10^9 \, \frac{N\,m^2}{C^2}$$

like charges repel, unlike attract

$$\vec{F} = q\,\vec{E}$$

$\vec{F}$ is parallel to $\vec{E}$ for + charges, anti-parallel for − charges

$$|\vec{E}| = k \frac{|q|}{r^2}$$

$\vec{E}$ points away from + charges, points toward − charges

$$EPE = q\,V$$

$$EPE_B - EPE_A = q\,(V_B - V_A)$$

$$V = k\,\frac{q}{r}$$

for a point charge assuming that $V = 0$ at infinite distance
Capacitors:

$$q = C\,V$$

$$\text{stored energy} = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}\,C\,V^2 = \frac{1}{2}\,q\,V$$

For a parallel-plate capacitor

$$C = \kappa\,\frac{\epsilon_0\,A}{d}, \qquad \epsilon_0 = 8.85 \times 10^{-12}\,\frac{C^2}{N\,m^2}$$

Electric current

$$I = \frac{\Delta q}{\Delta t}$$

[Equations continued on next page]

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Ohm's Law

$$V = I\,R$$

resistivity

$$R = \rho\,\frac{L}{A}$$

dissipated power

$$P = I^2\,R = \frac{V^2}{R} = I\,V$$

resistors in series

$$R_S = R_1 + R_2 + R_3 + \ldots$$

resistors in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Magnetic force on a moving charge

$$|F| = q\,v\,B\,\sin\theta$$

on a wire with current

$$|F| = I\,L\,B\,\sin\theta$$

use RHR #1 to find direction
circular motion of a charge in uniform magnetic field

$$r = \frac{m\,v}{|q|\,B}$$

torque on a coil of wire

$$\tau = N\,I\,A\,B\,\sin\phi$$

[Equations continued on next page]

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permeability of free space

$$\mu_0 = 4\,\pi\,10^{-7}\,\frac{T\cdot m}{A}$$

Magnitude of the magnetic field of a long straight wire

$$B = \frac{\mu_0}{2\,\pi}\,\frac{I}{r}$$

Magnitude of the magnetic field of a flat circular loop with N turns each of radius R

$$B = N\,\frac{\mu_0}{2}\,\frac{I}{R}$$

Magnitude of the magnetic field inside of a solenoid with n turns per meter

$$B = n\,\mu_0\,I$$

Magnetic flux through a loop with area A with ϕ the angle between the normal to the loop and $\vec{B}$

$$\Phi = B\,A\,\cos\phi$$

Induced EMF in a coil with N loops

$$|\mathcal{E}| = N\,\frac{|\Delta\Phi|}{\Delta t}$$

Lenz's law: induced current flows in the direction to create an induced magnetic field that *opposes* the *change* in flux.
EMF of a generator

$$\mathcal{E} = N\,A\,B\,\omega\,\sin(\omega\,t) = \mathcal{E}_0\,\sin(\omega\,t)$$

$$\mathcal{E}_{rms} = \frac{\mathcal{E}_0}{\sqrt{2}}$$

Transformer equation

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s}.$$

Back emf

$$I = \frac{V - \mathcal{E}}{R}$$

[**Equations continued on next page**]

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Simple Harmonic Motion

$$x = A\cos(\omega t), \quad v_x = -A\omega\sin(\omega t), \quad a_x = -A\omega^2\cos(\omega t)$$

frequency

$$f = \frac{1}{T}$$

angular frequency

$$\omega = 2\pi f$$

Hooke's law

$$F_x = -k x$$

Mass on spring

$$T = 2\pi\sqrt{\frac{m}{k}}, \quad \omega = \sqrt{\frac{k}{m}}$$

Elastic Potential Energy

$$PE_{elastic} = \frac{1}{2} k x^2$$

Pendulum

$$T = 2\pi\sqrt{\frac{L}{g}}, \qquad g = 9.8\, m/s^2$$

Waves

$$v = \lambda f$$

speed of light

$$c = 3 \times 10^8\, m/s$$

Spherical mirrors, lenses

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}, \quad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}, \quad \text{mirrors only}: \quad f = \pm\frac{R}{2}$$

Refraction

$$n_i = \frac{c}{v_i}, \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2$$

other useful constants

$$m_e = 9.11 \times 10^{-31} kg, \qquad e = 1.6 \times 10^{-19} C, \qquad m_p = 1.67 \times 10^{-27} kg$$