electron charge	e=1.60×10^{-19} C
electrostatic constant	K=8.99×10^{9} $\mathrm{N\cdot m^2/C^2}$
proton mass	m_p=1.67×10^{-27} kg
electron mass	m_p=9.1×10^{-31} kg
permittivity constant	ϵ_0=8.85×10^{-12} $\mathrm{C^2/N\cdot m^2}$
permeability constant	μ_0=1.26×10^{-6} $\mathrm{T\cdot m/A}$
speed of light	c=3.00×10^{8} m/s
Planck's constant	h=6.63×10^{-34} J·s=6.58×10^{-15} eV·s

Material	Resistivity $(\Omega\cdot m)$
Copper	1.7×10^{-8}
Tungsten (20°C)	5.6×10^{-8}
Tungsten (1500°C)	5.0×10^{-7}
Iron	9.7×10^{-8}
Nichrome	1.5×10^{-6}
Seawater	0.22
Blood	1.6
Muscle	13
Fat	25
Pure water	2.4×10^{5}
Cell membrane	3.6×10^{7}

Coulomb's Law: $F=\frac{K|q_1||q_2|}{r^2}$ $\epsilon_0=\frac{1}{4\pi K}$ Electric Field: $\vec{E}=\frac{\vec{F}}{q}$ $\vec{F}=q\vec{E}$

Electric Field of a Point Charge: $E=\frac{Kq}{r^2}$ Uniform Electric Field: $\vec{E}=\frac{Q}{\epsilon_0 A}$

Dipole: $\vec{E}=K\frac{2\vec{p}}{r^3}$ (on the axis of an electric dipole) $\vec{E}=K\frac{\vec{p}}{r^3}$ (perpendicular plane)

$\vec{p}=(qs$, from the negative to the positive charge)

$E_{rod}=K\frac{|Q|}{d\sqrt{d^2+(L/2)^2}}$ $E_{line}=K\frac{2|\lambda|}{r}$, $\lambda=\frac{Q}{L}$ $E_{ring,z}=K\frac{zQ}{(z^2+R^2)^{3/2}}$ $E_{disk,z}=\frac{\eta}{2\epsilon_0}\left(1-\frac{z}{\sqrt{z^2+R^2}}\right)$

$E_{plane,z}=\frac{\eta}{2\epsilon_0}$ $\vec{E}_{sphere}=\frac{Q}{4\pi\epsilon_0 r^3}\vec{r}$ $\Phi_e=\vec{E}\cdot\vec{A}$ $\Phi_e=\oint\vec{E}\cdot d\vec{A}=\frac{Q_{in}}{\epsilon_0}$

Electric Potential Energy: U_{ele}=qV Conservation of Mechanical Energy: $K_f+qV_f=K_i+qV_i$

1 eV=1.60×10^{-19} J $U_{elec}=K\frac{qq'}{r}=\frac{1}{4\pi\epsilon_0}\frac{qq'}{r}$ $U_{elec}=U_0+qEs$ $U_{dipole}=-\vec{p}\cdot\vec{E}$

Electric Potential of a Point Charge (Charged Sphere): $V=K\frac{q}{r}=\frac{1}{4\pi\epsilon_0}\frac{q}{r}$ $V=\sum_i\frac{1}{4\pi\epsilon_0}\frac{q_i}{r_i}$ $E_s=-\frac{dV}{ds}$

$V_{ring}=K\frac{Q}{\sqrt{R^2+z^2}}$ $V_{disk}=\frac{Q}{2\pi\epsilon_0 R^2}\left(\sqrt{R^2+z^2}-|z|\right)$ $\Delta V=-\int_i^f\vec{E}\cdot d\vec{s}$ $E=\frac{\Delta V}{d}$ $Q=C\Delta V_C$

Capacitance of a Parallel-Plate Capacitor: $C=\frac{\epsilon_0\kappa A}{d}$ Capacitor Energy: $U_C=\frac{1}{2}\frac{Q^2}{C}=\frac{1}{2}C(\Delta V_C)^2$

Density of Electric Energy: $u_E=\frac{1}{2}\kappa\epsilon_0 E^2$

$i_e=n_eAv_d$ $i_e=\frac{n_e e\tau A}{m}E$ Current: $I=\frac{\Delta Q}{\Delta t}$ Resistance: $R=\frac{\Delta V}{I}=\frac{\rho L}{A}$ Ohm's Law: $I=\frac{\Delta V}{R}$

$J=\frac{I}{A}=n_e e v_d$ $J=\sigma\cdot E$ Power: $P_{emf}=I\mathcal{E}$ $P_R=I\Delta V_R=I^2R=\frac{(\Delta V_R)^2}{R}$

Kirchhoff's Junction Law: $\sum I_{in}=\sum I_{out}$ Kirchhoff's Loop Law: $\Delta V_{loop}=\sum_i\Delta V_i=0$

$R_{eq}=R_1+R_2+\cdots+R_N$ $R_{eq}=\left(\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_N}\right)^{-1}$

$C_{eq}=\left(\frac{1}{C_1}+\frac{1}{C_2}+\cdots+\frac{1}{C_N}\right)^{-1}$ $C_{eq}=C_1+C_2+\cdots+C_N$

$Q=Q_0e^{-t/\tau}$ $I=I_0e^{-\frac{t}{RC}}$ $\Delta V_C=(\Delta V_C)_0e^{-\frac{t}{RC}}$ $\Delta V_C=\mathcal{E}(1-\mathrm{e}^{-t/\tau})$ $I=I_0e^{-t/\tau}$

Biot-Sacart Law: $\vec{B}=\frac{\mu_0}{4\pi}\frac{qv\sin\theta}{r^2}$ $\vec{B}=\frac{\mu_0}{4\pi}\frac{I\Delta\vec{s}\times\vec{r}}{r^3}$ $B_{loop}=\frac{\mu_0}{2}\frac{IR^2}{(z^2+R^2)^{3/2}}$

Magnetic Field of Long Stright Current Wire: $B=\frac{\mu_0 I}{2\pi r}$ Magnetic Field at the Center of Current Loop: $B=\frac{\mu_0 I}{2R}$

$B=\frac{\mu_0 NI}{2R}$ $B=\mu_0 I\frac{N}{L}$ Magnetic Dipole: $\vec{B}=\frac{\mu_0}{4\pi}\frac{2\vec{\mu}}{z^3}$ $\vec{\mu}=AI$ $f_{cyc}=\frac{qB}{2\pi m}$

Ampere's Law: $\oint\vec{B}\cdot d\vec{s}=\mu_0 I_{through}$ $\vec{F}=q\vec{v}\times\vec{B}$ $F=qvB\sin\alpha$ $F_{wire}=ILB$ $\vec{F}=I\vec{l}\times\vec{B}$

$F_{parallel\ wires}=\frac{\mu_0 LI_1I_2}{2\pi d}$

Magnetic flux: $\Phi=A_{eff}B$ $\Phi=\int\vec{B}\cdot d\vec{A}$ Faraday's Law: $\mathcal{E}=\left|\frac{\mathrm{d}\Phi}{\mathrm{dt}}\right|$ $\mathcal{E}_{\mathrm{coil}}=\mathrm{N}\left|\frac{\mathrm{d}\Phi_{\mathrm{per\,coil}}}{\mathrm{dt}}\right|$

Inductance: $L=\frac{\Phi_{in}}{I}$ $L_{sol}=\frac{\mu_0 N^2A}{L}$ $\Delta V_L=-L\frac{dI}{dt}$ $U_L=\frac{1}{2}LI^2$ $\omega=\sqrt{\frac{1}{LC}}$

$\vec{E}'=\vec{E}+\vec{V}\times\vec{B}$ $\vec{B}'=\vec{B}-\frac{1}{c^2}\vec{V}\times\vec{E}$ $\oint\vec{B}\times d\vec{s}=\mu_0\left(I_{through}+\epsilon_0\frac{d\Phi}{dt})\right)$

$\oint\vec{E}\cdot d\vec{A}=\frac{Q_{in}}{\epsilon_0}$ $\oint\vec{B}\cdot d\vec{A}=0$ $\oint\vec{E}\cdot d\vec{s}=-\frac{d\Phi_m}{dt}$ $\oint\vec{B}\cdot d\vec{s}=\mu_0 I_{through}+\epsilon_0\mu_0\frac{d\Phi_e}{dt}$ $c=\frac{1}{\sqrt{\mu_0\epsilon_0}}$

Poynting vector: $\vec{S}=\frac{1}{\mu_0}\vec{E}\times\vec{B}$ $I=\frac{P}{A}=\frac{1}{2}c\epsilon_0E_0^2=\frac{1}{2}\frac{c}{\mu_0}B_0^2$ Radiation pressure: $p=\frac{I}{c}$

Polarization: $I_{transmitted}=I_{incident}\cos^2\theta$ $E_{photon}=hf$

$\frac{Q}{\Delta t} = e\sigma A T^4$ σ=5.67×10^{-8} W/(m^2·K^4) $\lambda_{peak}(in\, nm) = \frac{2.9\times10^6 \text{nm·K}}{T}$

Emf of an AC source: $\mathcal{E} = \mathcal{E}_\prime \cos(2\pi \text{ft}) = \mathcal{E}_\prime \cos\left(\frac{2\pi \text{t}}{\text{T}}\right)$ $P_R = \frac{1}{2} I_R^2 R$ Transformer: $V_2 = \frac{N_2}{N_1} V_1$

Peak current and voltage trough capacitor: $I_C = \frac{V_C}{X_C}$ $V_C = I_C X_C$ $X_C = \frac{1}{\omega C}$

Inductor Circuits: $I_C = \frac{V_L}{X_L}$ $V_L = I_L X_L$ $X_L = \omega L$ LC oscillator: $f = \frac{1}{2\pi\sqrt{LC}}$

Peak current in an RLC curcuit: $I = \frac{\mathcal{E}_\prime}{\sqrt{R^2+(X_L-X_C)^2}} = \frac{\mathcal{E}_\prime}{\sqrt{R^2+(2\pi f L - 1/2\pi f C)^2}}$

Phase Angle: $\phi = tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ $P_{source} = I_{rms} E_{rms} = \frac{(V_{rms})^2}{R} = I_{rms}^2 R$

Wave speed: $v_{string} = \sqrt{\frac{T_s}{\mu}}$ $\mu = \frac{m}{L}$ $T = \frac{1}{f}$ $v = \lambda \cdot f$ $k = \frac{2\pi}{\lambda}$ $\omega = \nu \cdot k$

$D(x,t) = A\sin(kx - \omega t + \phi_0)$ Index of refraction: $n = \frac{c}{v}$ $\lambda_{mat} = \frac{\lambda}{n}$

Intensity: $I = \frac{P}{a}$ $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$ $\beta = (10dB)\log_{10}\left(\frac{I}{10^{-12}}\right)$

Doppler effect: $f_+ = \frac{f_0}{1 - v_s/v}$ $f_- = \frac{f_0}{1+v_s/v}$ $f_+ = (1 + v_0/v) f_0$ $f_- = (1 - v_0/v) f_0$

Standing waves: $D(x,t) = a(x)\cos\omega t$ $A(x) = 2a \sin kx$

String: $\lambda_m = \frac{2L}{m}$, $m = 1, 2, 3, ...$ $f_m = \frac{v}{\lambda_m} = \frac{mv}{2L}$, $m = 1, 2, 3, ...$

Open-open or closed-closed tube: $\lambda_m = \frac{2L}{m}$, $m = 1, 2, 3, ...$ $f_m = \frac{mv}{2L} = m f_1$, $m = 1, 2, 3, ...$

Open-closed tube: $\lambda_m = \frac{4L}{m}$, $m = 1, 3, 5, ...$ $f_m = \frac{mv}{4L} = m f_1$, $m = 1, 3, 5, ...$

$\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \Delta\phi_0 = m\cdot 2\pi$, $m = 0, 1, 2, 3, ...$ $\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \Delta\phi_0 = \left(m + \frac{1}{2}\right)\cdot 2\pi$, $m = 0, 1, 2, 3, ...$

Double-Slit Interference: $\theta_m = m\frac{\lambda}{d}$, m=0,1,2,3,... $y_m = \frac{m\lambda L}{d}$, m=0,1,2,3,...

$y'_m = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d}$, m=0,1,2,3,... $I_{double} = 4 I_1 \cos^2\left(\frac{\pi d}{\lambda L} y\right)$

Difraction Grating: $d \sin\theta_m = m\lambda$, m=0,1,2,3,... $y_m = L\tan\theta_m$ $I_{max} = N^2 I_1$

Thin-Film Interference: $2t = m\frac{\lambda}{n}$, m=0,1,2,3,... $2t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n}$

Single-Slit Diffraction: $\theta_p = p\frac{\lambda}{a}$, p=1,2,3,... $y_p = \frac{p\lambda L}{a}$, p=1,2,3,... $w = \frac{2\lambda L}{a}$

Circular-Aperture Diffraction: $w = 2y_1 = 2L\tan\theta_1 \approx \frac{2.44\lambda L}{D}$

Refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ Total Internal Reflection: $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

Magnification: $m = -\frac{h'}{h} = -\frac{s'}{s}$ Thin-lens equation: $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$ Refractive Power: $P = \frac{1}{f}$

$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\frac{n_1}{s} + \frac{n_2}{s'} = \frac{n_2 - n_1}{R}$

$f - \text{number} = \frac{f}{D}$ $I \propto \frac{D^2}{f^2}$ $M = \frac{25\text{cm}}{f}$ $M_{microscope} = -\frac{L}{f_{obj}}\frac{25\text{cm}}{f_{eye}}$ $M_{telescope} = -\frac{f_{obj}}{f_{eye}}$

Resolving Power of Microscope: $RP = d_{min} = \frac{0.61\lambda_0}{NA}$

Galilean Transformation: $u' = u - v$ $u = u' + v$

Time Dilation: $\Delta t = \frac{\Delta\tau}{\sqrt{1-\beta^2}}$

Length Contraction: $L = \sqrt{1-\beta^2}\, l$

Lorentz Transformation of Velocity: $u' = \frac{u-v}{1-uv/c^2}$ $u = \frac{u'+v}{1+u'v/c^2}$

Relativistic Momentum: $p = \gamma m u$, $\gamma = \frac{1}{\sqrt{1-u^2/c^2}}$

Relativistic Energy: $E = \frac{mc^2}{\sqrt{1-u^2/c^2}} = \gamma mc^2$

Bragg Condition: $\Delta r = 2d\cos\theta_m = m\lambda$, m=1,2,3,...

Photoelectric effect: $E = hf$

Matter Waves: $\lambda = \frac{h}{p} = \frac{h}{mv}$

Heisenberg Uncertainty Principle: $\Delta x \Delta p_x \geq \frac{h}{2\pi}$

Bohr Hydrogen Atom: $r_n = n^2 a_B$, n=1,2,3,... $E_n = -\frac{E_1}{n^2} = -\frac{13.60\, eV}{n^2}$, n=1,2,3,...

$L = n\frac{h}{2\pi}$, n=1,2,3,...