Kinematics and mechanics:

$x = x_0 + v_0 t + \frac{1}{2} a t^2$ $\quad v = v_0 + at$ $\quad v^2 = v_0^2 + 2a\Delta x$

$F = ma$ $\quad a_c = \frac{v^2}{r}$

$E_{tot} = K.E. + P.E.$ $\quad K.E. = \frac{1}{2} m v^2 = \frac{p^2}{2m}$ $\quad p = mv$ $\quad W_F = Fd\cos\theta$

Electrostatics:

$F_{12} = \frac{k q_1 q_2}{r^2}$ $\quad E \equiv \frac{F}{q_0}$ $\quad U_{12} = \frac{k q_1 q_2}{r}$ $\quad V \equiv \frac{U}{q_0}$ $\quad W_E = -\Delta U = -W_{you}$

Point charge: $E = \frac{kq}{r^2}$ $\quad V = \frac{kq}{r}$

Electric dipole: $p \equiv qd$ $\quad \tau_{dip} = pE\sin\theta$ $\quad U_{dip} = -pE\cos\theta$

Resistance:

$R \equiv \frac{V}{I}$ $\quad I = \frac{\Delta q}{\Delta t}$ $\quad$ Physical resistance: $R = \rho \frac{L}{A}$

$P = IV = I^2 R = \frac{V^2}{R}$ $\quad R_S = R_1 + R_2 + \cdots$ $\quad \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Capacitance:

$C \equiv \frac{Q}{V}$ $\quad$ Parallel plate capacitor: $C = \frac{\kappa \varepsilon_0 A}{d}$, $\quad E = \frac{Q}{\varepsilon_0 A}$, $\quad V = Ed$

$U_C = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2}\frac{Q^2}{C}$ $\quad C_P = C_1 + C_2 + \cdots$ $\quad \frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

Circuits:

$\sum \Delta V = 0$ $\quad \sum I_{in} = \sum I_{out}$

$q(t) = q_\infty (1 - e^{-t/\tau})$ $\quad q(t) = q_0 e^{-t/\tau}$ $\quad I(t) = I_0 e^{-t/\tau}$ $\quad \tau = RC$

Magnetism:

$F = qvB\sin\theta$ $\quad r = \frac{mv}{qB}$ $\quad F_{wire} = ILB\sin\theta$ $\quad \tau_{loop} = NIAB\sin\varphi$

Magnetic dipole: $\mu \equiv NIA$ $\quad \tau_{dip} = \mu B\sin\varphi$ $\quad U_{dip} = -\mu B\cos\varphi$

$B_{wire} = \frac{\mu_0 I}{2\pi r}$ $\quad B_{sol} = \mu_0 n I$

Electromagnetic induction:

$\varepsilon = -N \dfrac{\Delta\Phi}{\Delta t}$ $\Phi = BA\cos\varphi$

$|\varepsilon_{bar}| = BLv$ $\varepsilon_{gen} = \varepsilon_{max}\sin\omega t = \omega NAB\sin\omega t$ $\omega = 2\pi f$

$V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$ $I_{rms} = \dfrac{I_{max}}{\sqrt{2}}$ $\dfrac{V_p}{V_s} = \dfrac{I_s}{I_p} = \dfrac{N_p}{N_s}$

Electromagnetic waves:

$\lambda = \dfrac{c}{f}$ $E = cB$

$u_E = \dfrac{1}{2}\varepsilon_0 E^2$ $u_B = \dfrac{1}{2\mu_0}B^2$ $\bar{u} = \dfrac{1}{2}\varepsilon_0 E_{rms}^2 + \dfrac{1}{2\mu_0}B_{rms}^2 = \varepsilon_0 E_{rms}^2 = \dfrac{B_{rms}^2}{\mu_0}$ $S = I = \bar{u}c = \dfrac{P}{A}$

$f_o = f_e\sqrt{\dfrac{1+v_{rel}/c}{1-v_{rel}/c}} \approx f_e\left(1+\dfrac{v_{rel}}{c}\right)$ $I = I_0\cos^2\theta$

Reflection and refraction:

$\theta_r = \theta_i$ $\dfrac{1}{d_o} + \dfrac{1}{d_i} = \dfrac{1}{f}$ $f = \pm\dfrac{R}{2}$ $m = \dfrac{h_i}{h_o} = -\dfrac{d_i}{d_o}$

$n_1\sin\theta_1 = n_2\sin\theta_2$ $v = \dfrac{c}{n}$ $\sin\theta_c = \dfrac{n_2}{n_1}$ $M = \dfrac{\theta'}{\theta} \approx \dfrac{d_{near}}{f}$

Compound microscope: $m_{obj} = -\dfrac{L_{tube}}{f_{obj}}$ $M_{eye} = \dfrac{d_{near}}{f_{eye}}$ $M_{tot} = M_{eye}m_{obj}$

Interference and diffraction:

Double slit interference: $d\sin\theta = m\lambda$ $d\sin\theta = (m+\tfrac{1}{2})\lambda$ $m = 0, \pm 1, \pm 2\ldots$

Single-slit diffraction: $a\sin\theta = m\lambda$ $m = \pm 1, \pm 2\ldots$

Circular aperture: $a\sin\theta \approx 1.22\lambda$

Quantum mechanics:

$E = hf = \dfrac{hc}{\lambda}$ $\lambda = \dfrac{h}{p}$ $\Delta p_x \Delta x \geq \dfrac{\hbar}{2}$ $\hbar \equiv \dfrac{h}{2\pi}$

Bohr atom: $2\pi r_n = n\lambda$ $n = 1, 2, 3\ldots$ $L_n = m_e v_n r_n = n\hbar$

$r_n = \left(\dfrac{\hbar^2}{m_e k e^2}\right)\dfrac{n^2}{Z} \approx (5.29\times10^{-11}\,\text{m})\dfrac{n^2}{Z}$ $E_n = -\left(\dfrac{m_e k^2 e^4}{2\hbar^2}\right)\dfrac{Z^2}{n^2} \approx -(13.6\,\text{eV})\dfrac{Z^2}{n^2}$

$\dfrac{1}{\lambda} \approx (1.097\times10^7\,\text{m}^{-1})Z^2\left(\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right)$

Quantum atom: $L = \sqrt{\ell(\ell+1)}\hbar$ $L_z = m_\ell\hbar$ $S_z = m_s\hbar$

Atomic magnetism: $\mu_{e,z} = -\dfrac{e}{2m_e}L_z$ $\mu_{s,z} = -\dfrac{ge}{2m_e}S_z,\ g \approx 2$ $\mu_B \equiv \dfrac{e\hbar}{2m_e} \approx 5.8\times10^{-5}\,\text{eV/T}$

Nuclear physics and radioactive decay:

$A = Z + N$ $r \approx (1.2\times10^{-15} m)A^{1/3}$ $E_0 = mc^2$

$m_{nucleus} = Zm_{proton} + Nm_{neutron} - \frac{|E_{bind}|}{c^2}$

$\frac{\Delta N}{\Delta t} = -\lambda N$ $N(t) = N_0 e^{-\lambda t} = N_0 2^{-t/T_{1/2}}$ $T_{1/2} \equiv \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$

Constants and unit conversions:

$g = 9.8\,\text{m/s}^2$ $e = 1.60\times10^{-19}\,\text{C}$

$\varepsilon_0 = 8.85\times10^{-12}\,\text{C}^2/\text{Nm}^2$ $k \equiv \frac{1}{4\pi\varepsilon_0} = 8.99\times10^9\,\text{Nm}^2/\text{C}^2$ $\mu_0 = 4\pi\times10^{-7}\,\text{T}\cdot\text{m/A}$

$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 3\times10^8\,\text{m/s}$ $h = 6.626\times10^{-34}\,\text{J}\cdot\text{s}$ $hc = 1240\,\text{eV}\cdot\text{nm}$

$1\text{eV} = 1.60\times10^{-19}\,\text{J}$ $m_{electron} = 9.11\times10^{-31}\,\text{kg} = 511\,\text{keV}/c^2$

$m_{proton} = 1.673\times10^{-27}\,\text{kg} = 938.3\,\text{MeV}/c^2$ $m_{neutron} = 1.675\times10^{-27}\,\text{kg} = 939.5\,\text{MeV}/c^2$

SI Prefixes

Power	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^0	—	—
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p