

Mechanics:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + a t$$

$$F = m a$$

$$a_c = \frac{v^2}{r}$$

$$E_{tot} = K.E. + P.E.$$

$$K.E. = \frac{1}{2} m v^2 = \frac{p^2}{2m}$$

$$p = m v$$

$$W_F = F d \cos \theta$$

Electrostatics:

$$F_{12} = \frac{k q_1 q_2}{r^2}$$

$$E \equiv \frac{F}{q_0}$$

$$V \equiv \frac{U}{q_0}$$

$$\text{Point charge: } E = \frac{k q}{r^2}, \quad V = \frac{k q}{r}$$

$$U_{12} = \frac{k q_1 q_2}{r}$$

$$W_E = -\Delta U = -W_{you}$$

Capacitance:

$$C \equiv \frac{Q}{V}$$

$$\text{Parallel plate capacitor: } C = \frac{\kappa \epsilon_0 A}{d}, \quad V = E d$$

$$U_C = \frac{1}{2} Q V = \frac{1}{2} C V^2 = \frac{1}{2} \frac{Q^2}{C}$$

$$C_P = C_1 + C_2 + \dots$$

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

Resistance:

$$R \equiv \frac{V}{I}$$

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

$$\text{Physical resistance: } R = \rho \frac{L}{A}$$

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

$$R_S = R_1 + R_2 + \dots$$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

Circuits:

$$\sum \Delta V = 0$$

$$\sum I_{in} = \sum I_{out}$$

$$q(t) = q_\infty (1 - e^{-t/\tau})$$

$$q(t) = q_0 e^{-t/\tau}$$

$$I(t) = I_0 e^{-t/\tau}$$

$$\tau = RC$$

Magnetism:

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

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

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

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

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

$$B_{sol} = \mu_0 n I$$

Induction and inductance:

$$\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$$

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

$$\varepsilon_{bar} = B L v$$

$$\varepsilon_{gen} = \varepsilon_{max} \sin \omega t = \omega N A B \sin \omega t$$

$$\omega = 2 \pi f$$

$$L \equiv \frac{N \Phi}{I}$$

$$\varepsilon = -L \frac{\Delta I}{\Delta t}$$

$$\text{Solenoid inductor: } L = \mu_0 n^2 A \ell$$

$$U_L = \frac{1}{2} L I^2$$

AC circuits and transformers:

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

$$V_R(t) = V_{R,max} \sin(\omega t) = I_{max} R \sin(\omega t) \quad \omega = 2\pi f$$

$$V_C(t) = V_{C,max} \sin(\omega t - \pi/2) = I_{max} X_C \sin(\omega t - \pi/2) \quad X_C \equiv \frac{1}{\omega C}$$

$$V_L(t) = V_{L,max} \sin(\omega t + \pi/2) = I_{max} X_L \sin(\omega t + \pi/2) \quad X_L \equiv \omega L$$

$$V_{gen}(t) = V_{gen,max} \sin(\omega t + \phi) = I_{max} Z \sin(\omega t + \phi) \quad Z \equiv \sqrt{R^2 + (X_L - X_C)^2} \quad \tan \phi = \frac{X_L - X_C}{R}$$

$$\bar{P} = I_{rms} V_{R,rms} = I_{rms} V_{gen,rms} \cos \phi \quad f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Electromagnetic waves:

$$\lambda = \frac{c}{f} \quad E = cB$$

$$u_E = \frac{1}{2} \epsilon_0 E^2 \quad u_B = \frac{1}{2\mu_0} B^2 \quad \bar{u} = \frac{1}{2} \epsilon_0 E_{rms}^2 + \frac{1}{2\mu_0} B_{rms}^2 = \epsilon_0 E_{rms}^2 = \frac{B_{rms}^2}{\mu_0} \quad S = I = \bar{u}c$$

$$f' = f \left(1 \pm \frac{u}{c} \right) \quad I = I_0 \cos^2 \theta$$

Reflection and refraction:

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

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

Interference and diffraction:

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

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

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

Thin film: $\delta_1 = (0 \text{ or } \frac{1}{2}) \lambda_0$ $\delta_2 = (0 \text{ or } \frac{1}{2}) \lambda_0 + 2t \frac{n_{film}}{\lambda_0}$ $|\delta_2 - \delta_1| = (m \text{ or } m + \frac{1}{2}) \lambda_0$ $m = 0, 1, 2 \dots$

Quantum mechanics:

$$E = hf = \frac{hc}{\lambda} \quad \lambda = \frac{h}{p}$$

Blackbody radiation: $\lambda_{max} T = 2.898 \times 10^{-3} m \cdot K$ Photoelectric effect: $K.E. = hf - W_0$

$$\Delta p_x \Delta x \geq \frac{\hbar}{2} \quad \hbar \equiv \frac{h}{2\pi}$$

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

$$r_n = \left(\frac{\hbar^2}{mke^2} \right) \frac{n^2}{Z} \approx (5.29 \times 10^{-11} \text{ m}) \frac{n^2}{Z}$$

$$\frac{1}{\lambda} \approx (1.097 \times 10^7 \text{ m}^{-1}) Z^2 \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

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

$$E_n = - \left(\frac{mk^2e^4}{2\hbar^2} \right) \frac{Z^2}{n^2} \approx -(13.6 \text{ eV}) \frac{Z^2}{n^2}$$

$$L_z = m_\ell \hbar$$

Nuclear physics and radioactive decay:

$$A = Z + N$$

$$r \approx (1.2 \times 10^{-15} \text{ m}) A^{1/3}$$

$$E_0 = mc^2$$

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$N(t) = N_0 e^{-\lambda t} = N_0 2^{-t/T_{1/2}}$$

$$T_{1/2} \equiv \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$$

Special relativity:

$$\Delta t = \gamma \Delta t_0$$

$$L = \frac{L_0}{\gamma}$$

$$\gamma \equiv \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Constants and unit conversions:

$$g = 9.8 \text{ m/s}^2$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / \text{Nm}^2$$

$$k \equiv \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ Nm}^2 / \text{C}^2$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m} / \text{A}$$

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 3 \times 10^8 \text{ m/s}$$

$$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$hc = 1240 \text{ nm} \cdot \text{eV}$$

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

$$m_{\text{proton}} = 1.67 \times 10^{-27} \text{ kg} = 938 \text{ MeV}$$

$$m_{\text{electron}} = 9.11 \times 10^{-31} \text{ kg} = 511 \text{ keV}$$

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