Physics 11 in a nutshell

Thermal Physics

0 **Equipartition theorem**: $\bar{K} = 3\frac{1}{2}kT$ mean kinetic energy, temperature

1 Heat capacity/specific heat: $Q = C\ \Delta T = mc\ \Delta T$ heat, heat capacity, temperature change

1 Latent heat: $Q = m\ell$ Heat, mass

1 Heat conduction: $\frac{dQ}{dt} = kA\frac{dT}{dx}$

1 Radiation: $\frac{dQ}{dt} = \sigma\epsilon AT^4$

Electricity

0 **Coulomb's law**: $F = \frac{1}{4\pi\epsilon_0}\frac{|q|\ |Q|}{r^2}$

0 **Electric field**: $\vec{E} = \frac{\vec{F}_q}{q}$

0 **Electric potential**: $\Delta V = \frac{\Delta U_q}{q}$

0 **Relation potential and field**: $\Delta V = -\vec{E}\cdot\vec{\Delta}\ell$

1 Point charge electric potential: $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

1 Capacitance: $Q = CV_C$

2 Energy stored in a capacitor: $U = \frac{1}{2}CV^2$

0 **Electric current**: $I = \frac{dq}{dt}$

1 Ohm's law: $V_R = IR$

0 **Electrical power**: $P = IV$

0 **Kirchhoff's junction rule**: $\sum I = 0$

0 **Kirchhoff's loop rule**: $\sum V = 0$

2 Effective resistance: $R_S = R_1 + R_2$ and $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

2 Effective capacitance: $C_P = C_1 + C_2$ and $\frac{1}{C_R} = \frac{1}{C_1} + \frac{1}{C_2}$

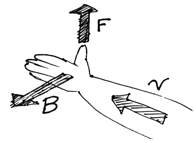
2 RC circuits: $V_C(t) - V_s = (V_C(0) - V_s)e^{-t/RC}$

Magnetism

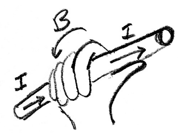
0 **Magnetic Force**: $\vec{F}_B = q\vec{v} \times \vec{B}$ force on charge, velocity, field

0 **Magnetic Force**: $\vec{F}_B = I\vec{L} \times \vec{B}$ force on current, length, field

0 **Right Arm Rule**: $\hat{F} = \hat{v} \times \hat{B}$ direction of magnetic force relative to velocity and field



0 **Right Hand Rule**: $\hat{B} = \hat{r} \times \hat{I}$ direction of field caused by current



1 Field due to a current: $B = \alpha I$ magnitic field is proportional to current

0 **Magnetic Flux**: $\Phi_B = \vec{B} \cdot \vec{A}$ definition of flux

0 **EMF**: $\mathcal{E} = -\oint \vec{E} \cdot d\vec{\ell}$ voltage around a loop

0 **Faradays Law**: $\mathcal{E} = -\frac{d\Phi_B}{dt}$ field caused by changing flux

0 **Lenzs law**: induced current opposes change direction of field

Electromagnetic Waves

1 Energy density: $\bar{u} = \frac{1}{2}\epsilon_0 E^2$ energy density of EM field

0 **Energy flux density**: $\bar{I} = \bar{u}c$ intensity is energy density times speed

0 **Wave speed**: $c = \frac{1}{\sqrt{\epsilon_0\mu_0}} = \frac{\lambda}{T} = \lambda f = \frac{\omega}{k}$

0 **Sinusoidal Wave**: $E = E_0 \cos(2\pi\frac{x}{\lambda} - 2\pi\frac{t}{T}) = E_0\cos(kx - \omega t) = E_0\cos(k(x - ct))$

Wave Optics

0 **Sum of two waves**: $E^2 = E_1^2 + E_2^2 + 2E_1E_2\cos(\Delta\phi)$ amplitude of sum of two waves

0 **Phase due to path**: $\Delta\phi = 2\pi\frac{\Delta x}{\lambda}$

1 Phase due to reflection: $\Delta\phi = 0$ or π

Ray Optics

0 **Index of refraction**: $n = \frac{c}{v}$

0 **Snells law**: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

0 **Thin lens equation**: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$

Quantum

0 **Energy-frequency**: $E = hf$

0 **Momentum-wavelength**: $p = \frac{h}{\lambda}$

1 Absorption: $E_{n_{\text{initial}}} + hf = E_{n_{\text{final}}}$

1 Emission: $E_{n_{\text{initial}}} = E_{n_{\text{final}}} + hf$

0 **Probability**: $N \propto P \propto \psi^2$

0 **Uncertainty principle**: $\Delta x \Delta p \geq \frac{\hbar}{2} = \frac{h}{4\pi}$

Nuclear

Common Nuclear Changes:

- α-decay: Emission of a helium nucleus,

$$^{A}_{Z}\text{X} \rightarrow \, ^{A-4}_{Z-2}\text{Y} + \, ^{4}_{2}\text{He}$$

- β-decay: Emission of an electron,

$$^{A}_{Z}\text{X} \rightarrow \, ^{A}_{Z+1}\text{Y} + e^- + \nu$$

this is the conversion of a neutron into a proton and electron $n \rightarrow p + e^- + \nu$

- γ-decay: Emission of a high energy photon.

$$^{A}_{Z}\text{X}^* \rightarrow \, ^{A}_{Z}\text{X} + \gamma$$

Nucleus does not change type or isotope but does drop to a lower energy state.

0 **Decay**: $N = N_0 \; e^{-\lambda t} = N_0 \; 2^{-t/T_{1/2}}$

0 **Decay Rate**: $R = -\frac{dN}{dt} = \lambda N_0 \; e^{-\lambda t} = R_0 \; e^{-\lambda t}$

1 Half life: $N(T_{1/2}) = \frac{1}{2} N_0 \quad \longrightarrow \quad \lambda T_{1/2} = \log 2$