Physics 11 in a nutshell

Thermal Physics

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

1 Heat capacity/specific heat: $\frac{dU}{dT} = C = mc$ rate of change of internal energy with temperature

1 Latent heat: $Q = m\ell$ heat for phase change per 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 $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

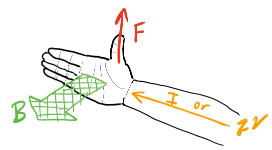
2 RC circuits: $V_C(t) - V_s = (V_C(0) - V_s)e^{-t/RC}$

Magnetism

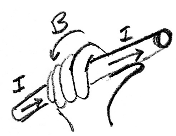
0 **Magnetic Force**: $\vec{F}_B = q\vec{v} \times \vec{B}$ — force on charge, velocity, field

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

0 **Right Arm Rule**: direction of magnetic force relative to velocity and field



0 **Right Hand Rule**: 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: $\langle u \rangle = \frac{1}{2}\epsilon_0 E^2$ — energy density of EM field

0 **Energy flux density**: $\langle I \rangle = \langle u \rangle c$ — intensity of EM field

0 **Radiation Pressure**: $P = \langle u \rangle$ — radiation pressure of EM field

0 **Wave speed**: $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = \frac{\lambda_0}{T} = \lambda_0 f$

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

Ray Optics

0 **Index of refraction**: $n = \frac{c}{v} \quad \longrightarrow \quad \lambda = \frac{\lambda_0}{n}$

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

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

(continued)

Wave Optics

2 Intensity of single slit: $I = I_0 \ \mathrm{sinc}^2\left(\pi \frac{a}{\lambda} \sin\theta\right) \approx I_0 \ \mathrm{sinc}^2\left(\pi \frac{a}{\lambda} \frac{x}{L}\right)$

2 Intensity of double slit: $I = I_0 \ \mathrm{sinc}^2\left(\pi \frac{a}{\lambda} \sin\theta\right) \cos^2\left(\pi \frac{d}{\lambda} \sin\theta\right) \approx I_0 \ \mathrm{sinc}^2\left(\pi \frac{a}{\lambda} \frac{x}{L}\right) \cos^2\left(\pi \frac{d}{\lambda} \frac{x}{L}\right)$

0 **Sum of two waves**: $E_0^2 = {E_0}_a^2 + {E_0}_b^2 + 2E_{0a}E_{0b}\cos(\Delta\phi)$ amplitude of sum of two waves

0 **Sum of two waves**: $I = I_a + I_b + 2\sqrt{I_a I_b}\cos(\Delta\phi)$ intensity of sum of two waves

0 **Phase due to path**: $\Delta\phi = \frac{2\pi}{\lambda}(r_b - r_a)$

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