Physics 232

$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/(Nm^2) $k = \frac{1}{4\pi\epsilon_0} = k = 9 \times 10^9$ Nm^2/C^2

$\mu_0 = 4\pi \times 10^{-7}$ Tm/A $c = 3.0 \times 10^8$ m/s

$e^- = -1.6 \times 10^{-19}$C $m_e = 9.11 \times 10^{-31}$kg

$p = +1.6 \times 10^{-19}$C $m_p = 1.67 \times 10^{-27}$kg

Resistivity, ρ, and Temperature Coefficients (at 20^o C), α,

Material	ρ (Ω.m)	α (C^o)$^{-1}$
Silver	1.59×10^{-8}	0.0061
Copper	1.68×10^{-8}	0.0068
Aluminum	2.44×10^{-8}	0.00429
Iron	9.71×10^{-8}	0.00651

Dielectric constants (at 20° C), K, ($\epsilon = K\epsilon_0$)

Material	K		
Vacuum	1.000	Paper	2.2
Air (1 atm)	1.006	Quartz	4.3
Parafin	2.2	Glass, Pyrex	5.0

Index of refraction:

Material	n	Material	n
Vacuum	1.0	Fused quartz	1.46
Air	1.0003	Crown glass	1.52
Water	1.33	Plexiglass	1.51
Ethyl alcohol	1.36	Diamond	2.42

$D(x) = D_0 sin(kx - \omega t + \phi)$ $k = \frac{2\pi}{\lambda}$ $\omega = \frac{2\pi}{T} = 2\pi f$ $v = \frac{\lambda}{T} = \lambda f = \frac{\omega}{k}$

$v = \sqrt{\frac{\tau}{\mu}}$ $v = \sqrt{\frac{\mathrm{E}}{\rho}}$ $v = \sqrt{\frac{\mathrm{B}}{\rho}}$ $v = 331 + 0.60T$

$\lambda_n = \frac{2L}{n}$ $f_n = n\frac{v}{2L}$ $\lambda_n = \frac{4L}{(2n-1)}$ $f_n = (2n-1)\frac{v}{4L}$ $n = 1, 2, 3,$

Beats: $D(x,t) = D_M \cos(2\pi(\frac{\triangle f}{2})t)\sin(2\pi f t)$ $I \propto D_o^2$ $I \propto \frac{1}{r^2}$ $\beta = 10\,\mathrm{lg}\frac{I}{10^{-12}}$

Doppler: $f' = \frac{f}{(1-\frac{v_S}{v})}$ $f' = \frac{f}{(1+\frac{v_S}{v})}$ $f' = f\left(1 + \frac{v_{obs}}{v}\right)$ $f' = f\left(1 - \frac{v_{obs}}{v}\right)$

$F = k\frac{Q_1 Q_2}{r^2}$ $\overrightarrow{E} = \frac{\overrightarrow{F}}{q}$ $E = k\frac{Q}{r^2}$ $\oint \overrightarrow{E} \cdot d\overrightarrow{A} = \frac{Q_{enc}}{\epsilon_0}$

$U = \frac{1}{4\pi\epsilon_0}\frac{Q_1 Q_2}{r}$ $V = \frac{U}{q}V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$

$W_{12} = U_1 - U_2 = q(V_1 - V_2)$ work by the el.force

$F_x = -\frac{\partial U}{\partial x}$ $E_x = -\frac{\partial V}{dx}$ $U_2 - U_1 = -\int_1^2 F \cdot dx$ $V_2 - V_1 = -\int_1^2 E \cdot dx$

$C = \frac{Q}{V}$ $C = K\epsilon_0 \frac{A}{d}$ $U_E = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$ $w_e = \frac{\epsilon_0 E^2}{2}$

series: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$ parallel: $C = C_1 + C_2 + C_3 + ...$

$I = \frac{dQ}{dt}$ $I = \frac{V}{R}$ $P = IV = I^2R = \frac{V^2}{R}$ $R = \rho\frac{l}{A}$ $\rho(T) = \rho_0(1 + \alpha(T - T_0))$

$V = V_0\sin(2\pi ft)$ $I = \frac{V}{R} = \frac{V_0}{R}\sin(2\pi ft) = I_0\sin(2\pi ft)$

$P = IV$ $\overline{P} = \frac{1}{2}IV = I_{rms}V_{rms}$ $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

$V_{AB} = \mathcal{E} - Ir$ series: $R = R_1 + R_2 + R_3 + ...$ parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

$Q = C\mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right)$ $V_c = \mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right)$ $I = \frac{\mathcal{E}}{R}e^{-\frac{t}{RC}}$ $V_R = \mathcal{E}e^{-\frac{t}{RC}}$

$\overrightarrow{F} = q(\overrightarrow{E} + \overrightarrow{v} \times \overrightarrow{B})$ $\overrightarrow{F} = I\,\overrightarrow{dl} \times \overrightarrow{B}$

$\overrightarrow{\mu} = NI\overrightarrow{A}$ $\overrightarrow{\tau} = \overrightarrow{\mu} \times \overrightarrow{B}$ $\tau = NIAB\sin\theta$ $U = -\overrightarrow{\mu} \cdot \overrightarrow{B}$

$B = \frac{\mu_0}{2\pi}\frac{I}{r}$[T] $\overrightarrow{F} = \frac{\mu}{2\pi}\frac{I_1I_2l}{r}$ [N] $\frac{\overrightarrow{F}}{l} = \frac{\mu}{2\pi}\frac{I_1I_2}{r}$ [N/m]

$d\overrightarrow{B} = \frac{\mu_0}{4\pi}I\frac{\overrightarrow{dl} \times \hat{r}}{r^2}$ $\oint\overrightarrow{B} \cdot \overrightarrow{dl} = \mu I_{encl}$ solenoid: $B = \mu_0 nI$

$\Phi = \int_A \overrightarrow{B} \cdot d\overrightarrow{A}$ $\mathcal{E} = -N\frac{d\Phi}{dt}$ $\mathcal{E} = -Blv$ $E = Bv$

$\mathcal{E} = NBA\omega\sin(\omega t + \phi)$ $I = \frac{NBA\omega}{R}\sin(\omega t + \phi)$ $\omega = 2\pi f$

$V_s = \frac{N_s}{N_p}V_p$ $I_s = \frac{N_p}{N_s}I_p$

$M_{12} = \frac{N_2\Phi_{21}}{I_1} = M_{21} = \frac{N_1\Phi_{12}}{I_2}$ $L = \frac{N\Phi}{I}$ in Henry [H]

$\mathcal{E}_2 = -M_{21}I_1$ $\mathcal{E}_1 = -M_{12}I_2$ $\mathcal{E} = -L\frac{dI}{dt}$

$M = \frac{\mu_0 N_1 N_2 A}{l}$ (coil and solenoid) $L = \frac{\mu_0 N^2 A}{l}$(solenoid)

$U_m = \frac{LI^2}{2}$ $U_e = \frac{CV^2}{2}$ $w_m = \frac{B^2}{2\mu_0}$ $w_e = \frac{\epsilon_0 E^2}{2}$

RC: $Q_C = Q_0(1 - e^{-\frac{t}{\tau}})$ $V_C = V_0(1 - e^{-\frac{t}{\tau}})$ $\tau = RC$

LR: $I_{tot} = \frac{V_0}{R}\left(1 - e^{-t/\tau}\right)$ $V_R = V_0\left(1 - e^{-\frac{t}{\tau}}\right)$ $\tau = \frac{L}{R}$

LC: $I_{tot} = I_0\cos(\omega_0 t)$ $\omega_0 = \sqrt{\frac{1}{LC}}$

LRC: $Q_C = Q_0 e^{-\frac{R}{2L}}\cos(\omega t)$ $V_C = V_0 e^{-\frac{R}{2L}}\cos(\omega t)$ $\omega = \sqrt{\omega_0^2 - \frac{R^2}{2L^2}}$

AC: $X_L = \omega L$ $X_C = \frac{1}{\omega C}$ $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$

$v = \frac{1}{\sqrt{\epsilon_0\mu_0}}$ $v = \lambda f$ $\overrightarrow{S} = \frac{1}{\mu_o}\overrightarrow{E} \times \overrightarrow{B}$ $I = \frac{1}{\mu_o}E_{rms}B_{rms}$ $B = \frac{E}{c}$ $n = \frac{c}{v}$

Reflection: $\theta_i = \theta_r$ Mirrors: $f = \frac{R}{2}$ $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

Refraction: $n_1\sin\theta_1 = n_2\sin\theta_2$ $\sin\theta_c = \frac{n_2}{n_1}$ $\frac{n}{d_o} + \frac{n_2}{d_i} = \frac{n_2 - n_1}{R}$

Lenses: $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$ $P = \frac{1}{f}$ $\frac{1}{d_o} + \frac{1}{d_i} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Double slit: $d\sin\theta = m\lambda$ $d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$ $y = L\tan\theta$

Single slit: $D\sin\theta = m\lambda$ $y = L\tan\theta$ Resolution: $\theta = \frac{1.22\lambda}{D}$

Polarization: $E = E_o\cos\theta$ $I = I_o\cos^2\theta$ $\tan\theta_B = \frac{n_2}{n_1}$
