Physics 21
Fall, 2011

Equation Sheet

speed of light *in vacuo*	c	3.00×10^8 m/s	Planck's constant	h	6.626×10^{-34} J s
Gravitational constant	G	6.67×10^{-11} N m^2/kg^2	Planck's constant/(2π)	$\hbar = h/2\pi$	1.055×10^{-34} J s
Avogadro's Number	N_A	6.02×10^{23} mol^{-1}	electron rest mass	m_e	9.11×10^{-31} kg
Boltzmann's constant	k_B	1.38×10^{-23} J/K	proton rest mass	m_p	1.6726×10^{-27} kg
charge on electron	e	1.60×10^{-19} C	neutron rest mass	m_n	1.6749×10^{-27} kg
free space permittivity	ϵ_0	8.85×10^{-12} C^2/(N m^2)	atomic mass unit	u	1.6605×10^{-27} kg
free space permeability	μ_0	$4\pi \times 10^{-7}$ T m/A	$1/(4\pi\epsilon_0)$	k	8.99×10^9 N m^2/C^2
gravitational acceleration	g	9.807 m/s^2			

$$\mathbf{F}_{\mathbf{2\,on\,1}} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2(\mathbf{r}_1 - \mathbf{r}_2)}{|\mathbf{r}_1 - \mathbf{r}_2|^3}$$

$$\mathbf{F} = q\mathbf{E}$$

$$d\mathbf{E}\,(\text{at }\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\frac{dQ\,(\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3}$$

$$\mathbf{E} = -\nabla V = -\left(\hat{\mathbf{i}}\frac{\partial V}{\partial x} + \hat{\mathbf{j}}\frac{\partial V}{\partial y} + \hat{\mathbf{k}}\frac{\partial V}{\partial z}\right)$$

$$V_f - V_i = -\int_i^f \mathbf{E}\cdot d\mathbf{l}$$

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r};\ dV = \frac{1}{4\pi\epsilon_0}\frac{dQ}{|\mathbf{r} - \mathbf{r}'|}$$

$$u_{\text{elec}} = \tfrac{1}{2}\epsilon_0 E^2,\ u_{\text{mag}} = \frac{1}{2\mu_0}B^2$$

$$\text{Work} = \int \mathbf{F}\cdot d\mathbf{l}$$

$$E_{\text{line}} = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r};\ E_{\text{plane}} = \frac{\sigma}{2\epsilon_0}$$

$$E = \frac{Q}{\epsilon_0 A} = \frac{\sigma}{\epsilon_0} \quad \text{for } \parallel \text{ plate capacitor}$$

$$Q = CV;\ C = \epsilon_0 K\frac{A}{d} = \epsilon\frac{A}{d}$$

$$U_{\text{cap}} = \tfrac{1}{2}CV^2 = \tfrac{1}{2}\frac{Q^2}{C}$$

$$U_{\text{ind}} = \tfrac{1}{2}LI^2$$

$$V = IR \qquad R = \frac{\rho L}{A}$$

$$P = IV \qquad P = I^2 R$$

$$R = mv_\perp/(qB) \quad \text{circ. orbit}$$

$$\mathbf{A}\times\mathbf{B} = \begin{vmatrix} \hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$\xi_i = C_i$ (series) or R_i (parallel):

$$\frac{1}{\xi_{\text{effective}}} = \frac{1}{\xi_1} + \frac{1}{\xi_2}$$

$\xi_i = C_i$ (parallel) or R_i (series):

$$\xi_{\text{effective}} = \xi_1 + \xi_2$$

$$X_R = R,\ X_L = \omega L,\ X_C = \frac{1}{\omega C}$$

RC time constant $= RC$

LR time constant $= L/R$

$Q(t)$ for RLC circuit

$$Q_0 \exp(-Rt/2L)\cos\omega t$$

$$\omega^2 = \frac{1}{LC} - \frac{R^2}{4L^2}$$

$$\mathbf{F} = q\mathbf{v}\times\mathbf{B};\ d\mathbf{F} = I d\mathbf{l}\times\mathbf{B}$$

$$d\mathbf{B} = \frac{\mu_0}{4\pi}\frac{I d\mathbf{l}\times(\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3}$$

long wire: $B = \dfrac{\mu_0 I}{2\pi R}$

center loop: $B = \mu_0 I/2R$

$$I = \frac{dQ}{dt} \qquad I = -neAv_d$$

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

$$\chi_m = \frac{\mu}{\mu_0} - 1$$

$$\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B} \qquad \boldsymbol{\mu} = I\mathbf{A}$$

solenoid $B = \mu_0 n I$

solenoid $L = \mu_0 N^2 A/l$

$$\oint \mathbf{E}\cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$$

$$\oint \mathbf{B}\cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E}\cdot d\mathbf{l} = -\frac{d}{dt}\int \mathbf{B}\cdot d\mathbf{A}$$

$$\oint \mathbf{B}\cdot d\mathbf{l} = \mu_0 I + \mu_0\epsilon_0\frac{d}{dt}\int \mathbf{E}\cdot d\mathbf{A}$$

$$\sin(a \pm b) = \sin a\cos b \pm \cos a \sin b$$

$$\sin(\theta \pm \tfrac{\pi}{2}) = \sin\theta\cos\tfrac{\pi}{2} \pm \cos\theta\sin\tfrac{\pi}{2} = \pm\cos\theta$$

$$\cos(a \pm b) = \cos a\cos b \mp \sin a \sin b$$

$$\sin a + \sin b = 2\cos\left(\frac{a-b}{2}\right)\sin\left(\frac{a+b}{2}\right)$$

$C = 2\pi r$	circumference of circle
$C = \pi d$	circumference of circle
$A = \pi r^2$	area of circle
$A = 4\pi r^2$	surface area of sphere
$V = \frac{4}{3}\pi r^3$	volume of sphere

$$ax^2 + bx + c = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\int \frac{du}{\sqrt{a^2 + u^2}} = \ln\left(u + \sqrt{a^2 + u^2}\right)$$

$$\int \frac{u\,du}{\sqrt{a^2 + u^2}} = \sqrt{a^2 + u^2}$$

$$\int \frac{du}{a^2 + u^2} = \frac{1}{a}\tan^{-1}\left(\frac{u}{a}\right)$$

$$\int \frac{u\,du}{a^2 + u^2} = \tfrac{1}{2}\ln\left(a^2 + u^2\right)$$

$$\int \frac{du}{(a^2 + u^2)^{3/2}} = \frac{u}{a^2\sqrt{a^2 + u^2}}$$

$$\int \frac{u\,du}{(a^2 + u^2)^{3/2}} = -\frac{1}{\sqrt{a^2 + u^2}}$$

$$\int e^{au}\,du = \frac{1}{a}e^{au}$$

$$\int \ln u\,du = u\ln u - u$$

$$\int u^n\,du = \frac{1}{n+1}u^{n+1}$$

$$\int \frac{du}{a + bu} = \frac{1}{b}\ln(a + bu)$$

$$\int \frac{du}{u} = \ln u$$

$$\int_0^{2\pi} \cos^2\theta\,d\theta = \int_0^{2\pi} \sin^2\theta\,d\theta = \pi$$

$$v = \sqrt{T/\rho} \quad (T\text{=tension})$$

$$v = (347.4\,\text{m/s})\sqrt{T/300}$$

$$v = \lambda f = \omega/k$$

$$\omega = 2\pi f \qquad k = 2\pi/\lambda$$

$$T = 1/f \quad (T\text{=period})$$

$$\langle P\rangle = \tfrac{1}{2}\rho A^2\omega^2 v$$

$$\frac{\partial^2 D}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 D}{\partial t^2}$$

$$\mathbf{S} = \frac{1}{\mu_0}(\mathbf{E}\times\mathbf{B})$$

$$\overline{S} = \tfrac{1}{2}\epsilon_0 c E_0^2 = \tfrac{1}{2}\frac{c}{\mu_0}B_0^2 = \frac{E_0 B_0}{2\mu_0} = \frac{E_{\text{rms}}B_{\text{rms}}}{\mu_0}$$

$$c = 1/\sqrt{\epsilon_0\mu_0}$$

$\mathbf{E}\times\mathbf{B} \propto \mathbf{v}$ (plane wave)

$\Delta x\Delta p \gtrsim \hbar$ $\quad(\hbar = h/2\pi)$

$\lambda = h/p$ (de Broglie)

$$-\frac{\hbar^2}{2M}\frac{\partial^2\psi}{\partial x^2} = i\hbar\frac{\partial\psi}{\partial t}$$

$$\text{KE} = p^2/(2M)$$

$$p = \hbar k \qquad E = \hbar\omega = hf$$

$$e^{i\theta} = \cos\theta + i\sin\theta$$

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August 16, 2011