

Physics 21  
Fall, 2004

Equation Sheet

speed of light <i>in vacuo</i>	$c$	$3.00 \times 10^8$ m/s	Planck's constant	$h$	$6.626 \times 10^{-34}$ J s
Gravitational constant	$G$	$6.67 \times 10^{-11}$ N m <sup>2</sup> /kg <sup>2</sup>	Planck's constant/(2π)	$\hbar = h/2\pi$	$1.055 \times 10^{-34}$ J s
Avogadro's Number	$N_A$	$6.02 \times 10^{23}$ mol <sup>-1</sup>	electron rest mass	$m_e$	$9.11 \times 10^{-31}$ kg
Boltzmann's constant	$k_B$	$1.38 \times 10^{-23}$ J/K	proton rest mass	$m_p$	$1.6726 \times 10^{-27}$ kg
charge on electron	$e$	$1.60 \times 10^{-19}$ C	neutron rest mass	$m_n$	$1.6749 \times 10^{-27}$ kg
free space permittivity	$\epsilon_0$	$8.85 \times 10^{-12}$ C <sup>2</sup> /N m <sup>2</sup>	atomic mass unit	$u$	$1.6605 \times 10^{-27}$ kg
free space permeability	$\mu_0$	$4\pi \times 10^{-7}$ T m/A		$k$	$8.99 \times 10^9$ N m <sup>2</sup> /C <sup>2</sup>

$$\mathbf{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r_{21}^3} (\mathbf{r}_1 - \mathbf{r}_2)$$

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

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

$$\mathbf{E} = -\nabla V$$

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

$$V_b - V_a = -\int_a^b \mathbf{E} \cdot d\mathbf{l}$$

$$V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

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

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

$$Q = CV$$

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

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

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

$$V = IR \text{ or } V - IR = 0$$

$$R = \rho \frac{l}{A} \quad \sigma = \frac{1}{\rho}$$

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

$$E = \frac{\sigma}{\epsilon_0} \text{ parallel plate capacitor}$$

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

$C$ 's in series or  $R$ 's in parallel:

$$\frac{1}{X_{\text{eff}}} = \frac{1}{X_1} + \frac{1}{X_2}$$

$C$ 's in parallel or  $R$ 's in series:

$$X_{\text{eff}} = X_1 + X_2$$

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

$$RC \text{ time constant} = RC$$

$$LR \text{ time constant} = L/R$$

$Q(t)$  for  $RLC$  circuit

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

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

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B} \text{ or } \mathbf{l} \times \mathbf{B}$$

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

$$\text{field of long wire: } B = \frac{\mu_0 I}{2\pi R}$$

$$I = \frac{dQ}{dt}$$

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

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

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

$$\text{solenoid } B = \mu_0 nI$$

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

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

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

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

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

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

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

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

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

$$C = 2\pi r \quad \text{circumference of circle}$$

$$C = \pi d \quad \text{circumference of circle}$$

$$A = \pi r^2 \quad \text{area of circle}$$

$$A = 4\pi r^2 \quad \text{surface area of sphere}$$

$$V = \frac{4}{3}\pi r^3 \quad \text{volume of sphere}$$

$$ax^2 + bx + c = 0 \Rightarrow$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$$v = (348 \text{ m/s}) \sqrt{T/300}$$

$$v = f\lambda$$

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

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

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

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

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

$$\bar{S} = \frac{1}{2} \epsilon_0 c E_0^2 = \frac{1}{2} \frac{c}{\mu_0} B_0^2$$

$$= \frac{E_0 B_0}{2\mu_0} = \frac{E_{\text{rms}} B_{\text{rms}}}{\mu_0}$$

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

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

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

$$\lambda = h/p \quad (\text{de Broglie})$$

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

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

$$p = \hbar k \quad E = \hbar \omega$$

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

