UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 106-4 / LeClair Fall 2008

Exam I Sample Formula Sheet

Constants:

$$\begin{aligned} k_e &\equiv 1/4\pi\epsilon_o = 8.98755\times10^9\,\mathrm{N\cdot m^2\cdot C^{-2}} \\ \epsilon_o &= 8.85\times10^{-12}\,\mathrm{C^2/N\cdot m^2} \\ e &= 1.60218\times10^{-19}\,\mathrm{C} \\ m_{e^-} &= 9.10938\times10^{-31}\,\mathrm{kg} \\ m_{p^+} &= 1.67262\times10^{-27}\,\mathrm{kg} \end{aligned}$$

Basic Equations:

$$\begin{aligned} 0 &= ax^2+bx^2+c \Longrightarrow x=\frac{-b\pm\sqrt{b^2-4ac}}{2a} \\ \vec{\mathbf{F}}_{\rm net} &= m\vec{\mathbf{a}} \ \text{Newton's Second Law} \\ \vec{\mathbf{F}}_{\rm centr} &= -\frac{mv^2}{r}\hat{\mathbf{r}} \ \text{Centripetal} \end{aligned}$$

Electric Force & Field:

$$\vec{\mathbf{F}}_{12}=k_e\frac{q_1q_2}{r^2}\,\hat{\mathbf{r}}=q_2\vec{\mathbf{E}}_1$$

$$\vec{\mathbf{E}}_1=\vec{\mathbf{F}}_{12}/q_2=k_e\frac{q_1}{r^2}\,\hat{\mathbf{r}}$$

$$\vec{\mathbf{E}}=k_e\sum_i\frac{q_i}{r_i^2}\,\hat{\mathbf{r}}_i\rightarrow k_e\int\frac{dq}{r^2}\,\hat{\mathbf{r}}=k_e\int\frac{\rho\hat{\mathbf{r}}}{r^2}\,dV_{ol}$$

$$\Phi_E=\oint\vec{\mathbf{E}}\cdot d\vec{\mathbf{A}}=4\pi k_eq_{\rm encl}=\frac{q_{\rm encl}}{\epsilon_o}$$

Electric Potential:

$$\oint\vec{\mathbf{E}}\cdot d\vec{\mathbf{l}}=0$$

$$\Delta U=-W=-q\int_A^B\vec{\mathbf{E}}\cdot d\vec{\mathbf{l}} \qquad q \text{ moved from } A \text{ to } B \text{ in } \vec{\mathbf{E}}$$

$$\Delta V=V_B-V_A=\frac{\Delta U}{q}=-\int_A^B\vec{\mathbf{E}}\cdot d\vec{\mathbf{l}}$$

constant E: $\Delta U=q\Delta V=-q|\vec{\mathbf{E}}||\Delta\vec{\mathbf{x}}|\cos\theta=-qE_x\Delta x$

$$V_{\rm point}=k_e\frac{q}{r}$$

$$U_{\text{pair of point charges}}=k_e\frac{q_1q_2}{r_{12}}=V_1q_2=V_2q_1$$

$$U_{\rm system}=\text{sum over unique pairs}=\sum_{\text{pairs }ij}\frac{k_eq_iq_j}{r_{ij}}$$

$$U_{\rm field}=\frac{1}{2}\int\epsilon_oE^2\,dV_{ol}=\frac{1}{2}\int\rho V\,dV_{ol}$$

$$V=k_e\int\frac{dq}{r} \quad \text{continuous}$$

$$E_x=-\frac{dV}{dx}\rightarrow\vec{\mathbf{E}}=-\vec{\boldsymbol{\nabla}}V$$

Ohm:

$$\begin{aligned} \Delta V &= IR \\ \vec{\mathbf{J}} &= \sigma\vec{\mathbf{E}} \\ \mathscr{P} &= E\cdot\Delta t=I\Delta V=I^2R=\frac{[\Delta V]^2}{R} \quad \text{power} \end{aligned}$$

Current:

$$\begin{aligned} I &= \int_S\vec{\mathbf{J}}\cdot d\vec{\mathbf{A}}\xrightarrow{\text{uniform J}}I=\frac{dQ}{dt}=nqAv_d \\ J &= \sum_k n_kq_kv_k\xrightarrow{\text{uniform J}}J=\frac{I}{A}=nqv_d \\ \int_S\vec{\mathbf{J}}\cdot d\vec{\mathbf{A}} &= -\frac{d}{dt}\int_V\rho\,dV_{ol} \\ \vec{\mathbf{v}}_d &= \frac{q\tau}{m}\vec{\mathbf{E}} \quad \tau=\text{scattering time} \\ \rho &= 1/\sigma=\frac{m}{nq^2\tau} \\ R &= \frac{\varrho l}{A} \\ \mathscr{P} &= E\cdot\Delta t=I\Delta V \quad \text{power} \end{aligned}$$

Other:

$$\left(\vec{\mathbf{E}}_2-\vec{\mathbf{E}}_1\right)\cdot\hat{\mathbf{n}}=4\pi k_e\sigma \quad \text{sheet of charge with } \sigma$$

$$F_{\rm sheet}=\frac{\sigma}{2}\left(E_1+E_2\right)$$

Capacitors:

$$\begin{aligned} Q_{\rm capacitor} &= C\Delta V \\ C_{\text{parallel plate}} &= \frac{\epsilon_0A}{d} \\ U_{\rm capacitor} &= \frac{1}{2}Q\Delta V=\frac{Q^2}{2C}=C\left(\Delta V\right)^2 \\ C_{\text{eq, par}} &= C_1+C_2+C_3+\cdots \\ 1/C_{\text{eq, series}} &= 1/C_1+1/C_2+1/C_3+\cdots \\ C_{\text{with dielectric}} &= \kappa C_{\text{without}} \qquad \kappa_{\rm air}=1 \end{aligned}$$

Vectors:

$$|\vec{\mathbf{F}}|=\sqrt{F_x^2+F_y^2} \quad \text{magnitude}$$

$$\theta=\tan^{-1}\left[\frac{F_y}{F_x}\right] \quad \text{direction}$$

$$d\vec{\mathbf{l}}=dx\,\hat{\mathbf{x}}+dy\,\hat{\mathbf{y}}+dz\,\hat{\mathbf{z}}$$

let $\vec{\mathbf{a}}=a_x\,\hat{\mathbf{x}}+a_y\,\hat{\mathbf{y}}+a_z\,\hat{\mathbf{z}}$ and $\vec{\mathbf{b}}=b_x\,\hat{\mathbf{x}}+b_y\,\hat{\mathbf{y}}+b_z\,\hat{\mathbf{z}}$

$$\vec{\mathbf{a}}\cdot\vec{\mathbf{b}}=a_xb_x+a_yb_y+a_zb_z=\sum_{i=1}^n a_ib_i=|\vec{\mathbf{a}}||\vec{\mathbf{b}}|\cos\theta$$

if $\vec{\mathbf{a}}\perp\vec{\mathbf{b}}$, then $\vec{\mathbf{a}}\cdot\vec{\mathbf{b}}=0$

Derived unit	Symbol	equivalent to
newton	N	kg·m/s^2
joule	J	kg·m^2/s^2 = N·m
watt	W	J/s=m^2·kg/s^3
coulomb	C	A·s
V	W/A = m^2·kg/·s^3·A	
farad	F	C/V = A^2·s^4/m^2·kg
ohm	Ω	V/A = m^2·kg/s^3·A^2
electron volt	eV	1.6×10^{-19} J
-	1 N/C	1 V/m

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T