

PHYSICS 208 EXAM II: Spring 2008

Formula/Information Sheet

• Basic constants:

Gravitational acceleration	g	$=$	9.8 m/sec^2
Permittivity of free space	ϵ_0	$=$	$8.8542 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$
Coulomb constant	$k = 1/4\pi\epsilon_0$	$=$	$8.9875 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
Permeability of free space	μ_0	$=$	$4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$ [$k_m = \mu_0/4\pi = 10^{-7} \text{ Wb/A}\cdot\text{m}$]
Elementary charge	e	$=$	$1.60 \times 10^{-19} \text{ C}$
Unit of energy: electron volt	1 eV	$=$	$1.60 \times 10^{-19} \text{ J}$
Unit of energy: kilowatt-hour	1 kWh	$=$	$3.6 \times 10^6 \text{ J}$

• Properties of some particles:

Proton	mass = $1.67 \times 10^{-27} \text{ kg}$	charge = $+1.60 \times 10^{-19} \text{ C}$
Electron	mass = $9.11 \times 10^{-31} \text{ kg}$	charge = $-1.60 \times 10^{-19} \text{ C}$
Neutron	mass = $1.67 \times 10^{-27} \text{ kg}$	charge = 0

• Some indefinite integrals:

$$\int \frac{dx}{x} = \ln x \quad \left| \quad \int \frac{dx}{a+bx} = \frac{1}{b} \ln(a+bx) \right.$$

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}} \quad \left| \quad \int \frac{x dx}{(x^2+a^2)^{3/2}} = -\frac{1}{\sqrt{x^2+a^2}} \right.$$

$$\int \frac{dx}{\sqrt{x^2\pm a^2}} = \ln(x + \sqrt{x^2\pm a^2}) \quad \left| \quad \int \frac{x dx}{\sqrt{x^2\pm a^2}} = \sqrt{x^2\pm a^2} \right.$$

Coulomb's law		$ \vec{F} = k \frac{ q_1 q_2 }{r^2}$
Electric field [N/C = V/m] (point charge q)		$\vec{E}(r) = k \frac{q}{r^2} \hat{r}$
		(\hat{r} = unit vector radially from q)
	(group of charges)	$\vec{E} = \sum \vec{E}_i = k \sum \frac{q_i}{r_i^2} \hat{r}_i$
	(continuous charge distribution)	$\vec{E} = k \int \frac{dq}{r^2} \hat{r}$
		(\hat{r} = unit vector radially from dq)
Electric force [N] (on q in \vec{E})		$\vec{F} = q \vec{E}$

Electric flux	(through a small area ΔA_i)	$\Delta \Phi_i = \vec{E}_i \cdot \Delta \vec{A}_i = E_i \Delta A_i \cos \theta_i$
	(through an entire surface area)	$\Phi_{surface} = \lim_{\Delta A \rightarrow 0} \sum \Delta \Phi_i = \int \vec{E} \cdot d\vec{A}$
Gauss' law	(through a closed surface area)	$\Phi_{closed} \equiv \oint \vec{E} \cdot d\vec{A} = \frac{Q_{in}}{\epsilon_0}$

Electric potential [V = J/C] (definition)		$\Delta V = V_B - V_A = - \int_A^B \vec{E} \cdot d\vec{s}$
	(\vec{E} = constant)	$\Delta V = -\vec{E} \cdot (\vec{r}_B - \vec{r}_A)$
	(point charge q)	$V(r) = k \frac{q}{r}$ (with $V(\infty) = 0$)
	(group of charges)	$V(\vec{r}) = \sum V_i(\vec{r}_i - \vec{r}) = k \sum \frac{q_i}{ \vec{r}_i - \vec{r} }$
		($V_i(\infty) = 0$)
	(continuous charge distribution)	$V(\vec{r}) = k \int \frac{dq}{ \vec{r}' - \vec{r} }$
		($V(\infty) = 0$)
Electric potential energy [J] (definition)		$\Delta U = U_B - U_A = -q_0 \int_A^B \vec{E} \cdot d\vec{s}$
		$= q_0 (V_B - V_A)$
\vec{E} from V		$\vec{E} = -\vec{\nabla} V,$
	where $\vec{\nabla}$ = gradient operator can be expressed	$\hat{i}(\partial/\partial x) + \hat{j}(\partial/\partial y) + \hat{k}(\partial/\partial z)$
Electric potential energy of two-charge system		$U_{12} = k \frac{q_1 q_2}{r_{12}}$

Capacitance [F] (definition)	$C \equiv \frac{Q}{ \Delta V }$
(parallel-plate capacitance)	$C = K \frac{\epsilon_0 A}{d}$
Dielectrics in capacitors	$C = KC_o$
Electrostatic potential energy [J] stored in capacitance	$U_E(t) = \frac{1}{2} \frac{Q(t)^2}{C}$
Energy density [J/m ³] in an Electric field	$u = \frac{1}{2} \epsilon E^2$
Electric dipole moment ($2a =$ separation between two charges)	$ \vec{p} = 2aq$
Torque on electric dipole moment	$\vec{\tau} = \vec{p} \times \vec{E}$
Potential energy of an electric dipole moment	$U = -\vec{p} \cdot \vec{E}$

Current [A] (definition)	$I \equiv \frac{dQ(t)}{dt}$
with motion of charges	$I = nqv_d A$
Current density [A/m ²]	$J = \frac{I}{A}$ (where $I = \int \vec{J} \cdot \vec{n} dA$)
Resistivity [$\Omega \cdot m$]	$\rho = \frac{ \vec{E} }{ \vec{J} }$
Resistance [Ω] (definition)	$R \equiv \frac{V}{I}$
for uniform cross-sectional area A	$R = \rho \frac{\ell}{A}$
Energy loss rate on R [J/s]	$P = I^2 R = V^2/R = IV$
Time constant in RC circuit [s]	$\tau_{RC} = RC$
Charging an RC circuit [q(t)]	$q(t) = q_f(1 - e^{-t/RC})$
Discharging an RC circuit [q(t)]	$q(t) = q_o e^{-t/RC}$