Midterm 2 Equations	PHSX519 Electrom
$\label{eq:continuous_def} \boldsymbol{\nabla} \cdot \mathbf{D} = \boldsymbol{\rho}_f, \boldsymbol{\nabla} \times \mathbf{E} = 0, \boldsymbol{\nabla} \cdot \mathbf{B} = 0,$	$ abla imes \mathbf{H} = \mathbf{J}_f$ Maxwell's equations in matter
$\mathbf{E}(\mathbf{x}) = \frac{1}{4\pi\epsilon_0} \int \rho(\mathbf{x}') \frac{\mathbf{x} - \mathbf{x}'}{ \mathbf{x} - \mathbf{x}' ^3} d^3x'$	Coulomb's Law (1.5)
$\delta(f(x)) = \sum_{i} \frac{1}{\left \frac{\mathrm{d}f}{\mathrm{d}x}(x_{i})\right } \delta(x - x_{i})$	Delta function Rule 5
$\oint_{S} \mathbf{E} \cdot \mathbf{n} \ da = \frac{1}{\epsilon_{0}} \int_{V} \rho(\mathbf{x}) d^{3}x$	Gauss' Law (1.11)
$\mathbf{E} = -\nabla \Phi$	Electric field in terms of scalar potential (1.16)
$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(\mathbf{x'})}{ \mathbf{x} - \mathbf{x'} } d^3x'$	Scalar potential in terms of charge density (1.17)
$\nabla^2 \Phi = -\rho/\epsilon_0$	Poisson Equation (1.28)
$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0} \int_V \rho(\mathbf{x}') G_D(\mathbf{x}, \mathbf{x}') d^3 x' =$	$\frac{1}{4\pi} \oint_{S} (\mathbf{x}') \frac{\partial G_D}{\partial n'} da'$ DBCs (1.44)
$\Phi(\mathbf{x}) = \langle \Phi \rangle_S + \frac{1}{4\pi\epsilon_0} \int_V \rho(\mathbf{x}') G_N(\mathbf{x}, \mathbf{x}')$	$d^3x + \frac{1}{4\pi} \oint_S \frac{\partial \Phi}{\partial n'} G_N da'$ NBCs (1.46)
$\frac{1}{ \mathbf{x} - \mathbf{x}' } = 4\pi \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} \frac{1}{2\ell+1} \frac{r_{<}^{\ell}}{r_{>}^{\ell+1}} Y_{\ell}^{r_{<}}$	${}^*_m(\theta',\phi')Y_{\ell m}(\theta,\phi) \qquad \qquad \text{GFE: } r,\theta,\phi \text{ (3.70)}$
$\frac{1}{ \mathbf{x} - \mathbf{x}' } = \frac{2}{\pi} \sum_{m = -\infty}^{\infty} \int_{0}^{\infty} dk e^{im(\phi - \phi')}$	$\cos[k(z-z')]I_m(k\rho_{<})K_m(k\rho_{>})$ GFE (3.148)
Where $r_{<}(r_{>})$ $[\rho_{<}(\rho_{>})]$ is the smaller ((larger) of $ \mathbf{x} $ and $ \mathbf{x'} $
$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0} \sum_{l=0}^{\infty} \sum_{m=-l}^{l} \frac{4\pi}{2l+1} q_{lm} \frac{Y_{lm}}{r^{l+1}}$	Potential outside spher of charge (4.1)
$q_{lm} = \int Y_{lm}^*(\boldsymbol{\theta}', \boldsymbol{\phi}') r'^l \rho(\mathbf{x}') \ d^3x'$	Multipole moments (4.3)
$q = \int \rho(\mathbf{x'}) \ d^3x'$	Monopole (4.4)
$\mathbf{p} = \int \mathbf{x'} \rho(\mathbf{x'}) \ d^3x'$	Dipole (4.8)
$Q_{ij} = \int (3x_i'x_j' - r'\delta_{ij})\rho(\mathbf{x}')d^3x' = 3M$	$T_{ij} - \text{Tr}(\mathbf{M}\delta_{ij})$ Quadrupole (4.9)
$M_{ij} = \int x_i' x_j' \rho(x') d^3x$	Dana definition
$\Phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0} \left[\frac{q}{r} + \frac{\mathbf{p} \cdot \mathbf{x}}{r^3} + \frac{1}{2} \sum_{i,j} Q_{ij} \frac{x_i^2}{r^5} \right]$	$\frac{\mathcal{E}_j}{\mathcal{E}_j} + \dots$ Multipole Expansion (4.10)
$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}$	Electric displacement (4.34)
$\mathbf{P} = \epsilon_0 \chi_e \mathbf{E}$ $\mathbf{P} = (\epsilon - \epsilon_0) \mathbf{E}$	Induced polarization (4.36) Better expression for polarization
$\mathbf{D} = \epsilon \mathbf{E}$	Electric displacement (4.37)
$\epsilon = \epsilon_0 (1 + \chi_e)$ $\sigma_b = \mathbf{P} \cdot \hat{\mathbf{n}}, \rho_b = -\nabla \cdot \mathbf{P}$	Electric permittivity (4.38) Electric bound charge density (G. 4.11)
$\begin{cases} (\mathbf{D}_2 - \mathbf{D}_1) \cdot \mathbf{n}_{21} = \sigma \\ (\mathbf{E}_2 - \mathbf{E}_1) \times \mathbf{n}_{21} = 0 \end{cases}$	Boundary conditions (4.40)
$\begin{cases} \Phi_{\rm in} = -\left(\frac{3}{\epsilon/\epsilon_0 + 2}\right) E_0 r \cos \theta \\ \Phi_{\rm out} = -E_0 r \cos \theta + \left(\frac{\epsilon/\epsilon_0 - 1}{\epsilon/\epsilon_0 + 2}\right) E_0 \frac{\epsilon^3}{r^2} \end{cases}$	Dielectric sphere in ${\bf E}=E_0{\bf \hat{z}}$ (4.54)
$W = \int \rho(\mathbf{x})\Phi(\mathbf{x}) d^3x = \frac{1}{2} \int \mathbf{E} \cdot \mathbf{D} d^3x$	Energy to bring charges from ∞ (4.83,89)
$\Delta W = -\frac{1}{2} \int_{V_{\bullet}} \mathbf{P} \cdot \mathbf{E}_0 \ d^3 x$	Dielectric placed in \mathbf{E}_0 (4.93)
$W = q\Phi(0) - \mathbf{p} \cdot \mathbf{E}(0) - \frac{1}{6} \sum_{i} \sum_{j} Q_{ij} \frac{\partial E}{\partial x_{i}}$	$\frac{j}{2}(0) + \dots$ Work multipole expsn. (4.24)
$6 \frac{1}{i} \frac{1}{j} + \partial x_i$ $\mathbf{N} = \mathbf{p} \times \mathbf{E}$	i Torque on electric dipole (G. 4.4)
$\mathbf{F} = (\mathbf{P} \cdot \nabla)\mathbf{E}$ $\begin{pmatrix} a^3 \end{pmatrix}$	Force on electric dipole (G. 4.5)
r^2	potential of conducting sphere in $\mathbf{E} = E_0 \hat{\mathbf{z}}$ (2.14)
$E_T = rac{2p\cos heta}{4\pi\epsilon_0}, E_ heta = rac{2p\sin heta}{4\pi\epsilon_0}$ $3\mathrm{n}(\mathbf{p}\cdot\mathbf{n}) - \mathbf{p}$	Electric dipole at origin in $\hat{\mathbf{z}}$ (4.12)
$\mathbf{E}(\mathbf{x}) = \frac{3\mathbf{n}(\mathbf{p} \cdot \mathbf{n}) - \mathbf{p}}{4\pi\epsilon_0 \mathbf{x} - \mathbf{x}_0 ^3}$	E-field due to dipole p (4.13)
$\mathbf{N} = \mathbf{m} \times \mathbf{B}$ $\nabla \cdot \mathbf{J} = 0$	Torque on magnetic dipole moment (5.1) Condition of magnetostatics (5.3)
$d\mathbf{B} = kI \frac{d1 \times \mathbf{x}}{ \mathbf{x} ^3}$	Biot-Savart Law (5.4)
$\oint_C \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$	Ampère's law (5.25)
$\mathbf{B}(\mathbf{x}) = \nabla \times \mathbf{A}(\mathbf{x})$ $\mu_0 \int \mathbf{J}(\mathbf{x}') \mathbf{a} \mathbf{J}'$	Magnetic vector potential (5.27)
$4\pi^{-J} \mathbf{x} - \mathbf{x}' $	etic vector potential of current distribution (5.32)
$\mathbf{m} = \frac{1}{2} \int \mathbf{x}' \times \mathbf{J}(\mathbf{x}') \ d^3 x$ $I f$	Magnetic moment definition (5.54)
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 $\mathbf{m} = \frac{1}{2} \oint \mathbf{x} \times d\mathbf{l}$ $|\mathbf{m}| = I \times (\text{Area})$ $\mathbf{A}(\mathbf{x}) = \frac{\mu_0}{4\pi} \frac{\mathbf{m} \times \mathbf{x}}{|\mathbf{x}|^3}$ $\mathbf{B}(\mathbf{x}) = \frac{\mu_0}{4\pi} \left[\frac{3\mathbf{n}(\mathbf{n} \cdot \mathbf{m}) - \mathbf{m}}{|\mathbf{x}|^3} \right]$

 $\mathbf{F} = \mathbf{\nabla}(\mathbf{m} \cdot \mathbf{B})$

Roy Smart	Theory 1	HSX519 Electromagne	
$\frac{1}{\mu_0} \mathbf{B} - \mathbf{M}$ Magnetic field (5.81)		l's equations in matter $H = -$	$ abla imes \mathbf{H} = \mathbf{J}_f$ Maxwell's equ
Magnetization in linear media (G. 6.29)	$\mathbf{M}=(\mu/\mu_0-1)\mathbf{H}$ Magnetization in linear media (G. 6		Cou
$\mathbf{B} = \mu \mathbf{H}$ Linear condition (5.84) $\begin{cases} (\mathbf{B}_2 - \mathbf{B}_1) \cdot \mathbf{n} = 0 \\ \mathbf{n} \times (\mathbf{H}_2 - \mathbf{H}_1) = \mathbf{K}_f \end{cases}$ Interface BC (5.86)		D.1: 6 D.1 *	Delta
Magnetic scalar potential (5.93)	•	$(\mathbf{n} \times \mathbf{Gauss'} \text{ Law } (1.11) \mathbf{H} = -$	(
Bound current density (G. 6.13,14) Effective magnetic charge density (5.96,99)	$\mathbf{K}_{b} = \mathbf{M} \times \mathbf{n}$ $\mathbf{M}, \mathbf{K}_{b} = \mathbf{M} \times \mathbf{n}$ $\mathbf{M}, \sigma_{M} = \mathbf{n} \cdot \mathbf{M}$	scalar potential (1.16) ${f J}_M = {f ho}_M =$	Electric field in terms of scala
$\Phi_M(\mathbf{x}) = \frac{\mathbf{m} \cdot \mathbf{x}}{4\pi r^3}$ Magnetic scalar potential of dipole (J. pg. 196)		f charge density (1.17) $\Phi_M(\mathbf{x})$	Scalar potential in terms of char
Total magnetic moment (J. pg. 197)	t^3x	oisson Equation (1.28) $\mathbf{m} = \int$	
terms of magnetic vector potential (5.101)	· 1/1	DBCs (1.44) $\nabla^2 \mathbf{A} =$	$\frac{1}{4\pi} \oint_{S} (\mathbf{x}') \frac{\partial G_{D}}{\partial n'} da'$
$\frac{\langle \mathbf{n'} \rangle}{ \mathbf{r'} } da'$ Discontinuous M (5.103)	$\int_{V} \frac{\nabla' \times \mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \oint_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}' } d^{3}x + \frac{\mu_{0}}{4\pi} \int_{S} \frac{\mathbf{M}(\mathbf{x}')}{ \mathbf{x} - \mathbf{x}$		$d^3x + \frac{1}{4\pi} \oint_S \frac{\partial \Phi}{\partial n'} G_N da'$
e with $\mathbf{M} = M_0 \hat{\mathbf{z}} [(r_{<}, r_{>}), (r, a)]$ (5.104)	$= \frac{1}{3} M_0 a^2 \frac{r}{r^2} \cos \theta \qquad \text{Sphere}$	GFE: r, θ, ϕ (3.70) $\Phi_M(r, \theta)$	$\hat{Y}_{m}(\theta', \phi') Y_{\ell m}(\theta, \phi)$ G
where in uniform magnetic field ${f B}_0$ (5.115)	$\mu + 2\mu_0$	$n(\kappa p >)$ GFE (3.148)	$\int \cos[k(z-z')]I_m(k ho <)K_m(k ho >$
Magnetic flux (5.133)	n da	$F=\int_{\Omega}$	(larger) of $ \mathbf{x} $ and $ \mathbf{x'} $
$\mathcal{E} = \oint_C \mathbf{E'} \cdot d\mathbf{l}$ Electromotive force (5.134)		$\mathscr{E} = \oint_{\mathcal{C}} \operatorname{espher of charge} (4.1)$	Potential outside sph
$= -k \frac{\mathrm{d}F}{\mathrm{d}t}$ Faraday's Law (5.135)		€ = -	
$W = \frac{1}{2} \int \mathbf{J} \cdot \mathbf{A} \ d^3x$ Energy to ramp current from zero (4.83)::(5.149)			Multipo
$W = \frac{1}{2} \int \mathbf{H} \cdot \mathbf{B} \ d^3x$ Magnetic energy in fields (4.89)::(5.148)		Monopole (4.4) $W = \frac{1}{2}$	
Power in magetic field (5.147)	$\mathbf{H} \cdot \frac{\mathrm{d}\mathbf{B}}{\mathrm{d}t} d^3x$	Dipole (4.8) $\frac{dW}{dt} = \frac{dW}{dt}$	$T_{ij} = \operatorname{Tr}(\mathbf{M}\delta_{ij})$
ace permeable object in \mathbf{B}_0 (4.93)::(5.150)			ij(ij)
Change in energy due to EMF	$\int \mathbf{J} \cdot \mathbf{E} \ d^3 x$	ipole Expansion (4.10) $\frac{dW}{dt}$	$\left[\frac{x_j}{5} + \dots\right]$ Multipole
(x) d^3x	$\left \mathbf{H}\right ^{2} d^{3}x = \frac{\mu_{0}}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \int \Phi_{M_{j}}(\mathbf{x}) \rho_{M_{j}}$	tric displacement (4.34) $W = \frac{1}{2}$ ced polarization (4.36)	
Inductive energy (5.152)	$L_{i}I_{i}^{2} + \sum_{i=1}^{N} \sum_{j>i}^{N} M_{ij}I_{i}I_{j}$		Electric dis
Mutual inductance (5.156)	F_{ij}	tric permittivity (4.38) marge density (G. 4.11) $M_{ij} =$	Electric po Electric bound charge
	$B_z(0,z) - \left(\frac{\rho^2}{4}\right) \left[\frac{\partial^2 B_z(0,z)}{\partial z^2}\right] + \dots$	ndary conditions (4.40) $B_z(\rho,$	Boundary
wn $\mathbf{J} = 0$, ϕ -sym, near origin (J Pr. 5.4)	$-\left(\frac{\rho}{2}\right)\frac{\partial B_z(0,z)}{\partial z} + \dots \qquad B_z \text{ km}$	here in $\mathbf{E} = E_0 \hat{\mathbf{z}}$ (4.54) $B_{\rho}(\rho,$	Dielectric sphere in $f \cos \theta$
$z = \frac{\mu_0 Ia}{2} \int_0^\infty J_1(ka) J_1(k\rho) dk$ A of current ring (J. PR. 5.10)	$\frac{\mu_0 Ia}{\pi} \int_0^\infty \cos(kz) I_1(k\rho_{<}) K_1(k\rho_{>}) dz$	arges from ∞ (4.83,89) $A_{\phi}(\rho,$	Energy to bring charges
$\mathbf{A}_{\mathrm{dip}} = \frac{\mu_0}{4\pi} \frac{m \sin \theta}{r^2} \Rightarrow \mathbf{B}_{\mathrm{dip}} = \frac{\mu_0 m}{4\pi r^3} (2 \cos \theta \hat{\mathbf{r}} + \sin \theta \hat{\boldsymbol{\theta}})$ Field of dipole (G 5.87,88)		ric placed in \mathbf{E}_0 (4.93) $\mathbf{A}_{\mathrm{dip}}$:	Dielectric pla
$ au = I\alpha = -rac{\partial W}{\partial a} = \mathbf{r} \times \mathbf{F}$ Mechanical torqu			$\frac{j}{i}(0) + \dots$ Work multip
$I = \int r^2 \rho(x, y, z) \ d^3x$ Moment of inertia		electric dipole (G. 4.4) $I = \int$	
$\frac{V}{-} < 0 \Rightarrow \text{Unstable}$	\Rightarrow Stable, $\frac{\partial^2 W}{\partial a^2} = 0 \Rightarrow$ Saddle, $\frac{\partial^2 W}{\partial a^2} = 0 \Rightarrow$	electric dipole (G. 4.5) $\frac{\partial^2 W}{\partial x^2}$	
	oq o	0 () 04	potential of conducting sphere in
$(a+x)^n = a^n + na^{n-1}x + \frac{n(n-1)}{2!}a^{n-2}x^2 + \dots =$ Binomial Expansion $f(x) \approx f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!}(x-a)^2 + \dots$ Taylor Series		ole at origin in z (4.12)	Electric dipole at
	1! 2!	due to dipole p (4.13)	E-field due t
$ \begin{array}{cccc} & \inf \theta \cos \phi & \sin \theta \sin \phi & \cos \theta \\ \cos \theta \cos \phi & \cos \theta \sin \phi & -\sin \theta \\ & -\sin \phi & \cos \phi & 0 \end{array} \right) \begin{pmatrix} \hat{\mathbf{x}} \\ \hat{\mathbf{y}} \\ \hat{\mathbf{z}} \end{pmatrix} $	$\begin{array}{ccc} \cos \phi & \sin \phi & 0 \\ -\sin \phi & \cos \phi & 0 \\ 0 & 0 & 1 \end{array} \begin{pmatrix} \mathbf{\hat{x}} \\ \mathbf{\hat{y}} \\ \mathbf{\hat{z}} \end{pmatrix}, \begin{pmatrix} \mathbf{\hat{f}} \\ \mathbf{\hat{\theta}} \\ \mathbf{\hat{\phi}} \end{pmatrix} = \begin{pmatrix} \mathbf{\hat{f}} \\ \mathbf{\hat{\phi}} \\ \mathbf{\hat{\phi}} \end{pmatrix}$	ic dipole moment (5.1) $\begin{pmatrix} \hat{\boldsymbol{p}} \\ \hat{\boldsymbol{\phi}} \\ \hat{\boldsymbol{z}} \end{pmatrix} =$ of magnetostatics (5.3)	Torque on magnetic dip Condition of mag
$ \begin{pmatrix} \sqrt{\rho^2 + z^2} & z/\sqrt{\rho^2 + z^2} & 0\\ 0 & 0 & 1\\ \sqrt{\rho^2 + z^2} & -\rho/\sqrt{\rho^2 + z^2} & 0 \end{pmatrix} \begin{pmatrix} \hat{\mathbf{r}} \\ \hat{\theta} \\ \hat{\phi} \end{pmatrix} $	$ \begin{array}{ccc} \sin \theta & 0 & \cos \theta \\ \cos \theta & 0 & -\sin \theta \\ 0 & 1 & 0 \end{array} \right) \begin{pmatrix} \hat{\boldsymbol{p}} \\ \hat{\boldsymbol{\phi}} \\ \hat{\boldsymbol{z}} \end{pmatrix}, \begin{pmatrix} \hat{\boldsymbol{p}} \\ \hat{\boldsymbol{\phi}} \\ \hat{\boldsymbol{z}} \end{pmatrix} = \begin{pmatrix} \boldsymbol{r} \\ \boldsymbol{\theta} \\ \hat{\boldsymbol{z}} \end{pmatrix} $	Biot-Savart Law (5.4) $\begin{pmatrix} \hat{\mathbf{r}} \\ \hat{\boldsymbol{\theta}} \\ \hat{\boldsymbol{\phi}} \end{pmatrix}$	Biot
/ V P 1 - P / V P 1 - 9 /	$= \left[A_i r^l + B_i^{-(l+1)} \right] P_l(\cos \theta), \mathbf{K} =$	Ampère's law (5.25) $\Phi_i(r,\theta)$	
	$\frac{1}{(l+1)\mu_I} \left(\frac{1}{A_I a^{2l+1} (\mu_I - \mu_{II})} \right)$		_
	1		etic vector potential of current d
$(1) + A_I(2l+1)\mu_I a^{2l+1} - K_0(l+1)\mu_I a^{l+2}$	$\mu_{II} + (l+1)\mu_{I}$ $\Big \Big \Big$	oment definition (5.54) $A_{II} =$	Magnetic moment
Decaying +k-r + + + + + + + + + + + + + + + + + + +	Wiggly		Magnetic moment of closed cir
$\frac{e^{\pm k_n x}, \ A\cosh(k_n x) + B\sinh(k_n x)}{AI_m(k_n \rho) + BK_m(k_n \rho)}$	$e^{\pm ik_n x}$, $A\cos(k_n x) + B\sin(k_n x)$ $e^{im\phi}$, $AJ_m(k_n \rho) + BY_m(k_n \rho)$	vector potential (5.55) x, y ρ, ϕ	_
$AI_m(\kappa_n\rho) + BK_m(\kappa_n\rho)$ $A_0 + B_0 \ln \rho + \sum A_m \rho^m + B_m \rho^{-m}$	$e^{im\phi}$	vector potential (5.55) ρ, φ	Dipole vector
$A\left(\frac{r}{a}\right)^{\ell} + B\left(\frac{r}{a}\right)^{-(\ell+1)}$	$P_{\ell}(\cos heta)$	Dipole induction (5.56) r, θ	Dipole
$A\left(\frac{r}{a}\right)^{\ell} + B\left(\frac{r}{a}\right)^{-(\ell+1)}$	$Y_{\ell m}(\theta,\phi)$	Force on dipole (5.69) r, θ	Force