PHGN361 Exam 3: NAME KEY

1. (10 pts) Find the mutual inductance of one solenoid of radius R_1 inside another or radius $R_2 > R_1$.

Principles	Method	Check
Defn: $\Phi_{12}^{tot} \equiv M_{12} I_2$ $= N_1 \Phi_{\substack{ONE \\ LOOP}}$	CALCULATE $\Phi_{\substack{ONE \\ LOOP}} = \int \vec{B} \cdot d\vec{a}$ USE AMPERES LAW TO FIND $B \propto I_2$ for the large solenoid. NOTE $\vec{B} \perp d\vec{a}$ & B is constant, SOLVE DEFN FOR M_{12} $M_{12} = \frac{N_1 \Phi_{\substack{ONE \\ LOOP}}}{I_2}$	$R_1 \to 0$ THEN $M \to 0$

2. (10 pts) A record of radius R with charge density $\sigma = \sigma_0 \rho \cos^2\phi$ glued to its surface is near a strong bar magnet. What force is exerted on the record? (ρ is the radial and ϕ the angular variable in cylindrical coords)

Principles	Method	Check
$\vec{F} = q\vec{v} \times \vec{B} \to$ $I d\vec{l} \times \vec{B} \to$ $\vec{K} \times \vec{B}\, da$	FIND $\vec{K} = \sigma \vec{v}$, FIND $\vec{v} = \vec{\omega} \times \vec{r}$ USE CARTESIAN UNIT VECTORS FOR INTEGRAL SINCE THEY COME OUTSIDE $\vec{r} = \rho\cos\varphi\,\hat{x} + \rho\sin\varphi\,\hat{y}$ $\quad \vec{\omega} = \omega_0 \hat{z}$ $da = \rho\, d\rho\, d\varphi$ FIND $\vec{B} = B_x\hat{x} + B_y\hat{y} + B_z\hat{z}$ $F = \int_0^{2\pi}\int_0^R \vec{K} \times \vec{B}\, da$	If $B \to 0$ then $F \to 0$ IF $R \to 0$ THEN $F \to 0$

3. (10 pts) A wire loop of radius R symmetrically located at the origin in the xy plane carries constant current I_0. What is the magnetic field generated?

Principles	Method	Check
$\vec{B} = \frac{\mu_0}{4\pi}\int \frac{I d\vec{l} \times \hat{\imath}}{r^2}$	USE CARTESIAN UNIT VECTORS FOR INTEGRAL SINCE THEY COME OUTSIDE, FIND $d\vec{l} = R\,d\varphi\,\hat{\varphi}$ in cartesian UNIT VECTORS $\vec{\imath} = \vec{r} - \vec{r}'$ $\quad \vec{r} = x\hat{x} + y\hat{y} + z\hat{z}$ $\vec{r}' = R\cos\varphi\,\hat{x} + R\sin\varphi\,\hat{y}$ $\hat{\imath} = \frac{\vec{\imath}}{\lvert\vec{\imath}\rvert}$ Calculate cross product & integrate φ from 0 to 2π	If $R \to 0$ then $B \to 0$ If $I_0 \to 0$ then $B \to 0$