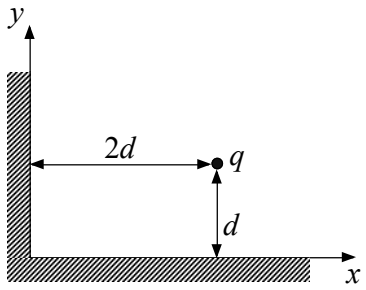
PHY 415 **Midterm Exam** **Fall 2018**

1) [20 points total]

A point charge q is positioned in front of two semi-infinite grounded conducting planes that meet at right angles, as shown in the diagram below. Write an expression for the force on the charge q. Is it attractive or repulsive with respect to the planes?



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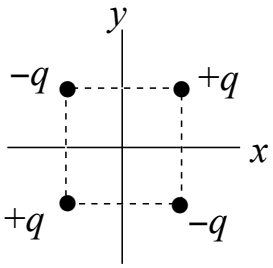
2) [20 points total]

Consider four charges at the corners of a square of side length a, lying in the xy plane at $z = 0$. The square is centered about the origin, and the charges have the same magnitude but oscillate in sign as one goes around the square, as in the diagram below.



Find the electrostatic potential $\phi(\mathbf{r})$ at a general position $\mathbf{r}$ to leading order in a/r. Write your answer in terms of spherical coordinates, i.e. $\phi(r, \theta, \varphi)$.

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3) [20 points total]

Consider a thin flat circular disk of radius R centered about the origin in the xy plane. The disk has a uniform surface charge density σ_0 and is rotating about the z axis with an angular velocity ω. Find the magnetic field $\mathbf{B}(\mathbf{r})$ at a general position $\mathbf{r}$ to leading order in R/r.

4) [40 points total]

The potential at the surface of a spherical shell of radius R is fixed at $\phi_0(\theta) = k\cos(3\theta)$, where θ is the usual spherical angle and k is a fixed constant.

a) Find the electrostatic potential $\phi^{in}(r, \theta)$ inside the sphere, $r < R$.

b) Find the electrostatic potential $\phi^{out}(r, \theta)$ outside the sphere, $r > R$.

c) Find the surface charge density $\sigma(\theta)$ on the surface of the sphere.