PHY 415 MIDTERM EXAM FALL '04

1) [35 points]
A conducting sphere of radius R is connected to a battery which keeps it at a constant potential ϕ_o, relative to a reference point at infinity (i.e. $\phi \to 0$ as $r \to \infty$).

a) What is the total amount of charge that the battery must deposit on the conducting sphere, to keep it at potential ϕ_o?

b) A point charge q is placed a distance r from the center of the sphere. Now what is the total amount of charge on the conducting sphere?

c) What is the force of attraction between q and the conducting sphere? Is it attractive or repulsive?

d) Suppose that a cavity exists in the interior of the conducting sphere, and a charge Q is inside the cavity. Now what is the force on the q outside?

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2) [35 points]
Two concentric spherical shells of radii R_1 and R_2, with $R_1<R_2$, are fixed with the following values of the electrostatic potential:

$$\phi(r,\theta,\varphi)= \phi_1 \cos\theta \quad \text{at } r=R_1, \quad \phi(r,\theta,\varphi)= \phi_2 \quad \text{at } r=R_2$$

where ϕ_1 and ϕ_2 are constants. The reference point is fixed so that $\phi \to 0$ as $r \to \infty$.

Find the electrostatic potential $\phi(r,\theta,\varphi)$ for:

a) $r < R_1$ inside the inner shell
$r > R_2$ outside the outer shell

b) $R_1 < r < R_2$ between the two shells.

c) Find the surface charge $\sigma(\theta,\varphi)$ on the shells at $r=R_1$ and $r=R_2$

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3) [30 points]
A thin circular disk of radius R, lying in the xy plane and centered at the origin, has on it a fixed surface charge densisty:

$$\sigma(r,\varphi) = Ar\sin 2\varphi$$

where r and φ are the usual polar coordinates in the xy plane.

Compute the electrostatic potential of this disk up through the electric quadrapole term. Express your answer in spherical coordinates.