$Avg = \frac{16.1}{20}$

**PHYSICS 142** **QUIZ #2** **NAME** Key
**Monday, July 28, 2008**

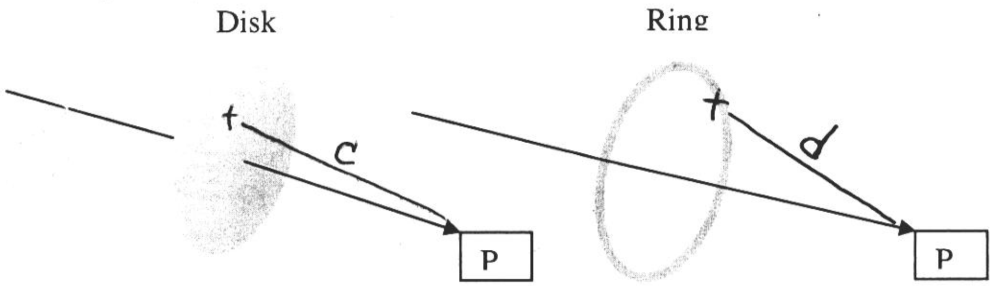
**T.A.** ______________

1) Two identical spheres, A and B, carry identical quantities of positive charge. However, sphere A is a metal conductor, while sphere B is an insulator with positive charge distributed evenly throughout its interior.
How do the magnitudes of the electric fields compare 1 inch outside the spheres?(2 pts)
   a) $E_A > E_B = 0$
   b) $E_A > E_B > 0$
   c) $E_A = E_B > 0$
   d) $E_A = E_B = 0$
   e) $E_A = E_B > 0$
   f) $0 < E_A < E_B$
   g) $0 = E_A < E_B$

SAME

How do the magnitudes of the electric fields compare 1 inch beneath the surface of each sphere?
(Choose the correct letter from the same menu of options)(2pts) (g) $E_B > E_A = 0$

2) Below are a disk and a ring of identical circumferences, made of identical insulating material, and carrying identical quantities of positive charge distributed evenly throughout their interiors.




The point P is located the same axial distance from both the center of the ring and the center of the disk. How do the electric fields at P compare for the disk and the ring? (2 pts)
   a) $E_{disk} > E_{ring}$
   b) $E_{disk} = E_{ring}$
   c) $E_{disk} < E_{ring}$
   d) Impossible to determine

Let d be the distance from a charge on the ring to point P, so $E_{Ring} \approx k\frac{8}{d^2}$

Now consider the distance c from any point on the disk to point P. We see that $c \leq d$ always, and the avg. value of $c = \langle c \rangle < d$

Therefore $E_{DISK} > E_{RING}$

Need $\varepsilon_0 = 8.85 \times 10^{-12}$
and $k = 9 \times 10^9$

3) A 10-gram piece of Styrofoam carries a net charge of $-7 \times 10^{-7}$ Coulombs and floats above a large, horizontal sheet of plastic that has a uniform charge density on its surface. What is the charge density σ on its surface? Hint: $E = \sigma/2\epsilon$ for an infinite plane of charge (8 pts).

$$F_\downarrow = mg = (.01\,kg)(9.8\,m/s^2) = 0.098\ N$$

$$F_\uparrow = qE = (-7\times10^{-7}\,C)(E\ N/C) = 0.098\ N$$

Therefore $E = \frac{mg}{q} = -1.4\times10^{5}\ N/C = \frac{\sigma}{2\varepsilon_0}$

so that $\sigma_{Foam} = 2E\varepsilon_0 = \boxed{-2.48\times10^{-6}\ Coulomb/m^2}$

Now suppose that the same piece of Styrofoam floats 1 meter above the surface of the Earth, because you were able to put a net charge Q on the Earth. Assume the Earth overall is a nearly perfect spherical conductor (nickel-iron interior). How much net charge Q would you need to put on the Earth? (3 pts)
Radius of the Earth = $R_{Earth}$ = 6,378 Kilometers

$$F_\downarrow = mg = 0.098\ N$$

$$F_\uparrow = k\frac{q\,Q_{Earth}}{(R_{Earth}+.001)^2} \approx k\frac{q\,Q_{Earth}}{R_{Earth}^2} = -1.55\times10^{-10}\,Q_{Earth} = 0.098\ \text{Newtons}$$

Solve for $Q_{Earth}$: $Q_{Earth} = \frac{mg\,R_{Earth}^2}{kq} = \boxed{-6.34\times10^{8}\ \text{Coulombs}}$

What is the charge per unit area σ on the surface of the Earth in that case? (3 pts)

$$\sigma_{Earth} = \frac{Q_{Earth}}{A_{Earth}} = \frac{-6.34\times10^{8}\ Coulomb}{4\pi R_{Earth}^2} = \boxed{-1.24\times10^{-6}\ C/m^2}$$

Xtra Credit: compare the two σ's you obtained, one for the plane and one for the Earth, and comment on their ratio (explain why it is so).

Notice that $\sigma_{Foam} = 2\sigma_{Earth}$. The same field requires twice as much charge on an insulator as on a conductor.