PHYS 350 E&M
Exam 4

GRADES 96 92 90 89 80 72

March 15, 2017

Name J. C. Daly

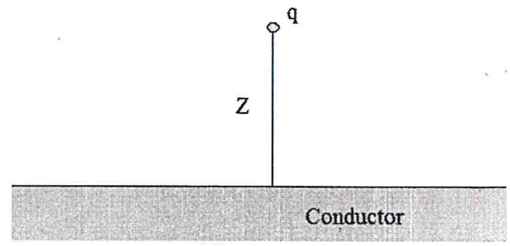

Figure 1

1. The charge q shown in Figure 1 is Z meters above the conducting plate.

   a. What is the force on the charge? $-\hat{z}\, q^2/16\pi\epsilon_0 z^2$

   b. How much energy did it take to bring the charge from infinity to its present location? $-q^2/16\pi\epsilon_0 z$

a) $\vec{F} = q\vec{E} = -\dfrac{q^2\,\hat{z}}{4\pi\epsilon_0(2z)^2} = -\dfrac{q^2\hat{z}}{16\pi\epsilon_0 z^2}$ Down Toward the Conduct

b) $W = -\frac{1}{2}qV = -\frac{1}{2}\dfrac{q^2}{4\pi\epsilon_0(2z)}$

$= -\dfrac{q^2}{16\pi\epsilon_0 z}$

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Exam 4

March 15, 2017

2. What is the capacitance of the two concentric spherical conducting shells shown in Figure 2? The dielectric material between the shells has a dielectric constant, k = 2. The inner shell has a radius of *a* meters. The outer shell has a radius of *b* meters.

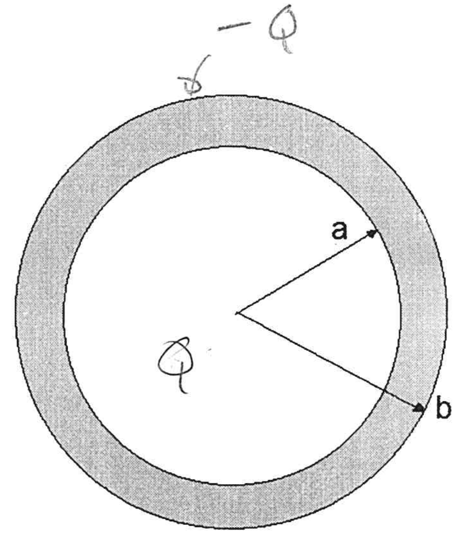

Figure 2

$$D = \frac{Q}{4\pi r^2} \qquad a < r < b$$

$$E = \frac{Q}{4\pi \epsilon r^2} \qquad \epsilon = \kappa \epsilon_0$$

$$V = V(a) - V(b) = -\int_b^a E \cdot dr = \frac{Q}{4\pi \kappa \epsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$$

$$= \frac{Q}{4\pi \kappa \epsilon_0}\left(\frac{b-a}{ab}\right)$$

$$C = \frac{Q}{V} = 4\pi \kappa \epsilon_0 \left(\frac{ab}{b-a}\right)$$

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3. The two charges, +*q* and -*q* separated by a distance *d* as shown in Figure 3, form a dipole.

   a. What is the dipole moment? ____________

   b. What is the torque on the dipole in the presence of the uniform electric field, *E*, shown in Figure 3? ____________

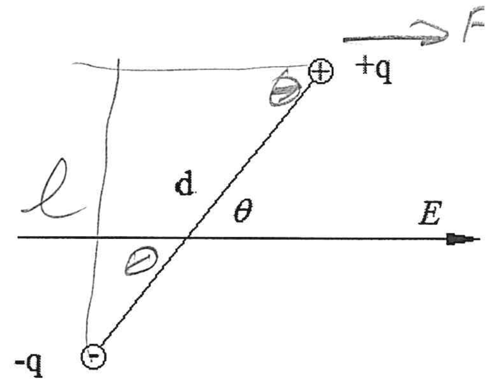

Figure 3

$\vec{F} = q\vec{E}$

$\overrightarrow{Torque} = -F\ell\,\hat{\theta}$

$\frac{\ell}{d} = \sin\theta$

$\overrightarrow{Torque} = -Fd\sin\theta\,\hat{\theta}$

$\overrightarrow{Torque} = -qEd\sin\theta\,\hat{\theta}$

$\overrightarrow{Torque} = \vec{p} \times \vec{E}$

where $\vec{p} = q\vec{d}$

In the direction of decreasing θ i.e. $-\hat{\theta}$