PHY3063 Spring 2019

HOMEWORK 2

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Due: February 7, 2018

1. CH26 Q-11.
Pay attention to the dependence on the distance. For a point charge $E \propto 1/r^2$*, for a dipole* $E \propto 1/r^3$*, and for a quadrupole* $E \propto 1/r^4$*. From the dimensional point of view, does it make sense?*

2. CH26 E-19.

3. Using the online simulation at http://www.falstad.com/vector3de/, simulate the electric field lines of a quadrupole moment as shown in Figure 26-27 (Q-11). Sketch the field lines on the $x - y$ plain (z-slice in the simulation) with the minimal charge spacing. This configuration will show the quadrupole field lines at a large distance. Compare the direction of the electric field along the diagonal direction and the x-direction.

4. CH26 E-39.

5. CH26 P-2.

For $d \ll \sqrt{x^2 + z^2}$,

$$\frac{1}{\{x^2 + (z \pm d/2)^2\}^{3/2}} \approx \frac{1}{(x^2 + z^2)^{3/2}} \Big(1 \mp \frac{3}{2} \frac{zd}{x^2 + z^2}\Big).$$

Expand the denominator, then immediately $x^2 + z^2 \pm zd + (d/2)^2 \approx \big(x^2 + z^2\big) \pm zd$ *(why?). Factor out* $(x^2 + z^2)$ *then* $zd/(x^2 + z^2)$ *becomes the small parameter for expansion.*

6. CH26 P-11.
(i) What is the net force (Coulomb + gravitational force) on the electron? (ii) Then you can calculate the y*-component velocity from the effective acceleration at the height of* d *and how long it would take to the height. (iii) During the time will it travel along the* x*-direction far enough to escape or not?*

7. Ch26 P-12.
At this point you know you have to do Taylor expansion to get a form $F \propto z$ *for* $z \ll R$ *near the center of the ring. This is the opposite limit of* $z \gg R$.

8. CH26 P-14.
You do not have to solve this problem. But I ask you to think about this. I will discuss this in class. For a mass loaded spring, the equation of motion is $m\ddot{x} = -kz$ *and the linear oscillation frequency* $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$*. For a rotational oscillation, the equation of motion is based on the torque* $\vec{\tau} = \vec{r} \times \vec{F}$*:* $\vec{\tau} = I\ddot{\theta} = -\alpha\theta$*, and the rotational frequency is* $f = \frac{1}{2\pi}\sqrt{\frac{\alpha}{I}}$ *where* I *is the moment of inertia and* α *is the torsional spring constant. Check the physical dimensions of* α *and* I *if they produce* $[\ f] \ = T^{-1}$.

9. CH27 E-3.
This figure may be helpful.

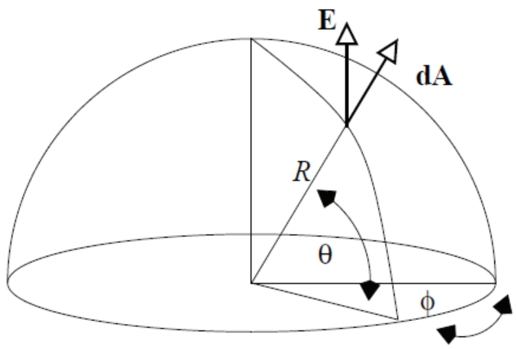

FIG. 1:

10. CH27 E-25.

11. CH27 P-14.
$\vec{r}$ is the radial vector to a point inside the hole (P). Then $\vec{a} = \vec{r} - \vec{b}$ where $\vec{b}$ is the vector to the point P from the center of the hole (O').

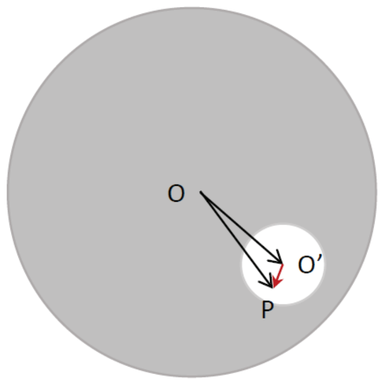

FIG. 2:

12. CH27 P-19.
Inside an isolated conductor $\vec{E} = 0$.