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- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.
- The rest is made by me.

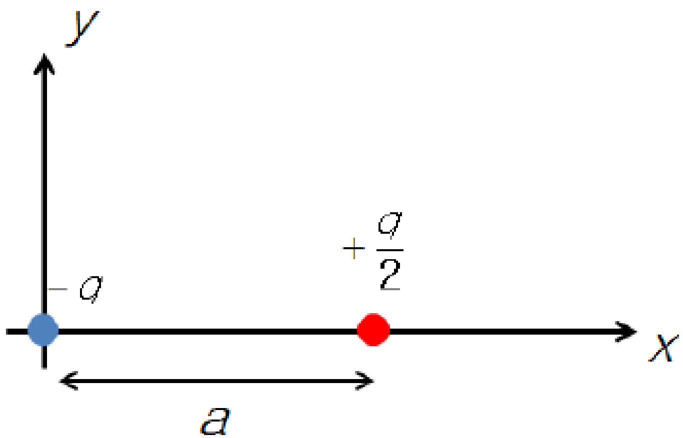
2012년

Problem 1. (25 points) Two point charges, $-q$ and $+\frac{1}{2}q$, are situated at the origin $(0,0,0)$ and at the point $(a,0,0)$ $(a>0)$ respectively, as shown in Fig. 1.

(a) At what point along the x-axis does the electric field vanish?

(b) Show that the $V=0$ equipotential surface is spherical in shape. What are the (x,y,z) coordinates of the center of this sphere?

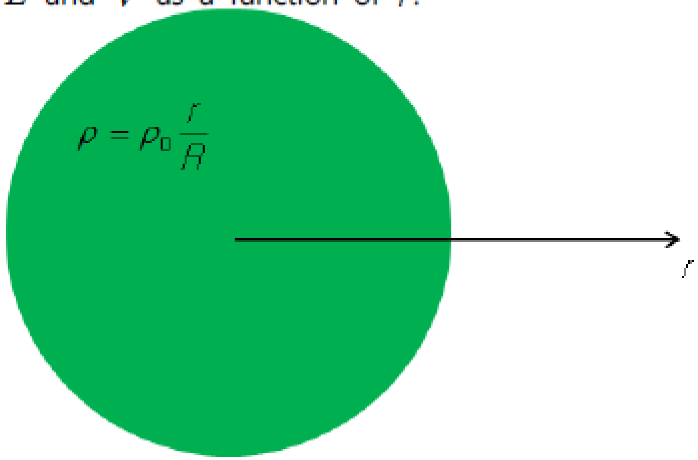
(c) Qualitatively, draw electric field and equipotential lines around the two charges. Be sure to include the case of (b).



<Fig. 1>

Problem 2. (25 points) A solid nonconducting sphere of radius R has a nonuniform charge distribution of volume charge density $\rho = \rho_0 \frac{r}{R}$, where r is the distance from the center of the sphere and $\rho_0 (> 0)$ is a constant of appropriate units.

(a) Find the electric field $\vec{E}$ both inside and outside the sphere.
(b) Find the electric potential V both inside and outside the sphere.
(c) Draw E and V as a function of r.



<Fig. 2>

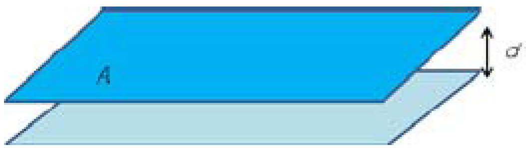
Problem 3-A. (25 points) A thin parallel plate capacitor with a gap thickness d and an area A is given as shown in Fig. 3-A-1. It is fully charged with a battery (voltage V), then disconnected.

(a) Derive an expression for the capacitance C in terms of d, A, and ϵ_0.

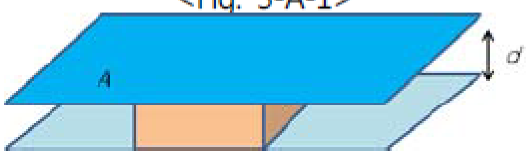
(b) If a dielectric with a dielectric constant $\kappa = 4$ is inserted into the capacitor, filling $1/3$ of the volume, as shown in Fig. 3-A-2. What will become the potential difference between the two plates?

(c) How much work needs to be done when we try to insert the dielectric block?

(d) What fraction of the total charge will be stored in the portion of the capacitor, which is filled by the dielectric?



<Fig. 3-A-1>



<Fig. 3-A-2>

Problem 3-B. (25 points) Two long cylindrical shells of radii R_a and R_b are placed coaxially and are charged to the potentials V_a and V_b, respectively (assume $R_b > R_a$ and the length of the shells $L \gg R_b$).

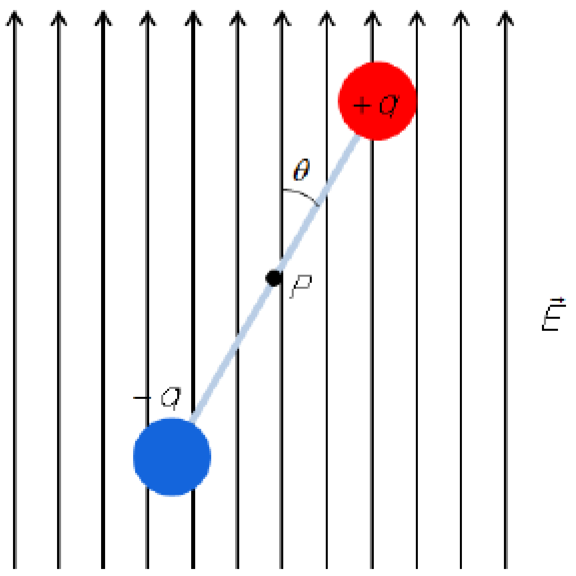
(a) Find the potential at r between the cylindrical shells.
(b) Express the capacitance C of the two coaxial shells with the given set of parameters.

Problem 4. (25 points) An electric dumbbell that is compose of $+q$ and $-q$, separated by a distance d, is placed in an uniform electric field $\vec{E}$ as shown in Fig. 4. Assume that each charge has a mass m and they are connected by a massless rigid bar, whose center can freely swing around the pivot at P. We ignore the effect of the gravitational force.

(a) If an oscillation started from an initial holding position $\theta = \theta_0$, what will be the kinetic energy of the dumbbell when it passes $\theta = \frac{1}{2}\theta_0$ position?

(b) What is the rotational inertia I of the dumbbell with respect to the pivot P?

(c) For a small angle harmonic oscillation around the vertical axis, what will be the period?



<Fig. 4>

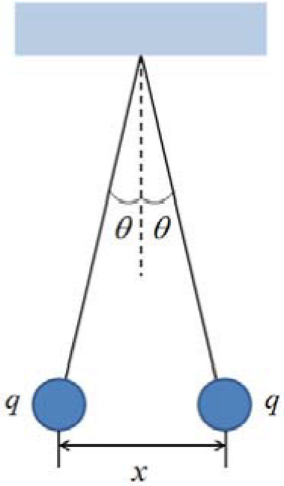
2011년

Problem 1. (25 points) Two tiny conducting balls of identical mass m and identical charge q hang from nonconducting threads of length L, as shown in Fig. 1. Assume that θ is small that $\tan\theta$ can be replaced by its approximate equal , $\sin\theta$.

(a) Express the equilibrium separation x in terms of m, q, L, g, and ϵ_0.

(b) If the charges are suddenly reduced to $q/2$ for both balls (say, at time $t=0$), the balls will start to swing from the equilibrium position. What will be the instantaneous acceleration (magnitude) at $t=0$?

(c) And then, for $t>0$ both balls will undergo a periodic oscillation about a new equilibrium separation $\tilde{x}$. Find $\tilde{x}$ in terms of m, q, L, g, and ϵ_0.

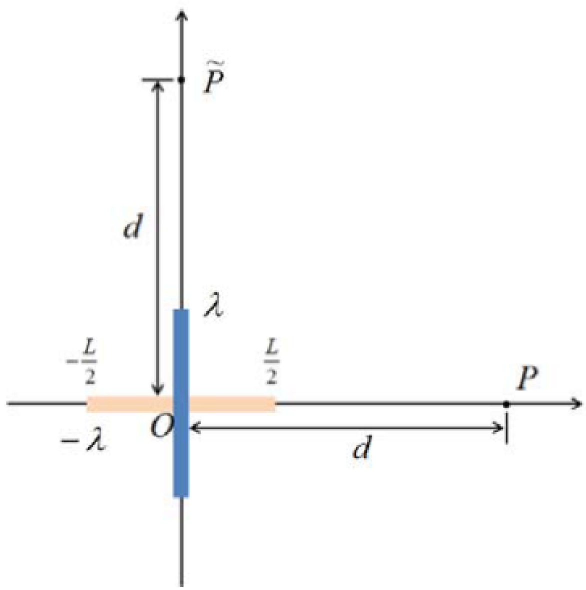


<Fig. 1>

Problem 2. (25 points) Two thin nonconducting rods of length L are uniformly charged but with an opposite sign [charge density λ (>0) and $-\lambda$, respectively], and fixed in the middle being perpendicular to each other, as shown in Fig. 2.

(a) Find the electric field at Point P and $\widetilde{P}$ that are distance d away from the crossing point O.

(b) Qualitatively, draw **electric field lines** and **equi-potential lines** around this object.



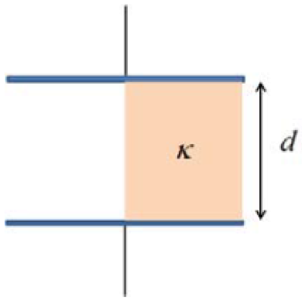
<Fig. 4>

Problem 3-A. (25 points) A dielectric slab (dielectric constant κ) fills only half of the space between the plates of a parallel-plate capacitor in two different shapes, as shown in Fig. 3-a and 3-b.

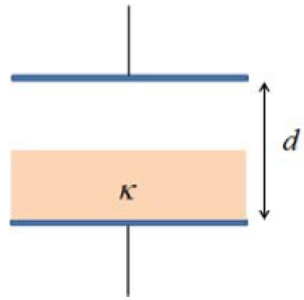
(a) In terms of κ, derive expressions for the fraction f of the total energy that is stored in the dielectric for the two different cases (say, f_a and f_b)

(b) When the capacitance of the emptied capacitor is C, what will be the equivalent capacitance of the two half-filled capacitors shown in Fig. 3-a and 3-b connected in parallel?

(c) When the total energy stored in the capacitor is E, derive an expression for the work W that needs to be done for completely pulling out the dielectric slab in Fig. 3-b.



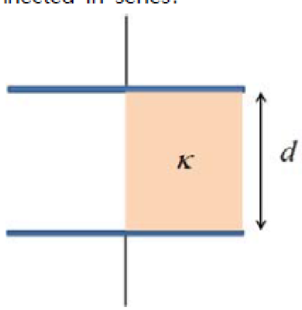
<Fig. 3-a>



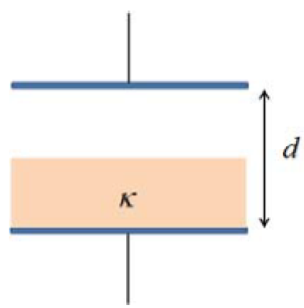
<Fig. 3-b>

Problem 3-B. -(a)와 (b)는 3-A와 동일

(c) What will be the equivalent capacitance of the two capacitors connected in series?



<Fig. 3-a>

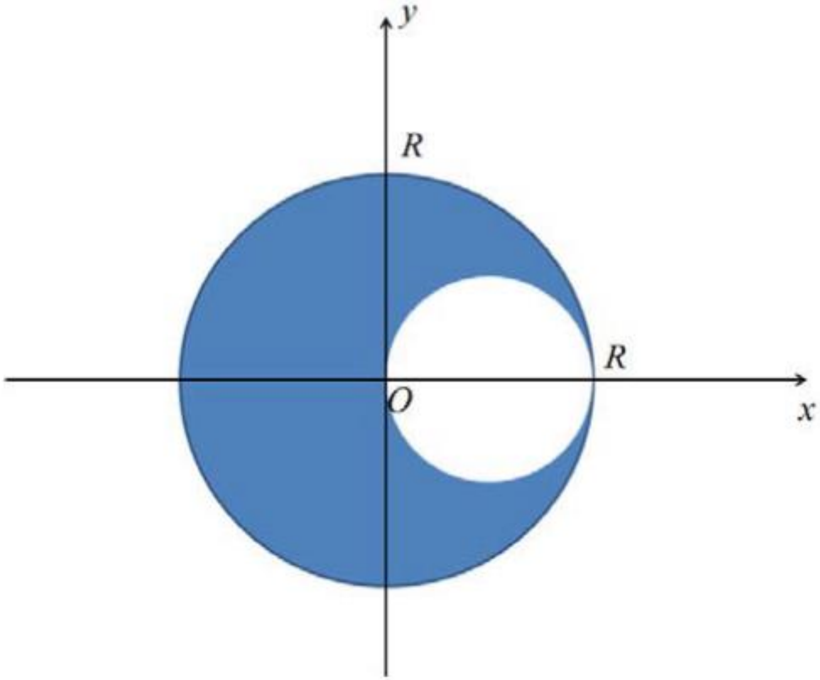


<Fig. 3-b>

Problem 4. (25 points) A nonconducting spherical ball (radius R), which has a spherical hole (radius $R/2$), is charged uniformly with a volume density $\rho(>0)$ and placed, as shown in Fig. 4

(a) Along the positive x-axis (i.e., $x \geq 0$, $y = z = 0$), find $\vec{E}(x)$ (magnitude and direction).

(b) Along the positive x-axis, find and draw electric potential $V(x)$.



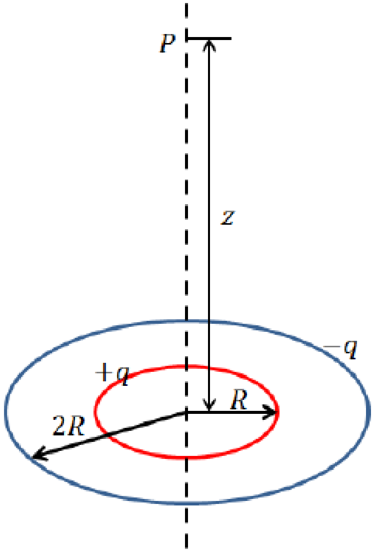
<Fig. 4>

2010년

Problem 1. (20 points) Two concentric rings of radii R and $2R$ are uniformly charged with net charges $+q$ and $-q$, respectively. Permittivity constant is ϵ_0.

(a) Find the electric potential at a point P whose vertical distance from the center of the rings is z. Take the potential to be zero at infinity.

(b) Find the electric field at the point P.



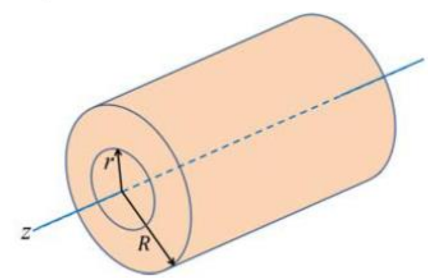
<Fig. 1>

Problem 2. (30 points) An infinitely long nonconducting, solid cylinder of radius R has a uniform charge density ρ. The axis of the cylinder lies at z-axis, $(0,0,z)$, with arbitrary z. Permittivity constant is ϵ_0.

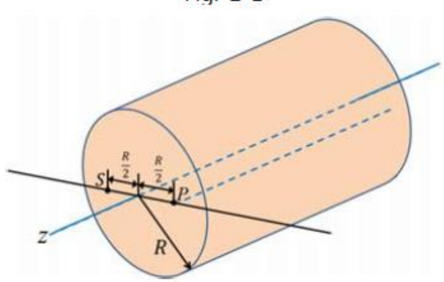
(a) Find the electric field at a point whose radial distance is r from the z-axis. Find the electric field for $r < R$ and $r \geq R$, respectively.

(b) A line charge is additionally placed at $\left(+\frac{R}{2},\, 0,\, z\right)$ along the z-axis, which makes electric field at $\left(-\frac{R}{2},\, 0,\, z\right)$ vanish. Find the line charge density λ.

(c) In (b), find the electric potential difference between $\left(-\frac{R}{2},\, 0,\, z\right)$ and $(-R,\, 0,\, z)$.



<Fig. 2-1>



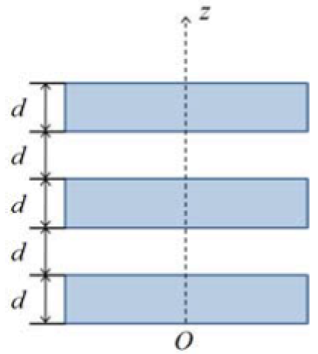
<Fig. 2-2>

Problem 3. (30 points) The bottom surfaces of three large conducting plates (area A and thickness d) are fixed parallel at $z=0$, $2d$ and $4d$. The conductors at 0 and at $4d$ are charged with $+Q$ and $-Q$, respectively. Permittivity constant is ϵ_0 and edge effect can be neglected.

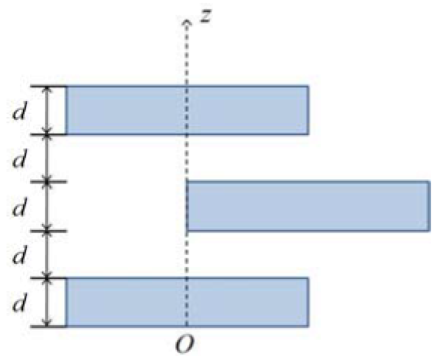
(a) Draw the charge distributions in a cross-section diagram.

(b) Find the electric field at $d < z < 3d$.

(c) The plate at $z=2d$ is released and moved horizontally as shown in Fig. 3-2. Find how much work should be done by external forces. (Notify sign of the work.)



<Fig. 3-1>



<Fig. 3-2>

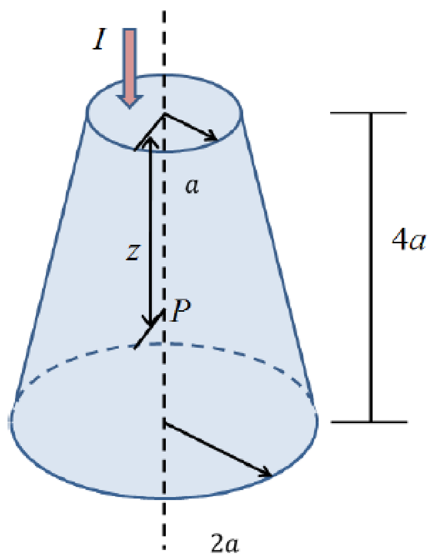
Problem 4. (20 points) A truncated right circular cone has top radius, bottom radius, height, and resistivity, a, $2a$, $4a$ and ρ. Current I flows from the top to bottom making uniform current density across any cross section taken perpendicular to the length.

(a) Find the electric current density at a point P, whose distance is z from the top surface.

(b) Using Ohm's law in electric field, find electric field at the point P.

(c) Find the electric potential difference between the top and bottom surfaces.

(d) Find the power loss of the system.



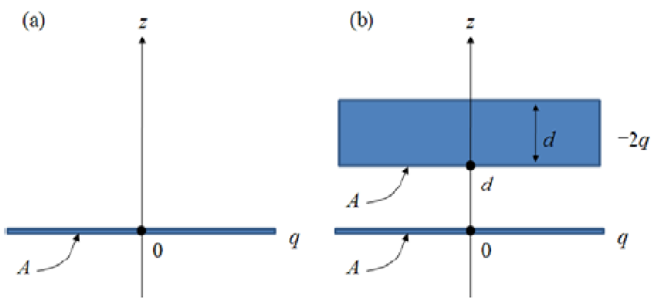
<Fig. 4>

문제 1. (30점) 그림 1(a)와 같이 두께가 0이며 면적이 A로 충분히 넓은(즉 모서리 효과는 무시함) 절연체 판이 $z=0$인 평면에 놓여 있고 이에 양의 알짜전하 q가 균일하게 분포해 있다. 유전율은 ϵ_0이다.

(a) 절연체 판의 면전하밀도를 구하시오.

(b) 절연체 판의 위쪽과 아래쪽에서 전기장의 크기 및 방향을 구하시오.

(c) 이 상태에서 그림 1(b)와 같이 두께가 d이고 면적이 A이며 알짜전하가 $-2q$인 도체판을 추가했다. 이때 도체판의 아랫면이 $z=d(>0)$인 위치가 되도록 나란히 했다. 도체판의 아랫면에서 면전하밀도를 구하시오.



<그림 1>