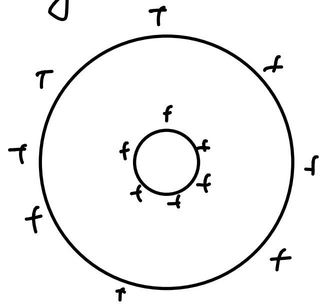
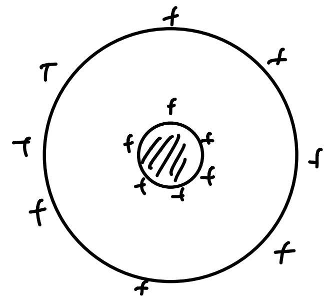
VP250 S1 RC2 Tong Jin

★ Quiz

A.



B.



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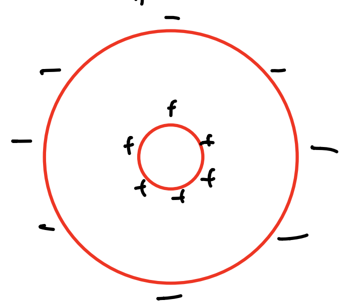

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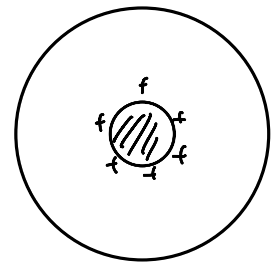
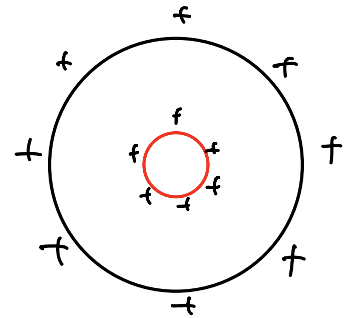


E.



Chp3 Electrical Potential

☆ Conservative Force: work is not related to path

Curl: $\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix}$

* central force conservative

$f(r) = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_i q_0}{r^2}$

$U(r) = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_i q_0}{r} + C$

$U(\infty) = 0 \Rightarrow U(r) = \frac{1}{4\pi\epsilon_0} \frac{q_i q_0}{r}$

☆ Potential Energy:

① ⊕ ⊕ / ⊖ ⊖

② ⊕ ⊖

☆ Potential: $V = \frac{U}{q_0}$

how to calculate V:

$V = \frac{1}{4\pi\epsilon_0} \int_{object} \frac{dq}{|\bar{r} - \bar{r}'|}$ ☆ useful (scalar)

$V_A - V_B = \int_{A \to B} \bar{E}\, dr$ * pay attention how you integral

☆ Self-Energy Charge Configuration

$U = \frac{1}{8\pi\epsilon_0} \sum_{\substack{i,j=1 \\ i \neq j}}^{n} \frac{q_i \cdot q_j}{r_{ij}} = \frac{1}{2} \sum_{i=1}^{n} q_i \cdot V(r_i)$

$U = \frac{1}{2} \int_{object} \rho \cdot V(r) \cdot dv$

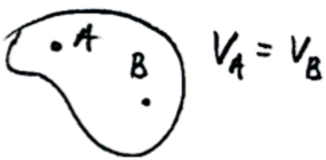
☆ Equipotential Surface: electric field line normal to equipotential surface

✫ Properties:

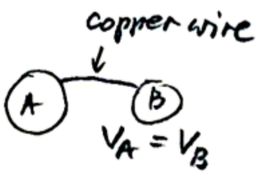
(i) $\overline{E} = 0$ inside a conductor.

(ii) No net (excess) charge inside a conductor; any net charge resides on the surface.

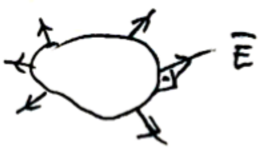
(iii) A conductor is an equipotential.



Example



(iv) Just outside of the conductor, $\overline{E}$ is perpendicular to the conductor's surface.

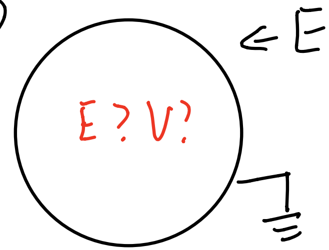


$$\overline{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$

☆ Electrostatic Shield: (静电屏蔽)

①

②



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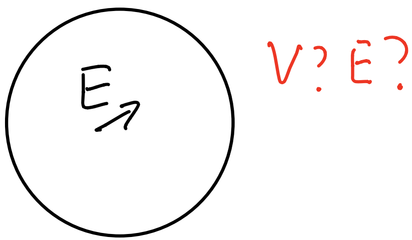

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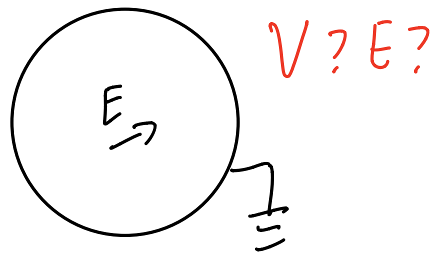
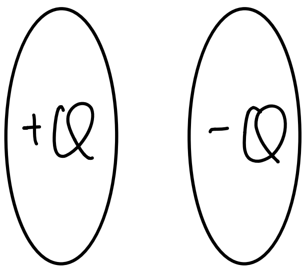


e.g. charge inside

☆

$$\begin{tikzcd} E \arrow[r, "q"] \arrow[d, "dl"'] & F \arrow[d, "dl"] \\ V \arrow[r, "q"] & U \end{tikzcd}$$

Chp4 Capacitor

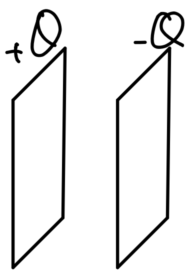


★ $C = \dfrac{Q}{V}$ $(1F = 1C/1V)$

⇓

geometry

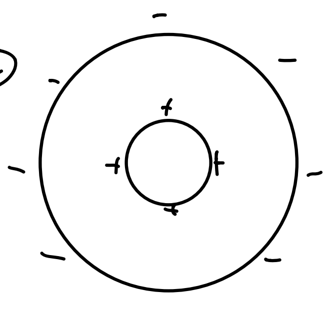
①



$C = \dfrac{Q}{V}$ $V = \int E \cdot dl = \dfrac{\sigma}{\varepsilon_0} \cdot d = \dfrac{Q}{\varepsilon_0} \dfrac{d}{A}$

$\therefore C = \varepsilon_0 \dfrac{A}{d}$

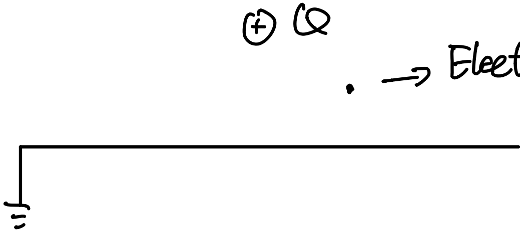
②



$C = \dfrac{Q}{V}$ $V = \int E \cdot dl \Rightarrow C = 4\pi\varepsilon_0 \dfrac{R_a R_b}{R_b - R_a}$

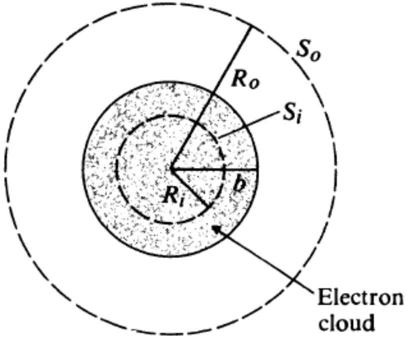
★ Series: $C = \dfrac{C_1 C_2}{C_1 + C_2}$ Parallel: $C = C_1 + C_2$ (VE215)

★ Methods of Images:



→ Electric Field?

EXAMPLE 3–7 Determine the **E** field caused by a spherical cloud of electrons with a volume charge density $\rho = -\rho_o$ for $0 \le R \le b$ (both ρ_o and b are positive) and $\rho = 0$ for $R > b$.



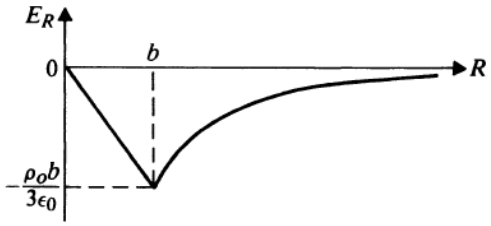


FIGURE 3–10
Electric field intensity of a spherical electron cloud (Example 3–7).

Solution First we recognize that the given source condition has spherical symmetry. The proper Gaussian surfaces must therefore be concentric spherical surfaces. We must find the **E** field in two regions. Refer to Fig. 3–10.

a) $0 \le R \le b$

A hypothetical spherical Gaussian surface S_i with $R < b$ is constructed within the electron cloud. On this surface, **E** is radial and has a constant magnitude:

$$\mathbf{E} = \mathbf{a}_R E_R, \qquad d\mathbf{s} = \mathbf{a}_R\, ds.$$

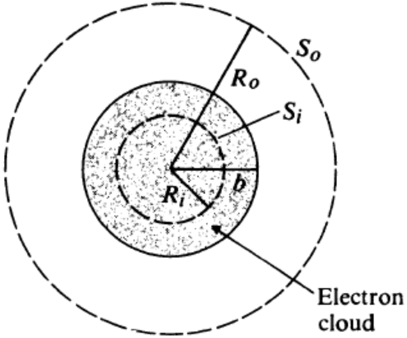
The total outward E flux is

$$\oint_{S_i} \mathbf{E} \cdot d\mathbf{s} = E_R \int_{S_i} ds = E_R 4\pi R^2.$$

The total charge enclosed within the Gaussian surface is

$$Q = \int_V \rho\, dv$$

$$= -\rho_o \int_V dv = -\rho_o \frac{4\pi}{3} R^3.$$

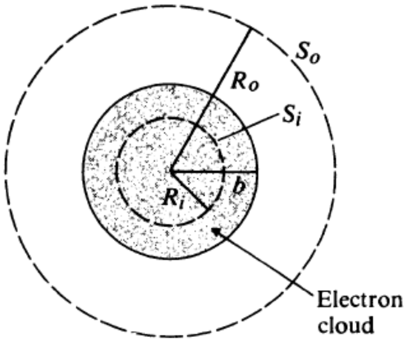


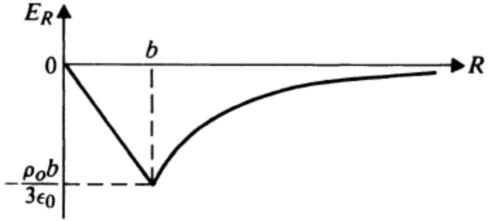
$$E \cdot 4\pi R^2 = \frac{Q}{\varepsilon_0}$$

Substitution into Eq. (3–7) yields

$$\mathbf{E} = -\mathbf{a}_R \frac{\rho_o}{3\epsilon_0} R, \qquad 0 \le R \le b.$$

We see that within the uniform electron cloud the **E** field is directed toward the center and has a magnitude proportional to the distance from the center.





b) $R \geq b$

For this case we construct a spherical Gaussian surface S_o with $R > b$ outside the electron cloud. We obtain the same expression for $\oint_{S_o} \mathbf{E} \cdot d\mathbf{s}$ as in case (a). The total charge enclosed is

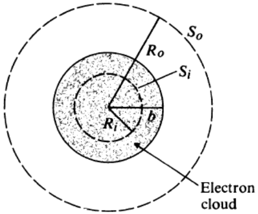
$$\boxed{\oint_{S_i} \mathbf{E} \cdot d\mathbf{s} = E_R \int_{S_i} ds = E_R 4\pi R^2.} \qquad Q = -\rho_o \frac{4\pi}{3} b^3.$$

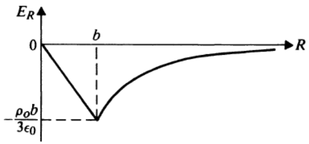
Consequently,

$$\mathbf{E} = -\mathbf{a}_R \frac{\rho_o b^3}{3\epsilon_0 R^2}, \qquad R \geq b,$$

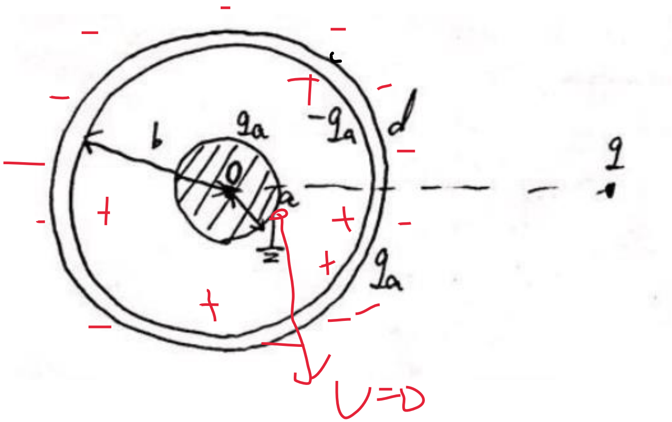
which follows the inverse square law and could have been obtained directly from Eq. (3–12). We observe that *outside* the charged cloud the $\mathbf{E}$ field is exactly the same as though the total charge is concentrated on a single point charge at the center. This is true, in general, for a spherically symmetrical charged region even though ρ is a function of R. ■

$$\boxed{\mathbf{E} = \mathbf{a}_R E_R = \mathbf{a}_R \frac{q}{4\pi\epsilon_0 R^2} \qquad \text{(V/m)}.}$$





Electric Potential



Metal spherical shell and ball (originally not charged);
The inner ball is grounded;
A charge q (q>0) is placed at distance d from the center of inner ball;

(1) Find induced charge qa
(2) Find the potential difference between inner shell and the surface of the inner ball (distance: b and a from O)

Ans d:

1) $V_0 = k \cdot \frac{q_a}{a} + k \frac{-q_a}{b} + k \frac{q_a}{b} + k \cdot \frac{q}{d} = 0$

$q_a = -\frac{a}{d} \cdot q$

2) $k \frac{q_a}{b} - k \frac{q_a}{a}$