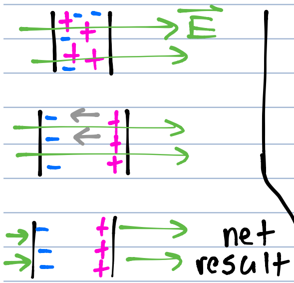
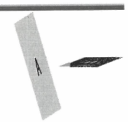
Effects of external fields



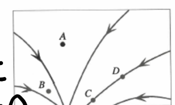
each free e^- feels electric force $\vec{F}_e = -e\vec{E}$, so it moves to the left. After enough have moved, an internal E field is created that cancels the external field

Pretest: Electric field and flux Name ________

1. Shown at right are two sheets of paper. Sheet A has three times the area of sheet B. Describe how you could use a vector for each sheet to specify the orientation and area of that sheet. Draw these vectors on the diagram.



2. Electric field lines for an unknown charge distribution are shown at right. Rank the magnitude of the electric field at the four points *A, B, C, D*. Explain.



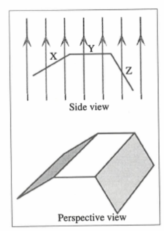
$E_B > E_C > E_D > E_A$

3. An imaginary surface made of three flat pieces is shown. The entire surface is placed in a uniform electric field *E* pointing toward the top of the page, as shown in the side view.

   a. The areas of the three flat sides X, Y, and Z are identical. Rank the magnitude of the electric flux through sides X, Y, and Z. Explain.

   $\phi_Y > \phi_X > \phi_Z$

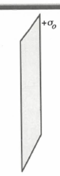
   b. Is the electric flux through the entire surface *positive, negative,* or *zero?* Explain. If you cannot tell, explain why not.



Pretest: Gauss' law Name ________

1. Shown at right is a small portion near the center of a *very large* nonconducting sheet. The sheet has a uniform positive charge per unit area $+\sigma_o$.

   If the entire sheet has a width *W* and a height *H*, how much charge is distributed over the entire sheet?

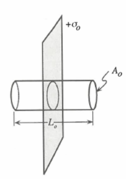


2. An imaginary cylindrical surface encloses a small portion of the sheet near the center. The cylinder has a length L_o, and the area of each end cap is A_o.

   a. What is the net charge enclosed by the cylinder? Explain.

   $Q_{encl} = \sigma_o A_o$

   b. Is the electric flux through the curved side wall of the cylinder *positive, negative,* or *zero?* Explain.

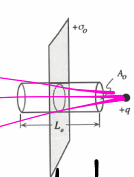


3. A positive point charge is now placed to the right of the imaginary cylinder, as shown.

   a. Does the electric flux through the left-hand end cap of the cylinder *increase, decrease,* or *remain the same?* Explain.

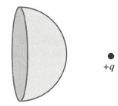
   b. Does the net electric flux through the entire imaginary cylinder *increase, decrease,* or *remain the same?* Explain.

   no new enclosed charge



GAUSS' LAW Name ______________ EM HW–83

1. The *closed* Gaussian surface shown at right consists of a hemispherical surface and a flat plane. A point charge $+q$ is outside the surface, and no charge is enclosed by the surface.



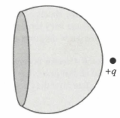
a. What is the flux through the *entire* closed surface? Explain.

$$\phi_{net} = 0$$

Let Φ_L represent the flux through the flat left-hand portion of the surface. Write an expression in terms of Φ_L for the flux through the curved portion of the surface, Φ_c.

$$\phi_{net} = \phi_L + \phi_c \Rightarrow \phi_L = -\phi_c$$

b. Suppose that the curved portion of the Gaussian surface in part a is replaced by the larger curved surface as shown. The flat left-hand portion of the surface is unchanged.



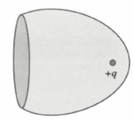
i. Does the value of Φ_L change? Explain.

no

ii. How does the flux through the new curved portion of the surface compare to the flux through the original curved portion of the surface? Explain.

$$\phi_L = -\phi_c' \Rightarrow \phi_c = \phi_c'$$

c. Suppose that the curved portion of the Gaussian surface is replaced by the larger curved surface that encloses the charge as shown. The flat left-hand portion of the surface is still unchanged.



i. Does the value of Φ_L change? Explain.

no

ii. How does the flux through the new curved portion of the surface compare to the flux through the original curved portion of the surface? Explain.

$$\phi_{curved\ new} > \phi_{curved\ old}$$

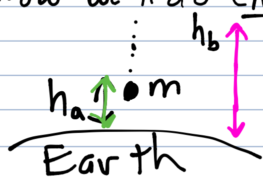
iii. Use Gauss' law to write an expression in terms of Φ_L and q for the flux through the curved portion of the surface.

$$\phi_{total} = \frac{q}{\epsilon_0} = \phi_L + \phi_c$$
$$\Rightarrow \phi_c = q/\epsilon_0 - \phi_L$$

Electric Potential Energy

Forces and fields may seem somewhat removed from everyday experience

Now we'll do energy and work done



potential E $U_a = mgh_a$

$U_b = mgh_b$

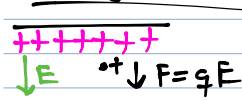
$$W_{a\to b} = U_a - U_b = mgh_a - mgh_b = mg(h_a - h_b) = -mg\Delta h$$

where $\Delta h = h_b - h_a$

recall $W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{l} = \int_a^b F\,dl\cos\theta = \int_a^b mg\,dl\cos 180° = -mg\int_a^b dl = -mg\Delta h$ ✓

why $U_a - U_b$ instead of $U_b - U_a$?? $W \equiv \Delta K$ (not ΔU) but if energy is conserved, then $\Delta K = -\Delta U$

Straight analogy to E field & potential



raising the charge from h_a above bottom surface to h_b would be

$$W_{a\to b} = \int_a^b qE\,dl\cos 180° = -qE\Delta h$$

$m_1 \leftarrow r \rightarrow m_2$ | $q_1 \bullet \leftarrow r \rightarrow \bullet q_2$

$F_g = Gm_1m_2/r^2$ | $F_e = kq_1q_2/r^2$

Can quantify P.E. by seeing how much work is done on the objects when moving apart from r_a to r_b

$W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{l} = \int_a^b \frac{Gm_1m_2}{r^2}\,dr\cos 180°$

$= -Gm_1m_2 \int_a^b \frac{dr}{r^2}$

$= \frac{-Gm_1m_2}{r_a} - \frac{-Gm_1m_2}{r_b}$

$\Rightarrow PE = \frac{-Gm_1m_2}{r}$

$W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{l} = \int_a^b k\frac{q_1q_2}{r^2}\,dr\cos 0°$

$= kq_1q_2 \int_a^b \frac{dr}{r^2}$

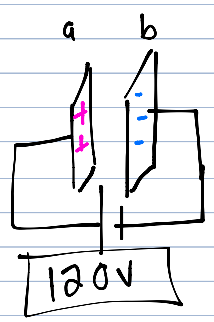
$= \frac{kq_1q_2}{r_a} - \frac{kq_1q_2}{r_b}$

$\Rightarrow PE = \frac{kq_1q_2}{r}$

Voltage ΔV is difference in potential ; $V_a - V_b$; physically meaningful

$\Delta V = \Delta U/q_0 = V_a - V_b = W_{a\to b}/q_0$

example 120V battery is connected between 2 parallel plates of separation $\Delta x = 10.0$ cm.



a) What is $\vec{E}$ between plates?

$W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{l} = q_0\int_a^b \vec{E}\cdot d\vec{l}$

$\rightarrow V_a - V_b = \Delta V = \frac{W}{q_0} = \frac{q_0}{q_0}\int_a^b \vec{E}\cdot d\vec{l} = E\int_a^b dl\cos 0° = E\Delta x$

$\rightarrow E = \frac{V_a - V_b}{\Delta x} = \frac{120V}{0.1m} = 1200\frac{V}{m}$

b) If you place a proton at rest near plate a, what is the change in P.E. after it hits the negative plate b?

$\Delta U = \Delta V q = (V_b - V_a)\,q = (-120V)(1.6\cdot 10^{-19}C) = -1.92\cdot 10^{-17}$ J

c) what is the impact speed?

cons. of E $\Rightarrow \Delta K + \Delta U = 0$

$\Delta K = -\Delta U$

$\frac{1}{2} m_p V_f^2 - \frac{1}{2} m_p V_i^2 = 1.92 \cdot 10^{-17}$ J $\longrightarrow$ $V_f = 152$ Km/s

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