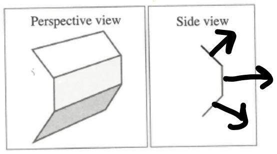
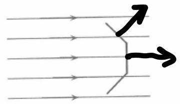
ELECTRIC FIELD AND FLUX Name ________ EM HW–79

1. A piece of paper is folded into three equal parts as shown.



   a. How many area vectors are needed to describe the surface of the paper? Sketch the area vectors on the side view diagram and label them $\vec{A}_1$, $\vec{A}_2$, *etc.*

   b. Consider an imaginary surface in a uniform electric field $\vec{E}$ as shown. The surface has the same size and shape as the paper above. Is the flux through the top third of the surface *greater than*, *less than*, or *equal to* the flux through the middle third? Explain.



   c. Write an expression for the net electric flux Φ_{net} through the entire surface in terms of the area vectors and the electric field $\vec{E}$. (*Hint:* Use the vector definition for electric flux found in tutorial to first write expressions for the flux through each of the flat surfaces.)

Notes on Lab 3

trial #1 $\varepsilon_1 = 100 \times \dfrac{(q_{angle} - q_{pail})}{q_{pail}}$

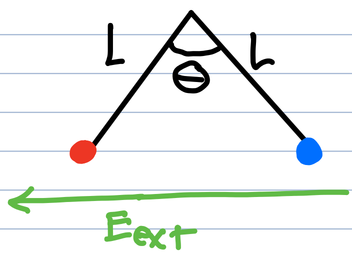
trial #2 $\varepsilon_2 = \ldots$

trial #3 $\varepsilon_3 = \ldots$

average "error" $= \dfrac{\varepsilon_1 + \varepsilon_2\, \varepsilon_3}{3}$

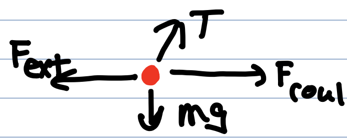
uncertainty on $\langle \varepsilon \rangle = \dfrac{\sigma(\varepsilon)}{\sqrt{3}}$

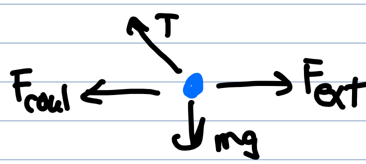
example 2 oppositely-charged balls, each with $|q| = 72.0\ nC$
AND there's an external E field



a) which ball is positive? red

b) draw free-body diagrams





c) solve for E_{ext}

red ball $\sum F_y = 0 \Rightarrow mg = T\cos\frac{\theta}{2} \rightarrow T = \dfrac{mg}{\cos\theta/2}$

$$\sum F_x = 0 \Rightarrow \frac{k|q|^2}{r^2} + T\sin\frac{\theta}{2} - qE_{ext}$$

we know that $\frac{1}{2}r = L\sin\frac{\theta}{2}$

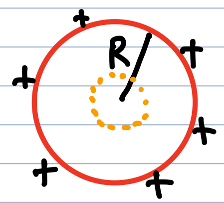
$$\Rightarrow E_{ext} = \frac{\frac{k|q|^2}{(2L\sin\frac{\theta}{2})^2} + mg\tan\theta/2}{q}$$

More Gauss' Law

$$\phi = \int \vec{E}\cdot d\vec{A} = Q_{enc}/\epsilon_0$$

ch 6 Concept Q #2: no charge → haven't changed the Q_{encl} for any surface

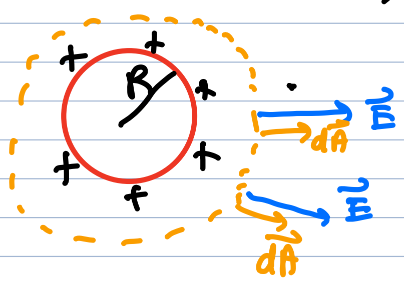
example $\vec{E}$ for a thin spherical shell of charge $+Q$



a) E inside $r < R$

$$\phi = \int \vec{E}\cdot d\vec{A} = Q_{encl}/\epsilon_0 = 0 \Rightarrow E = 0$$

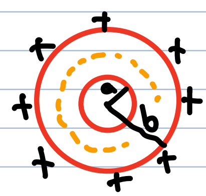
b) outside shell, $r > R$



$$\phi = \int \vec{E}\cdot d\vec{A} = \int E\,dA\cos 0^\circ = E\int dA = E 4\pi r^2$$

$$\rightarrow E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

example thick conducting shell of charge $+Q$, radii a & b



a) $r < a$

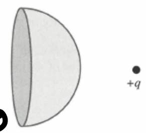
$Q_{encl} = 0 \Rightarrow E = 0$

b) $r > b$ $\quad Q_{enc} = +Q \Rightarrow E 4\pi r^2 = \frac{Q}{\epsilon_0} \Rightarrow E = \frac{kQ}{r^2}$

c) $a < r < b$ $\quad Q_{encl} = 0 \Rightarrow E = 0$!!

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.



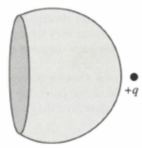
a. What is the flux through the *entire* closed surface? Explain.

zero $Q_{encl} = 0$

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.

$\phi_C = -\phi_L$

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.



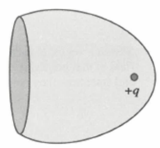
i. Does the value of Φ_L change? Explain.

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.

it remains the same. There is now more surface area for curved surface, but there are also different dot products

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

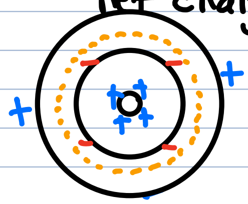
ii. How does the flux through the new curved portion of the surface compare to the flux through the original curved portion of the surface? Explain.

$\phi_{c\,new} > \phi_{c\,old}$

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.

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

<u>example</u> solid conducting sphere of radius a and charge +2Q, centered within a hollow conducting shell of radii b & c and net charge −Q.



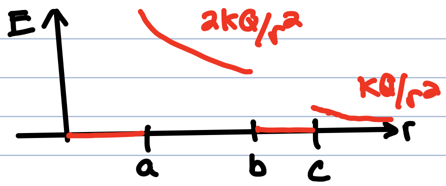
a) $r < a$ $E = 0$

b) $a < r < b$ $Q_{encl} = +2Q \Rightarrow E = \frac{k(+2Q)}{r^2}$

c) $r > c$ $Q_{encl} = +2Q - 1Q = +1Q$
$\Rightarrow E = k(+Q)/r^2$

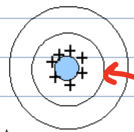
d) $b < r < c$ $Q_{encl} = 0$ since it's a conductor
$\Rightarrow E = 0$

∴ if charge on outer surface of ball is +2Q
→ −2Q on inner surface of shell
→ +1Q on outer surface of shell

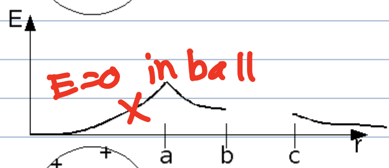


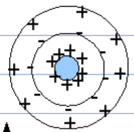
Ch 6 Concept Q 3

A neutral, conducting spherical shell surrounds a charged conducting ball. Which is correct?

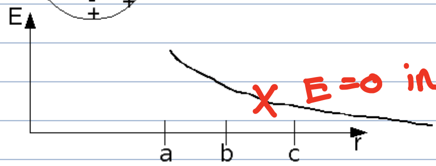
a) 

must have charge on inner surface to cancel net charge on ball.

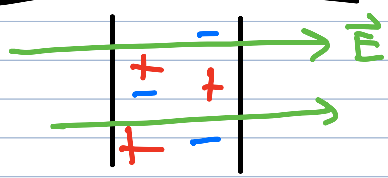
b) 

c) 

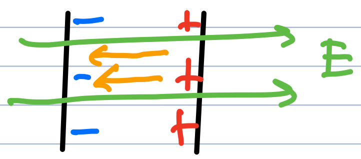
✓

d) 

External $\vec{E}$ fields



each free e^- feels an electric force $\vec{F} = -e\vec{E}$. so they move to the left



after enough have moved, an internal $\vec{E}$ field is created that cancels the external field inside