① Phys 2426 2017-09-12 Lec 3

- Equation Sheet posted w/ Lecture Notes
- HW1 Due Wed 9/20 night

Electric field causes Force

$$\vec{F_E} = q_0 \vec{E}$$

⊕ is pushed with $\vec{E}$; ⊖ pulled against $\vec{E}$

Source charges (not q_0) cause $\vec{E}$.

- Point Charge $E = \frac{kQ}{r^2}$ (away from ⊕

- Charge Distribution
$$\vec{E} = \int \frac{k\,dQ}{r^2}\hat{r}$$

- Gauss's Law
  - Electric Flux is like "total $\vec{E}$ piercing a surface".

$$\Phi_E = \iint \vec{E} \cdot d\vec{A} = E_{\perp avg} A$$

  - Each charge generates flux proportional to Q.

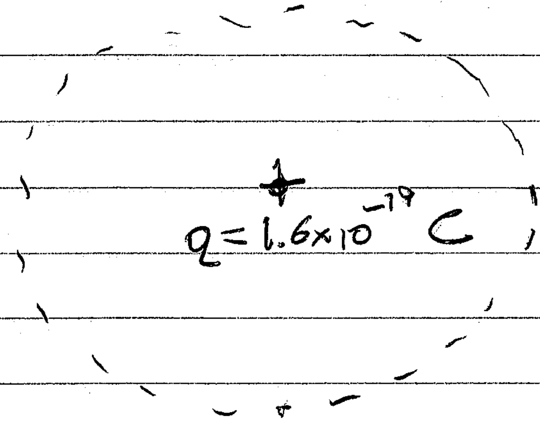
$$\Phi_E = Q/\varepsilon_0 = 4\pi k Q$$

(2)

To apply Gauss's Law, we must create an imaginary surface to "catch" the flux generated by our charges.

$$\left(\frac{Nm^2}{C^2}\right)(C)=\left(\frac{N}{C}\right)(m^2)$$

Ex: Point Charge



Flux generated:

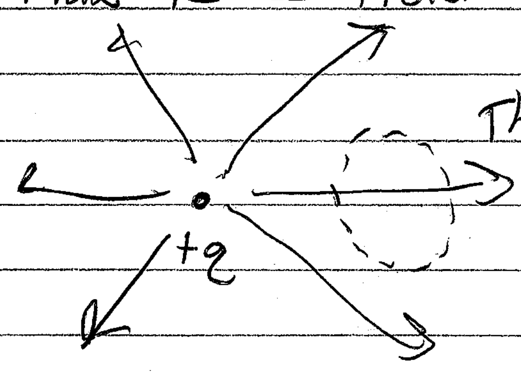
$$\Phi = 4\pi k Q$$
$$= 4\pi(9\times10^{9})(1.6\times10^{-19})$$
$$= 1.8\times10^{-8}\left(\frac{N}{C}\right)(m^2)$$

"Catch" with sphere of radius r.

$$\Phi = E_{\perp} A$$

$$E = \frac{\Phi}{A} = \frac{4\pi kQ}{4\pi r^2} = \frac{kQ}{r^2}$$

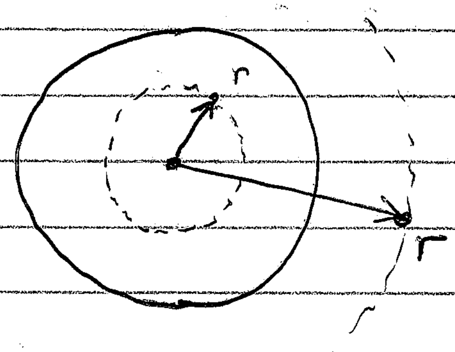
- Any charges inside our "net" contribute to the flux caught.
- Any charges outside it don't contribute.
- Flux is E-Field Lines.



This line goes in & out of the net.
This charge doesn't contribute to caught Φ_E

③

Solid Ball of Charge



$Q = +5\ nC$
$R = 0.25\ m$

For points outside, $r > 0.25\ m$
Our "net" surrounds the whole ball.

Q_{enc} = Q enclosed by "net"

$$\Phi = 4\pi k Q_{enc}$$
↑ entire Q

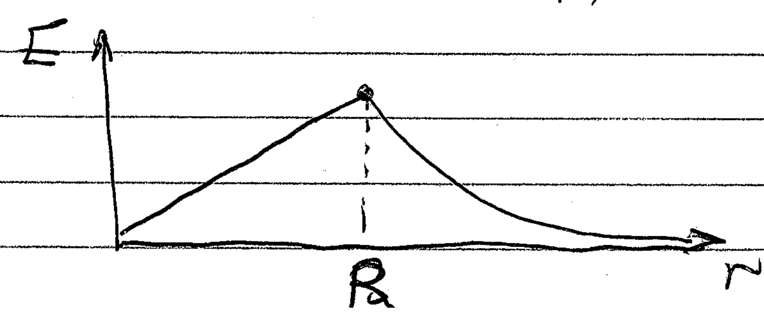
$$E = \frac{\Phi}{A} = \frac{4\pi k Q_{enc}}{4\pi r^2} = \frac{kQ}{r^2} = \frac{k(5\,nC)}{r^2}$$

For points inside, $r < 0.25\ m$

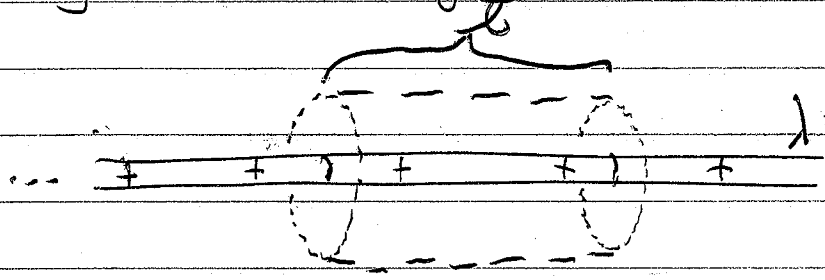
Q_{enc} isn't the entire ball.

$$\rho = \frac{Q}{\frac{4}{3}\pi R^3} = \frac{Q_{enc}}{\frac{4}{3}\pi r^3} \rightarrow \frac{Q_{enc}}{\cancel{\ }} = \frac{r^3}{R^3} Q$$

$$E = \frac{kQ_{enc}}{r^2} = \frac{k}{r^2}\frac{r^3 Q}{R^3} = \frac{kQr}{R^3}$$



Long Line Charge



$$\lambda = \frac{Q}{L} = \frac{Q_{enc}}{\ell}$$

This is cylindrical symmetry.

Total Flux caught

- Generated by Q_{enc}

$$\Phi_E = 4\pi k Q_{enc} = 4\pi k \lambda \ell$$

- Caught by "net":

Round Part: $\Phi_E = E_\perp A = E\, 2\pi r \ell$

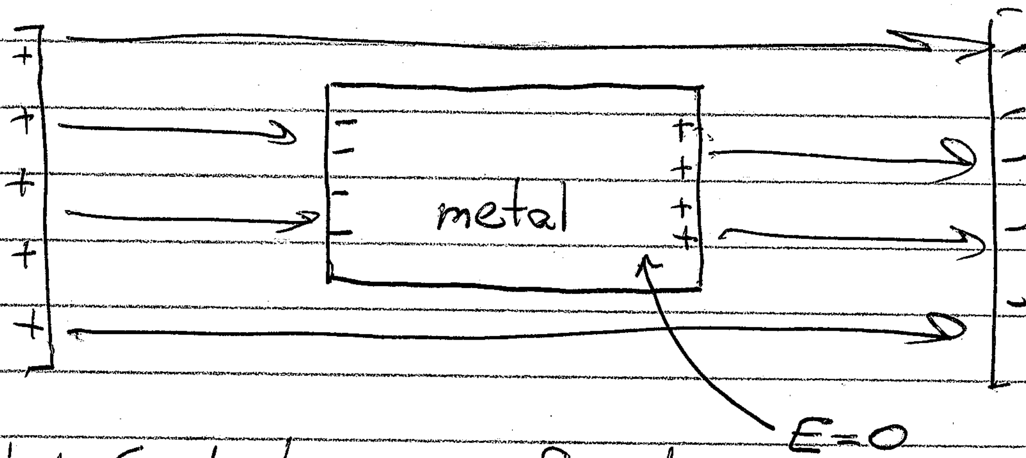
Flat Caps: $\Phi_E = E_\perp A = 0\, \pi r^2 = 0$

$$E\, 2\pi r \ell = 4\pi k \lambda \ell$$

$$E = \frac{2k\lambda}{r}$$

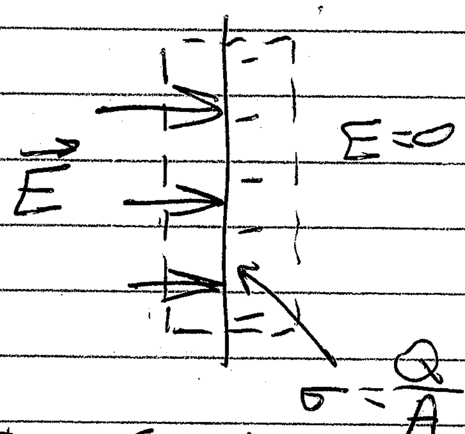
Electric Field of infinite line charge.

Conductor in an E-field



Solid Conductor: ⊕ fixed
most ⊖ fixed
valence ⊖ mobile (~1 or 2 per atom)

How much ⊖ or ⊕ on the metal surface?



Flux generated

$$\Phi_E = 4\pi k Q_{enc} = 4\pi k \sigma A$$

Flux Caught

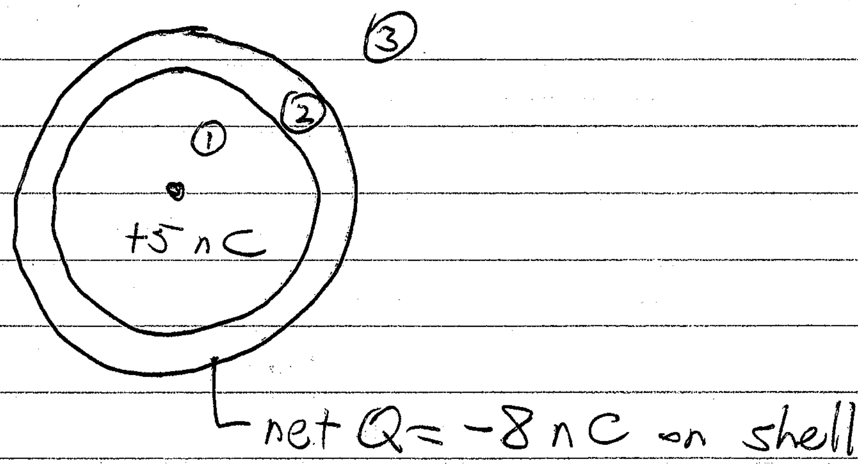
Left: $\Phi_E = EA$
Right: $\Phi = 0$

$$E = 4\pi k \sigma$$
$$= \sigma / \varepsilon_0$$

E outside metal surface

⑥

Conductive Shell



① Inside: $E = \frac{k(5\,nC)}{r^2}$

③ Outside: $E = \frac{k(5\,nC - 8\,nC)}{r^2}$

② In metal: $E = 0 = \frac{k(5\,nC + {}^{-}5\,nC)}{r^2}$

Where is the −5 nC?
On inner surface of shell.
Where is the other −3 nC?
On the outer surface of the shell.