Announcements

1. Tutorial schedule
2. WebAssign class rolls
2. HW1 & HW2 due at 5 PM this evening.
3. Topics for today:

   Review of the notion of an electric field

   Coulomb's law ←→ Gauss's law

PHY 114 General Physics II -- Section B

MWF 11-11:50 AM	OPL 101	http://www.wfu.edu/~natalie/s03phy114/

Instructor: Natalie Holzwarth	**Phone:** 758-5510	**Office:** 300 OPL	**e-mail:** natalie@wfu.edu

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Tutorials for PHY 114 will be scheduled in room Olin 107 as listed below. Network connections are available at most of the seats. The (C), (S), and (H) labels refer to tutorials especially designed for Carlson, Salsbury, and Holzwarth sections, respectively. Please address any questions or suggestions about the tutorial schedule or format to natalie@wfu.edu.

Schedule for PHY 114 tutorials in Olin 107 (starting Tuesday, Jan. 22, 2003)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	3-5 PM (C)					
7-9 PM	6-8 PM (S)	7-9 PM	7-9 PM	7-9 PM (H)		

Problem solving session for Section B 6-7 PM

The tutors:

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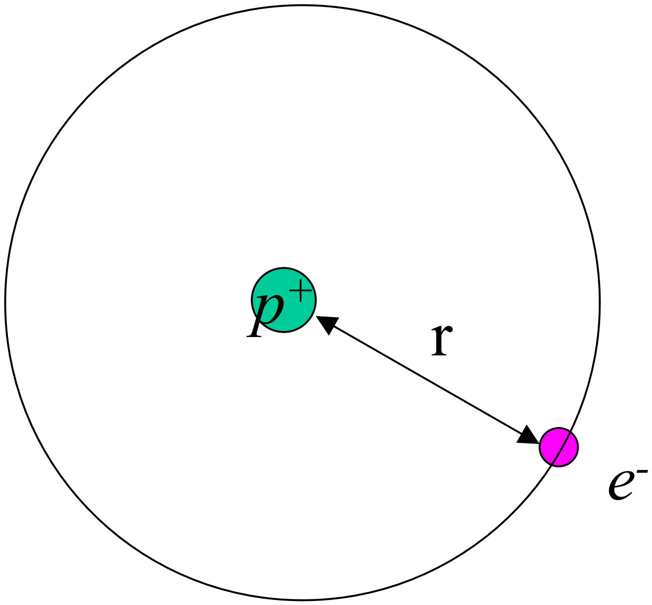
Doug Bonessi <bonedk1@wfu.edu>

Bryan Stephens <stepbj1@wfu.edu>

Review – Coulomb's law



$$\mathbf{F} = k_e \frac{q_e q_p}{r^2} \hat{\mathbf{r}}$$

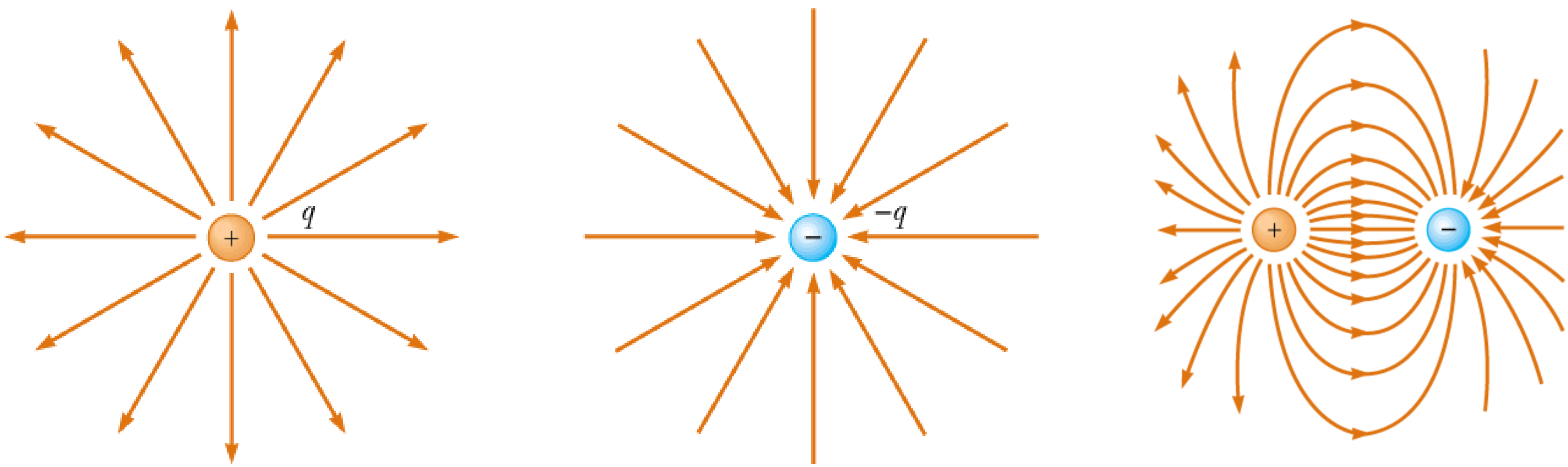
Consider an electron and a proton attracted to each other according to Coulomb's law. Show that the electron can have a stable circular orbit around the proton. Suppose that the radius is r = 0.529x10^{-10} m; calculate the period and energy of the orbit.

Electric field:

$$\mathbf{E}(\mathbf{r}_1) = \sum_i k_e \frac{q_i}{|\mathbf{r}_1 - \mathbf{r}_i|^2}\hat{\mathbf{r}}_{1i}$$

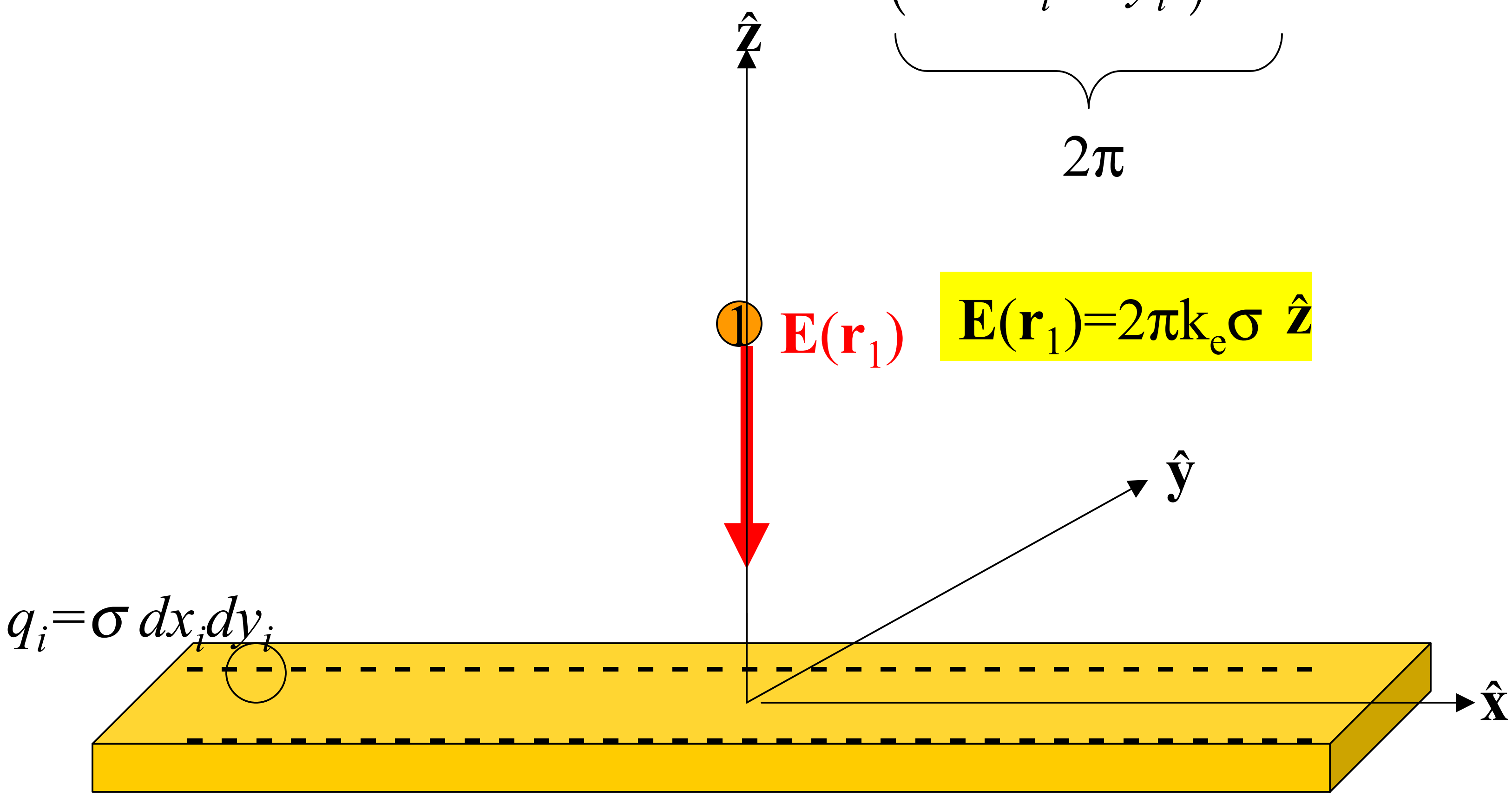
The force on a 1 C charge placed at r_1.

Field lines help to visualize electric field:



Electric field due to large uniformly charge plate:

$$\mathbf{E}(\mathbf{r}_1) = \sum_i k_e \frac{q_i}{|\mathbf{r}_1 - \mathbf{r}_i|^2}\hat{\mathbf{r}}_{1i} = k_e \sigma \hat{\mathbf{z}} \int_{-\infty}^{\infty} \underbrace{\frac{z\,dx_i\,dy_i}{\left(z^2 + x_i^2 + y_i^2\right)^{3/2}}}_{2\pi}$$



$$\boxed{\mathbf{E}(\mathbf{r}_1) = 2\pi k_e \sigma\ \hat{\mathbf{z}}}$$

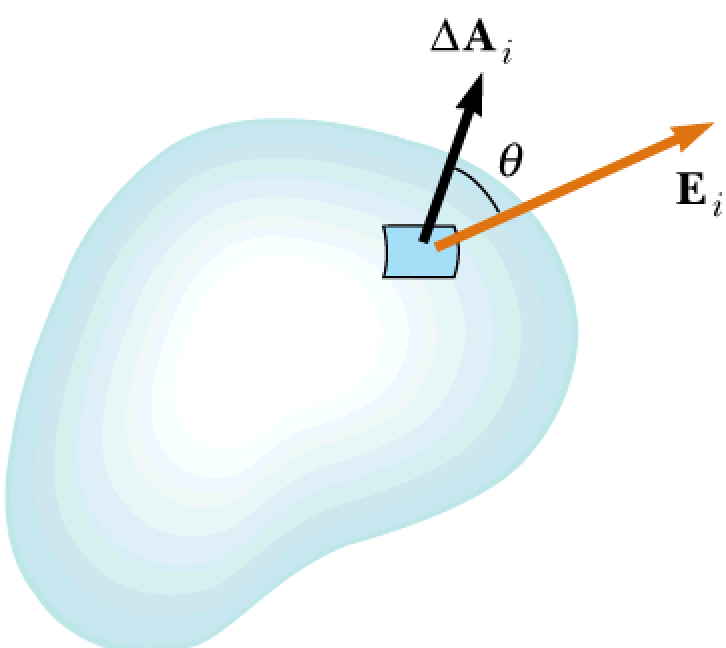
Peer instruction question

We have discussed the notion that if we know that field at the point $\mathbf{r}_1$ is $\mathbf{E}(\mathbf{r}_1)$, we can determine the force on a charge q at that point according to $\mathbf{F} = q\,\mathbf{E}(\mathbf{r}_1)$. This assumes that the charges that determine $\mathbf{E}(\mathbf{r}_1)$ are not effected by q. When is this a good approximation?

(A) Always (B) Never (C) Most often for metals.
(D) Most often for insulators.

An alternative method for calculating electric fields – Gauss's Law

Define electric "flux":



$$\Phi_E \equiv \int \mathbf{E} \cdot d\mathbf{A}$$
$$= \int E\,dA\cos\theta$$

Gauss's law says:

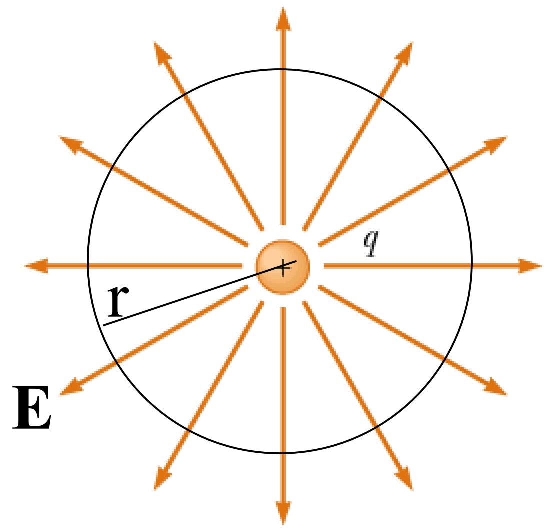
$$\oint \mathbf{E} \cdot d\mathbf{A} = 4\pi k_e (\text{charge inside})$$

Integral of surrounding surface

$$\oint \mathbf{E} \cdot d\mathbf{A} = 4\pi k_e (\text{charge inside})$$

How can it be true?:

Consider simple case:



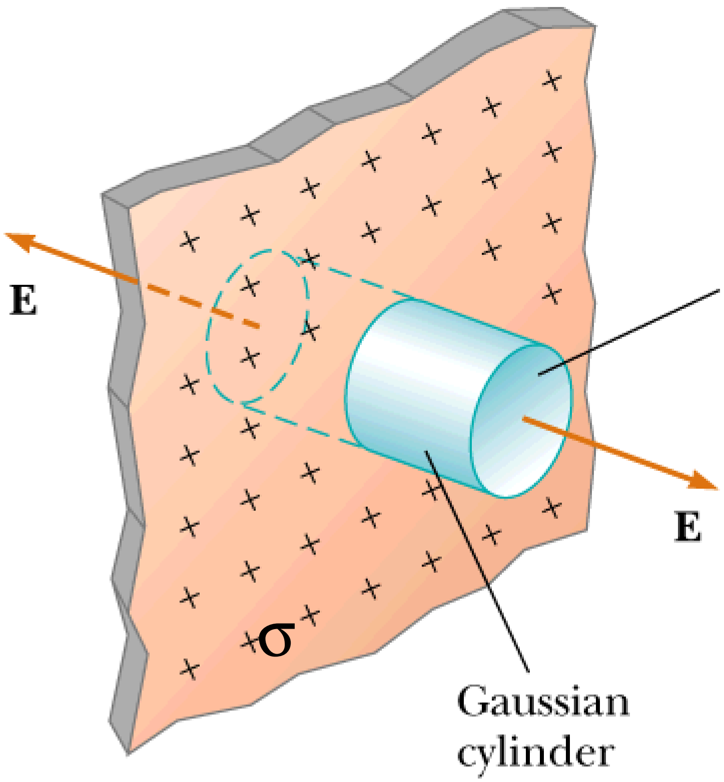
Assume **E** is purely radial and has a constant value on the surface of a sphere of radius r.

$$\oint \mathbf{E} \cdot d\mathbf{A} = |\mathbf{E}|(\text{area of sphere}) = |\mathbf{E}|\ (4\pi r^2)$$

$$|\mathbf{E}|\ (4\pi r^2) = 4\pi\, k_e q$$

$$|\mathbf{E}| = \frac{k_e q}{\mathrm{r}^2}$$

Electrostatic field from charged sheet



2 ends of cylinder

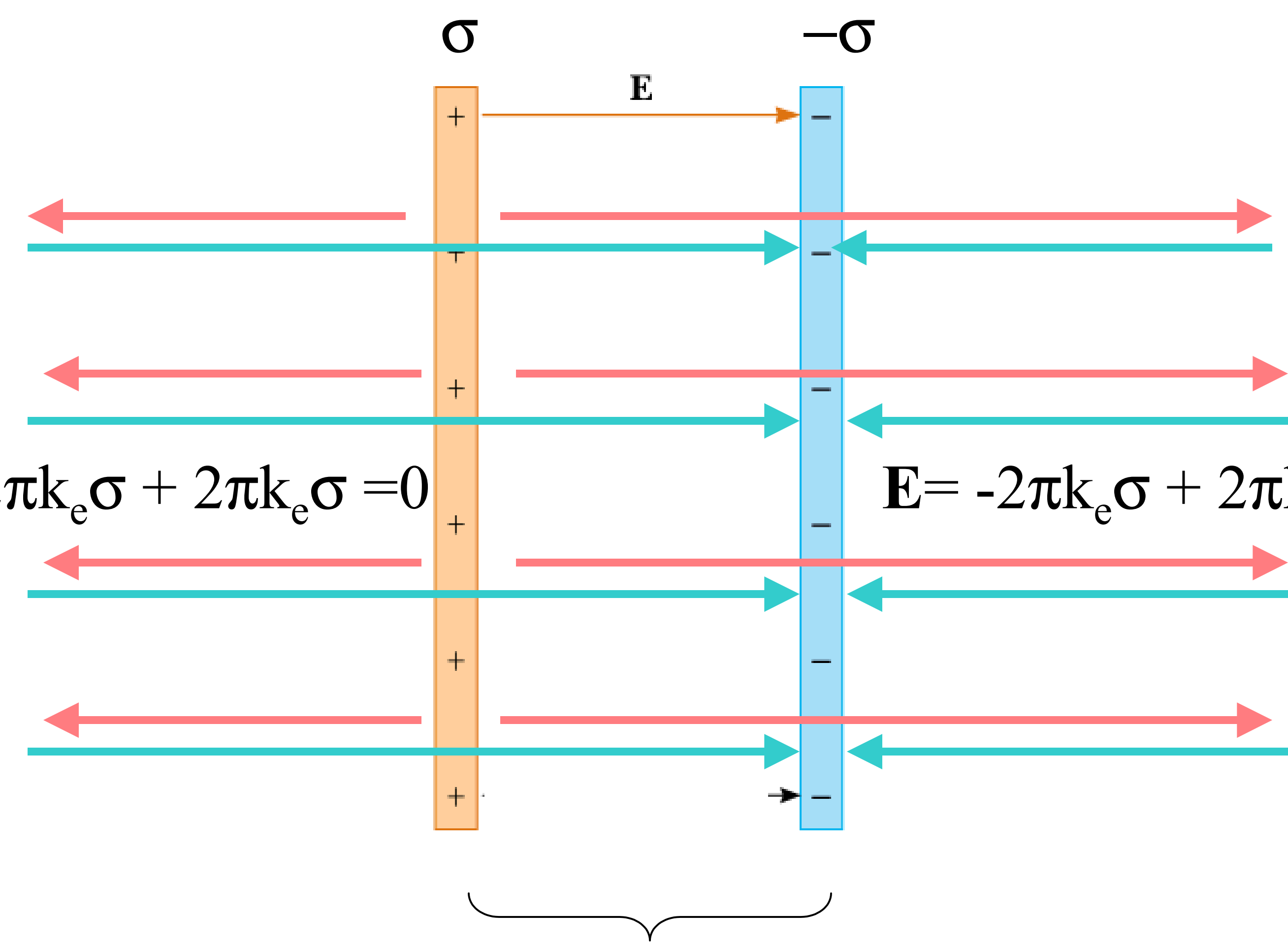
$$2EA = 4\pi k_e(\text{charge inside})$$

$$\Rightarrow E = \frac{4\pi k_e \sigma A}{2A} = 2\pi k_e \sigma$$

$$k_e \equiv \frac{1}{4\pi\varepsilon_0} \Rightarrow 2\pi k_e = \frac{1}{2\varepsilon_0}$$

$$\Rightarrow E = \frac{\sigma}{2\varepsilon_0}$$

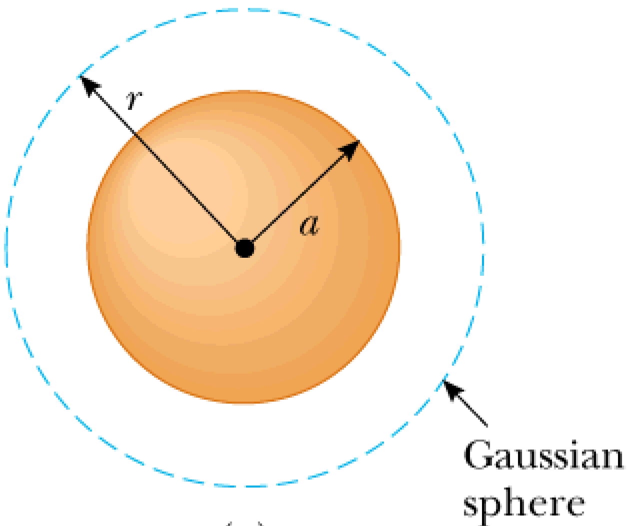
permittivity constant $=8.854\times10^{-12}\ C^2/(Nm^2)$



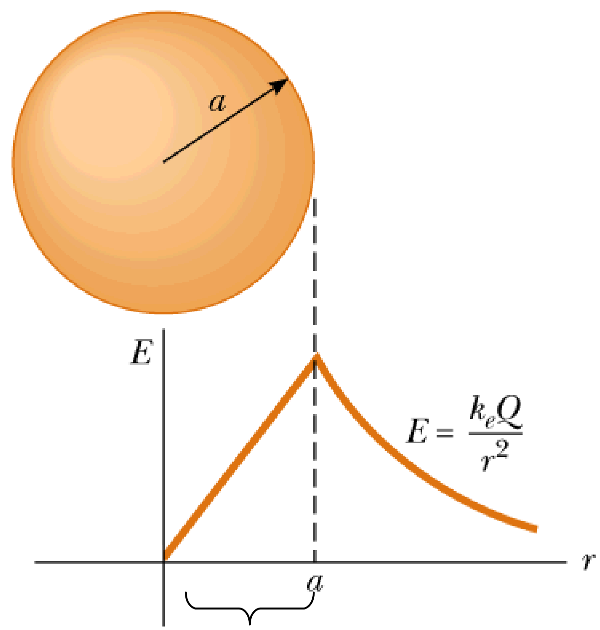
$$\mathbf{E}= -2\pi k_e\sigma + 2\pi k_e\sigma =0 \qquad \mathbf{E}= -2\pi k_e\sigma + 2\pi k_e\sigma =0$$

$$\mathbf{E}= 2\pi k_e\sigma + 2\pi k_e\sigma = 4\pi k_e\sigma = \sigma/\varepsilon_0$$

Electric field inside and outside uniformly charged sphere:



(a) (b)



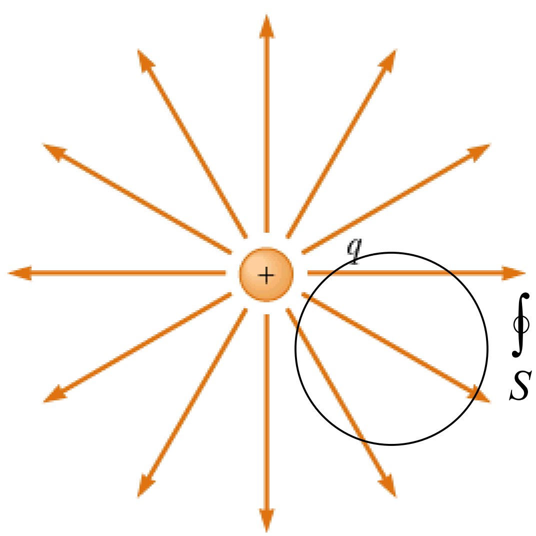
$$E = \frac{k_e Q r}{a^3}$$

Summary – Gauss's law

$$\oint_S \mathbf{E} \cdot d\mathbf{A} = 4\pi k_e \int_V dV \rho = \frac{1}{\varepsilon_0} \int_V dV \rho$$

closed surface

volume inside surface



$$\oint_S \mathbf{E} \cdot d\mathbf{A} = 0$$

Behavior of materials in an electric field

➔ Charges move in response to the forces applied to them until they come to equilibrium.

- Insulators – charges are (more or less) held in place by atomic and molecular forces

- Conductors – charges are mobile and move such that the electric field within the conductor is approximately 0.