Physics 231a Course Update 27 Aug 2003

- Reading Assignment Chapter 21(§1-6), 22(§1-5)
- The 1st problem is on line.
- The 1st problem set will be due at 08:00 Mon. 08 Sept.
- Dr. Greene is ***usually*** in his office Monday afternoons (until ~3:00pm) and Wednesday afternoons. He is NOT on campus on Tuesdays and Thursdays.

The First Hour Exam will be held during the Wednesday 17 Sept. class meeting. The Test will cover material in Chapter 21 (§1-8), Chapter 22 and parts of Chapter 23 (TBD)

The Electric Field

Minor Problem…What if putting charge q in the vicinity of the other charges causes them to move?

Definition of the Electric Field:

$$\boxed{\vec{E} = limit_{q \to 0} \frac{\vec{F}}{q}}$$

We can calculate the Electric filed from a collection of charges from:

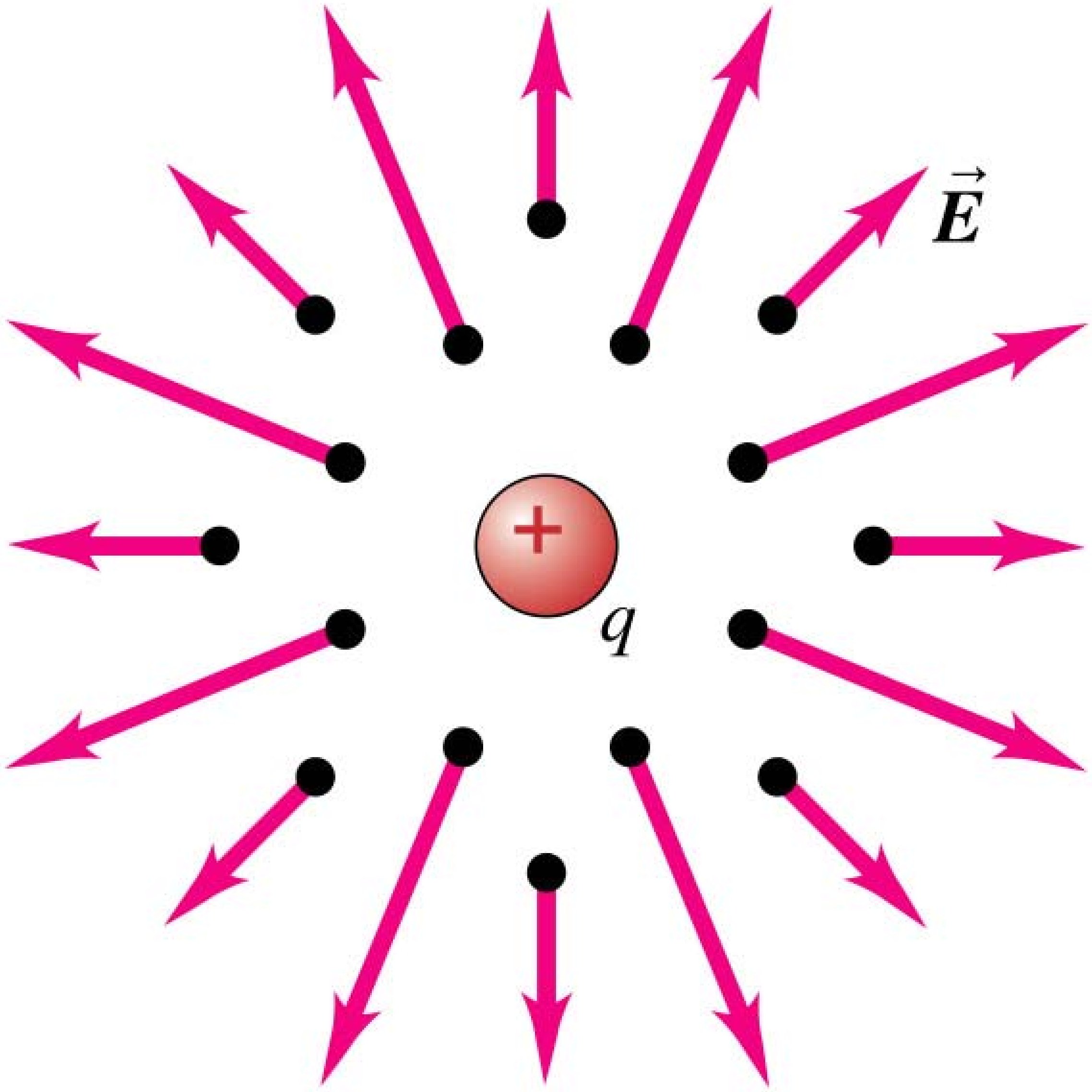
$$\vec{F} = q \sum_i \frac{1}{4\pi\varepsilon_0} \frac{q_i}{r_i^2} \hat{r}_i$$

Which Gives

$$\vec{E} = \sum_i \frac{1}{4\pi\varepsilon_0} \frac{q_i}{r_i^2} \hat{r}_i$$

or for continuous charge distribution

$$\vec{E} = \int_{all} \frac{1}{4\pi\varepsilon_0} \frac{\rho(\vec{r})}{r^2} \hat{r} dv$$



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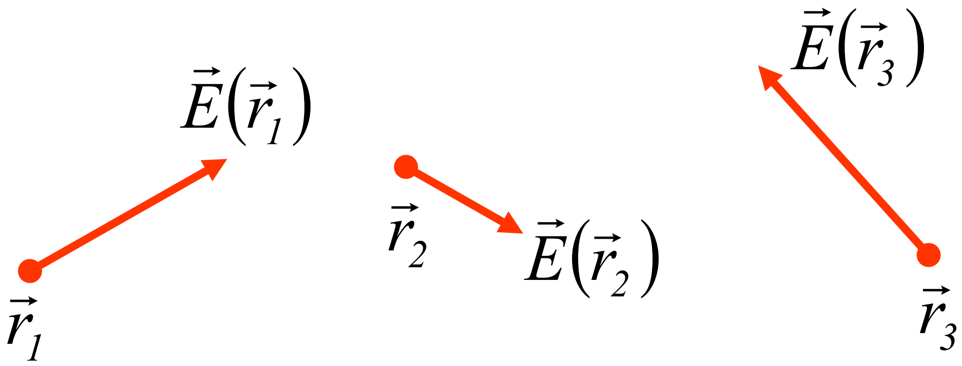
ELECTRIC FIELD "LINES"

An Electric Field assigns VECTOR to each point in space:



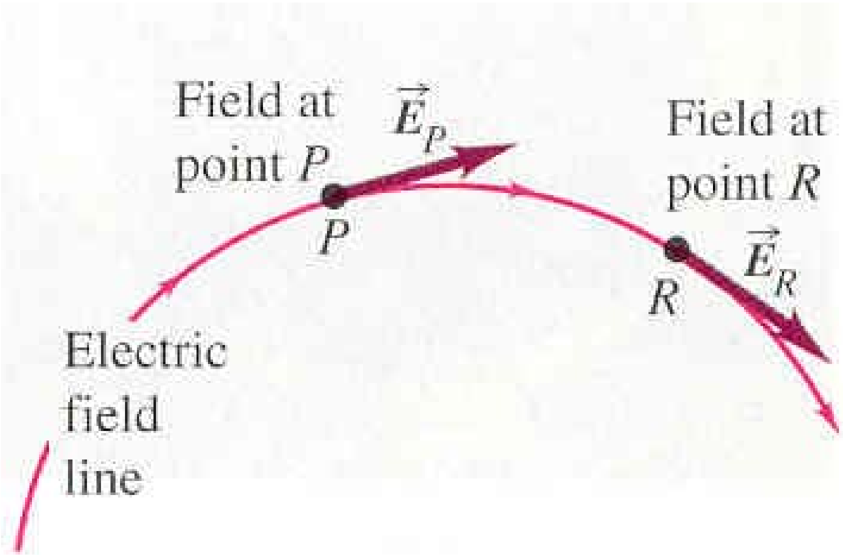
A convenient way to visualize the Electric Field is with "ELECTRIC FIELD LINES"

The local direction of the Field Lines is the direction of the electric field at that point

The "density" of electric field lines is proportional to the magnitude of the electric field at that point

The direction of the electric field line give the direction of the force on a charge particle at that point. It does not necessarily represent the direction of motion of a charged particle at that point!

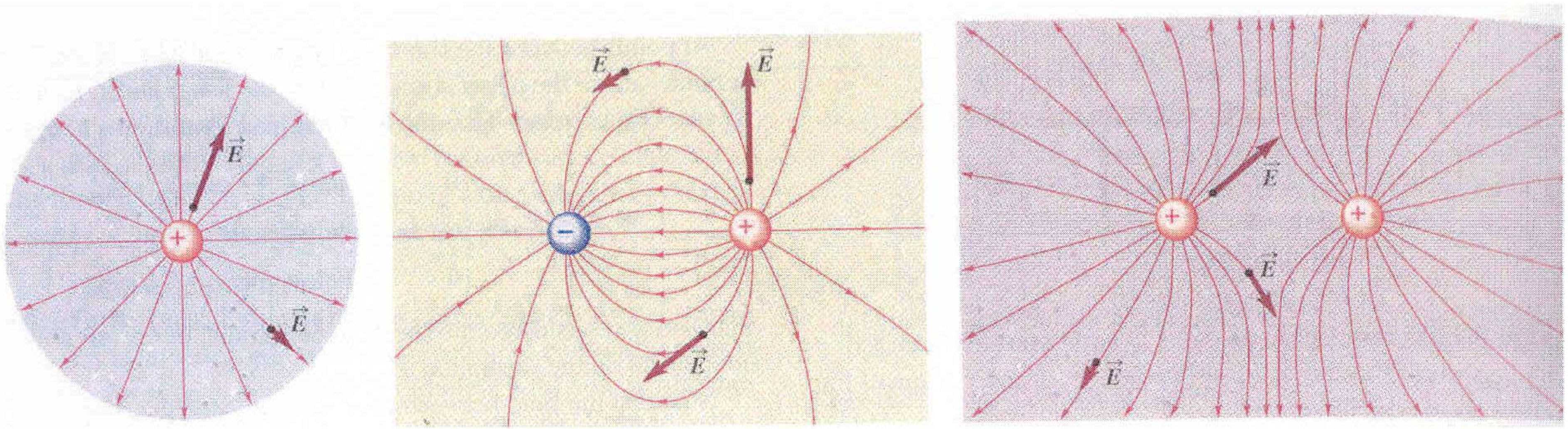
Electric Field Lines



22–21 The direction of the electric field at any point is tangent to the field line through that point.

Electric Field Lines are CONTINUOUS Lines t
That Begin and End on Charges

The Sense of the Field Lines is Away from the + charge



The Local Direction of the Electric Field is along the Field Line
The Local Strength of the Electric Field is Proportional to the Density of Lines

A Note About Conductors and Insulators

*A **CONDUCTOR** is a material in which electric charges are free to "move around"*

*An **INSULATOR** is a material in which the electric charges are immobile*

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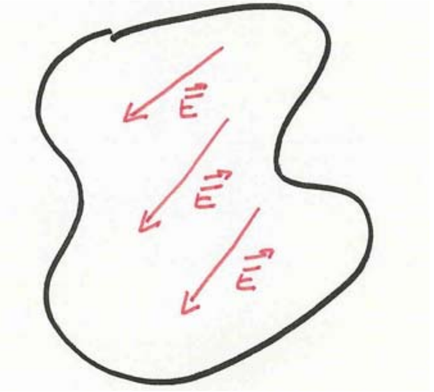
*Conductors can be **CHARGED** or **UNCHARGED*** *(refers to net charge)*

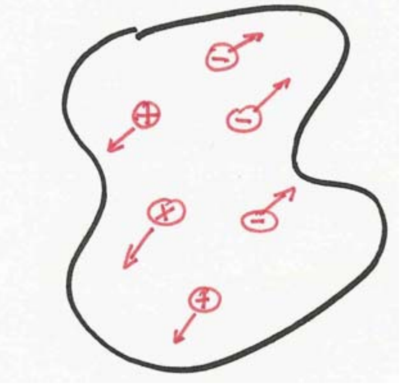
*Insulators can be **CHARGED** or **UNCHARGED***

Electric Field Inside a Conductor

1. Charges can move freely inside a conductor
   (actually it is only the electrons that move)
2. Assume that there is an Electric Field Inside Conductor:



3. Since the Charges are free to move, they we be pushed towards the surface of the Conductor:



4. The field of these charges will tend to cancel the original Field.
5. They will continue to move until the field is zero

The Electric Field inside a Conductor is EXACTLY ZERO

End of Chapter 21

You are expected to:

- Know what the following are:
  charge, electrons, protons, atomic number, conductors, insulators, electrostatic force, superposition, and electric field.

- Understand Coulomb's Law including the notion of a unit vector r and to be able to express the direction of the electric field.

- Calculate the force on a point charge due to another point charge.

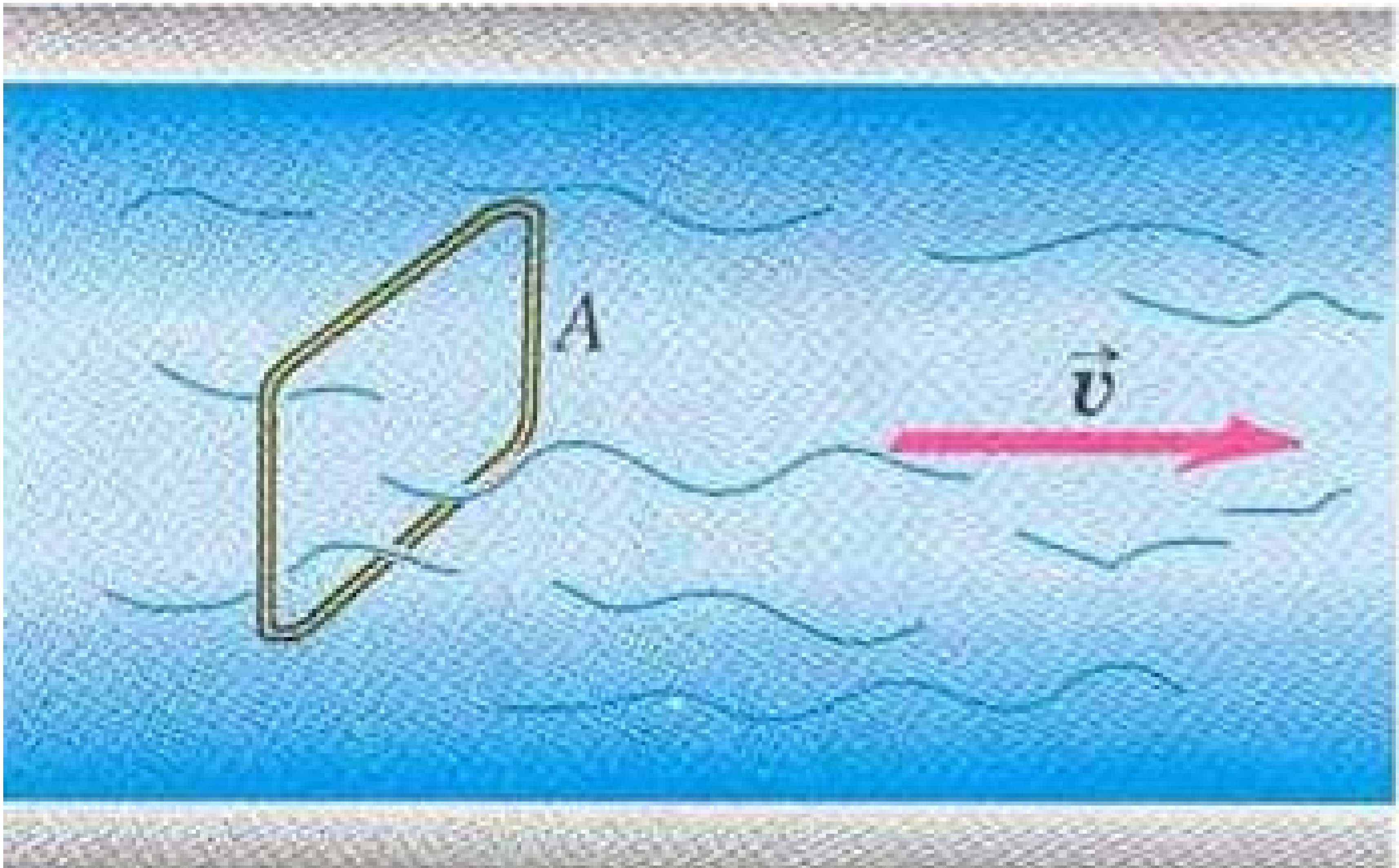
- Calculate the electric field from a point charge and, using superposition, calculate the electric field from a simple collection of point charges.

- Understand the notion of Electric Field Lines and be able to roughly sketch the field lines for simple collections of charges.

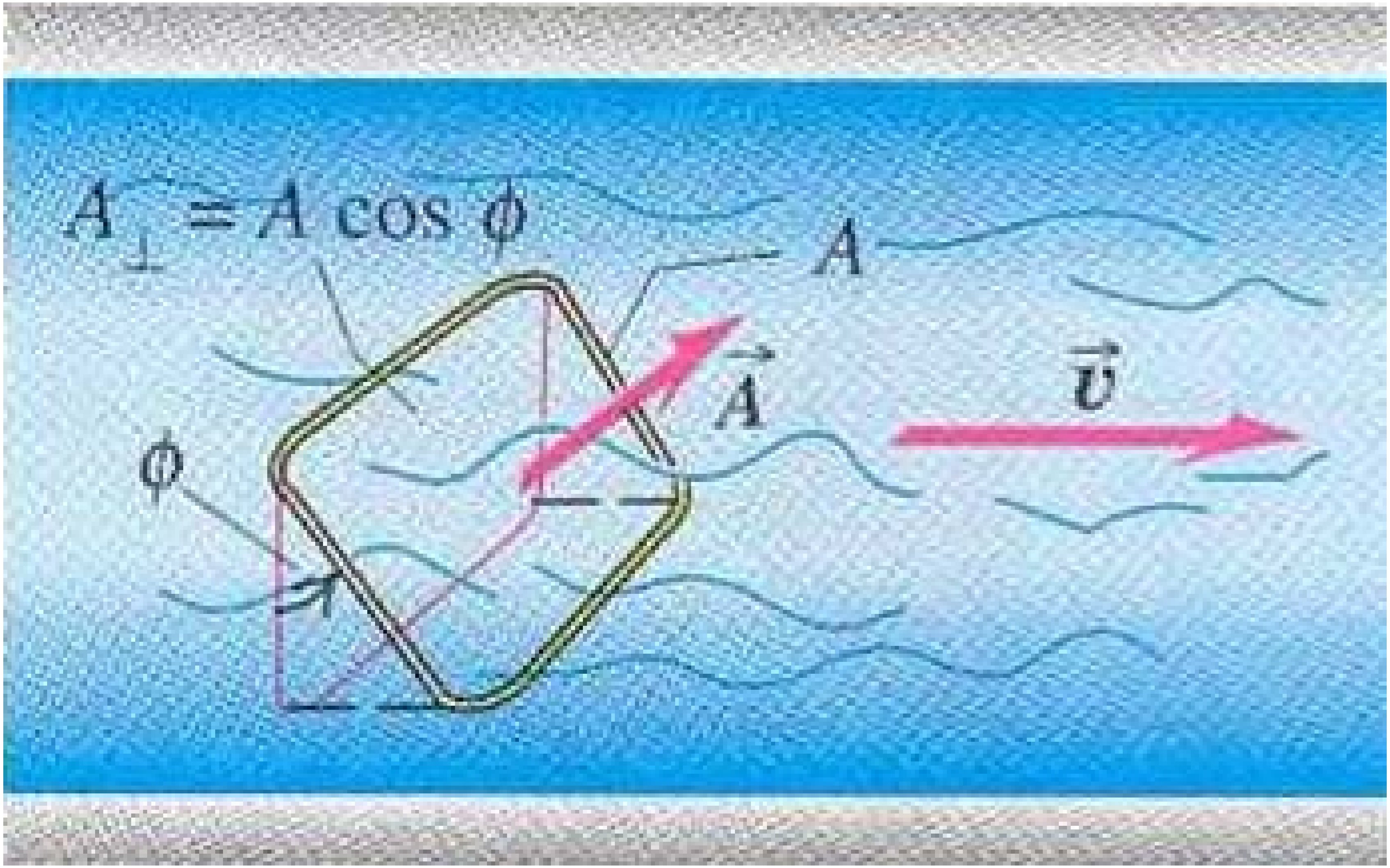
Recommended F&Y Exercises chapter 21:

- 3,13,14,15,16,24,32

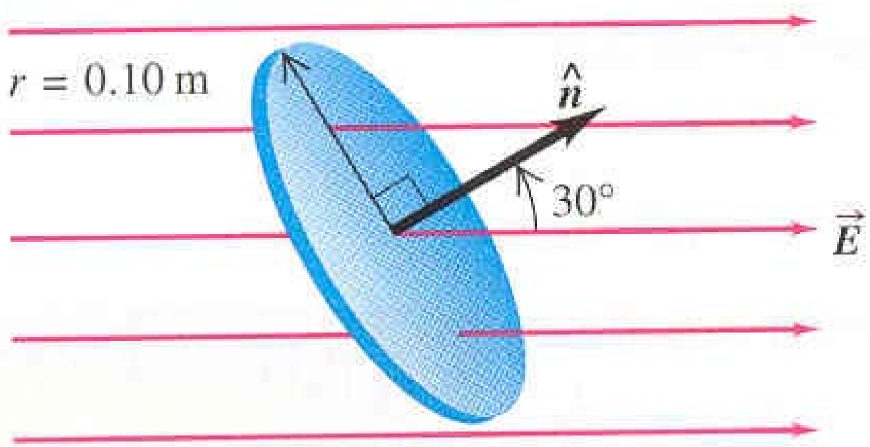
Flux is the "Amount of Stuff" going through an Area



Flux Depends on the orientation of the "Area"



Electric Flux



$$\Phi_E = EA\cos\phi$$

$$\Phi = \vec{E}\cdot\vec{A}$$

Direction of $\vec{A}$ is $\perp$ to the surface

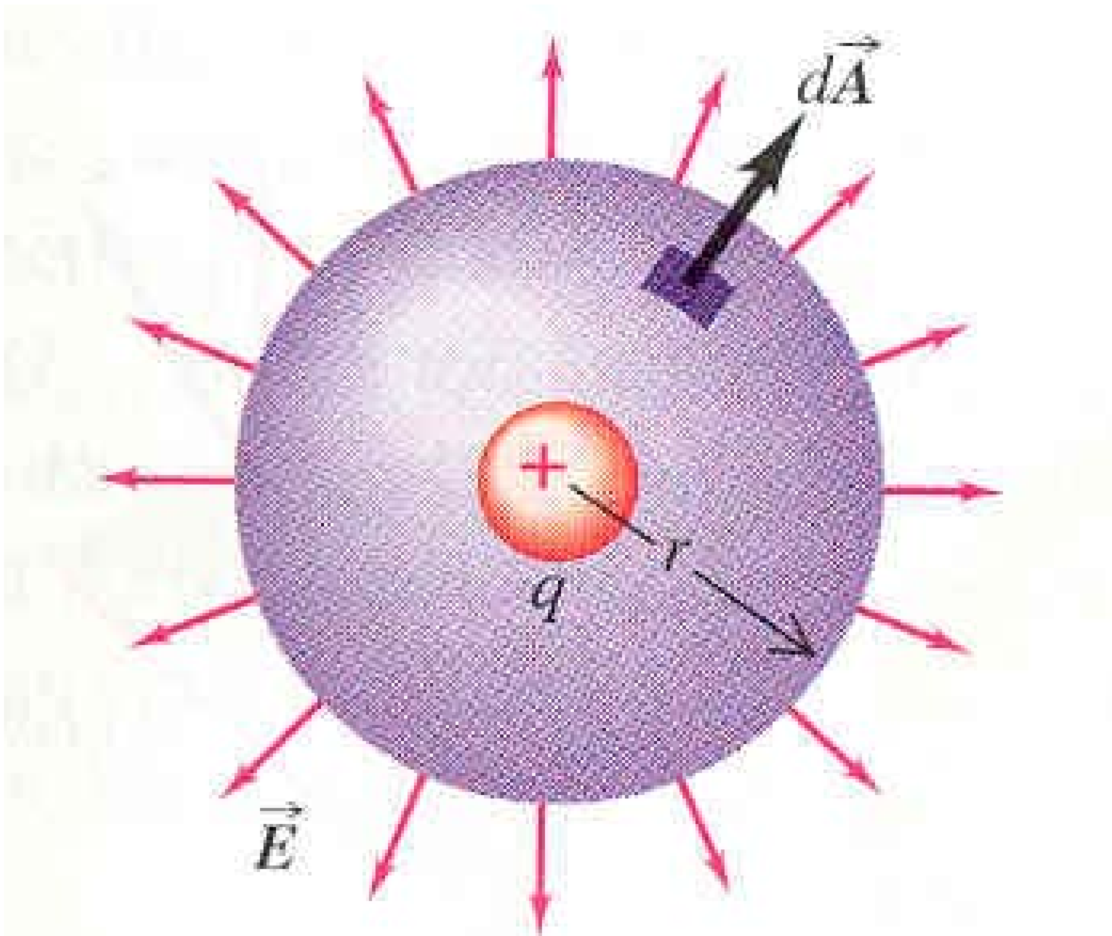
Magnitude of $\vec{A}$ is equal to area of surface

$$\vec{A} = A\hat{n}$$

TOTAL FLUX $\Phi = \int E\cos\phi\, dA = \int E_{\perp}\, dA = \int \vec{E}\cdot d\vec{A}$

IMPORTANT: Nothing is really "flowing'

Total Flux From a Point Charge Through a Sphere



$$\Phi = \int \vec{E} \cdot d\vec{A}$$

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r} \qquad d\vec{A} = \hat{r}\, dA}$$

$$\Phi = \int \left(\frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \right) \hat{r} \cdot \hat{r}\, dA$$

$\boxed{\hat{r} \text{ is a unit vector} \quad \hat{r} \cdot \hat{r} = (1)(1) \cos 0 = 1}$

$$\Phi = \frac{q}{4\pi\varepsilon_0} \frac{1}{r^2} \underbrace{\int dA}_{\text{AREA OF SPHERE} = 4\pi r^2}$$

$$\Phi = \frac{q}{4\pi\varepsilon_0} \frac{1}{r^2} 4\pi r^2$$

$$\Phi = \frac{q}{\varepsilon_0}$$