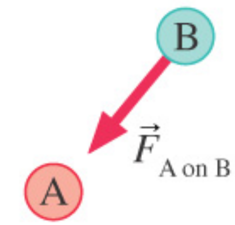
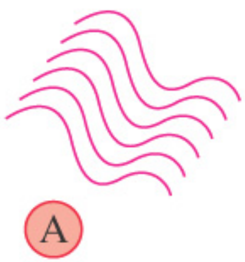
PHY294H

- Professor: Joey Huston
- email:huston@msu.edu
- office: BPS3230
- Homework will be with Mastering Physics (and an average of 1 hand-written problem per week)
  - **first MP assignment due Wed Jan. 20; first hand-written problem as well**
  - **Introduction to MP is for no credit, just help**
  - **I'm working on setting up some hours in the help-room**
- Quizzes by iclicker (sometimes hand-written)
  - there are 5 of you who have still not given me your iclicker numbers
- Course website: www.pa.msu.edu/~huston/phy294h/index.html
  - lectures will be posted frequently, mostly every day if I can remember to do so

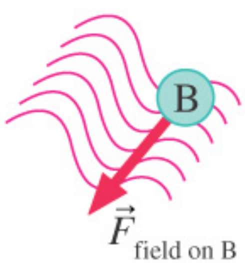
Compare action at a distance and field



In the Newtonian view, A exerts a force directly on B.



In Faraday's view, A alters the space around it. (The wavy lines are poetic license. We don't know what the alteration looks like.)

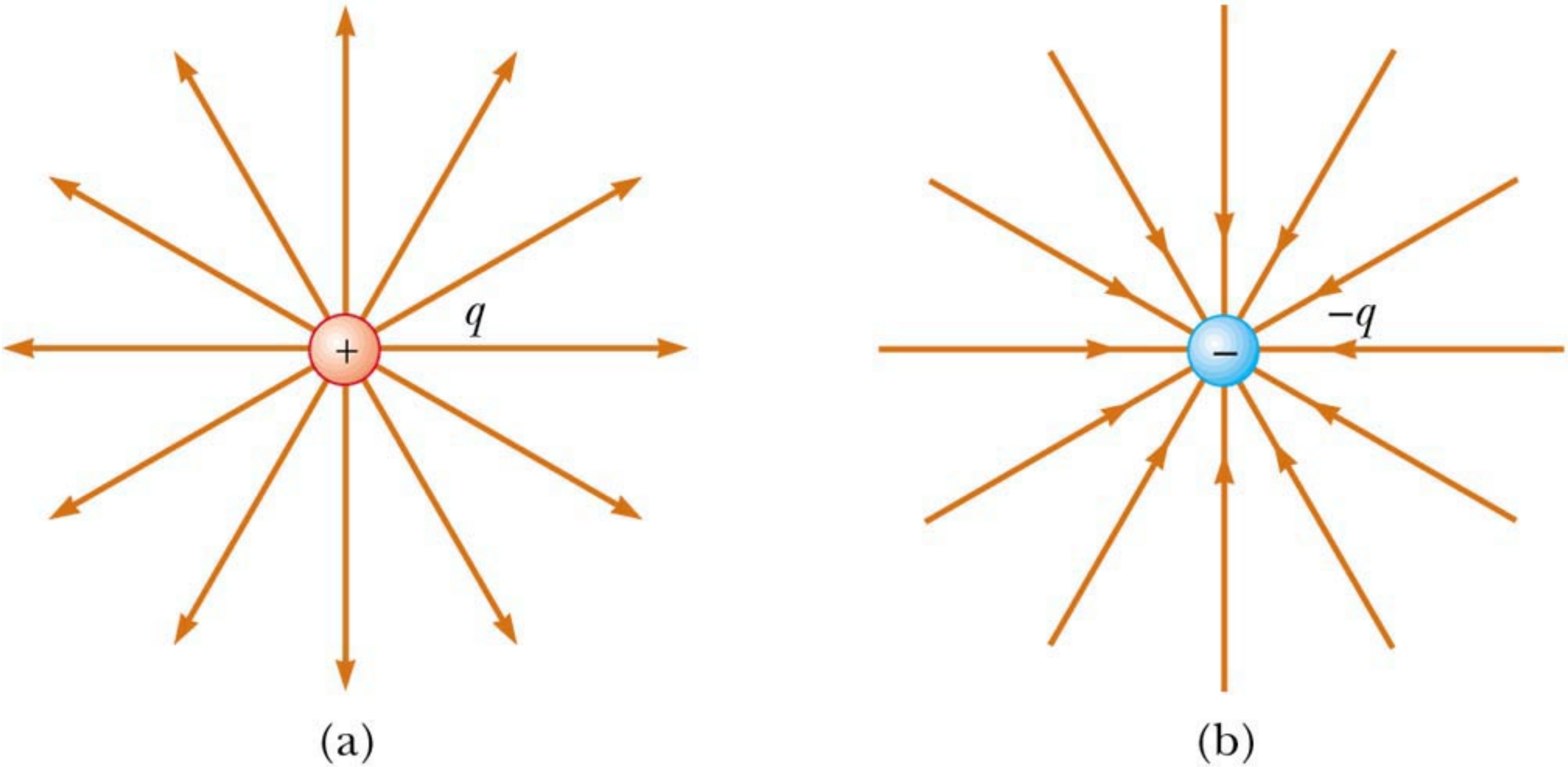


Particle B then responds to the altered space. The altered space is the agent that exerts the force on B.

- So we're going to replace the idea of action at a distance by the concept of a field
- Particles don't interact directly with each other
- They create fields which then interact with the other particles
  - we will need this when we start talking about dynamic situations
- We'll be dealing with electric and magnetic fields in this course

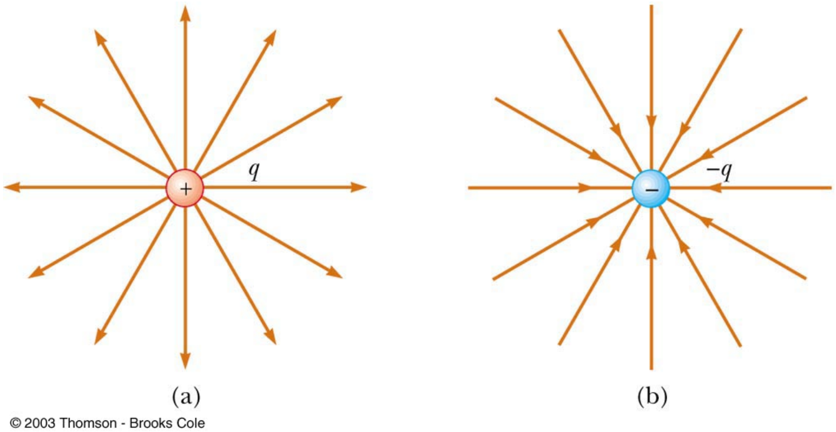
Electric Field Lines

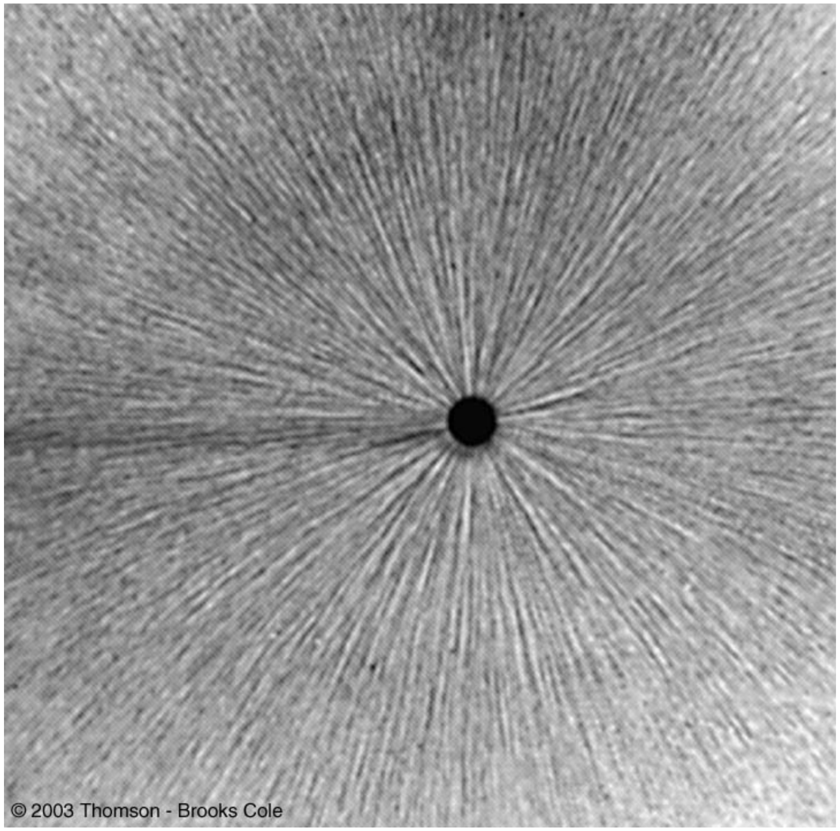
Indicate direction and magnitude of electric field at any point in space



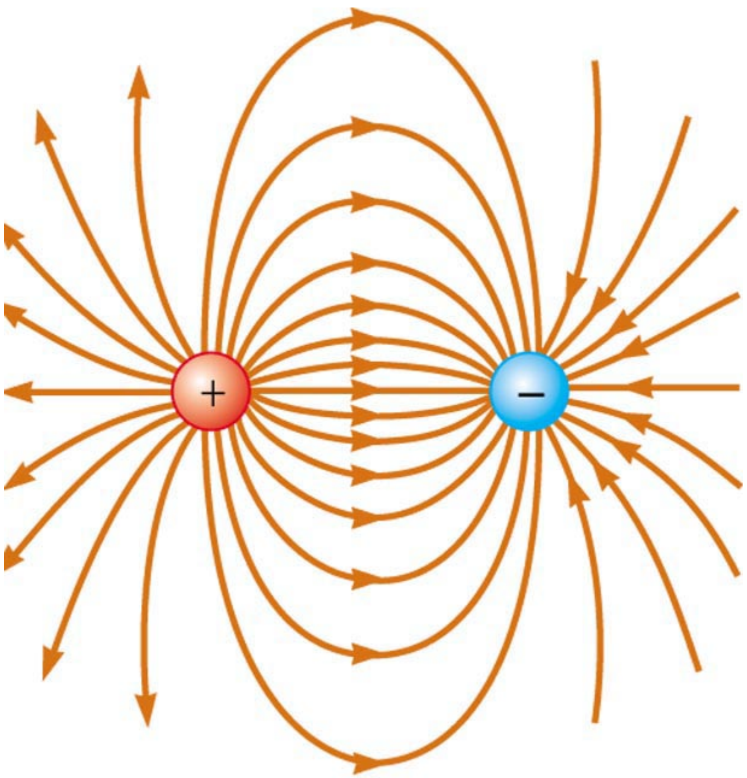
If only there was some way to see them.

Single Point Charge

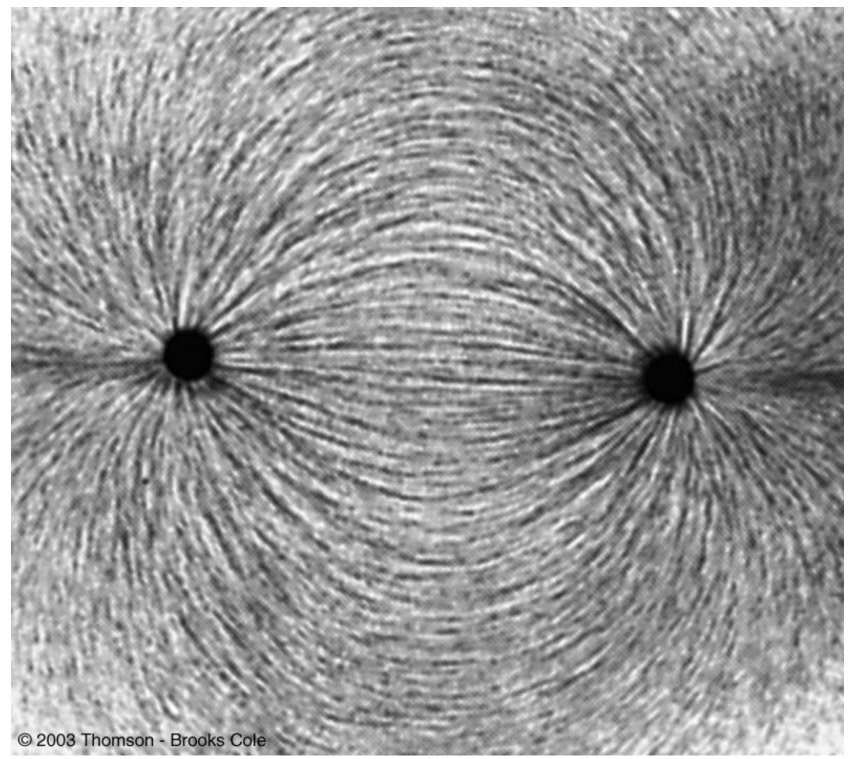




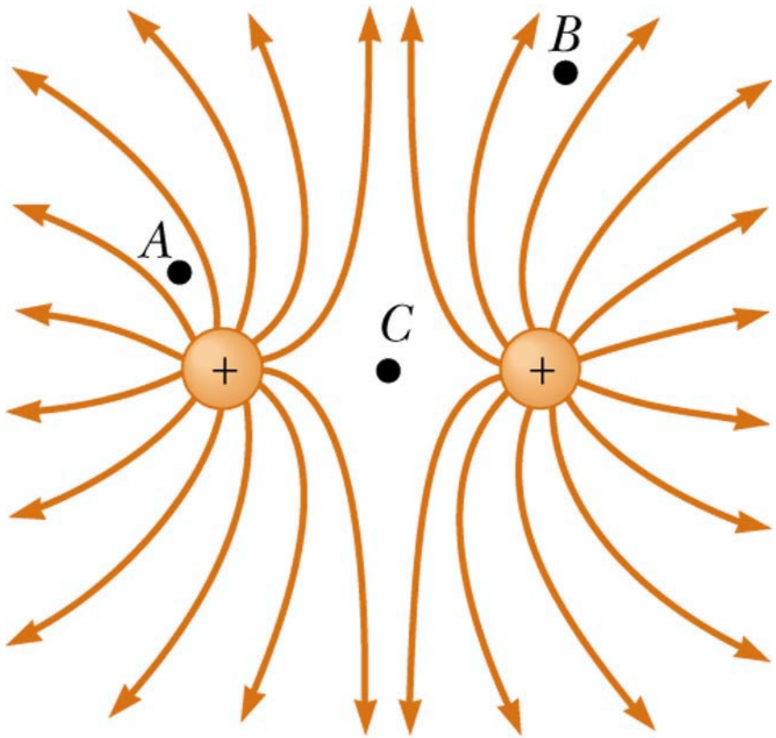
Electric Dipole



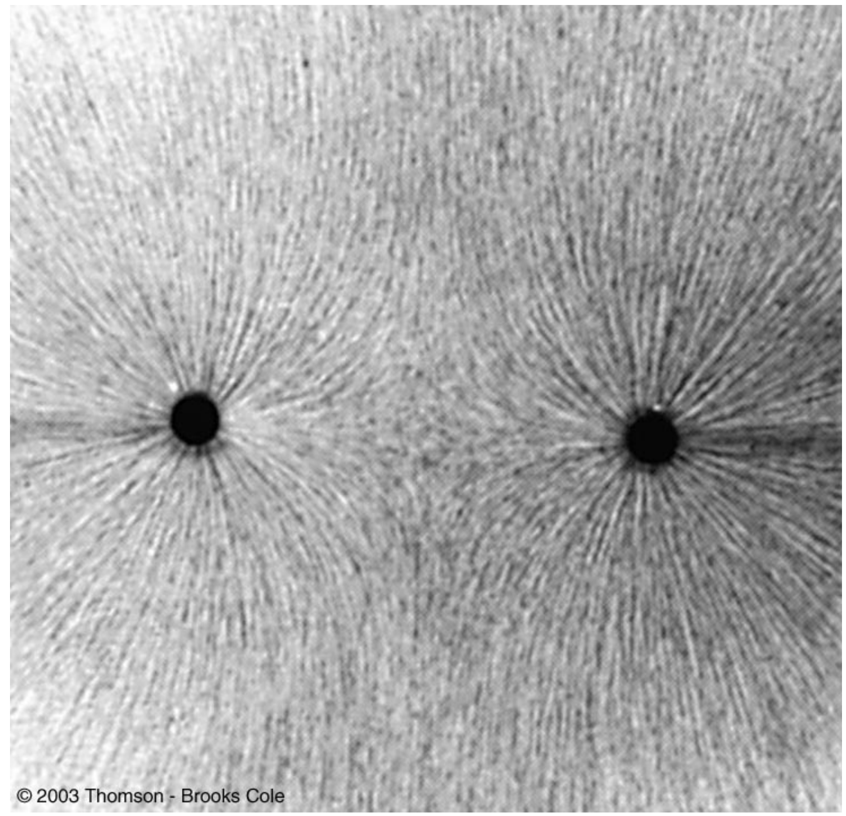
(a)



2 equal positive charges

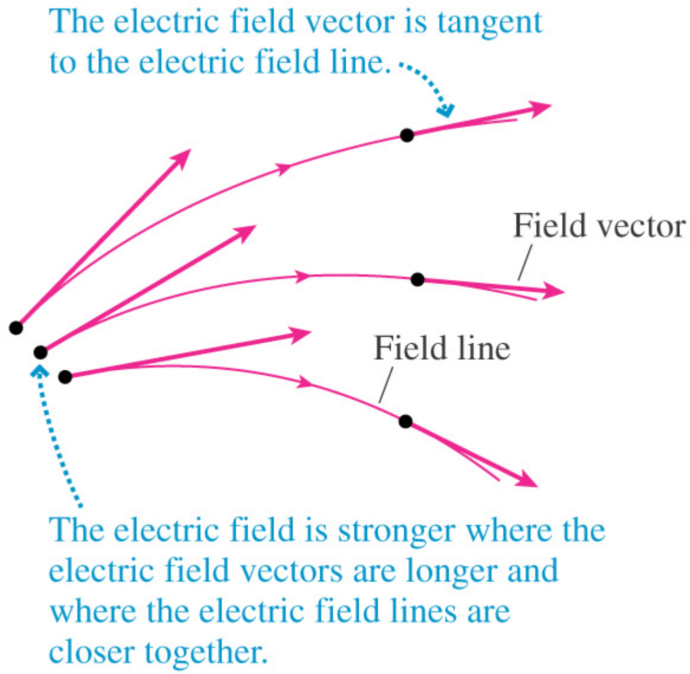


(a)

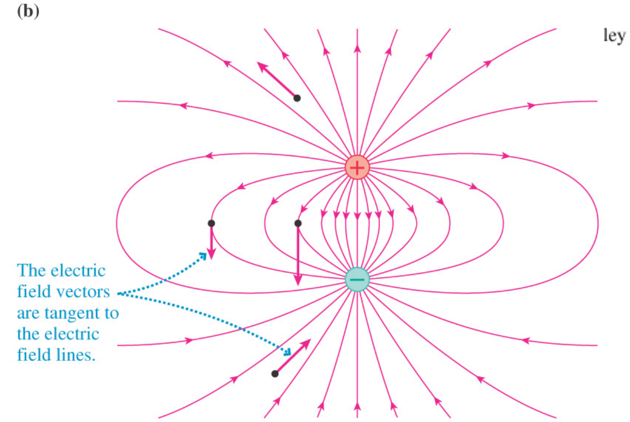


Drawing/interpreting electric field lines

- Pretty useful idea but we need some guidelines
  - electric field lines point in direction of field at that point in space
  - the total number of electric field lines is proportional to the size of the charge
  - close to an electric charge, the field lines look like that due to the point charge alone
  - the density of field lines is proportional to the strength of the electric field
  - electric field lines originate on + charges and terminate on - charges
  - no 2 field lines can cross in free space
    - don’t cross the streams



(b)

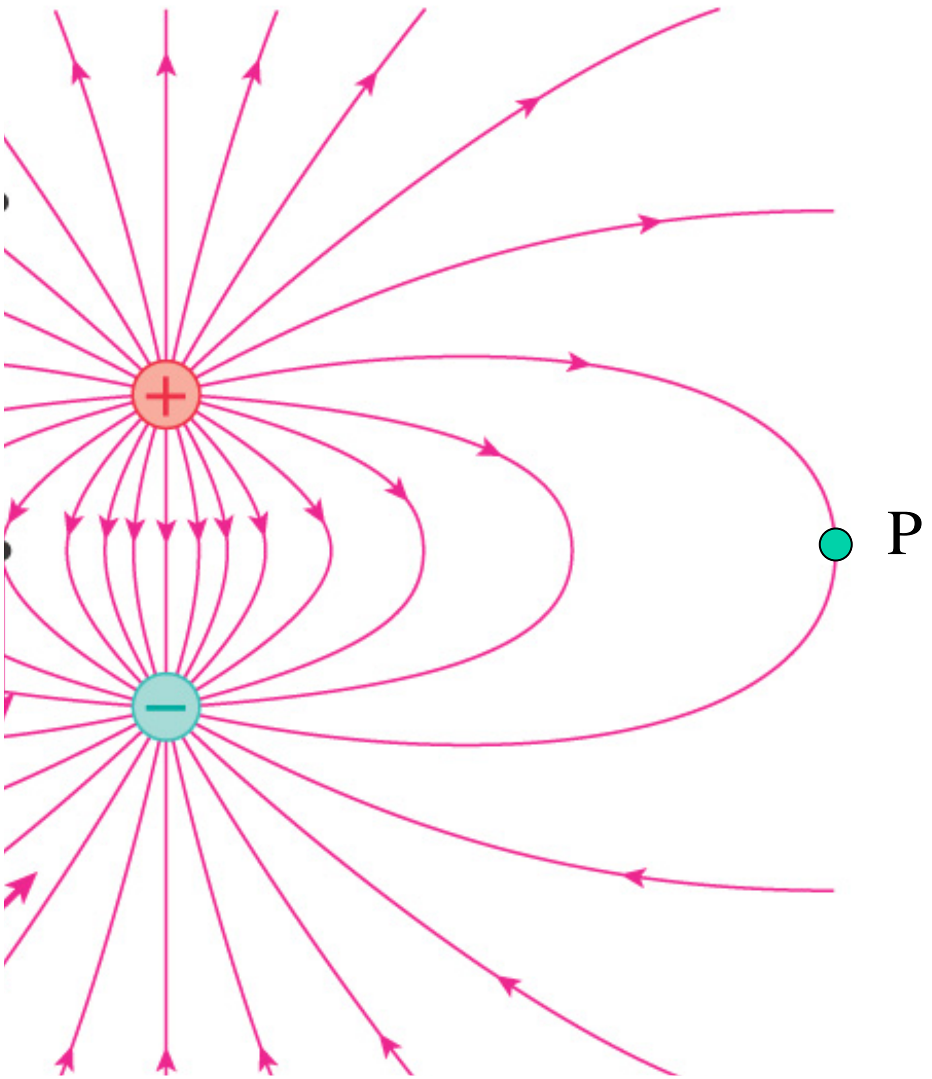


Don’t cross the electric field lines

- Dr. Egon Spengler: There's something very important I forgot to tell you
- Peter Venkman: What?
- Egon Spengler: Don't cross the streams.
- Peter Venkman: Why?
- Egon Spengler: It would be bad.
- Peter Venkman: I'm fuzzy on the whole good/bad thing. What do you mean, "bad?”
- Egon Spengler: Try to imagine all life as you know it stopping instantaneously and every molecule in your body exploding at the speed of light.
- Ray Stantz: Total protonic reversal.
- Peter Venkman: Right. That's bad. Okay. All right. Important safety tip. Thanks, Egon.

iclicker question

1. A negative charge is at point P. What direction does it move?
    a) left
    b) right
    c) up
    d) down
    e) it doesn't move

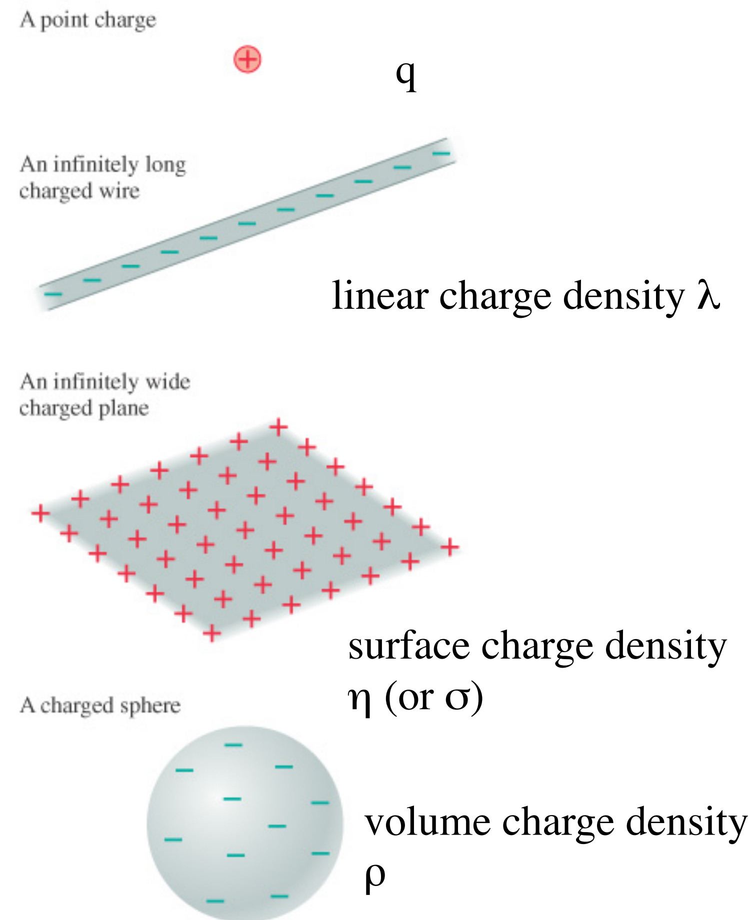


Electric fields to know and love

- Four different situations shown to the right will often be encountered in the problems you'll be solving for this course (and even in real life); in each case, you'll want to calculate the electric field

$$\vec{E} = \int \frac{dq}{r}\hat{r}$$

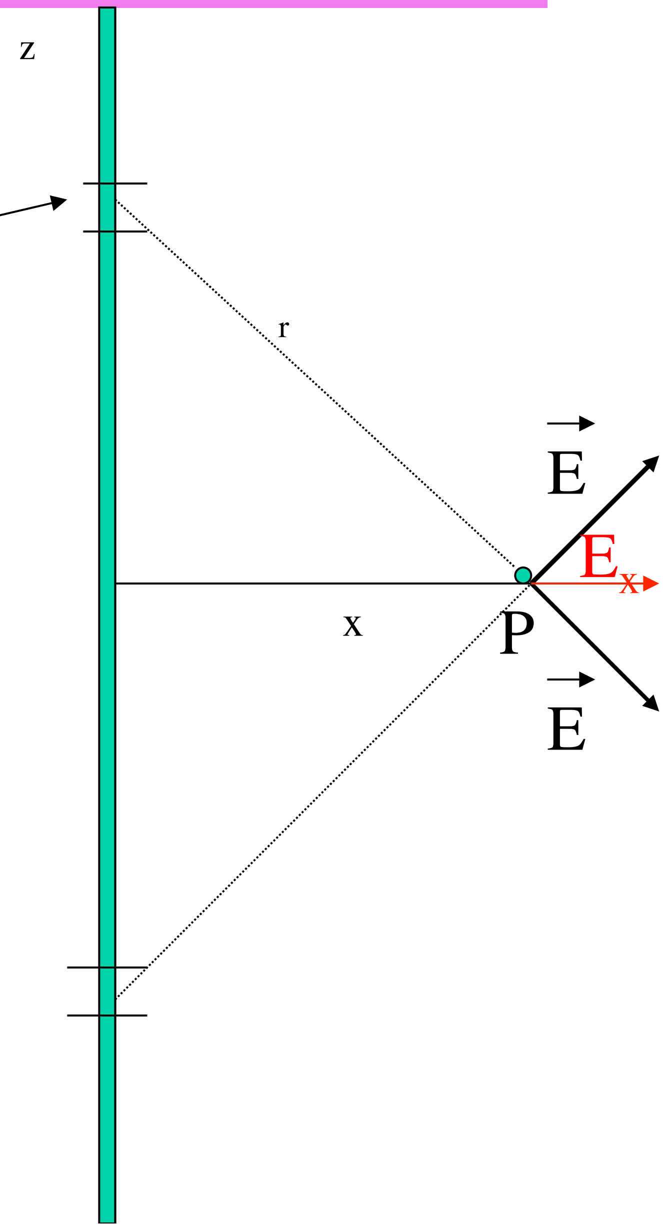
- …or even if the problem doesn't quite look like one of these, you can make some approximations
- For example, if I get very far away from a (finite) charge distribution, I should find an electric field that looks like that due to a point charge
  - this is a good limiting circumstance to take to see if you've done a calculation correctly



Hmm, a lot of symmetry for these situations. Remember that when we get to Gauss' Law.

Long thin wire

- Electric field from a long (i.e. infinite) thin wire
- dq = +λ dy
- Integration along one axis
- Note that by symmetry, the net electric field will be along the x-axis

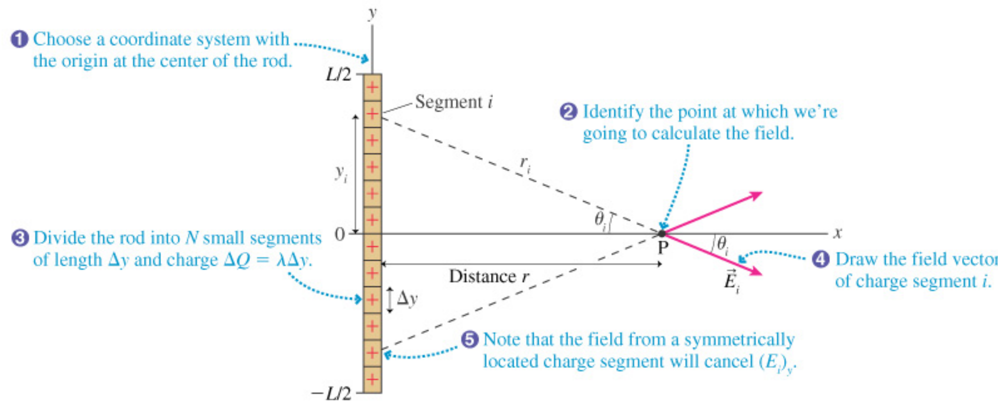


What if the wire isn't infinite?

- See derivation in book

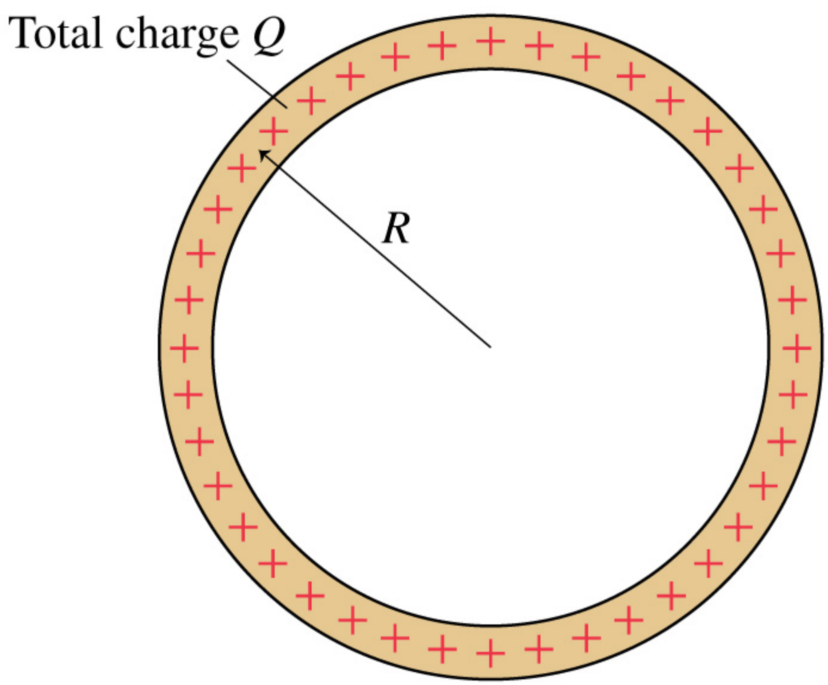
λL

$$|E_{rod}| = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r\sqrt{r^2+(L/2)^2}}$$



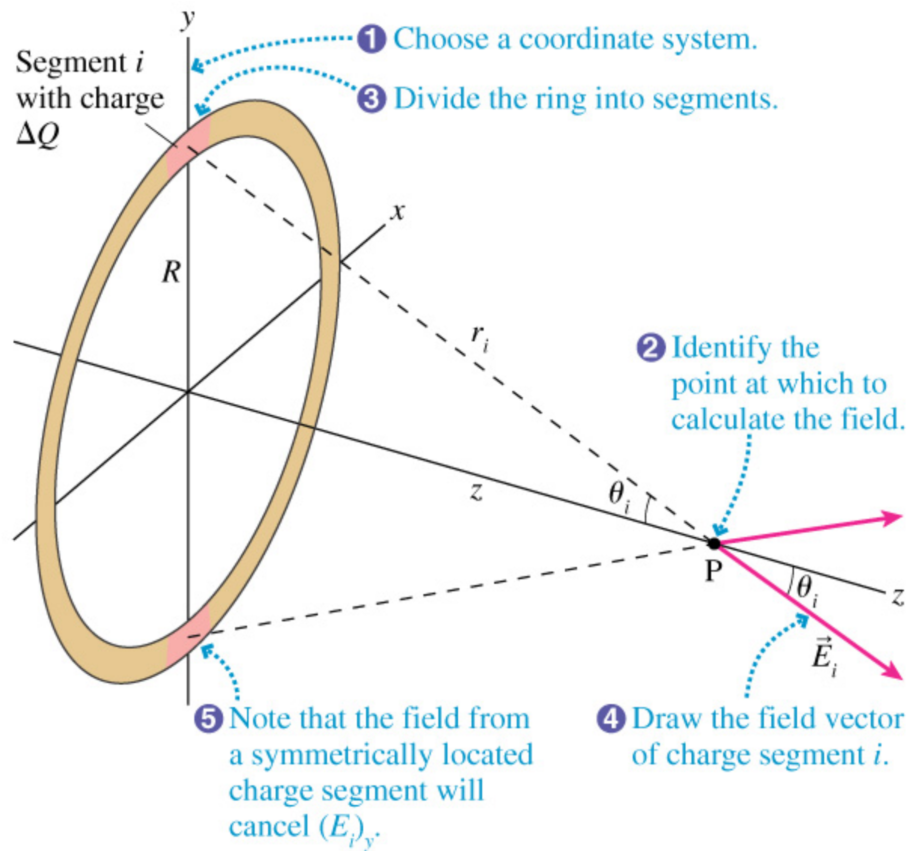
…if r>>L, then denominator becomes $r[r^2]^{1/2}$ and
$E_{rod} \Rightarrow Q/4\pi\varepsilon_o r^2$
or field due to point charge
what if L>>r?

Electric field of ring of charge



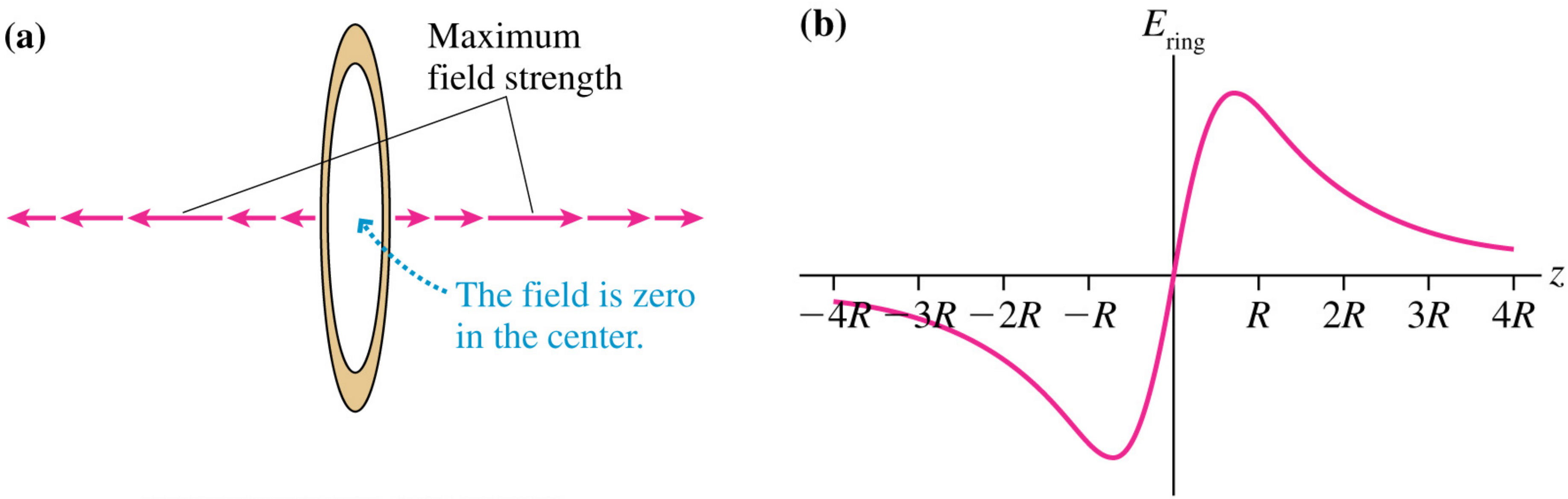
$\lambda = Q/2\pi R$

- Calculate E on axis of ring



Electric field of ring

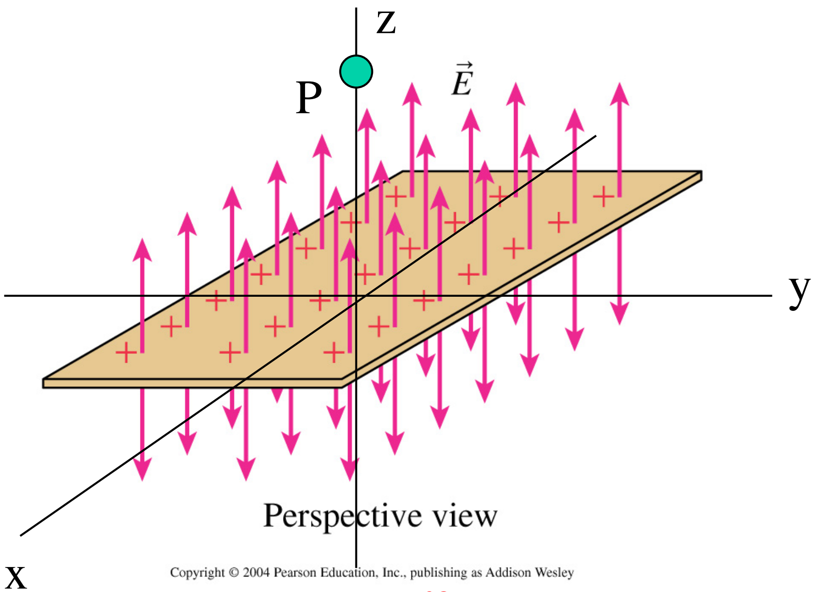
$$\left(E_{ring}\right)_z = \frac{1}{4\pi\varepsilon_o}\frac{zQ}{\left(z^2+R^2\right)^{3/2}}$$



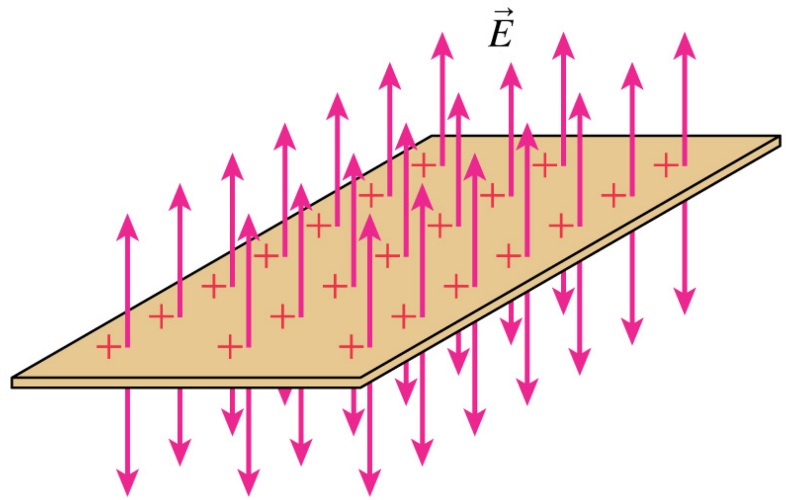
Note that for z>>R, it falls off as $1/r^2$

Uniform (infinite) sheet of charge

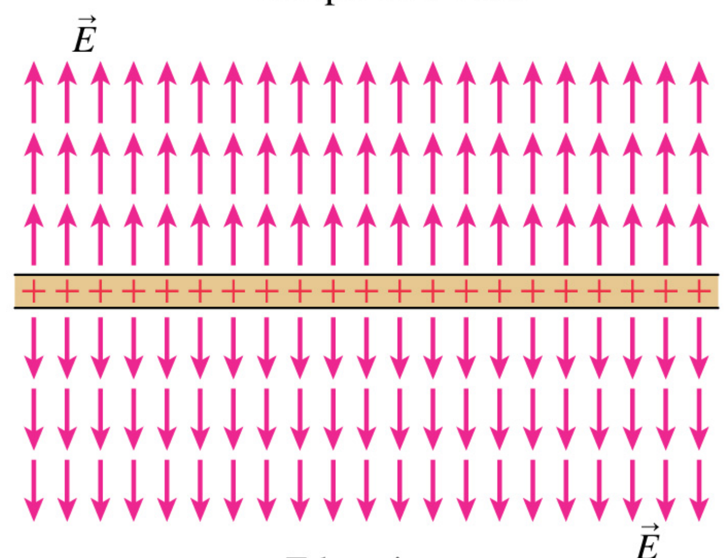
- Consider the electric field from a uniform infinite sheet of charge with density η
- What is the E field at a point P on the z axis?



$$\left(E_{disk}\right)_z = \frac{\eta}{2\varepsilon_o}$$



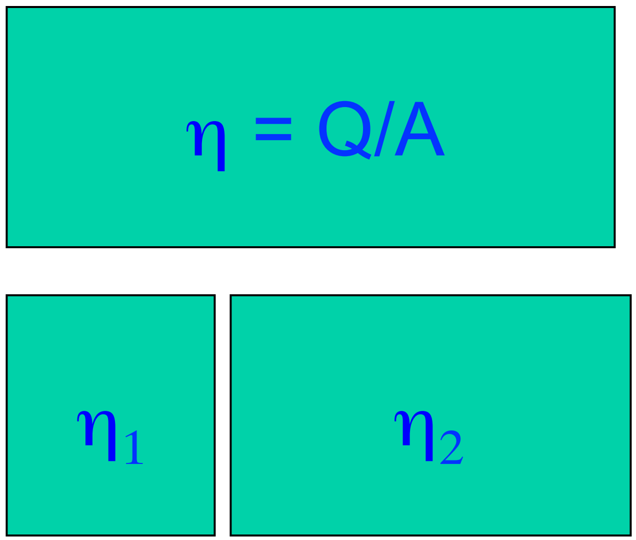
Perspective view



Edge view

Consider a uniform surface charge distribution

- $\eta = Q/A$ (units of C/ m^2)
- Suppose that I split the rectangle on top into two unequal pieces
- How do η_1 and η_2 relate to η?

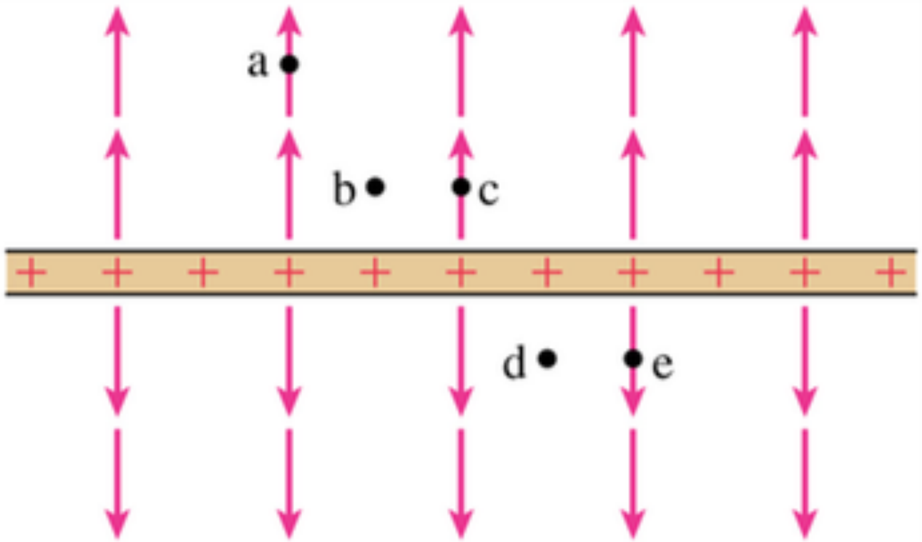


iclicker question

Rank in order, from **largest to smallest**, the electric field strengths E_a to E_e at these five points near a plane of charge.

$$E_{plane} = \frac{\eta}{2\varepsilon_0}$$

A. $E_a > E_c > E_b > E_e > E_d$
B. $E_a = E_b = E_c = E_d = E_e$
C. $E_a > E_b = E_c > E_d = E_e$
D. $E_b = E_c = E_d = E_e > E_a$
E. $E_e > E_d > E_c > E_b > E_a$



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C. $E_a > E_b = E_c > E_d = E_e$
D. $E_b = E_c = E_d = E_e > E_a$
E. $E_e > E_d > E_c > E_b > E_a$