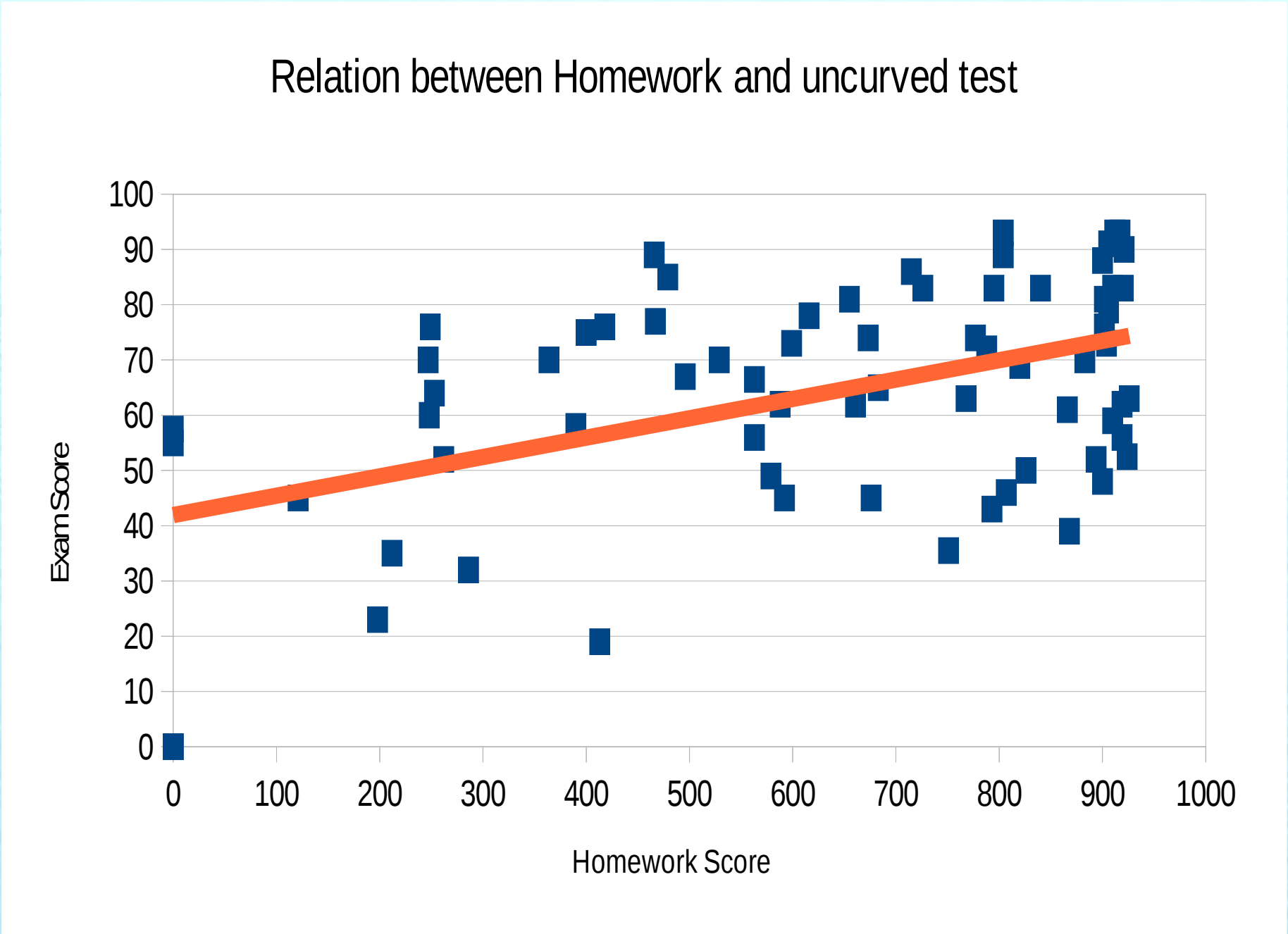
Physics 122 – Class #15 – Outline

- About Exam #1 (and #2)
- Electric Field lines
- Effect of Electric Field on motion
- Field of continuous distributions
- Derivation of field of a line

Do homework … increase test score



High Homework but Low Test Score?

- Working with a group but not understanding the result?
- Taking too many short cuts by Googling?
- What else? … Come see me.

Educational and Life Philosophy

- Don't be like Cleopatra

Educational and Life Philosophy

- Don't be like Cleopatra
- "I will try harder" … does not work if there is some reason that you cannot.
  - Holes in background?
  - Difficult personal life?
  - Too many classes?
  - Disability?
- Don't do the same thing which did not work well and expect a different result.
- A 2-4 points extra credit for a reflective essay on what did not work on exam (by Friday) (mpsonnenfeld@gmail.com)

Ask Cleo …

- Make your index card as you do your home work.
- You will see what equations you needed.
- Those are the same ones you will probably need on the test.

Ask Cleo ...

- Read book before lecture (or at least read the book)
- Take notes on content (if you like) but
- ALSO work the green sections of the book with pencil and paper.
- This is called “active reading” and prevents ...

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Starfish …

I will report all D's and F's on “Starfish”

You are not “in trouble”. The theory is tutors etc. are supposed to contact you an offer to help.

Let me know if it helps or DOES NOT help. I do not have to report these grades, and I won't if it bothers you.

Test #2 … before or after break?

Chapters 25, 26 … if next week

All vectors … all the time.

Chapter 25, 26, 27 … if after … more time to do homework.

What did we learn from the discussion Of empirical electrostatics?

[A] Only electrical conductors may be charged

[B] Only electrical insulators may be charged

[C] Both conductors and insulators may be charged

[D] You can't charge anything, only polarize it.

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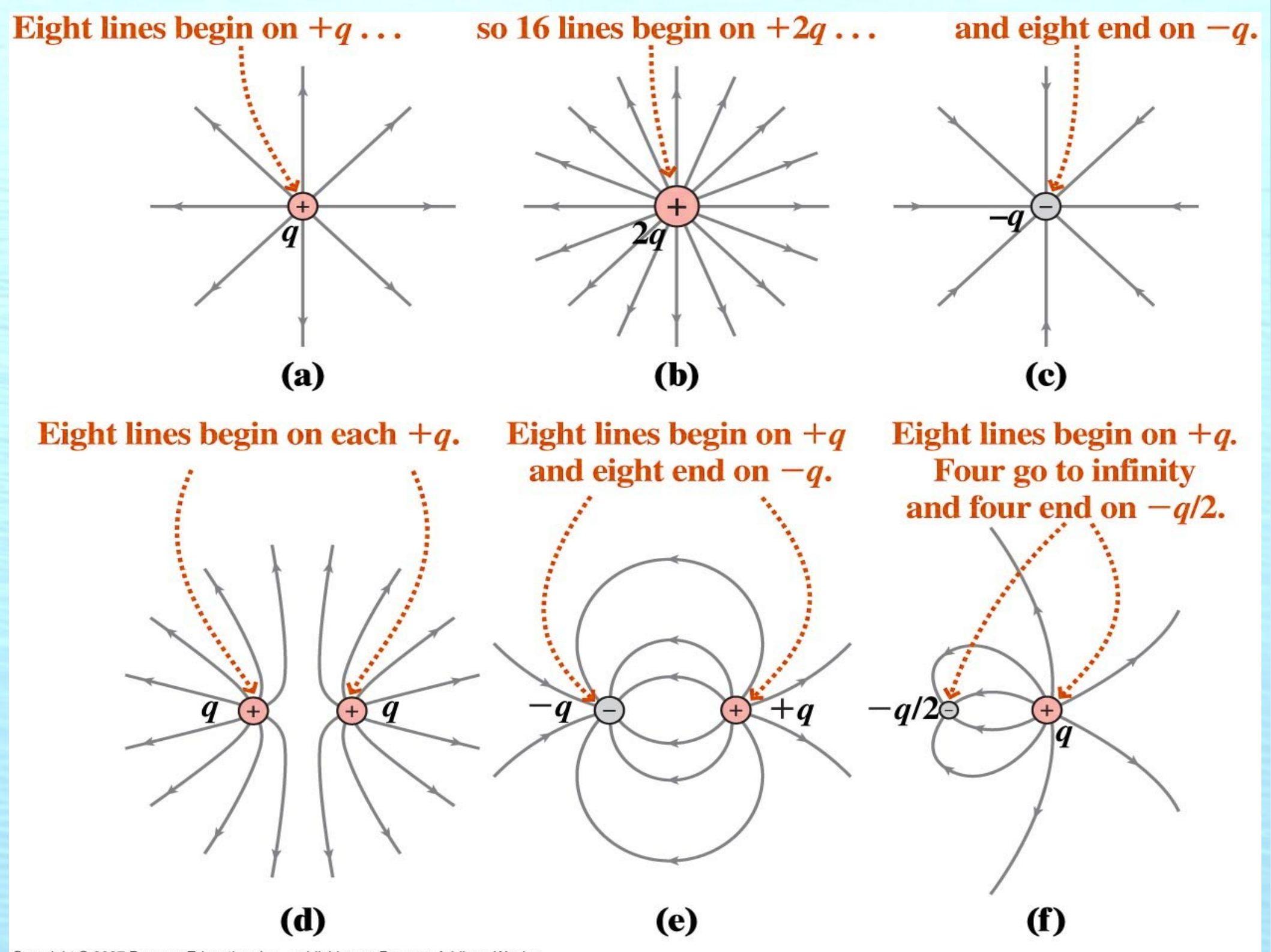
Electric Field Lines

- A way of getting intuition for the fields caused by a few charges (without calculating)

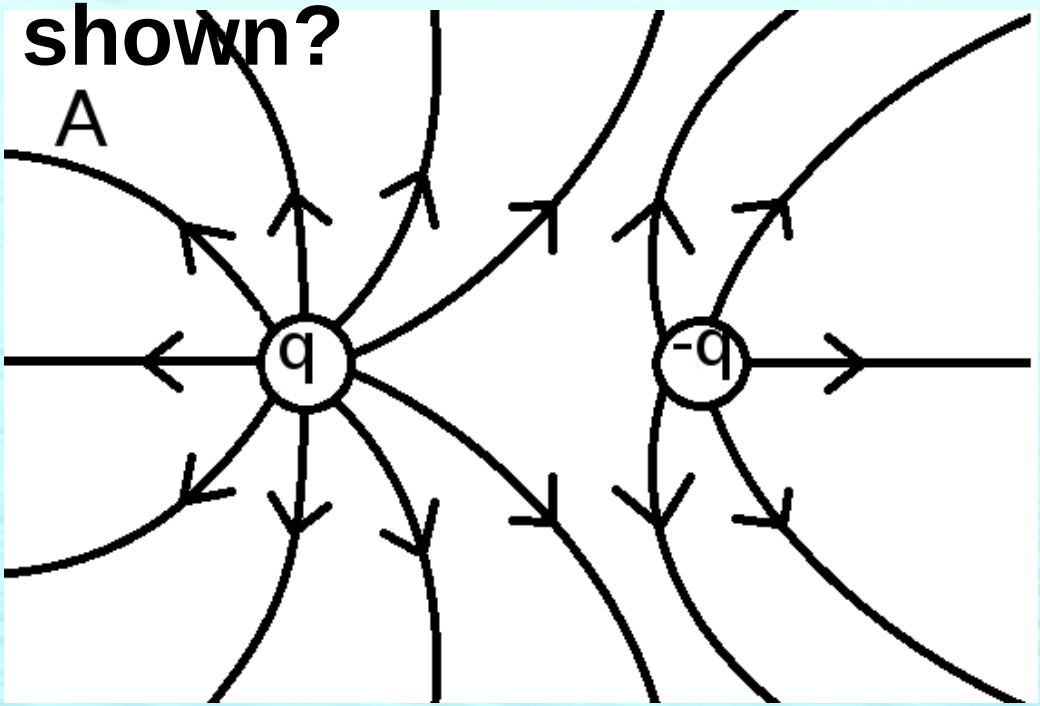
- Positive charges "emit" field lines.
- Negative charges "absorb" field lines.
- Field lines begin at + charge and end at infinity or negative charge.
- The tangent to an electric field line gives direction of force
- Electric field lines do not cross


Eight lines begin on +q . . .
so 16 lines begin on +2q . . .
and eight end on −q.
q
2q
−q
(a)
(b)
(c)
Eight lines begin on each +q.
Eight lines begin on +q
and eight end on −q.
Eight lines begin on +q.
Four go to infinity
and four end on −q/2.
q
q
−q
+q
−q/2
q
(d)
(e)
(f)

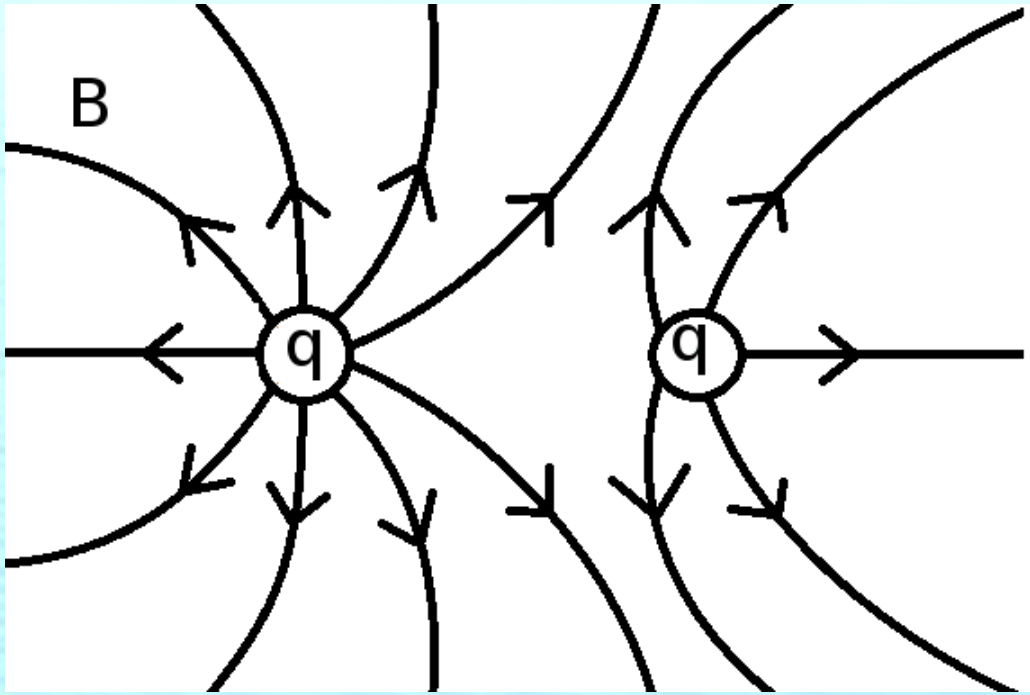
PheT …
Charges and fields
Electric field of dreams

Which set of field lines corresponds to charges shown?

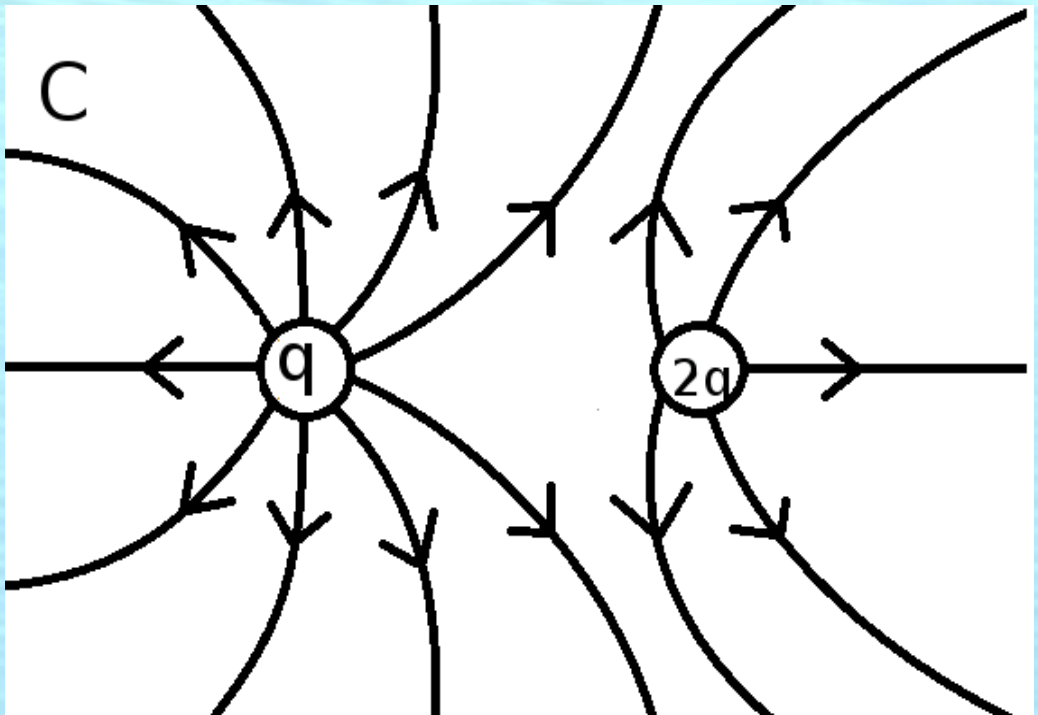
A



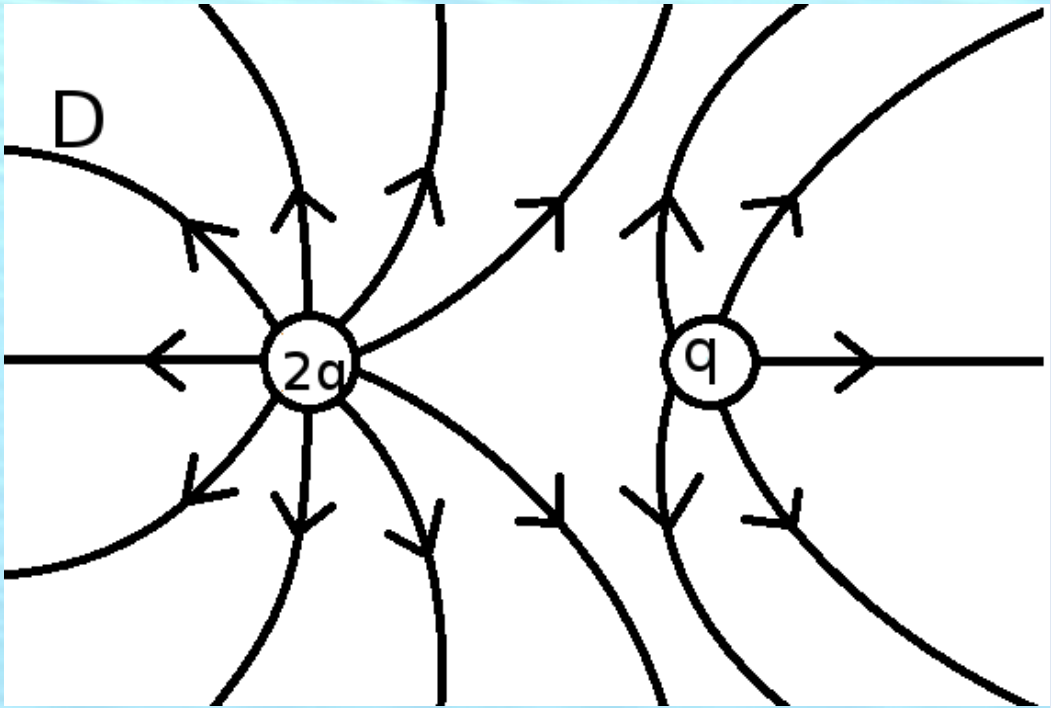
B



C



D



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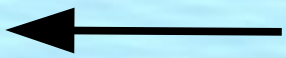
Clicker

The green arrows represent velocity vectors vs. time for a positively charged particle. Which arrow below represents the Electric field direction causing this?

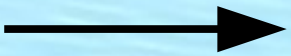
A



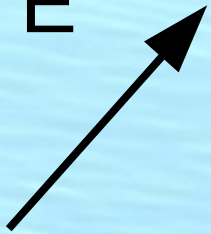
B

C

D



E



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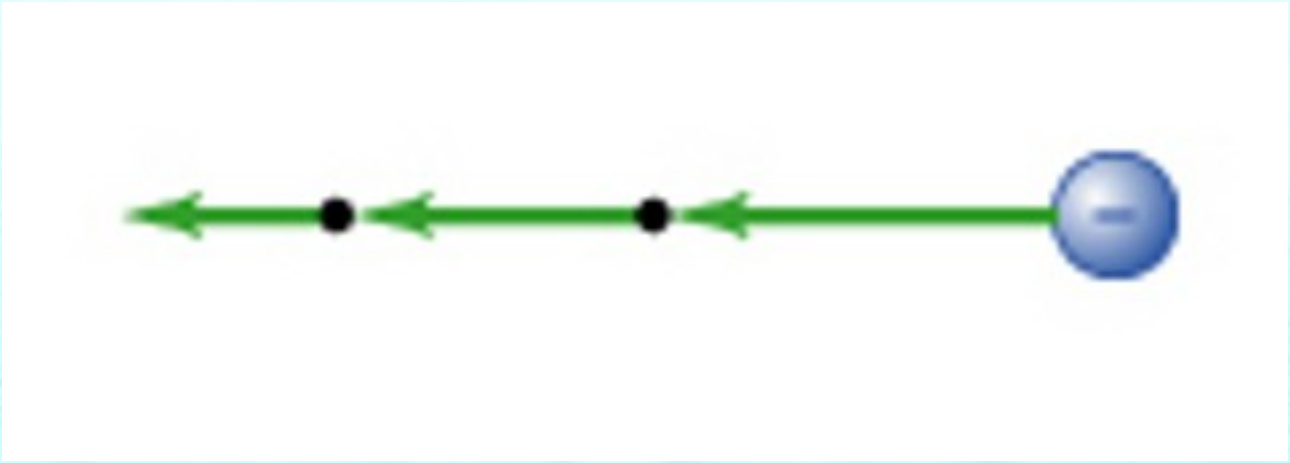
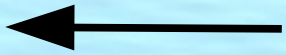


The green arrows represent velocity vectors vs. time for a negatively charged particle. Which arrow below represents the Electric field direction causing this?

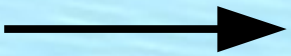
A



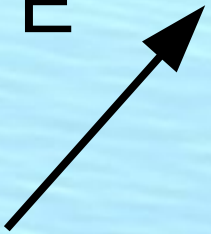
B

C

D



E



Problems

Electric field needed to accelerate a proton to 1000 km/s from rest in 2 meters?

$$q_p = 1.6 \times 10^{-19} C \quad m_p = 1.67 \times 10^{-27} kg$$

$$W = \vec{F} \cdot \Delta \vec{r} = K_f - K_i$$

$$v_f^2 - v_i^2 = 2 a \Delta x$$

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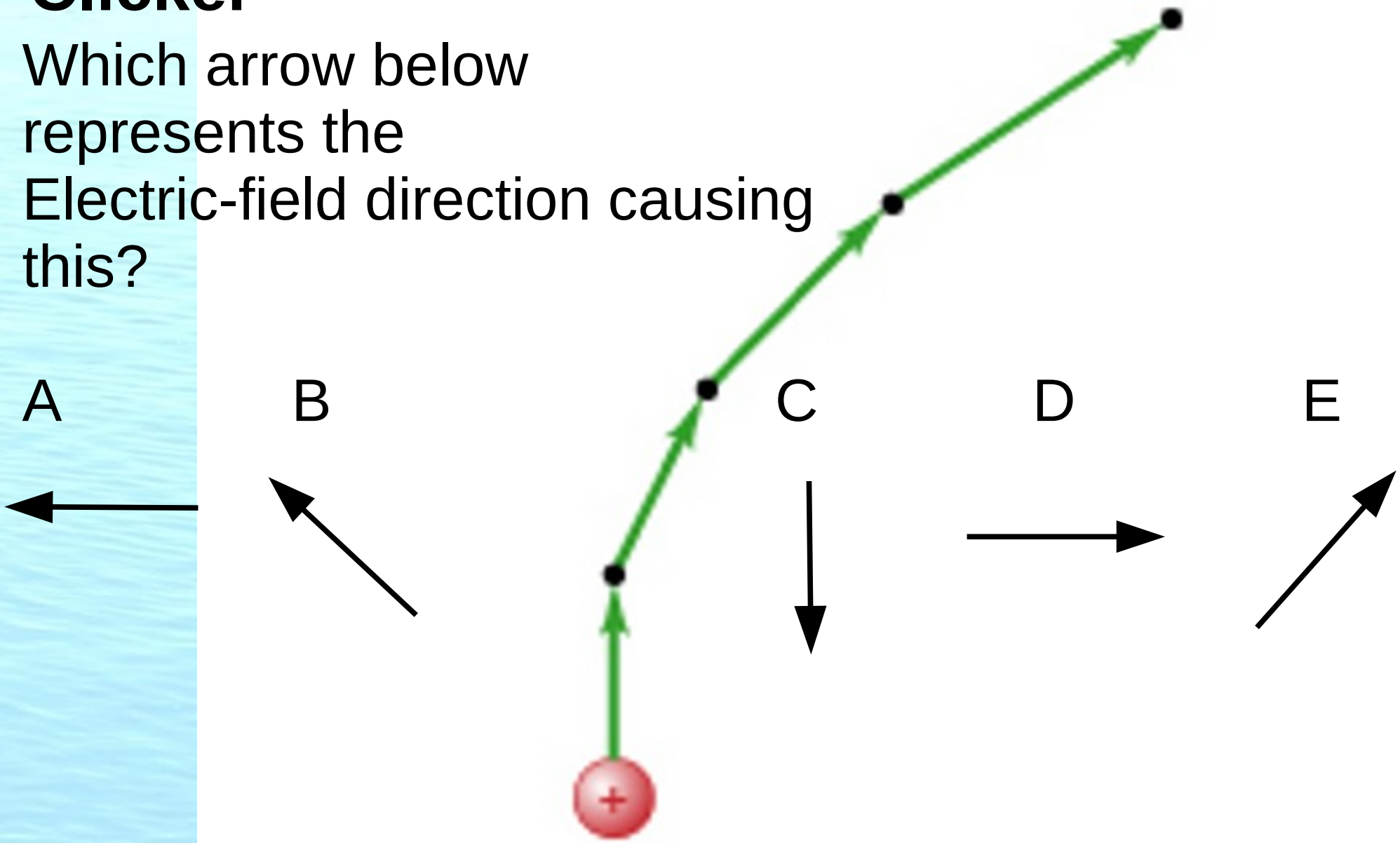
Clicker

Which arrow below represents the Electric-field direction causing this?



Clicker

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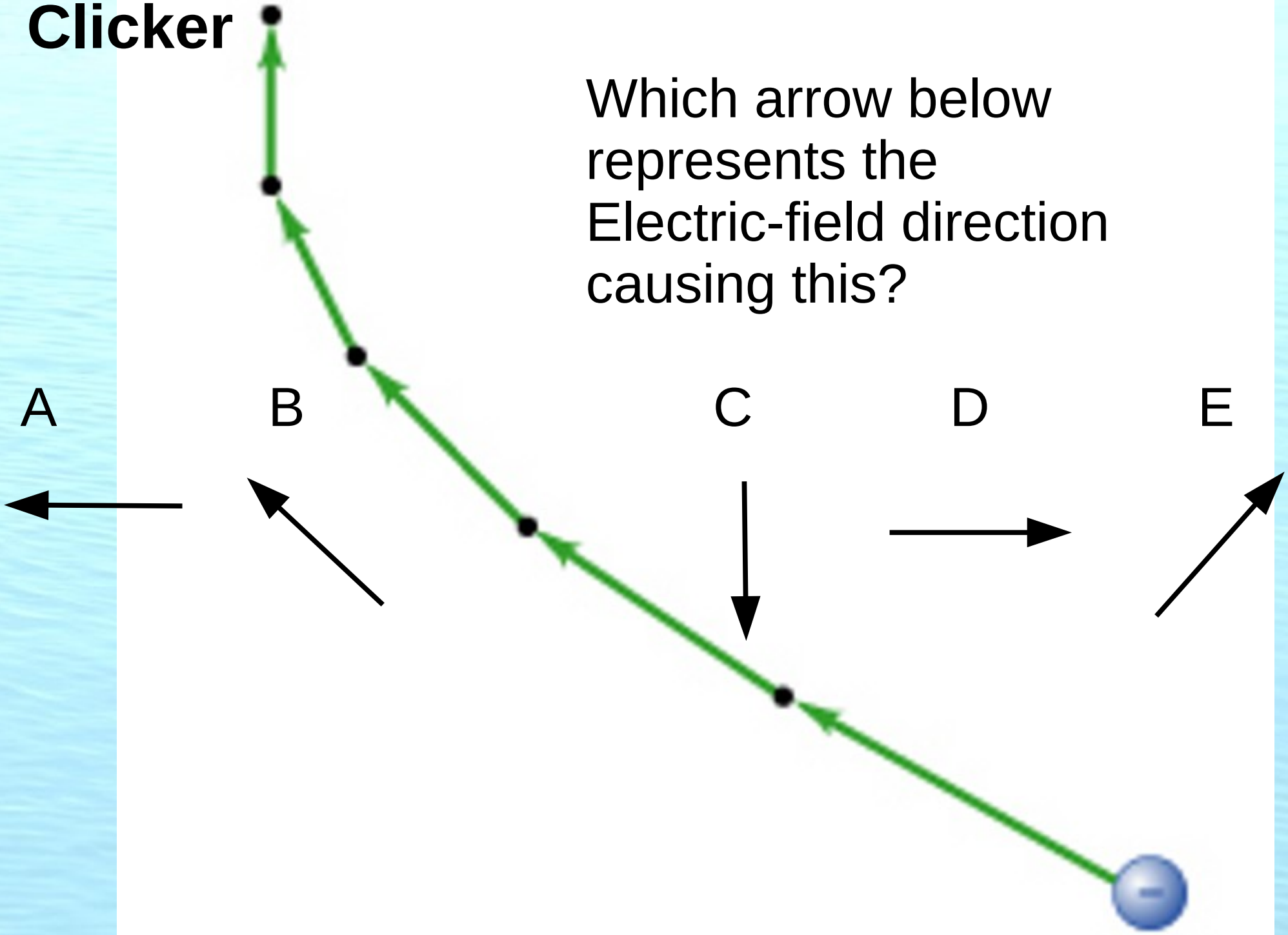

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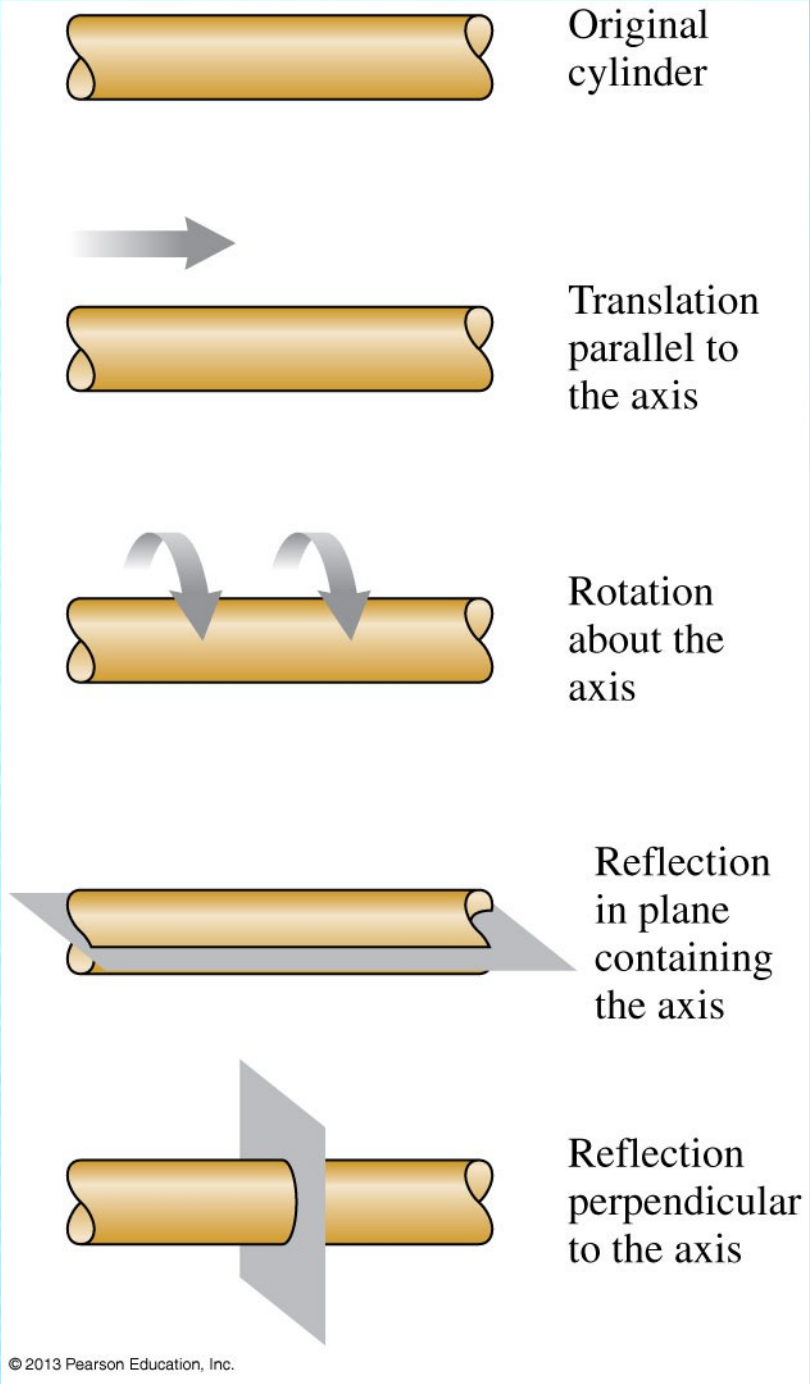
- Field of continuous distributions/symmetry
- Derivation of field of a line

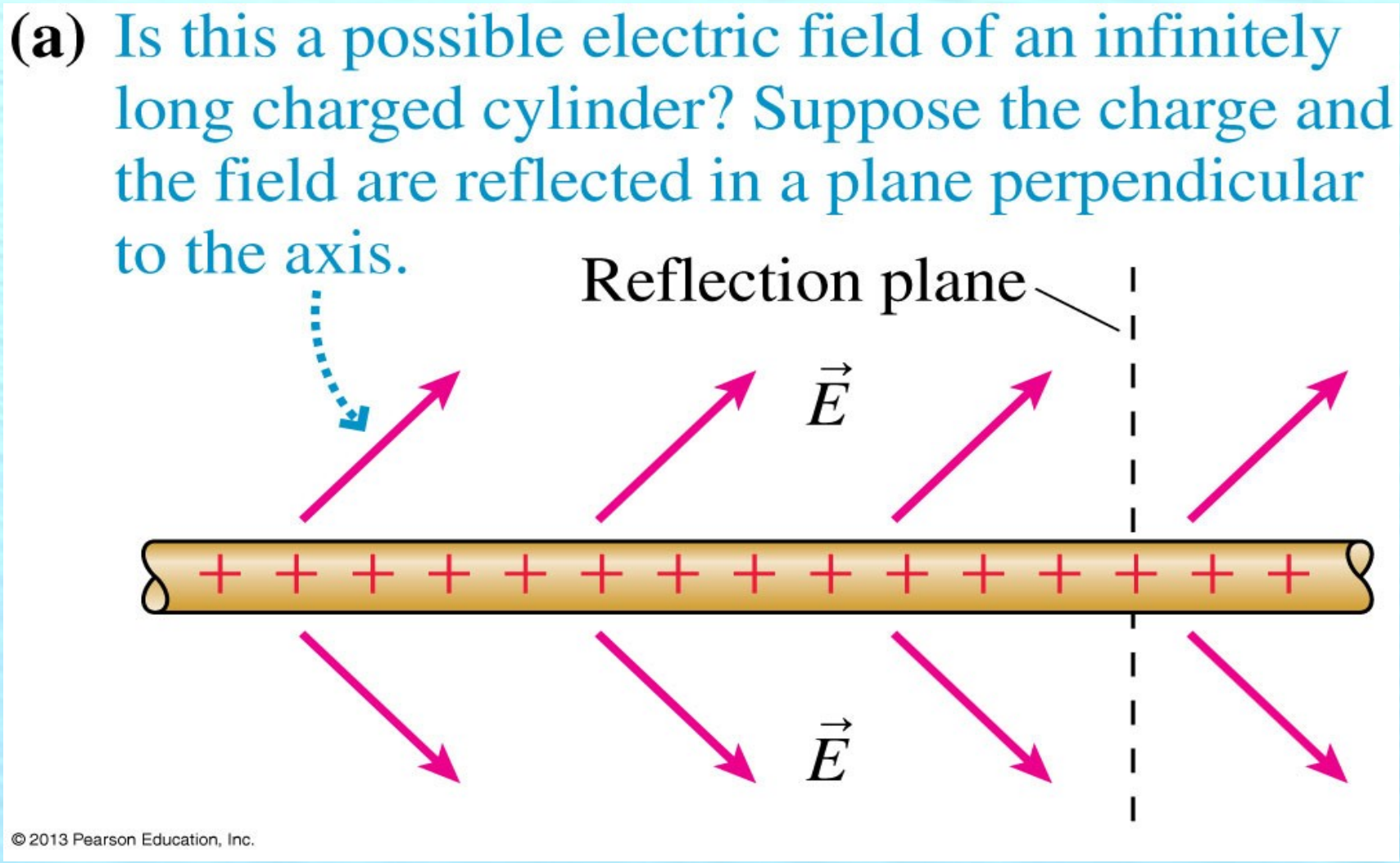
Relation between symmetry and Electric Field

If you can't physically tell where you are with respect to a charge, a line, or a surface (or any
Other charge distribution) then the Electric field direction cannot give you a hint.
Consider first an infinitely long cylinder.

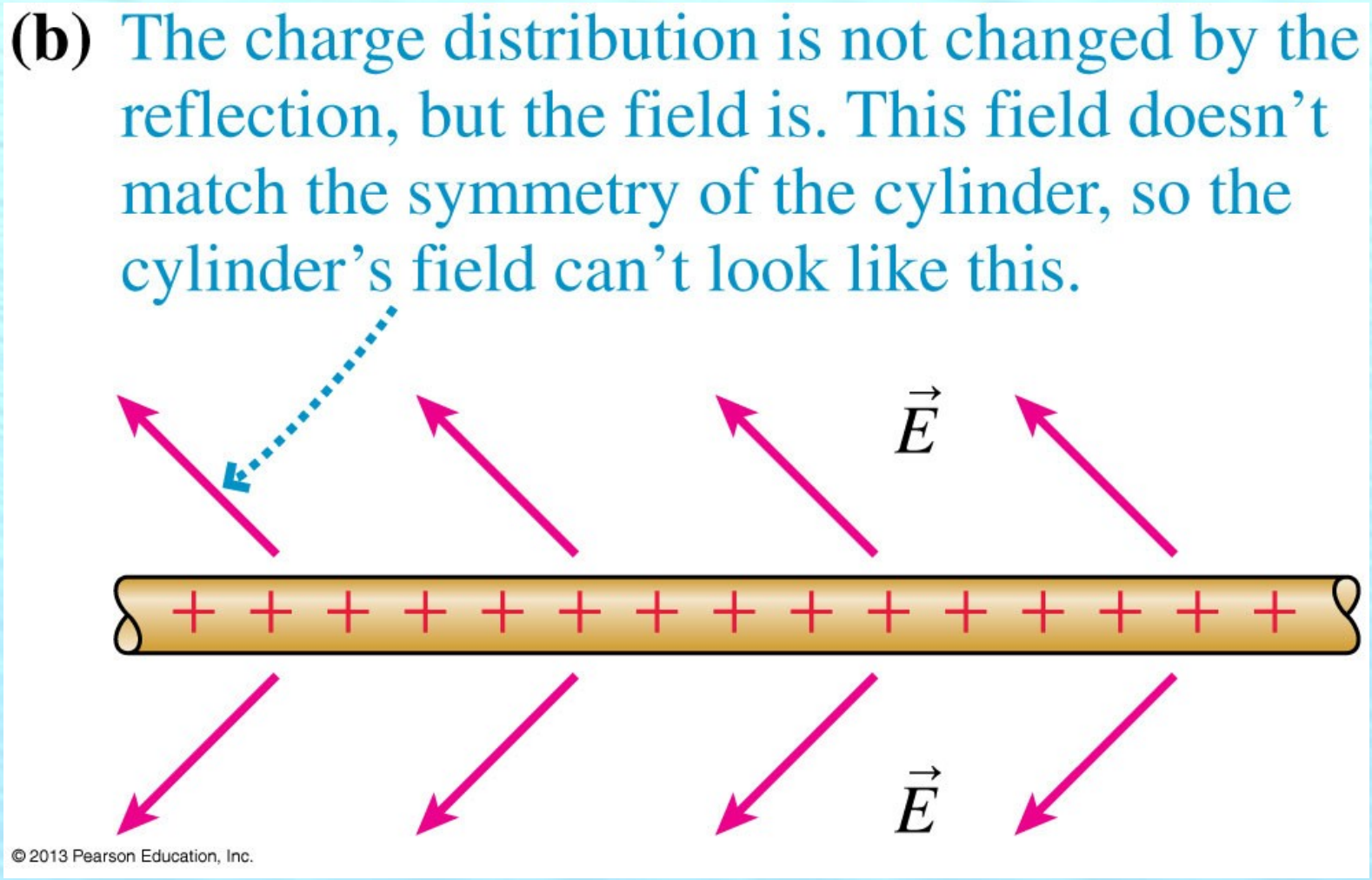
Relation between symmetry and Electric Field



Relation between symmetry and Electric Field



Relation between symmetry and Electric Field



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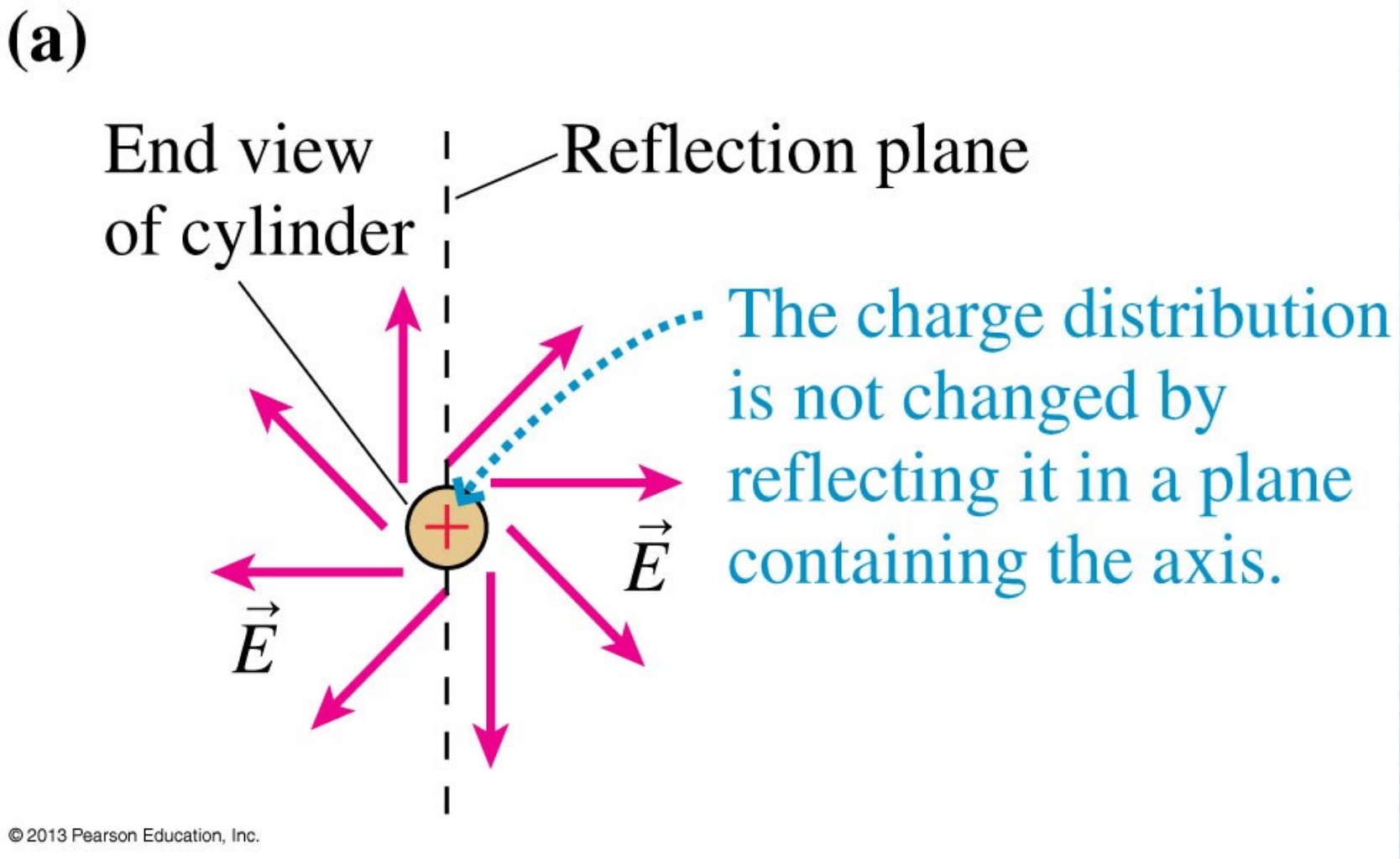
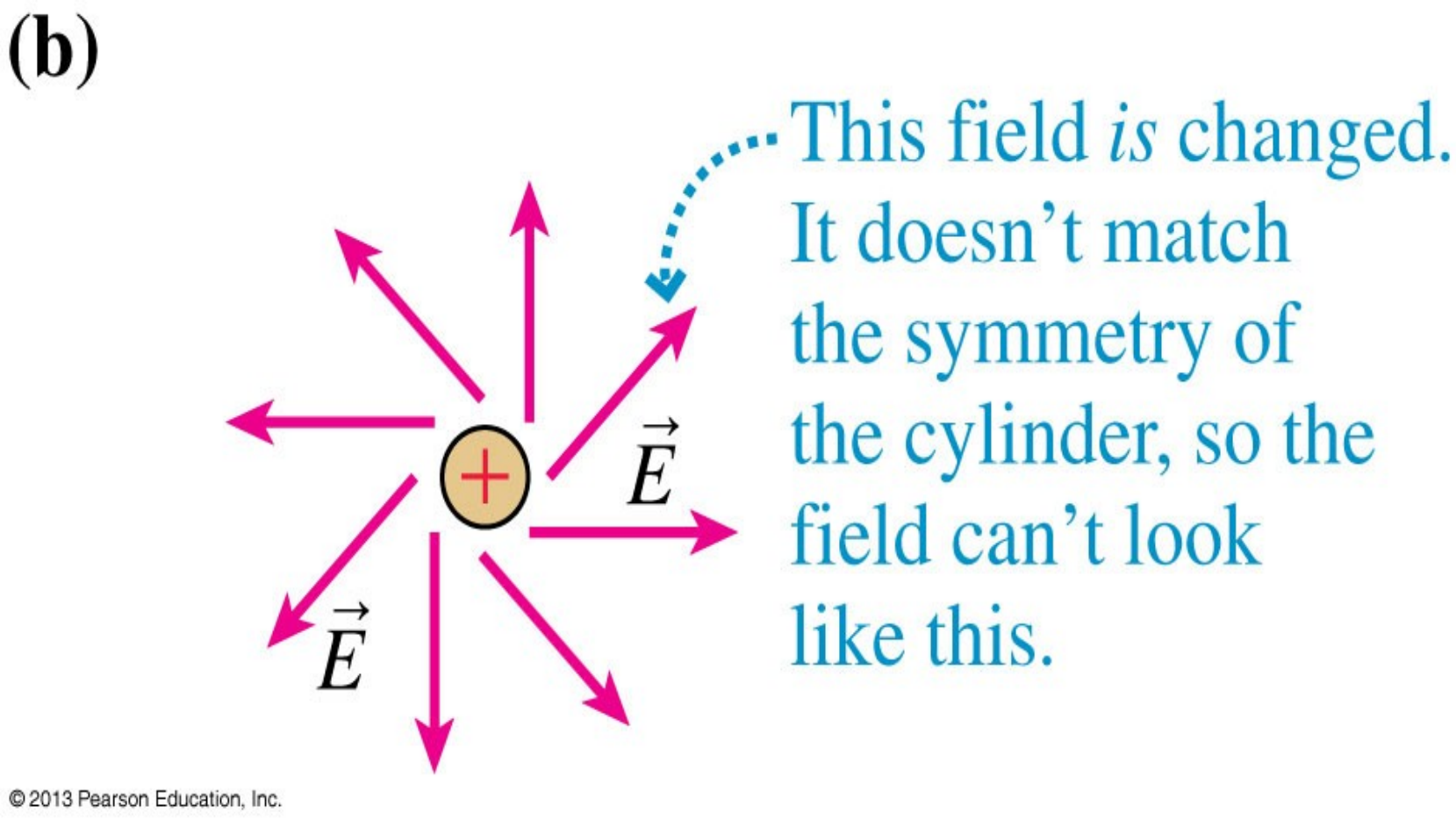
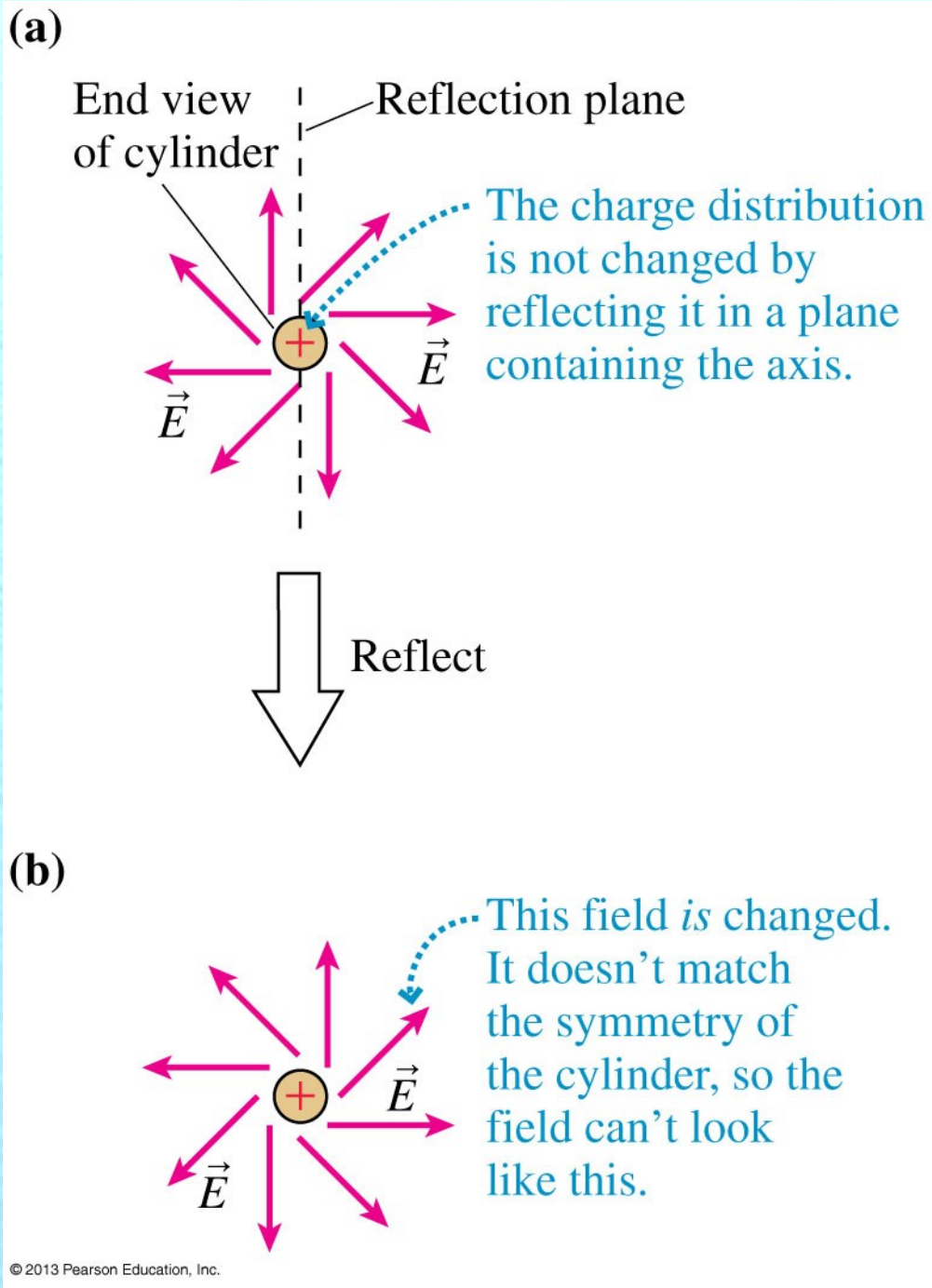


Relation between symmetry and Electric Field

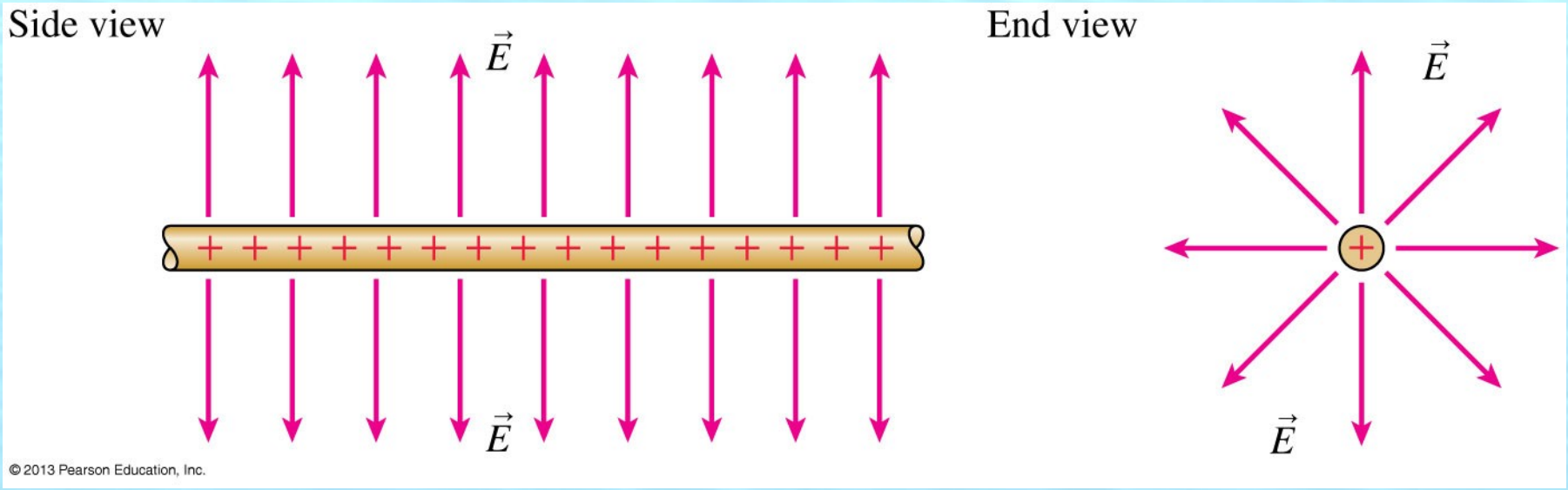


Relation between symmetry and Electric Field



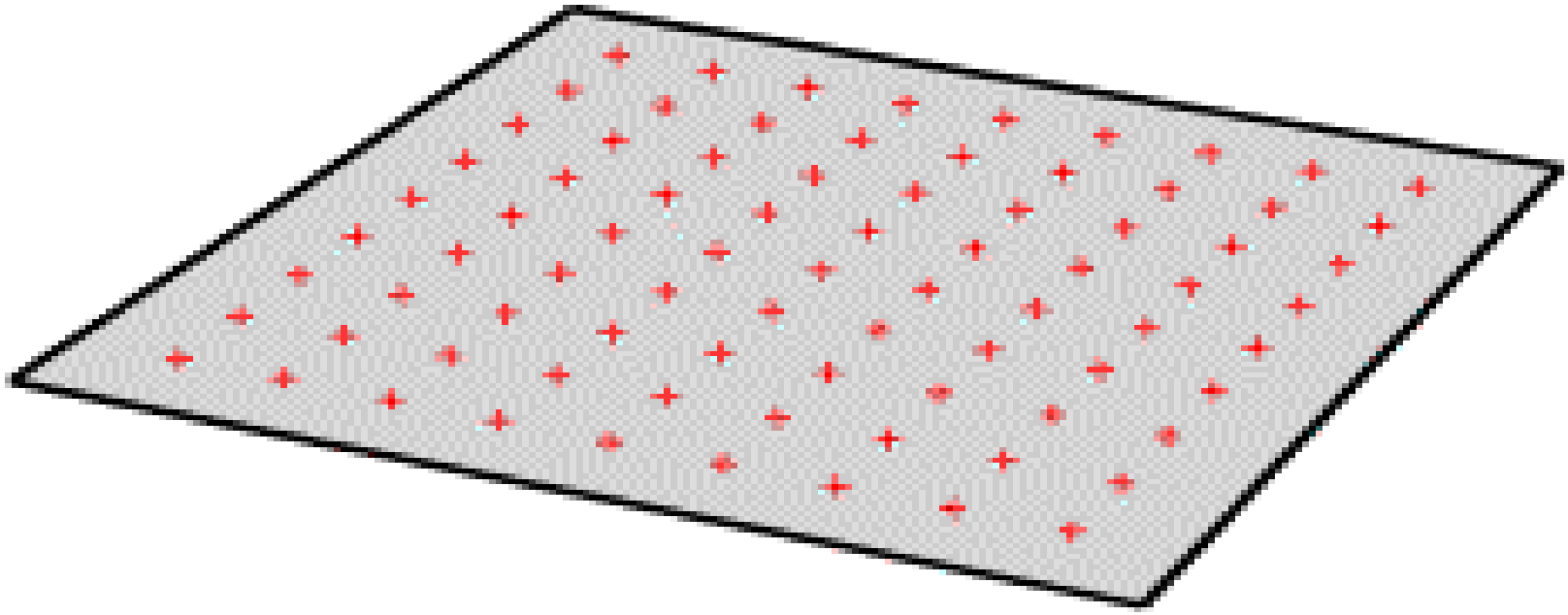
Relation between symmetry and Electric Field

The ONLY field consistent with symmetry of an infinitely long cylinder points radially outward.



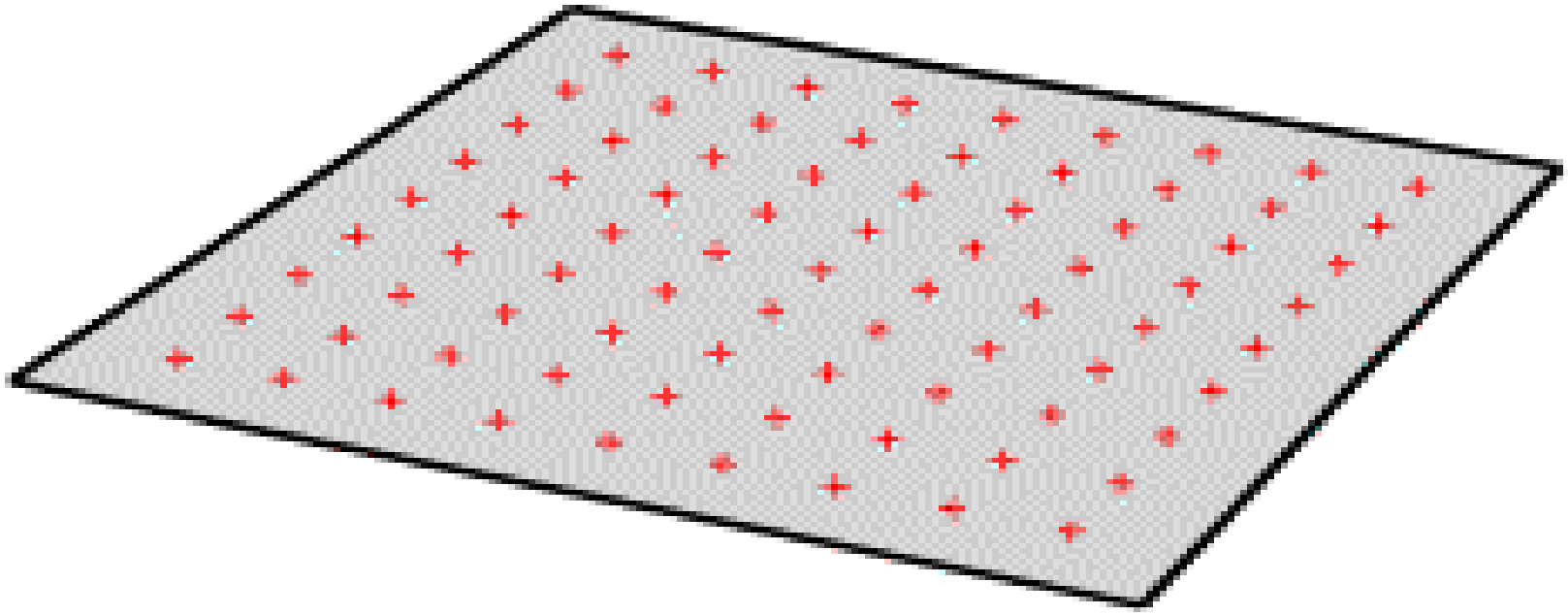
Relation between symmetry and Electric Field

Now imagine an infinite plane of charge.



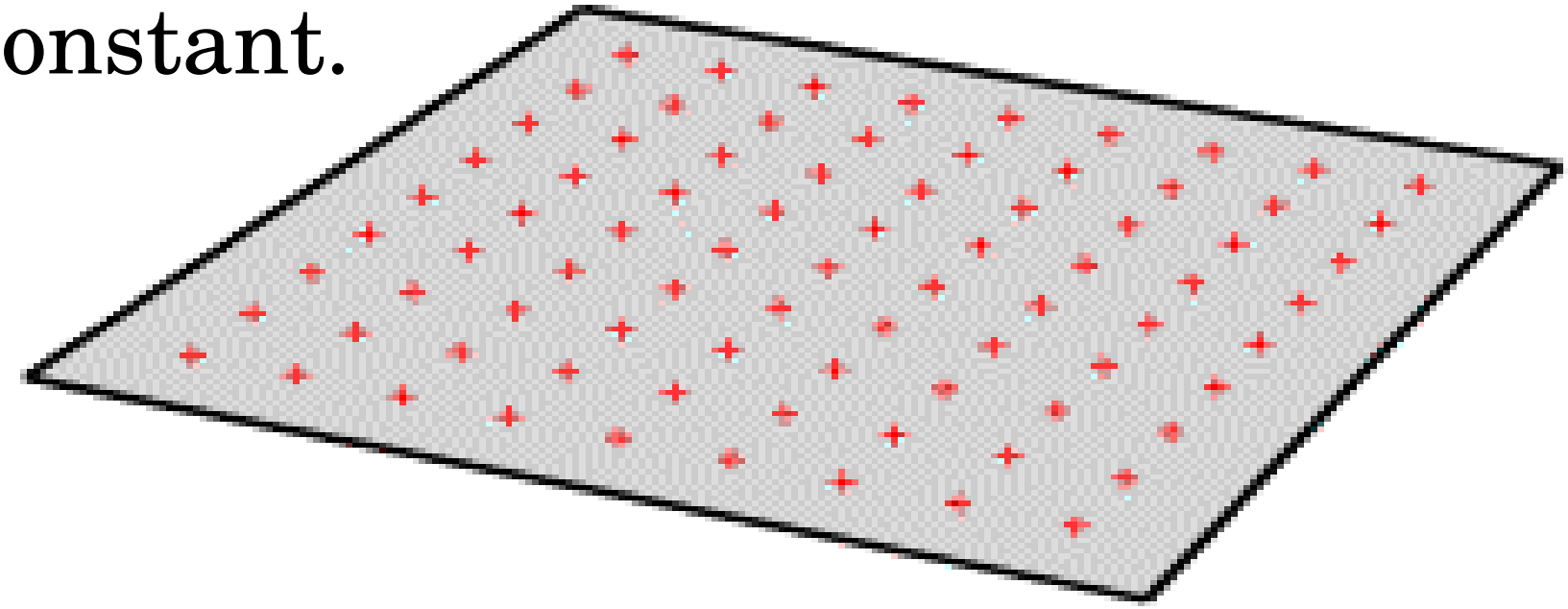
Relation between symmetry and Electric Field

Because you can't tell what direction you are facing, the field must be ONLY Perpindicular to the plane.



Relation between symmetry and Electric Field

Because you ALSO can't tell how far away you are from the plane, the field cannot change magnitude. It must be constant.



$$\vec{E} = \frac{\sigma}{2\epsilon_0}\hat{j}$$

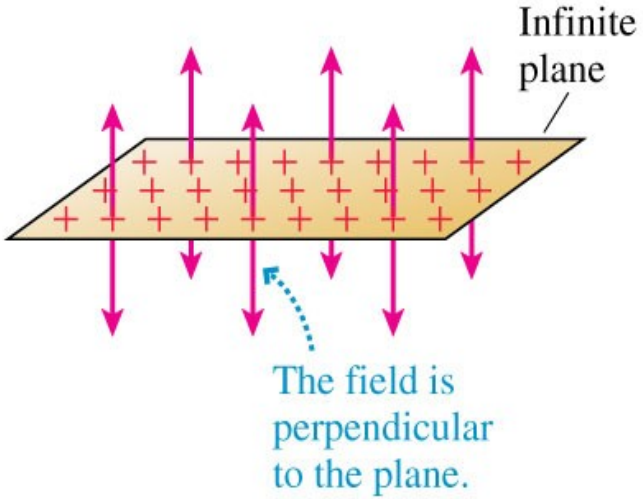
$$\vec{E} = \frac{\lambda}{2\pi r \epsilon_0}\hat{r}$$

$$\vec{E} = 2\frac{k}{r}\hat{r}$$

$$\vec{E} = \frac{Q}{4\pi r^2 \epsilon_0}\hat{r}$$

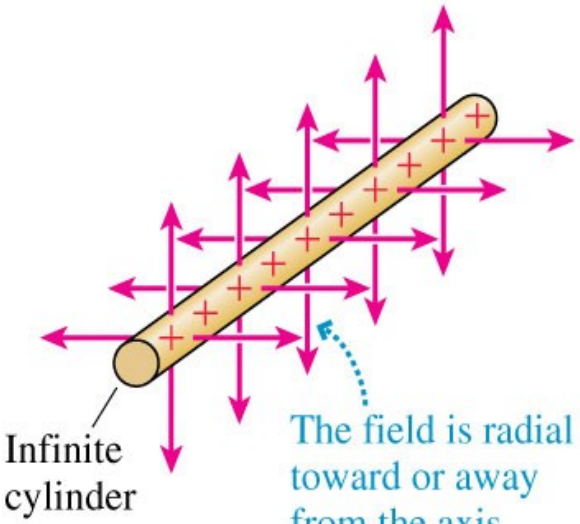
$$\vec{E} = k\frac{Q}{r^2}\hat{r}$$

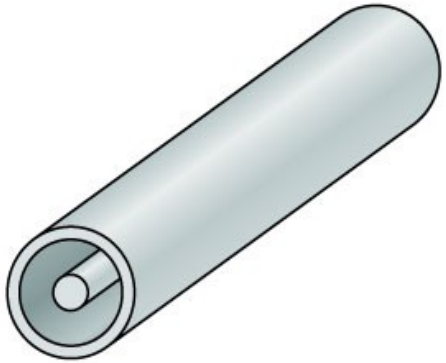
Planar symmetry



Infinite parallel-plate capacitor

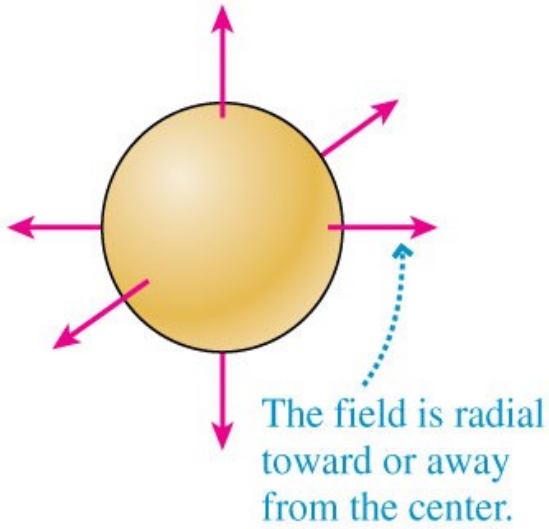
Cylindrical symmetry

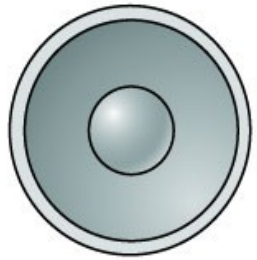




Coaxial cylinders

Spherical symmetry





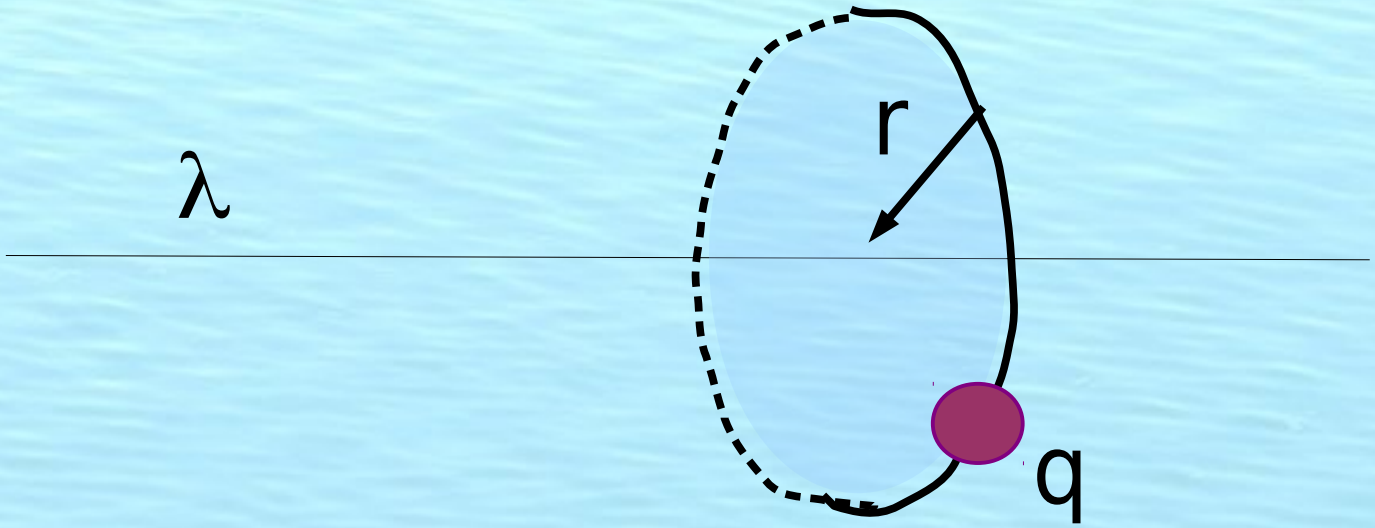
Concentric spheres

Problem

What is line charge density on a long wire if a 10 microgram particle carrying 3 nC orbits at 300 m/s?

$$\vec{E}_{wire} = 2k\frac{\lambda}{r}\hat{r}$$

$$\lambda = \frac{Q}{L}$$



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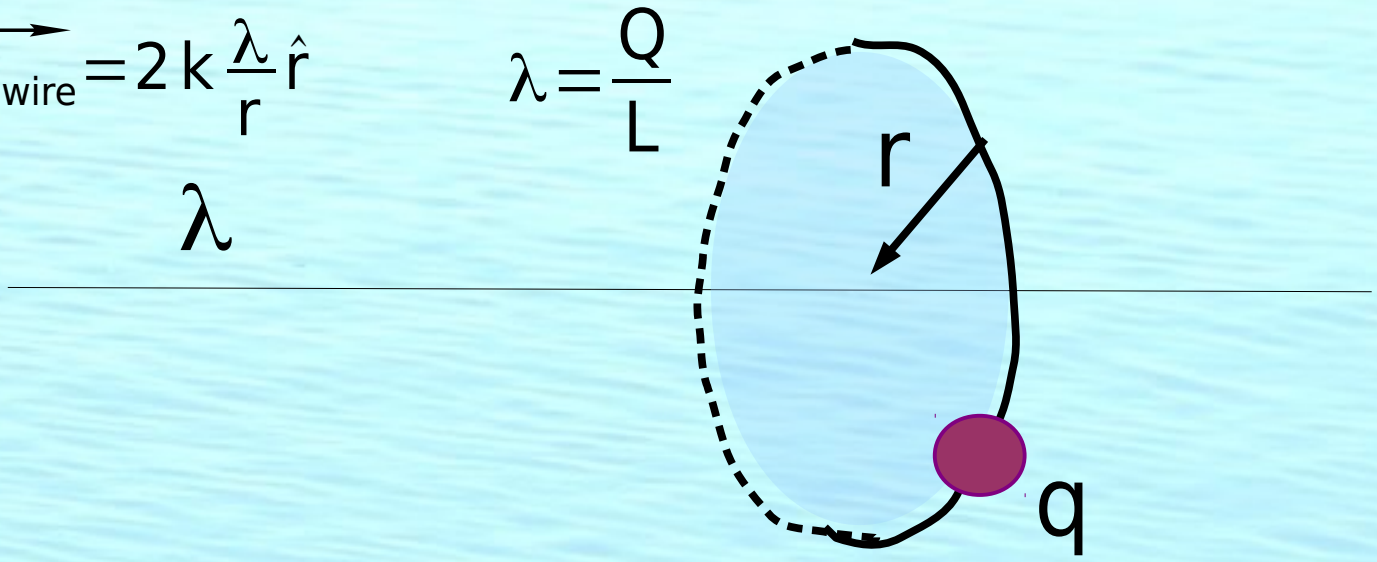

Clicker

You are 1 cm away from a 10 meter long charged wire, and the electric field has magnitude 27 N/C. What is the field if you go 3 cm away?

[A] 27 N/C

[B] 13.5 N/C

[C] 9 N/C

[D] 3 N/C

$$\vec{E}_{PLANE} = \frac{\sigma}{2\epsilon_0}\hat{i} \qquad \vec{E}_{LINE} = \frac{\lambda}{2\pi r \epsilon_0}\hat{r} \qquad \vec{E}_{SPHERE} = \frac{Q}{4\pi r^2 \epsilon_0}\hat{r}$$

Clicker

You are 1 cm away from a 10 m square charged

To 2 nCoul. What is the electric field?

[A] 1.13 V/m

[B] 2.26 V/m

[C] 113 N/C

[D] 2×10^{-9} V/m

[E] 2×10^{-11} V/m

$$\vec{E}_{PLANE} = \frac{\sigma}{2\epsilon_0}\hat{i}$$

$$\vec{E}_{SPHERE} = k\frac{Q}{r^2}\hat{r} = \frac{Q}{4\pi r^2 \epsilon_0}\hat{r}$$

Clicker

You are 100 m away from a 10 m square charged to 2 nCoul. What is the electric field?

[A] 1.13 V/m

[B] 1.13×10^{-2} V/m

[C] 113 V/m

[D] 18×10^{-2} V/m

[E] 18×10^{-4} V/m

$$\vec{E}_{PLANE}=\frac{\sigma}{2\epsilon_0}\hat{i}$$

$$\vec{E}_{SPHERE}=k\frac{Q}{r^2}\hat{r}=\frac{Q}{4\pi r^2\epsilon_0}\hat{r}$$

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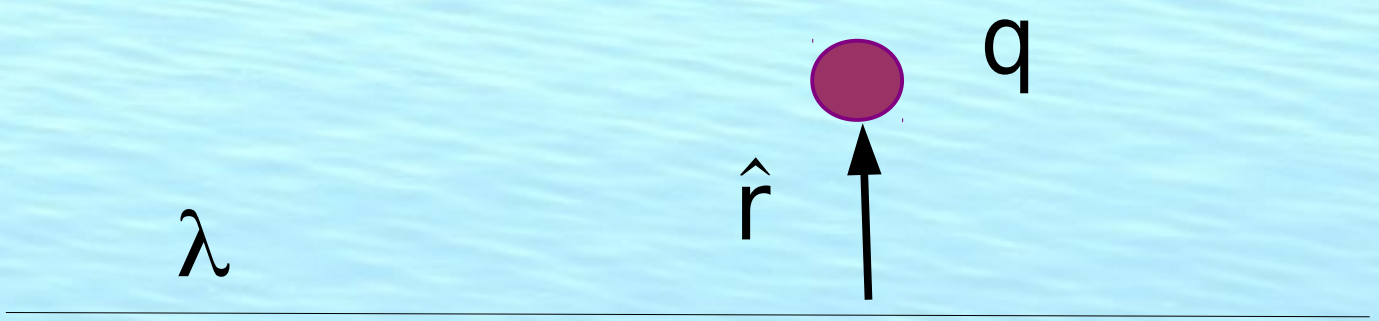
Electric field of a charged wire – Derivation

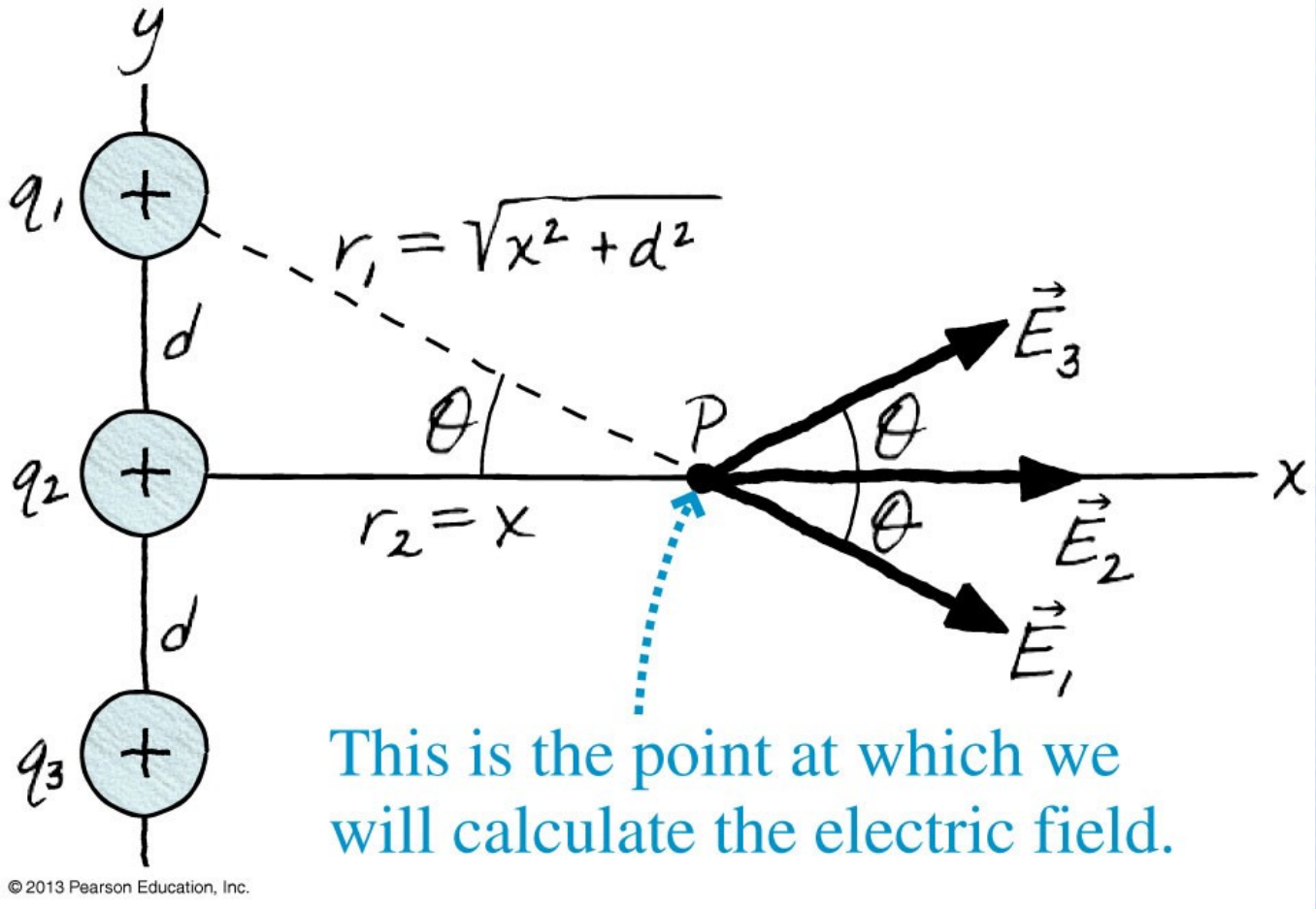
$$\overrightarrow{E_{wire}} = 2k\frac{\lambda}{r}\hat{r}$$

$$\lambda = \frac{Q}{L}$$

$$\vec{E} = \int k\frac{dq}{r^2}\hat{r}$$



Electric field of three charges



Electric field of three charges

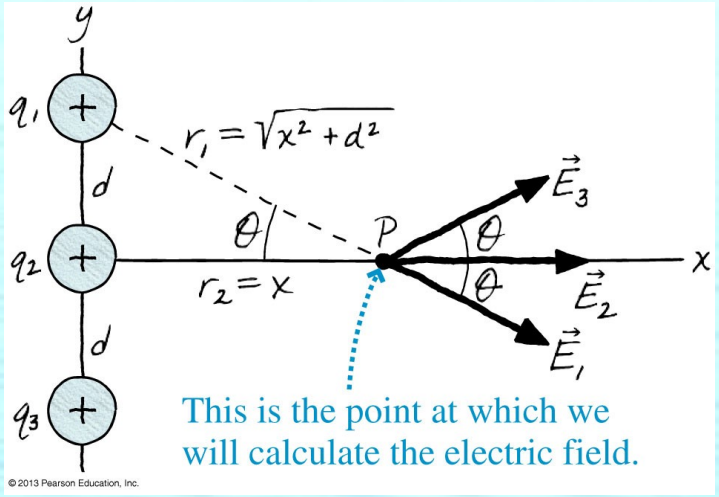
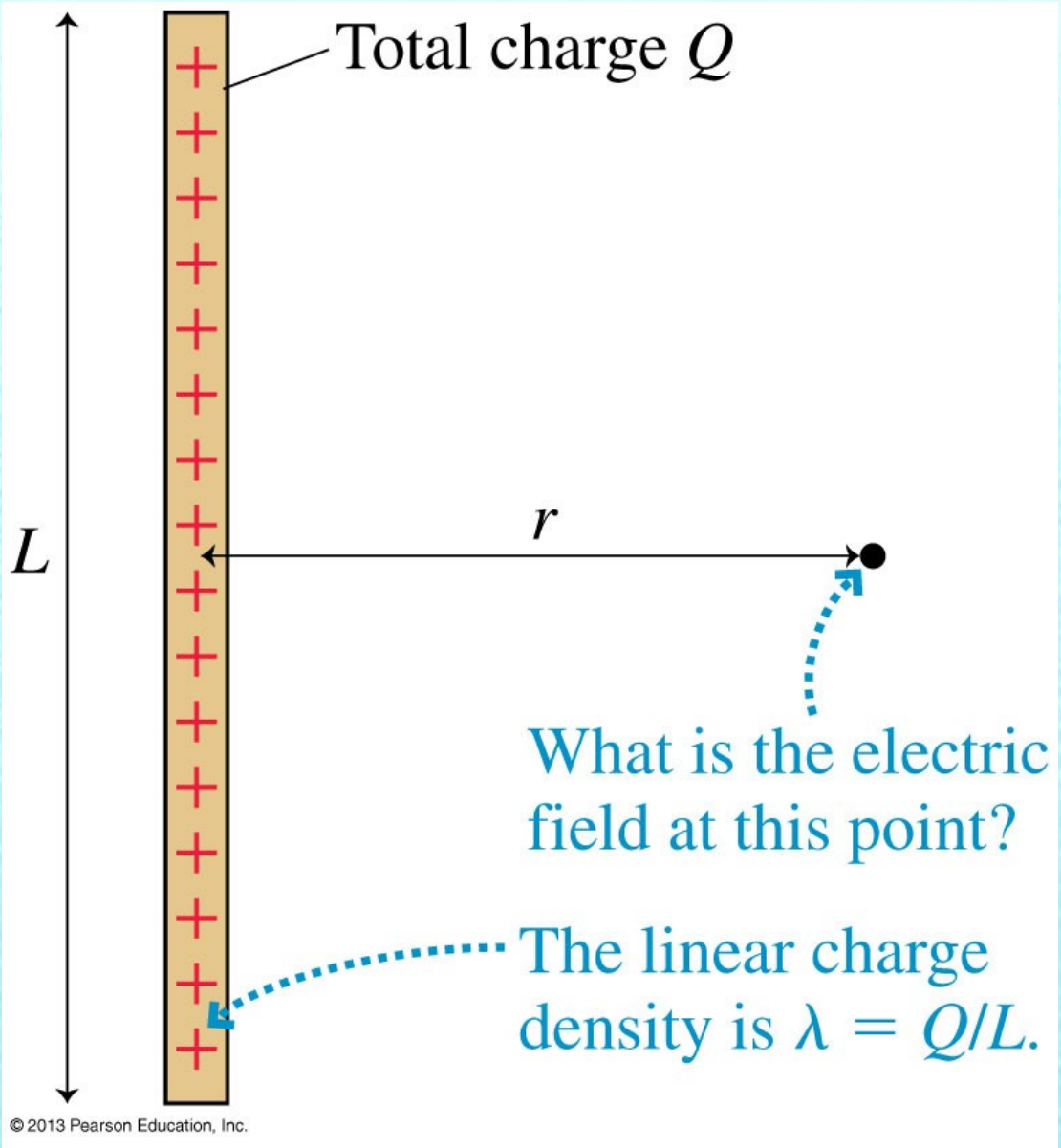
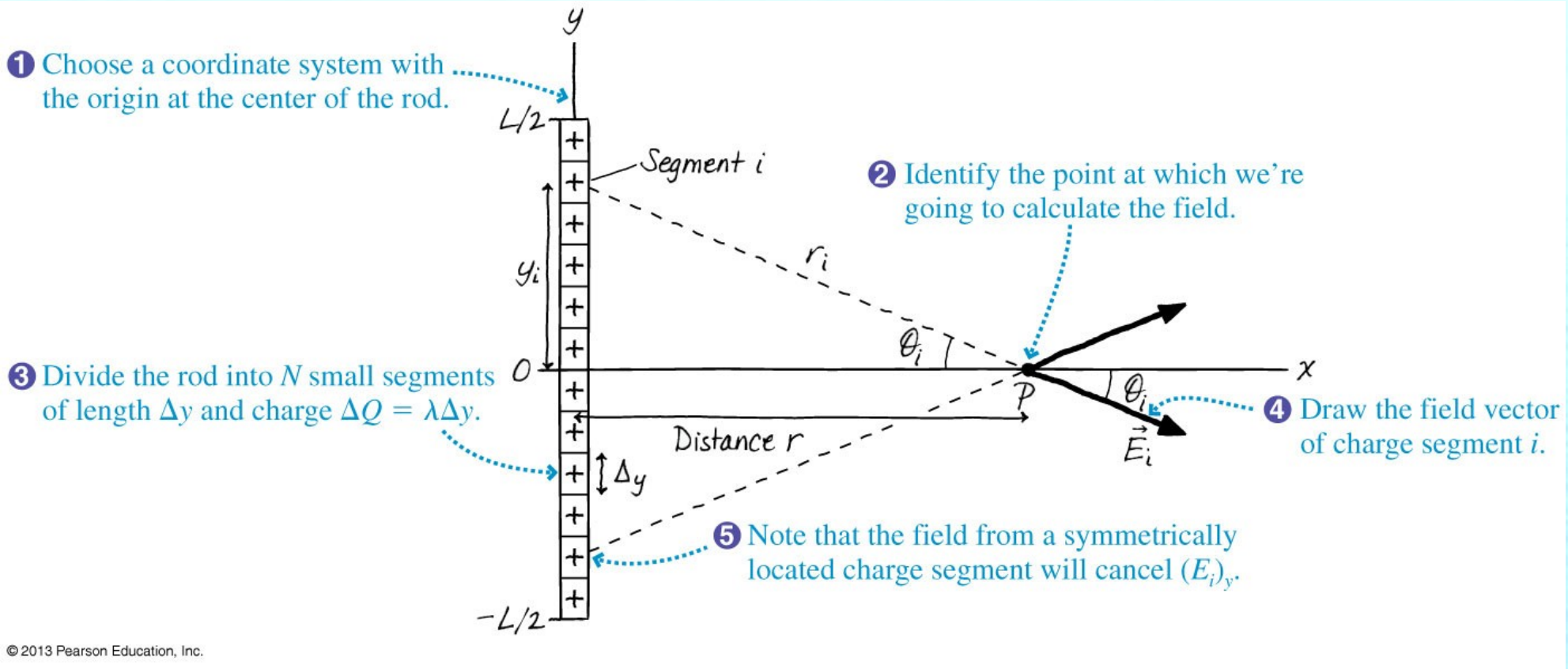
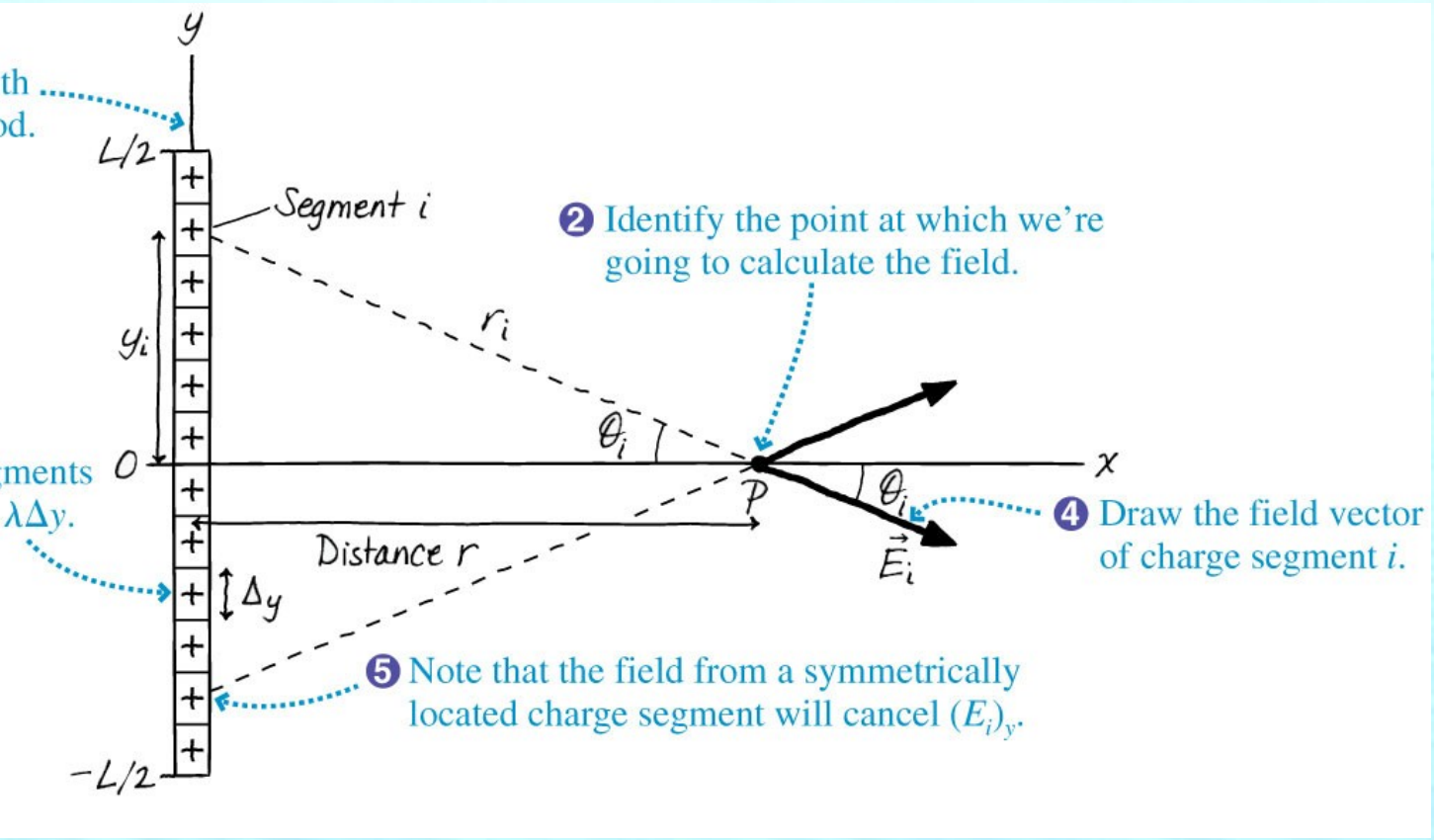


Figure 26.11

Electric field of charged wire






y
L/2
Segment i
y_i
r_i
θ_i
0
x
P
θ_i
$\vec{E}_i$
Distance r
Δy
$-L/2$
2 Identify the point at which we're going to calculate the field.
4 Draw the field vector of charge segment i.
5 Note that the field from a symmetrically located charge segment will cancel $(E_i)_y$.

Electric field of a charged wire