Course Updates

http://www.phys.hawaii.edu/~varner/PHYS272-Spr10/physics272.html

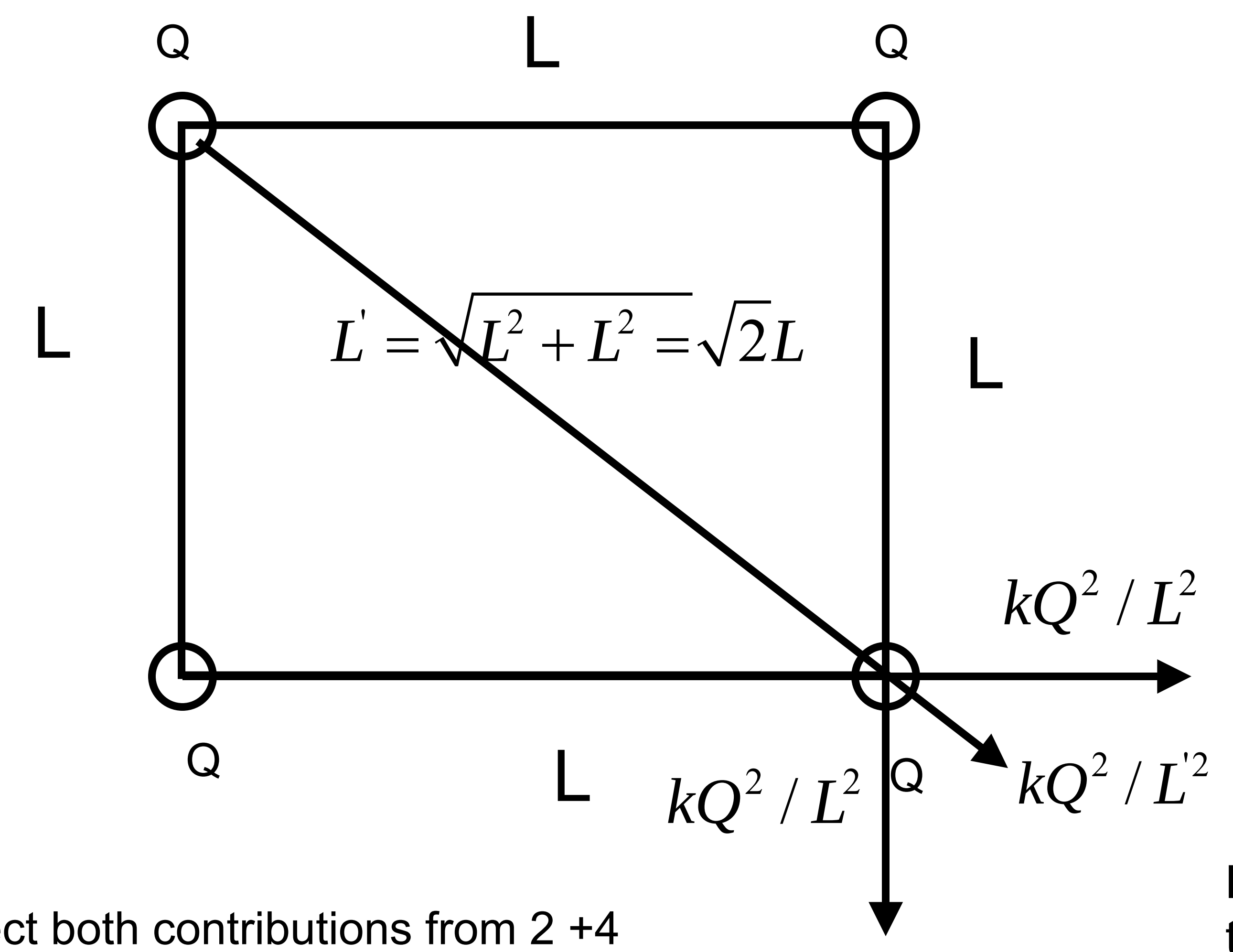
Reminders:

1) Updates posted on web

2) Online HW, written (turn-in) problems today

3) Chapter 22 this week
   (all this information on web page)

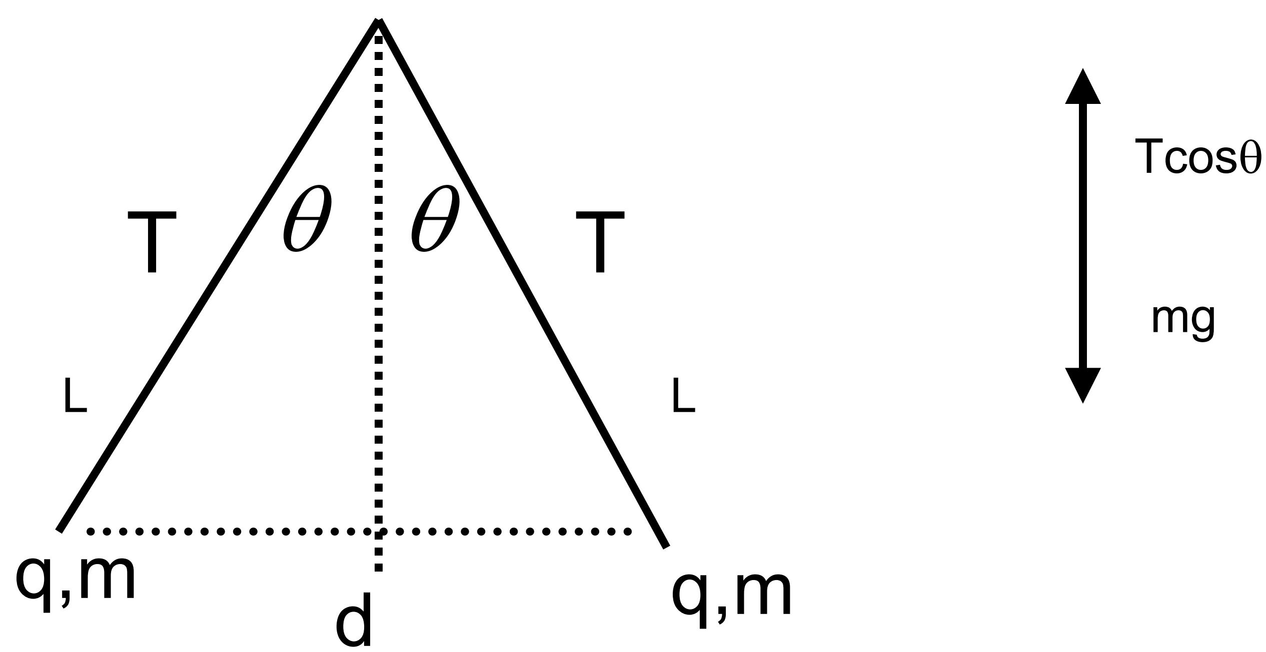
Hints for 21.23



Project both contributions from 2 +4
on the diagonal.

Don't forget
the force is
a vector !!!

Hints for 21.74

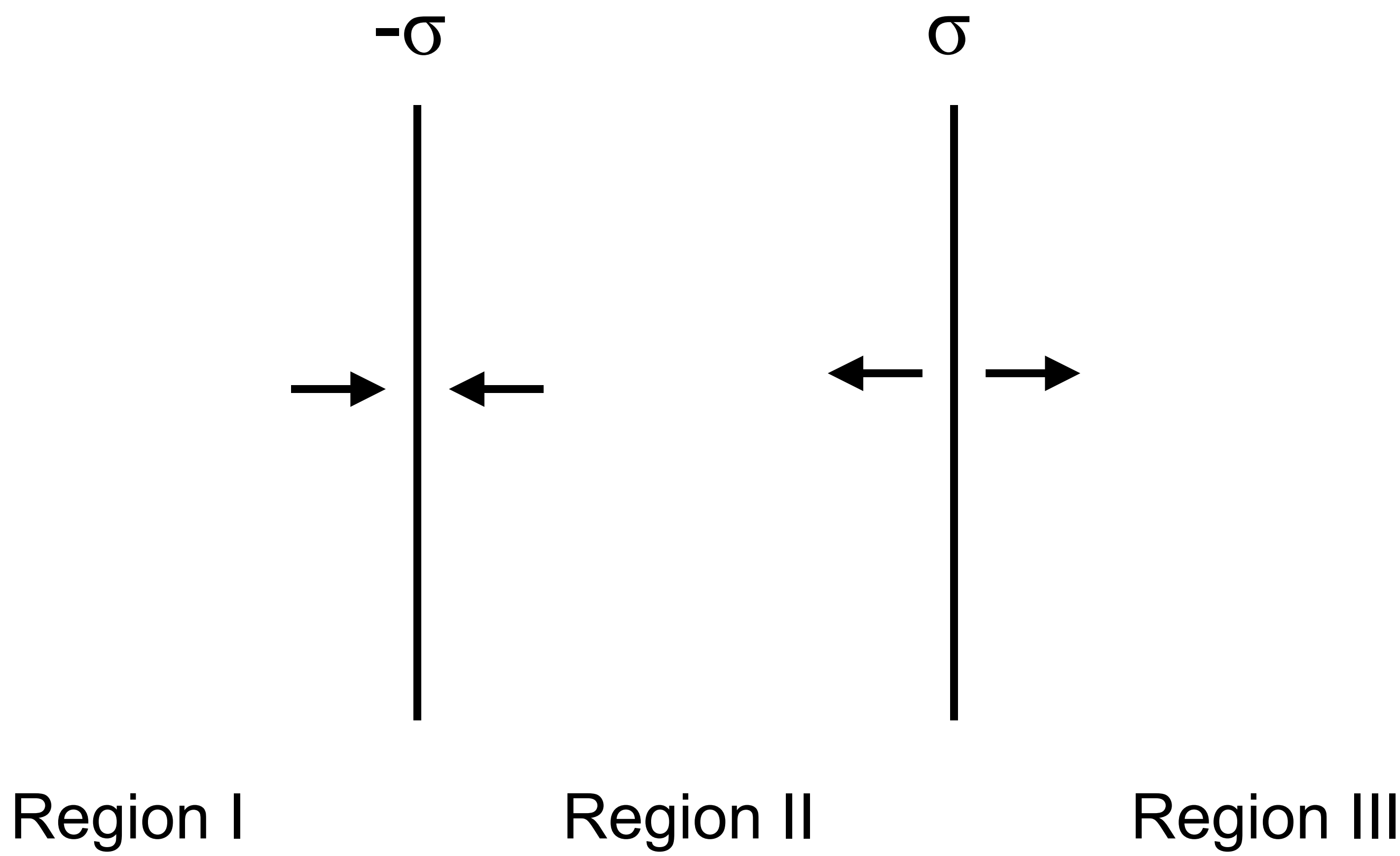


Balance forces in the vertical direction $T\cos\theta = kq^2/d^2$

Balance forces in the horizontal direction $T\sin\theta = kq^2/d^2$

Relate θ to d and L $\sin\theta = (d/2)/L$

Hints for HWK



Continuous Charge Distributions

Review

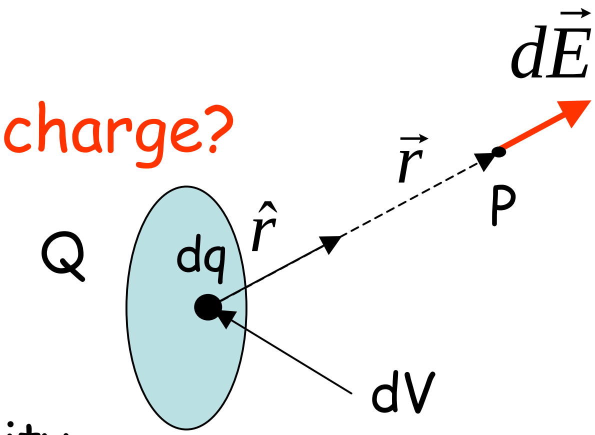
What if we have a distribution of charge?

Q – charge of distribution.

dq – element of charge.

$d\vec{E}$ – contribution to $\vec{E}$ due to dq.

Can write dq = ρ dV; ρ is the charge density.



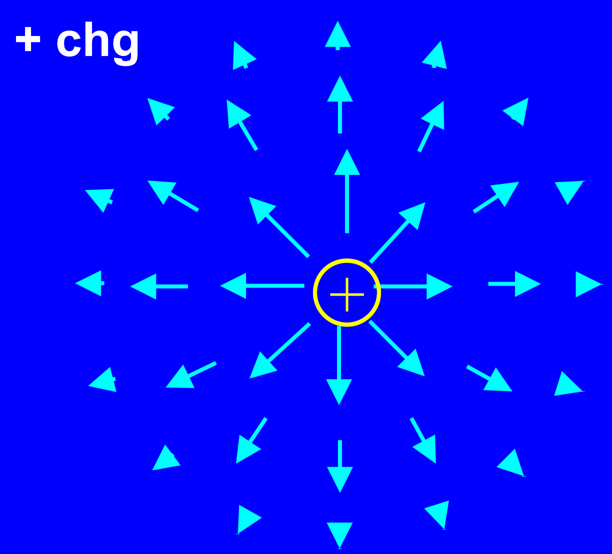
$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i^2}\hat{r}_i \rightarrow \frac{1}{4\pi\varepsilon_0}\int_V \frac{dq}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\int_V \frac{\rho dV}{r^2}\hat{r}$$

1. Can use calculus to determine electric fields for a few special charge distributions.
2. Method important. Know how to do.
3. For most problems, we cannot solve them analytically, but we can solve using computer methods.

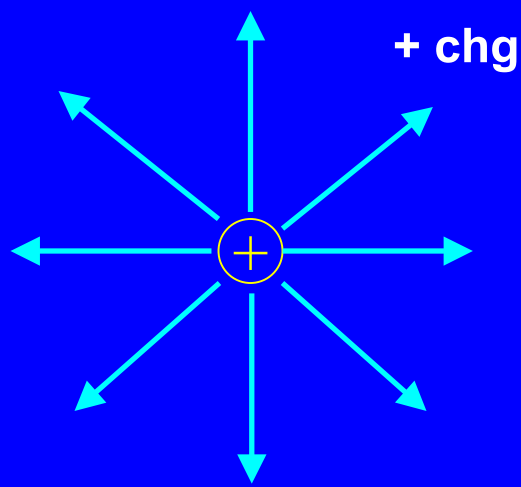
Ways to Visualize the E Field

Consider the E-field of a positive point charge at the origin

vector map

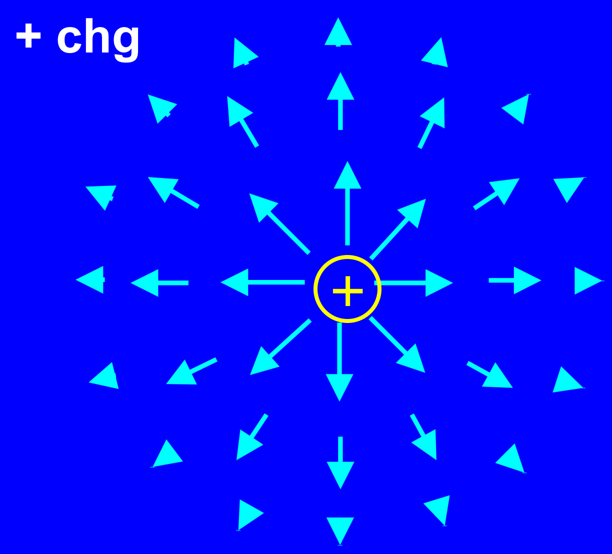


field lines



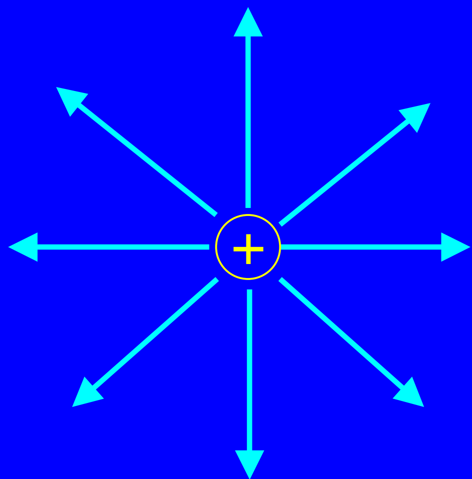
Introduced by
Michael Faraday (1791-1867)

Rules for Vector Maps

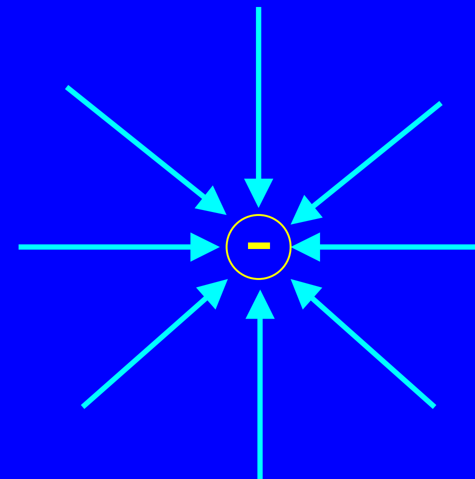


- **Direction** of arrows indicates the *direction* of the field at each point in space
- **Length** of arrows is proportional to the *magnitude* of the field at each point in space

Rules for Field Lines



graphical "trick" for visualizing E fields

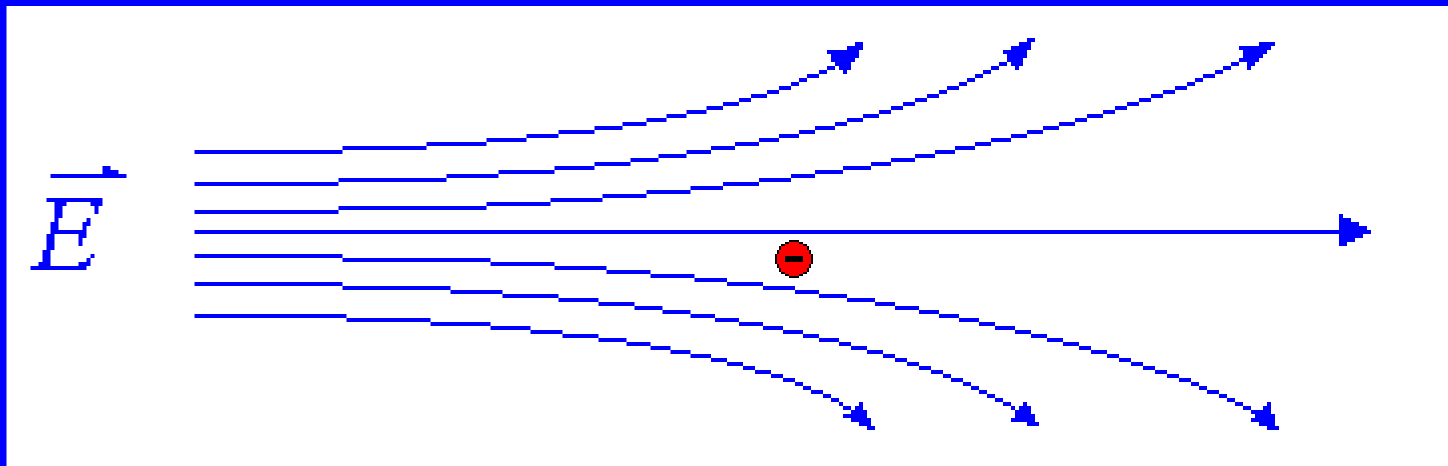


- Lines leave (+) charges and return to (-) charges
- Number of lines leaving/entering charge $\propto$ amount of charge
- Field lines never cross

→ Tangent of line = **direction** of *E* at each point

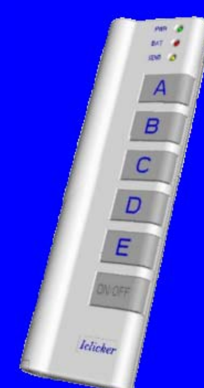
→ Local density of field lines ~ **magnitude** of *E* at each point

Exercise1:



6) A negative charge is placed in a region of electric field as shown in the picture. Which way does it move ?

a) up
b) down
c) left
d) right
e) it doesn't move



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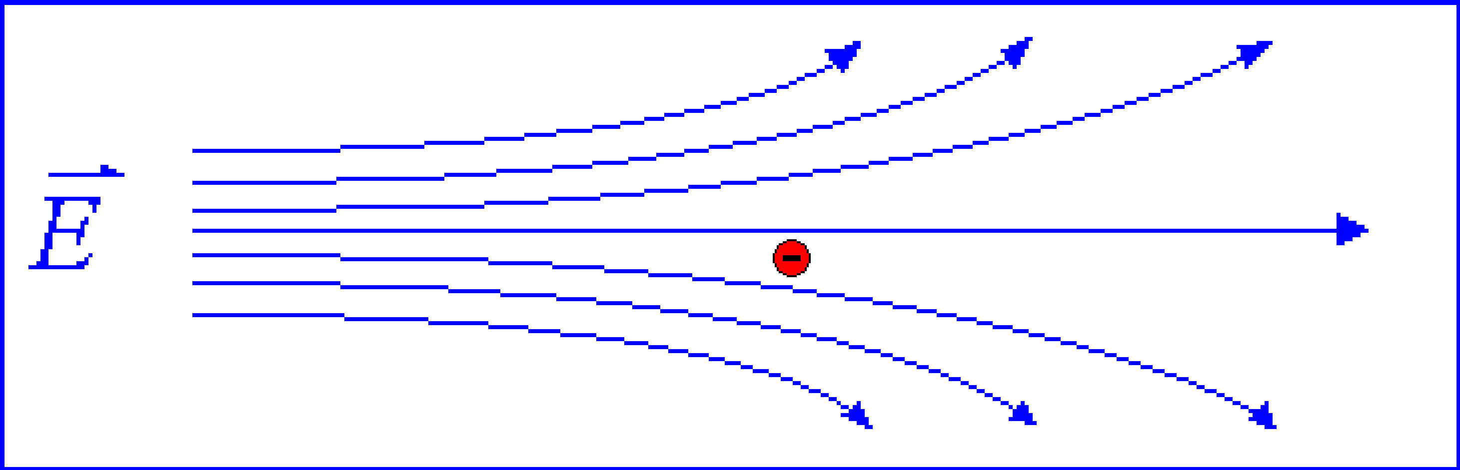

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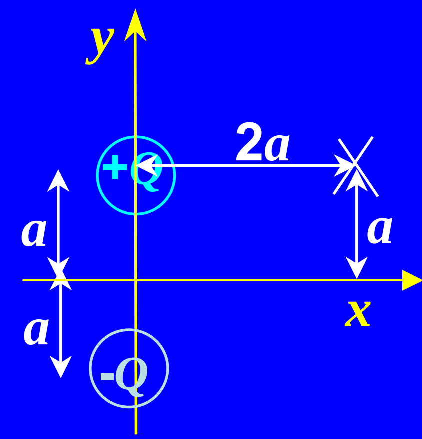
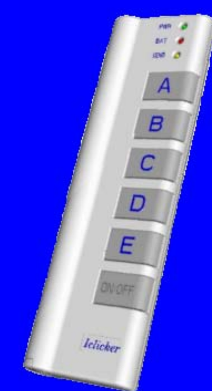
Exercise2:

- Consider a dipole (2 separated equal and opposite charges) with the y-axis as shown.

-Which of the following statements about $E_x(2a,a)$ is true?



(a) $E_x(2a,a) < 0$ (b) $E_x(2a,a) = 0$ (c) $E_x(2a,a) > 0$



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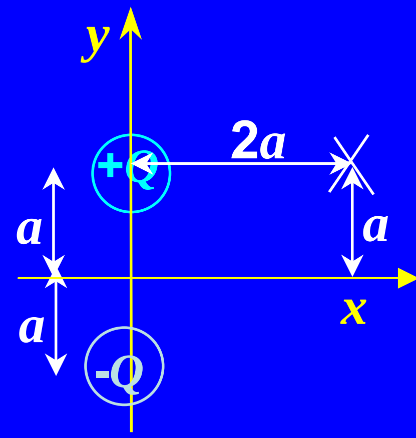

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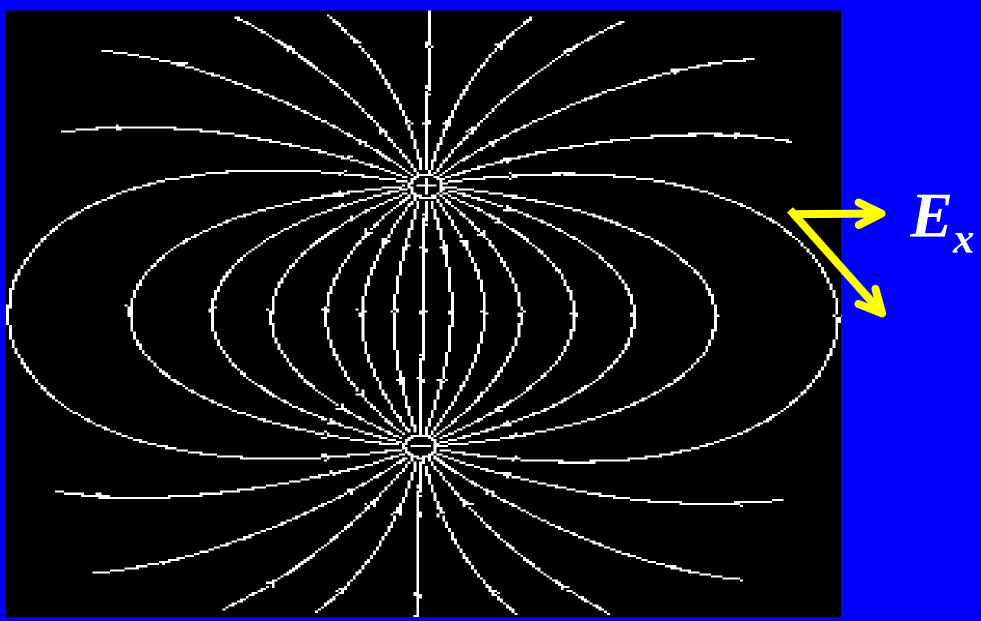
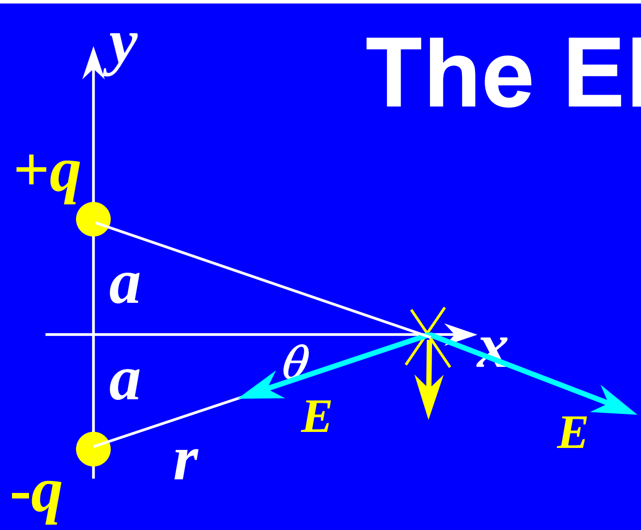


Solution: Draw some field lines according to our rules.

The Electric Dipole



What is the E-field generated by this arrangement of charges?

Calculate for a point along x-axis: $(x, 0)$

E_x = ??

Symmetry

$E_x(x,0) = 0$

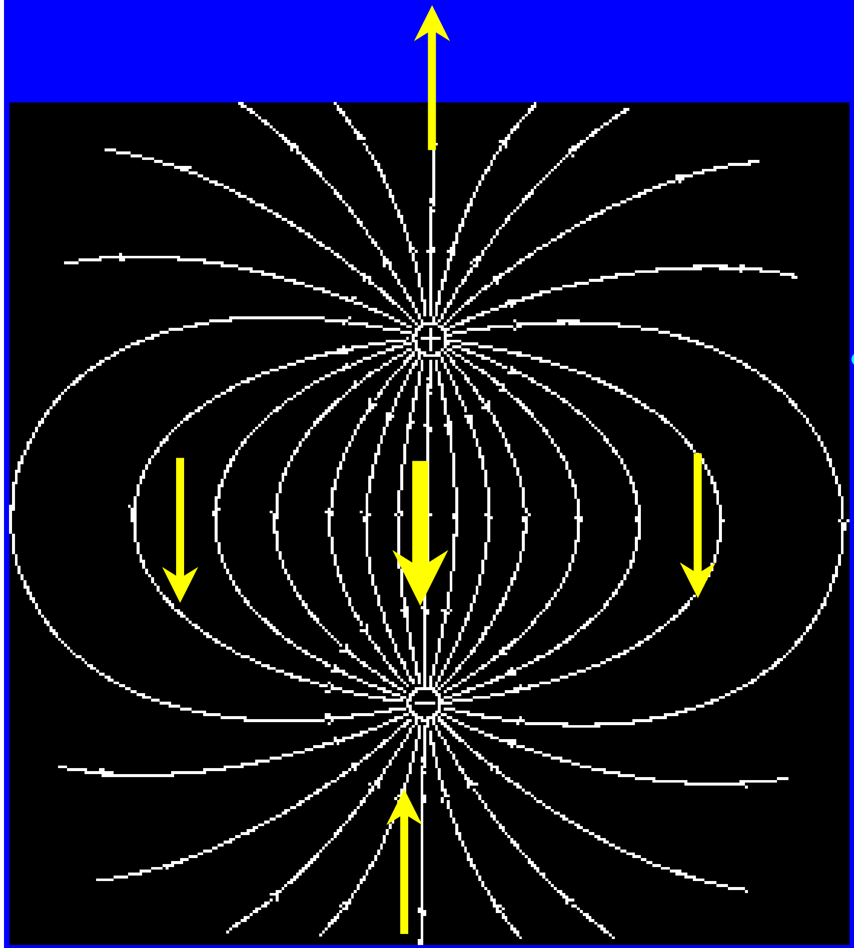
E_y = ??

$$E_y\left(x,0\right) = -2\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\sin\theta$$

$$\sin\theta = \frac{a}{r} \qquad r^2 = x^2 + a^2$$

$$E_y\left(x,0\right) = -2\frac{1}{4\pi\varepsilon_0}\frac{q\,a}{\left(x^2+a^2\right)^{3/2}}$$

Electric Dipole Field Lines



- Lines leave positive charge and return to negative charge

- Field largest in space between two charges

- We derived:

$$E_y(x,0) = -2\frac{1}{4\pi\varepsilon_0}\frac{q\,a}{\left(x^2+a^2\right)^{3/2}}$$

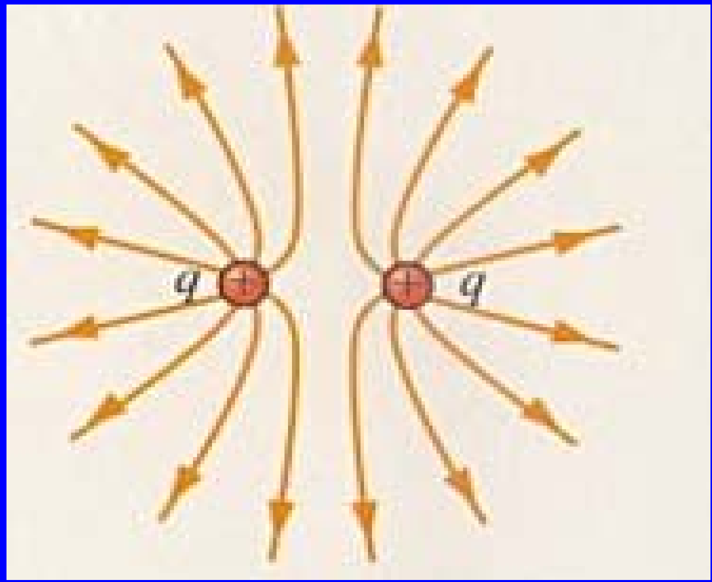
... for $r >> a$,

$$E_y(x,0) \propto \frac{1}{x^3}$$

Field Lines From Two Like Charges

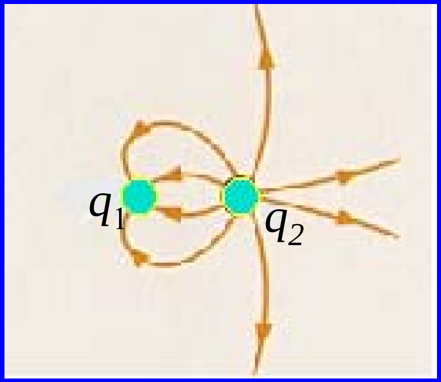
- There is a zero halfway between the two charges

- $r >> a$: looks like the field of point charge ($+2q$) at origin

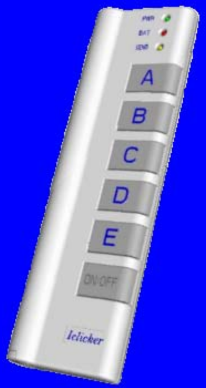


Example 3:

- Examine the electric field lines produced by the charges in this figure.
- Which statement is true?



(a) q_1 and q_2 have the same sign
(b) q_1 and q_2 have the opposite signs and $|q_1| > |q_2|$
(c) q_1 and q_2 have the opposite signs and $|q_1| < |q_2|$



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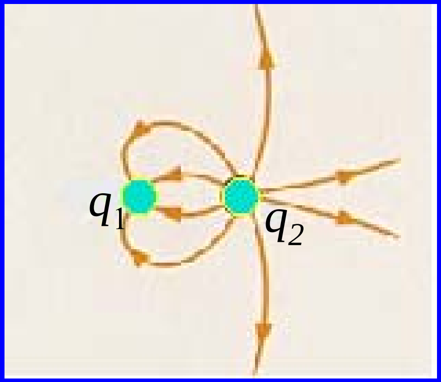

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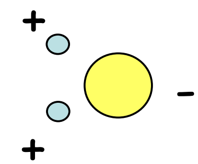
Field lines start from q_2 and terminate on q_1.
This means q_2 is positive; q_1 is negative; so, … not (a)

Now, which one is bigger?

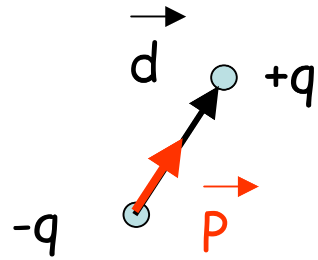
Notice along a line of symmetry between the two, that the E-field still has a positive y component. If they were equal, it would be zero; This indicates that q_2 is greater than q_1

Electric Dipoles

Molecules can have a permanent dipole moment.
Called polar molecules.
example: H_2O

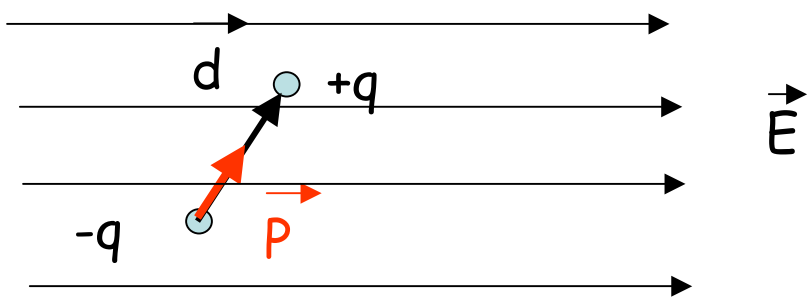


Dipole moment: $$\vec{p} = q\vec{d}$$



ideal dipole

What happens to a dipole in a uniform electric field?



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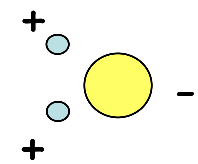

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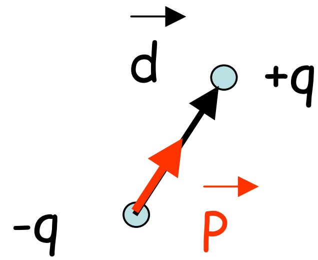

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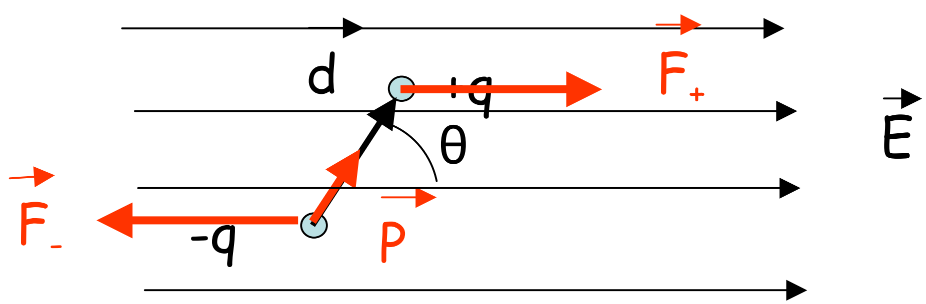


No net force;
but torque.

torque = Fd sin θ

= qEd sin θ

= pE sin θ

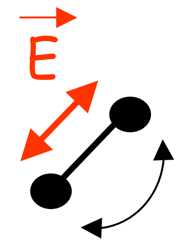
can write as: $$\vec{\tau} = \vec{p} \times \vec{E}$$ Cross product

Electric Dipoles

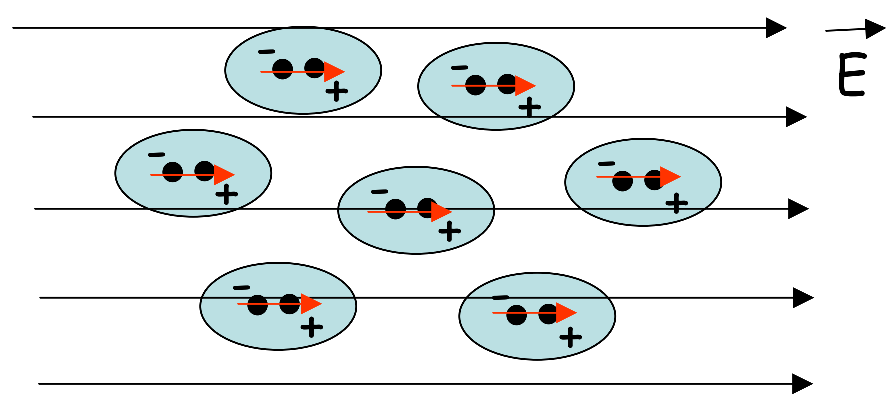
A dipole in a nonuniform electric field will experience a force.

Microwave ovens: dipole moment of water used to cook food.

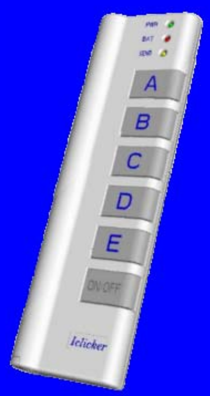
- Microwave frequency at natural frequency of vibration of water.
- Molecules resonate with the rapidly oscillating electric field and absorb a large amount of energy.
- The KE of the excited molecules is converted to thermal energy by collisions of the molecules.

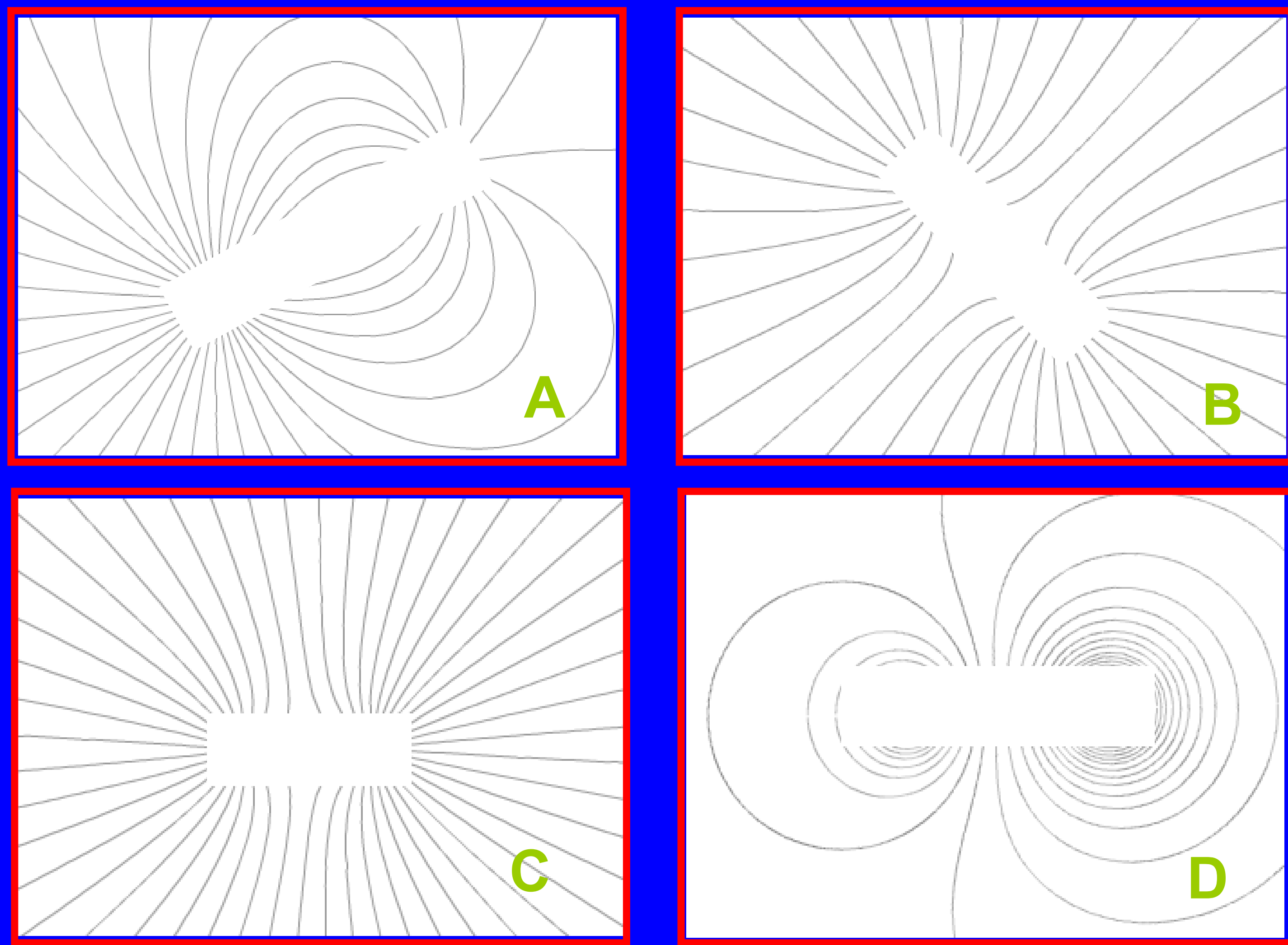


Non polar molecules: no permanent dipole moment, but an electric field can cause an induced dipole moment by causing charge separation. Molecules are polarized.



Which of the following field line pictures best represents the electric field from two charges that have the <u>same</u> sign but different magnitudes?





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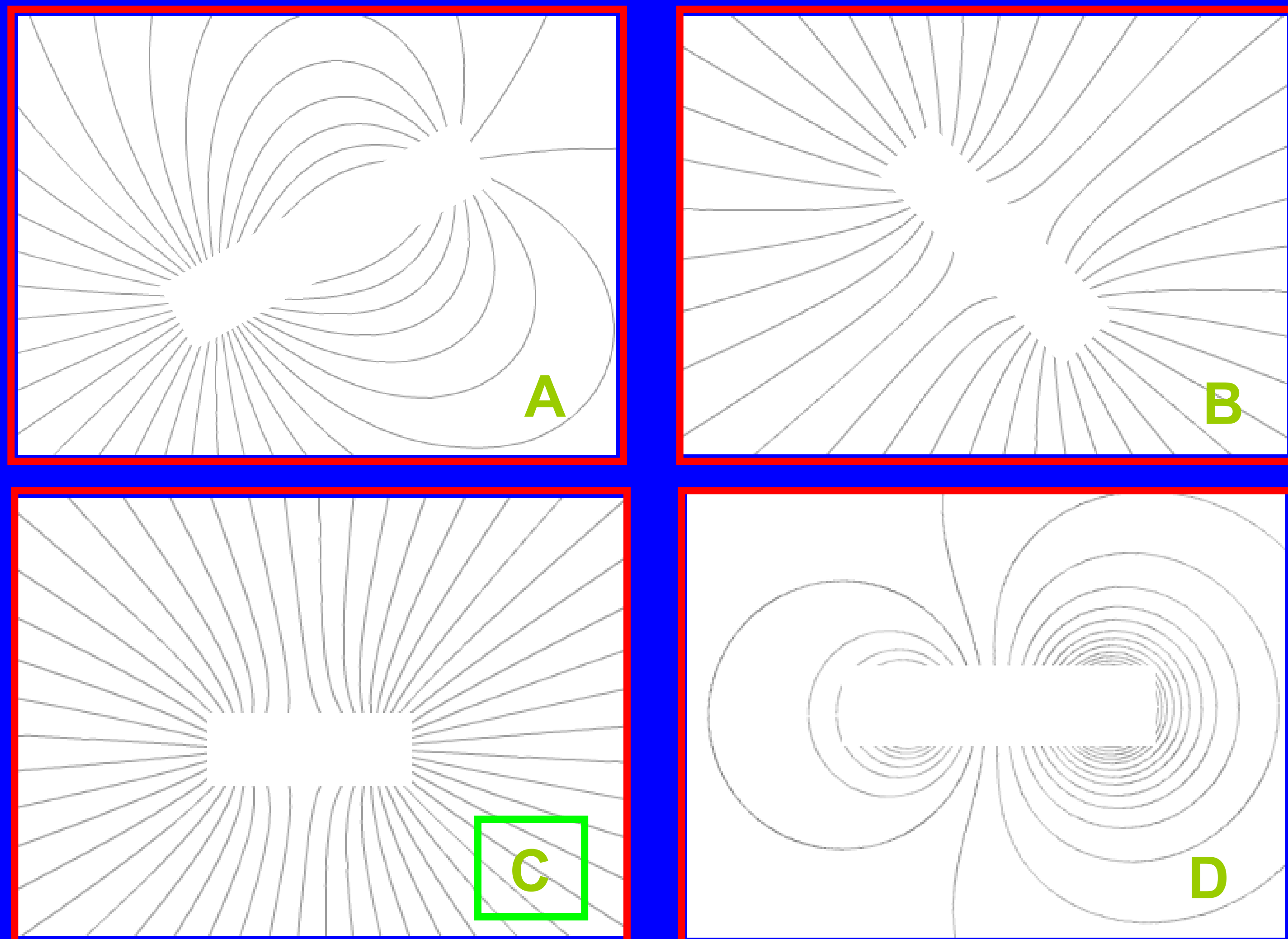


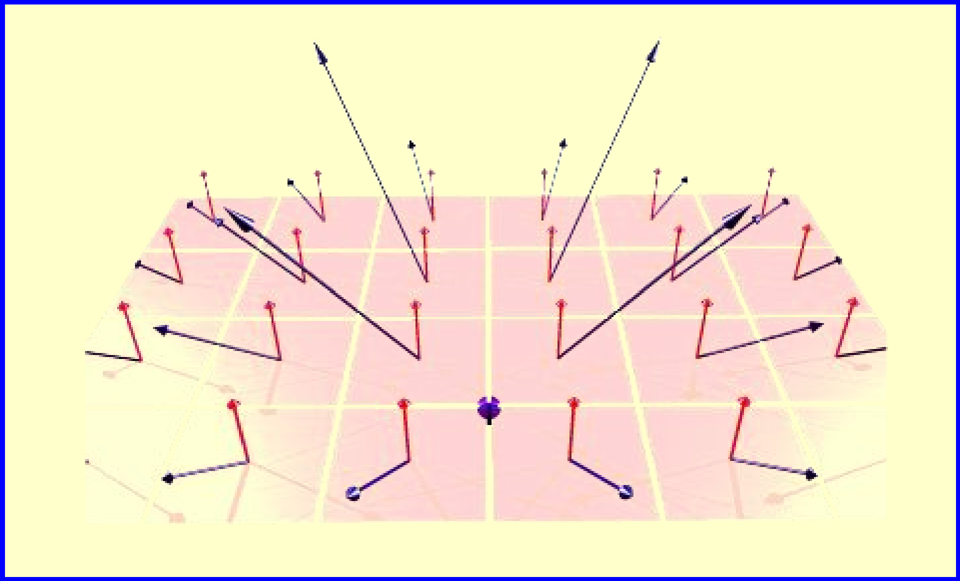
Investigate with simulation:

Electric Flux "Counts Field Lines"

$$\Phi_S = \int_S \vec{E} \cdot d\vec{A}$$

Flux through surface S

Integral of $\vec{E} \cdot d\vec{A}$ on surface S



For next time

- Quiz on Friday
- Coulomb's Law, Electric Fields
- Office Hours usually after this class (9:30 – 10:00) in WAT214 – not today (1-1:30pm)
- Turn in HW #1 (Hand In), HW #2 available