Electric Fields

- Determining direction of E-Field from a “Base” and Force on Test Charge.

    1. Determine the direction of the E-Field

    2. Determine the Test Charge type and location

    3. Determine the direction of the force on that Test Charge

Do One

- Sketch all four combinations for +/- base charges and +/- test charges. Include the direction of E and F.

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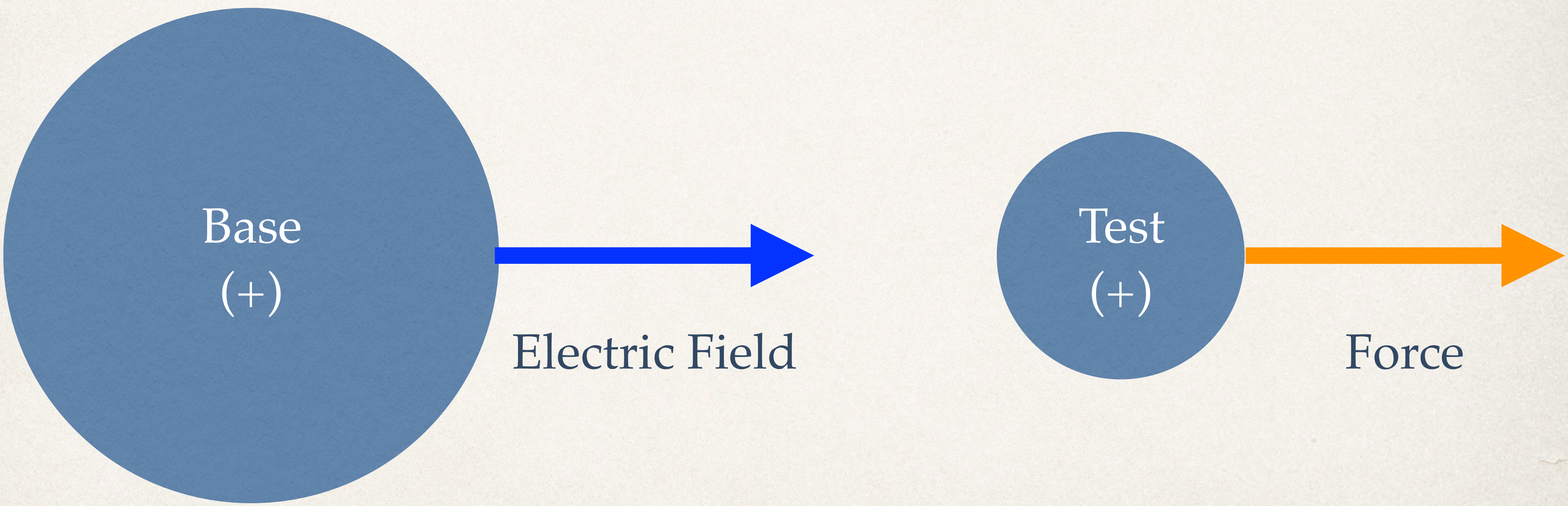

Do One

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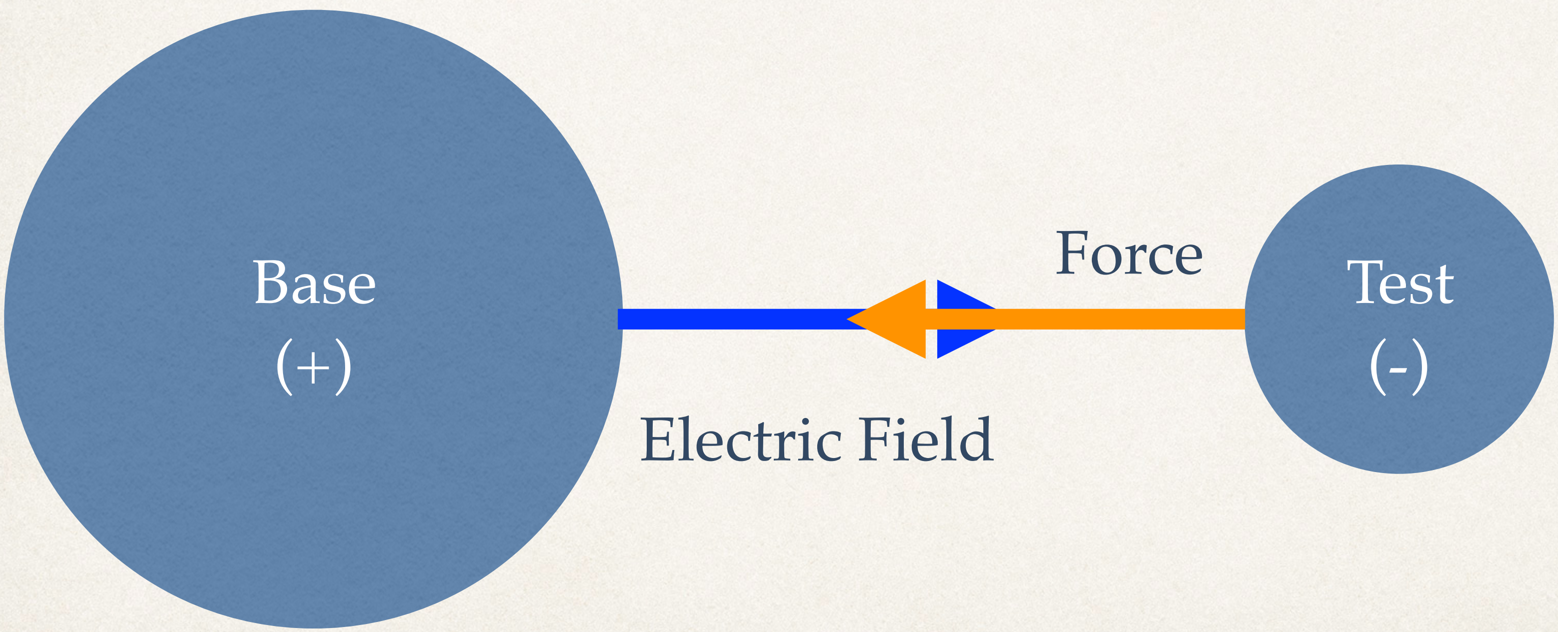

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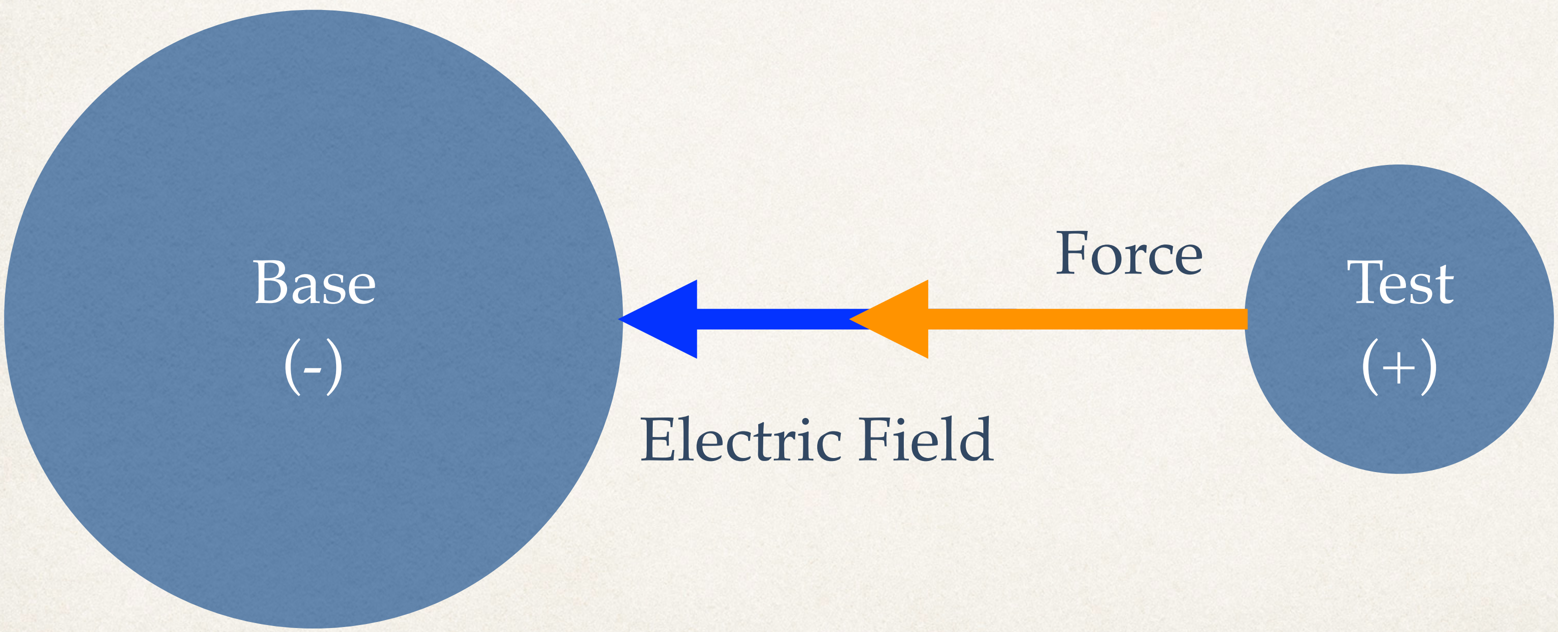

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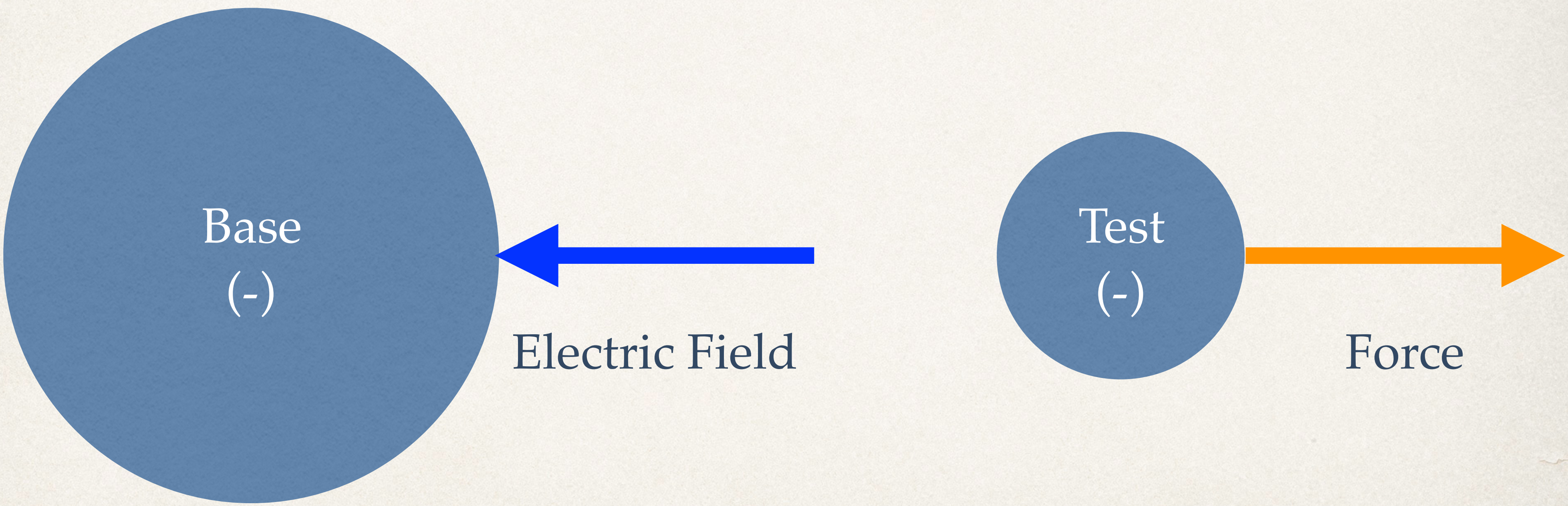
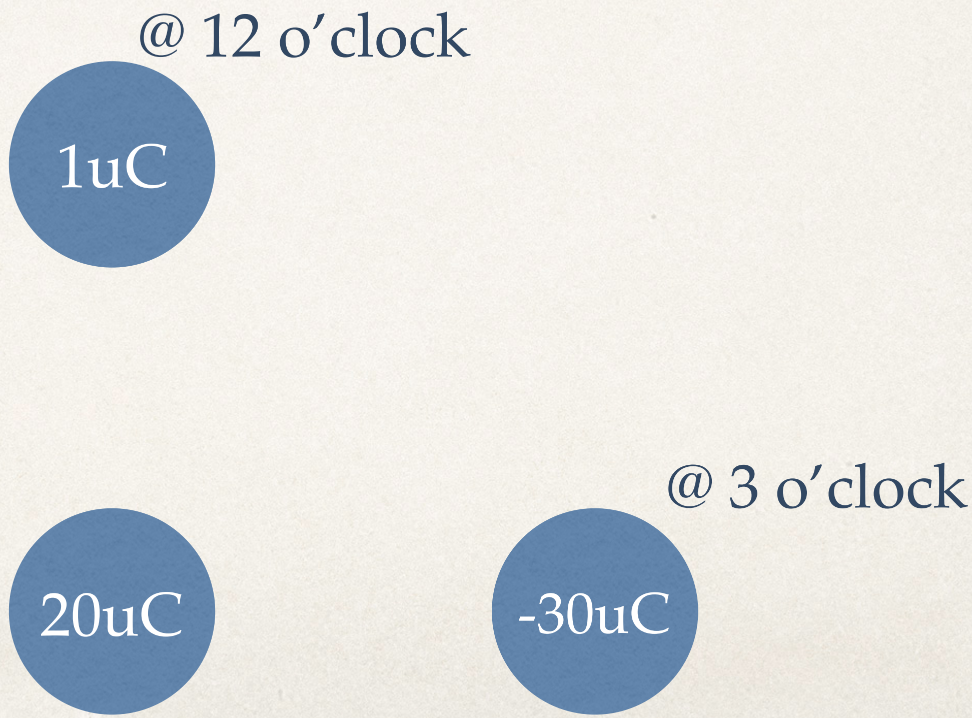


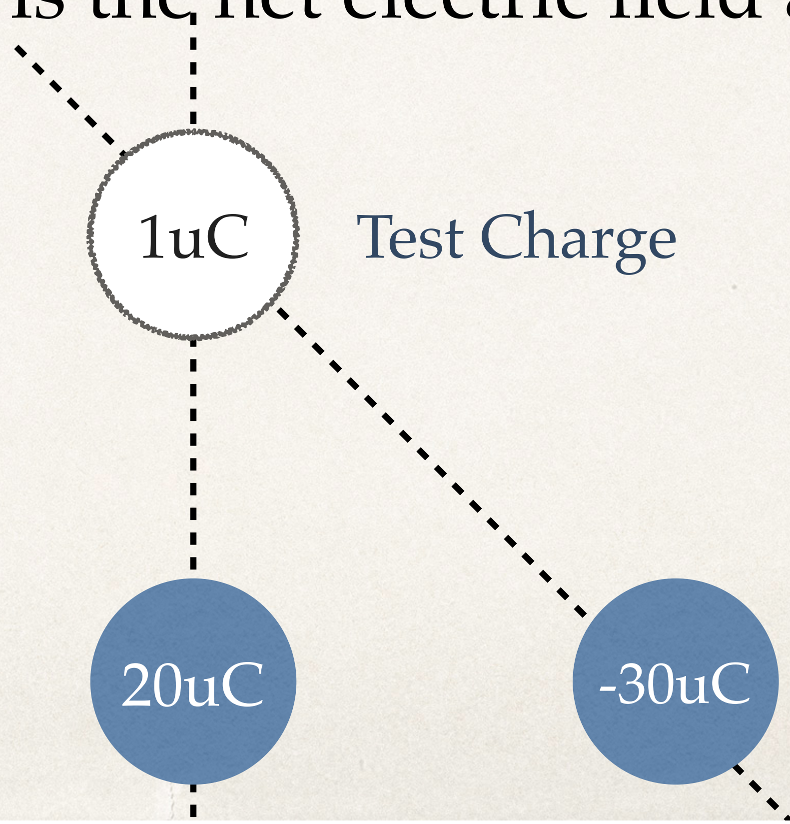
Extra Practice

- Three charges: 1 μC, 20 μC, and -30 μC are placed on the face of a clock as shown below. The radius of the clock is 25cm. What is the net electric field at the test charge?



Extra Practice

- Three charges: 1 μC, 20 μC, and 30 μC are placed on the face of a clock as shown below. The radius of the clock is 25cm. What is the net electric field at the test charge?



Extra Practice

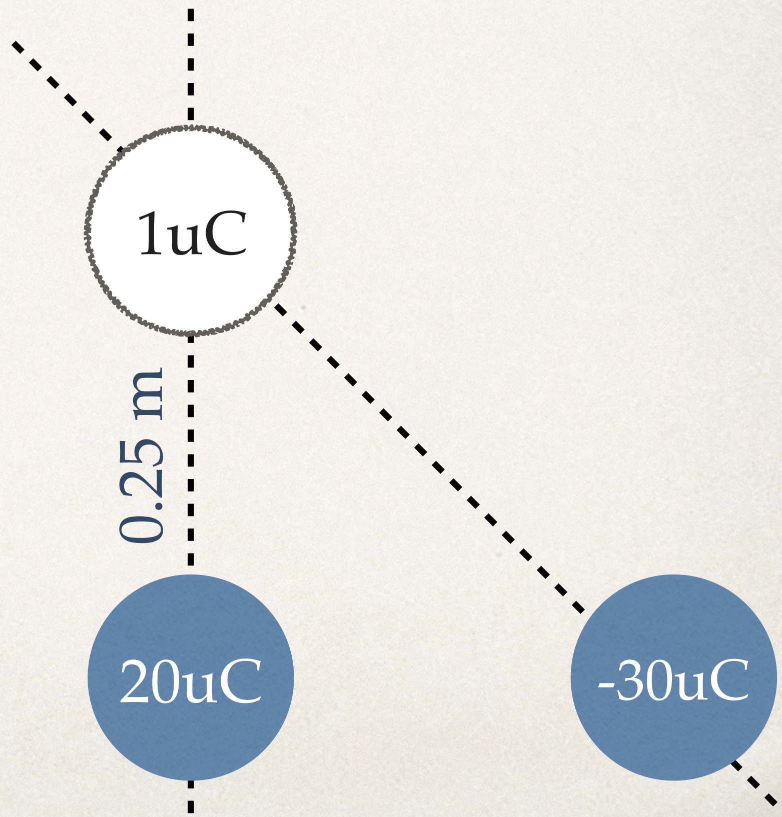
Electric Field due to 20 μC charge @ 1 μC charge

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

$$E = \left(9x10^9\right)\frac{\left|2.0x10^{-5}\right|}{\left(0.25\right)^2}$$

$$\boxed{E = 2.88x10^6 \ ^{N}/_{C}}$$

+y Direction



Extra Practice

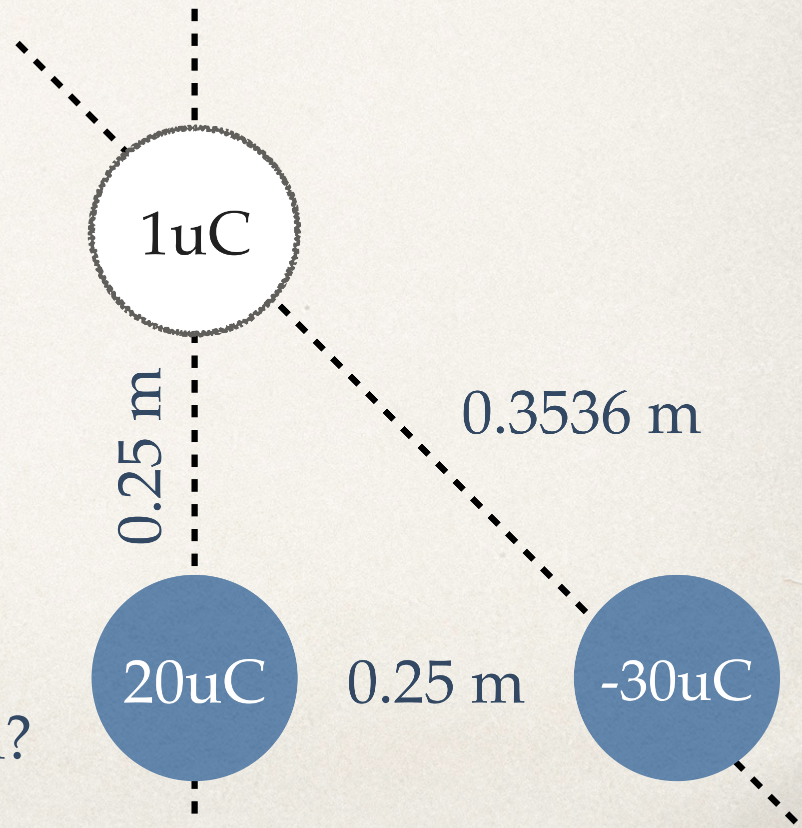
Electric Field due to-30 μC charge @ 1 μC charge

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

$$E = \left(9x10^9\right)\frac{\left|3.0x10^{-5}\right|}{\left(0.3536\right)^2}$$

$$\boxed{E = 2.16x10^6 \ {}^{N}\!/_{C}}$$

but what direction?



Extra Practice

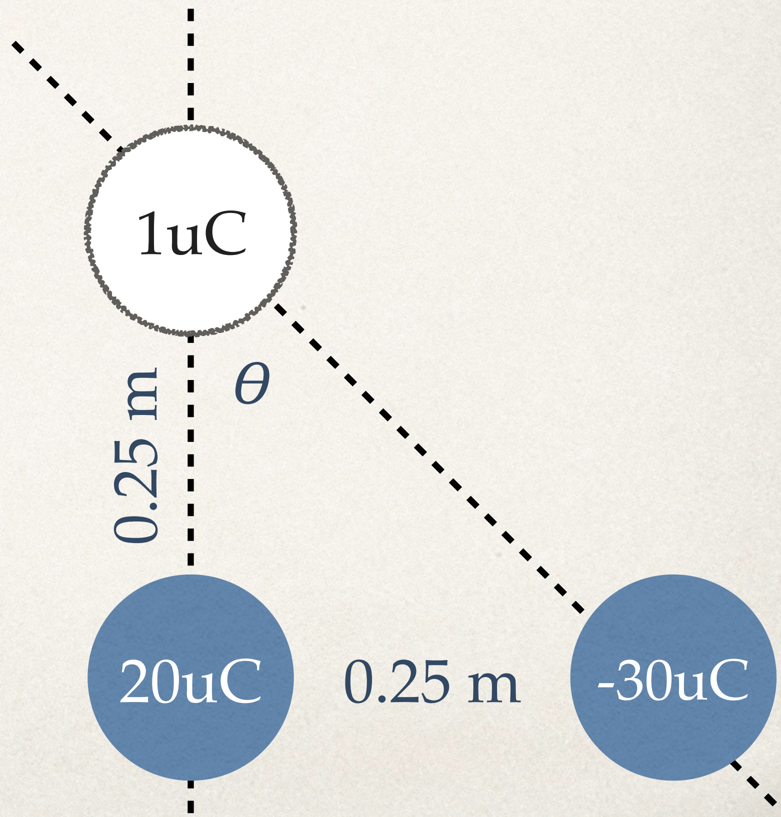
Electric Field due to-30 μC charge @ 1 μC charge

$$\boxed{E = 2.16x10^6 \; {}^{N}\!/\!{}_{C}}$$ @ θ° to the right of the -y axis

$$\tan\theta = \frac{opp}{adj}$$

$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right) = \tan^{-1}\left(\frac{0.25}{0.25}\right)$$

$$\theta = 45°$$



Extra Practice

Find individual components of the electric fields in the x or y direction

$$\boxed{E_{20uC@1uC} = 2.88x10^{6}\ {}^{N}\!/\!_{C}}$$

+y direction

$$E_{-30uC@1uC} = 2.16x10^{6}\ {}^{N}\!/\!_{C}$$

@ 45° right of -y axis

$$\left(E_{-30uC@1uC}\right)_x = \left(2.16x10^{6}\ {}^{N}\!/\!_{C}\right)\mathrm{Sin}\left(45°\right) = 1.53x10^{6}\ {}^{N}\!/\!_{C}$$

+x direction

$$\left(E_{-30uC@1uC}\right)_y = \left(2.16x10^{6}\ {}^{N}\!/\!_{C}\right)\mathrm{Cos}\left(45°\right) = 1.53x10^{6}\ {}^{N}\!/\!_{C}$$

-y direction

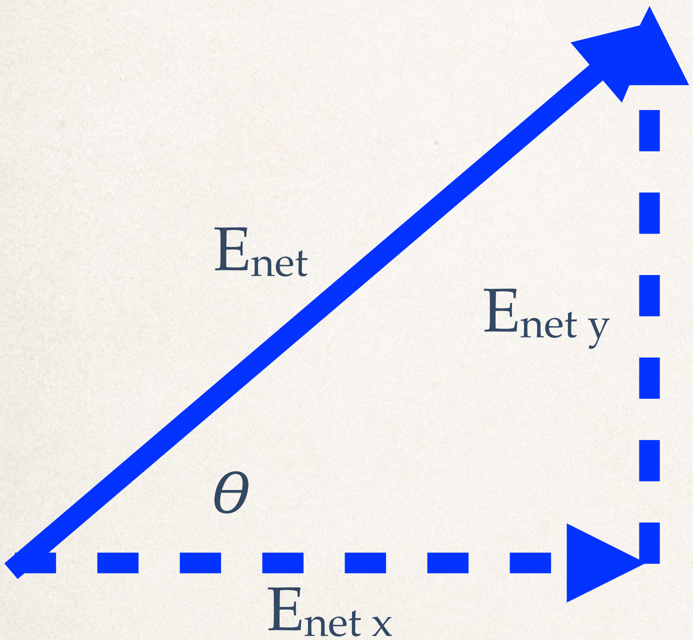
Extra Practice

In Summary

	x-axis	y-axis
$E_{20\mu C}$	$0\ ^{N}/_{C}$	$+2.88\text{x}10^{6}\ ^{N}/_{C}$
$E_{-30\mu C}$	$+1.53\text{x}10^{6}\ ^{N}/_{C}$	$-1.53\text{x}10^{6}\ ^{N}/_{C}$
E_{net}	$+1.53\text{x}10^{6}\ ^{N}/_{C}$	$+1.35\text{x}10^{6}\ ^{N}/_{C}$

Extra Practice

	x-axis	y-axis
E_{net}	$+1.53 \times 10^6\ N/C$	$+1.35 \times 10^6\ N/C$



$$E_{net} = \sqrt{\left(E_{net\ x}\right)^2 + \left(E_{net\ y}\right)^2}$$

$$E_{net} = \sqrt{\left(1.53x10^6\right)^2 + \left(1.35x10^6\right)^2}$$

$$\boxed{E_{net} = 2.04x10^6\ N/C}$$

$$\tan\left(\theta\right) = \frac{E_{net\ y}}{E_{net\ x}} \qquad \theta = \tan^{-1}\left(\frac{1.35x10^6}{1.53x10^6}\right) \qquad \boxed{\theta = 41.4^\circ}$$

above +x-axis

E-Field Lines

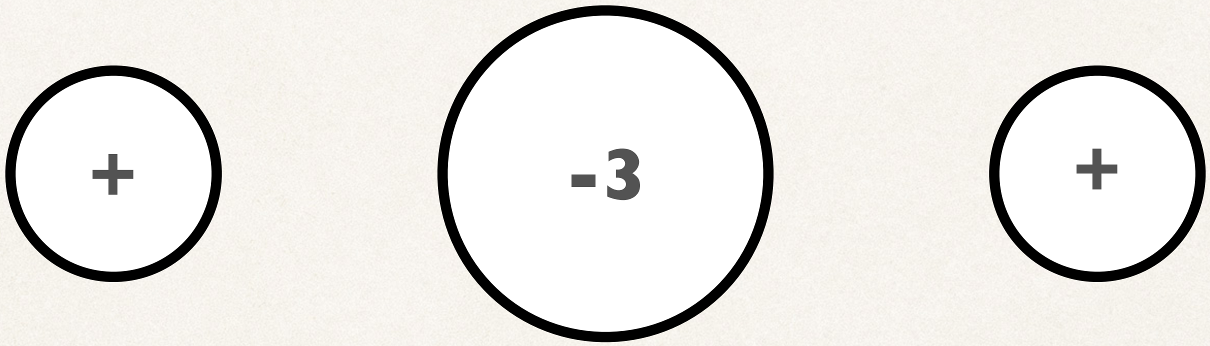
- Number of E-Field lines is determined by the size of the Base Charge.
- Direction of E-Field lines is determined by the sign of the Base Charge.
- Any imbalance in field lines between charges will result in extra lines going to or coming from ∞.
- Field Lines are **ALWAYS** ‘normal’ to the surface (90°)

See One

- What will the field lines look like between two charges?

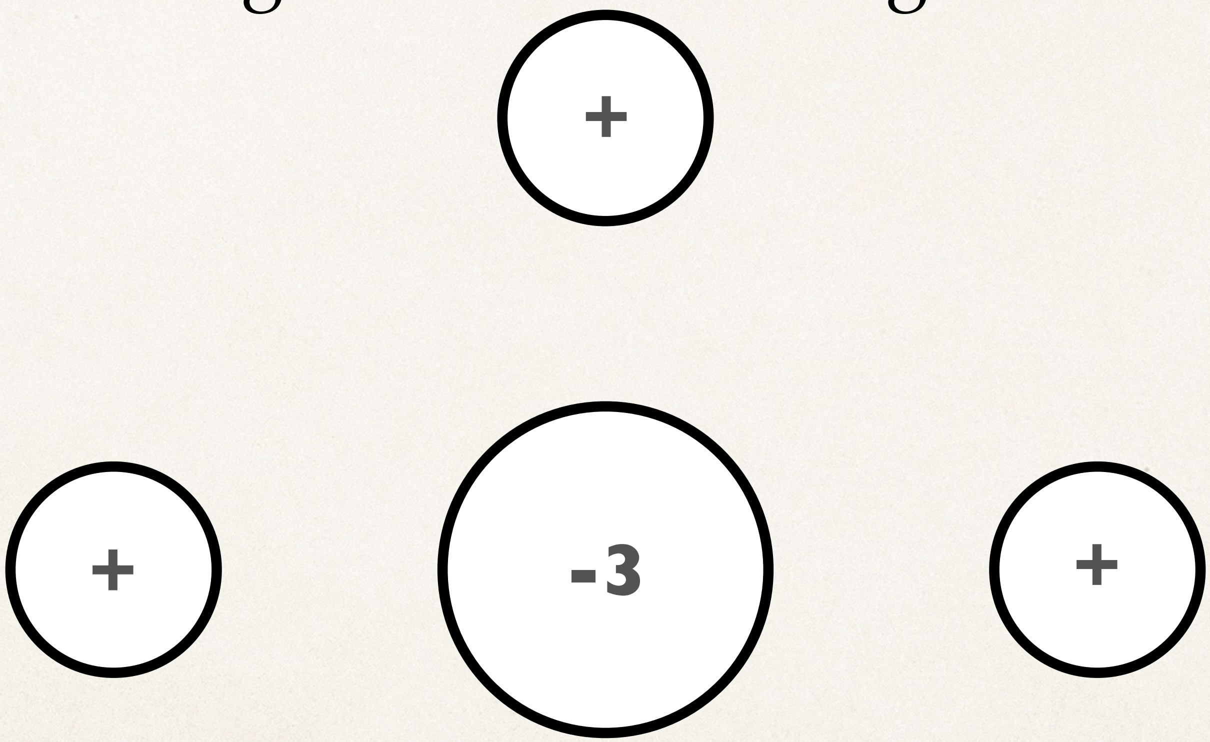
Do One

- What will the field lines look like between three charges?



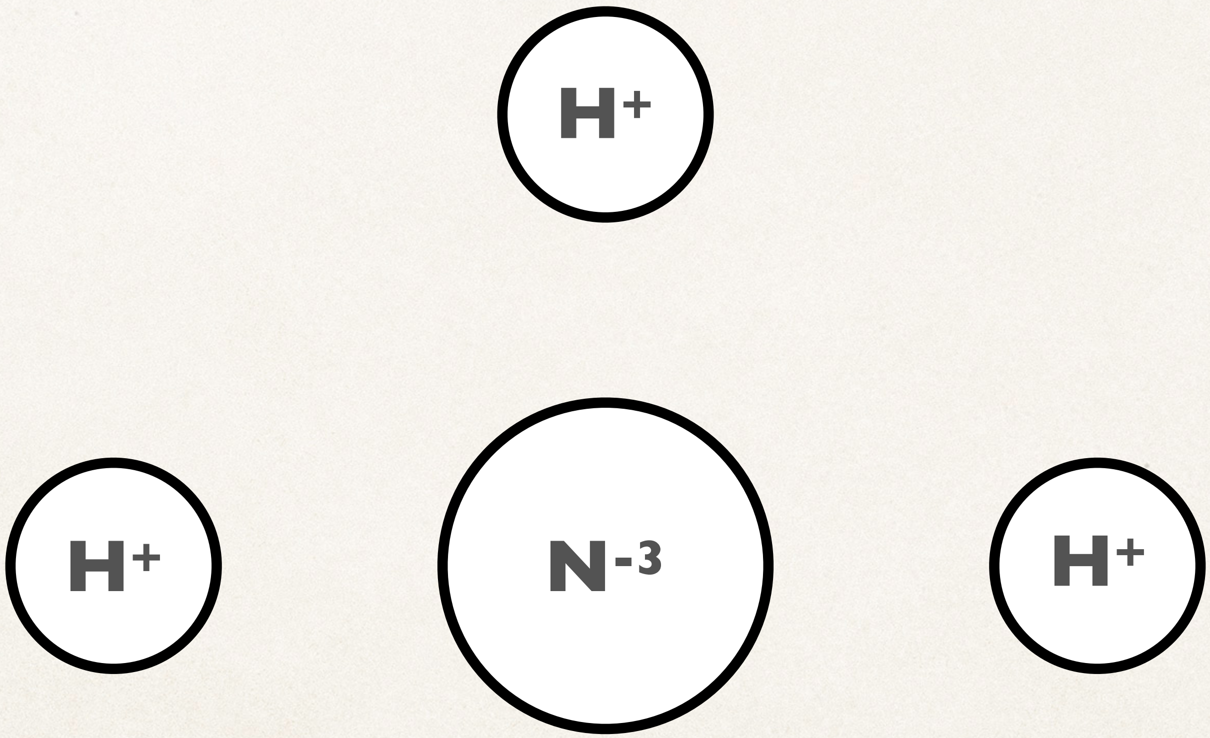
Do One

- What if we bring in one more charge?



Do One

- Now is it more familiar?



Test question

- An unknown positive charge produces an electric field with a magnitude of 0.005 N/C. If the unknown charge is made negative, how does the electric field change?
- A negative test charge is placed next to a positive base charge and then moved near a negative base charge. What will happen to the test charge in each case. Why?

E-Fields in a conductor

- KEY: We are talking about **electrostatics**
- Charge on a conductor is equally distributed on the surface.
- E-Field lines are normal to the surface (90°)
- E-Field in a conductor is zero

WHY?

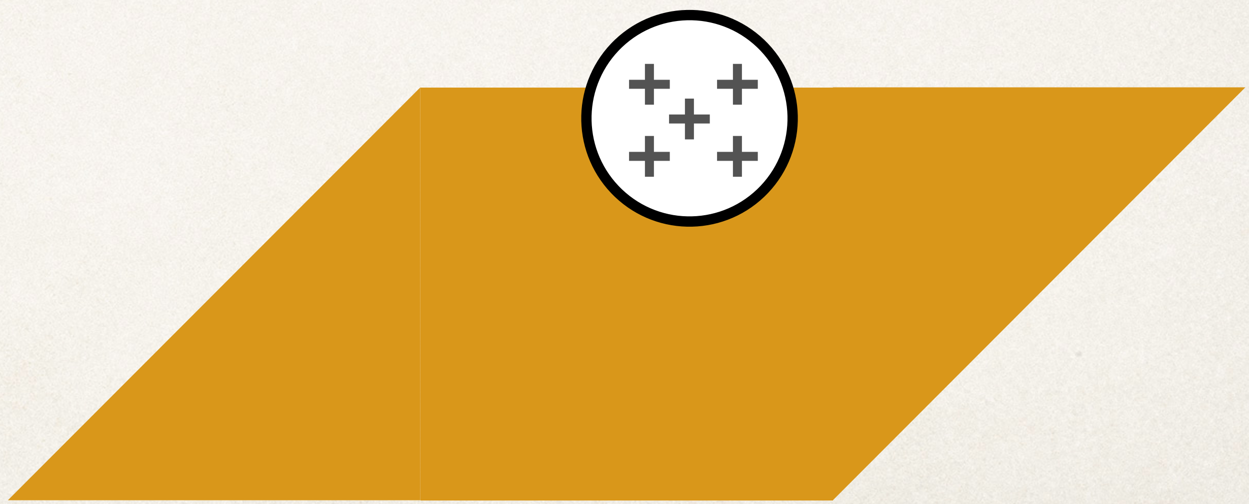
- Why is the E-Field in a conductor **zero** in electrostatics?

$$\vec{F} = q\vec{E}$$

- If **E** is not zero then there is a net force on the charge q and the situation is not static.

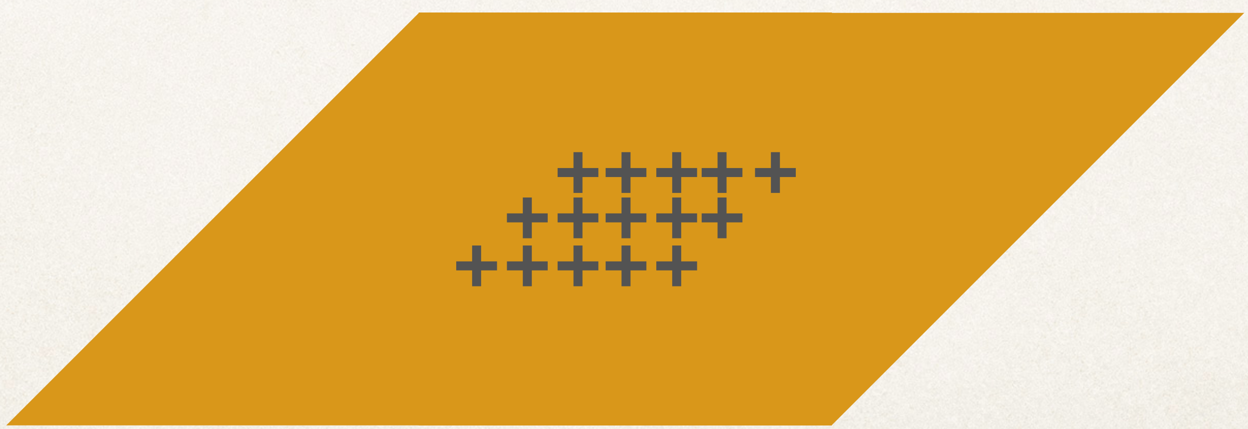
E-Fields ON a conductor

- Question: Imagine an infinitely large sheet of which has no net charge. We then use an eyedropper to place one "drop" of charge in the center of that sheet. What will happen to the charge?



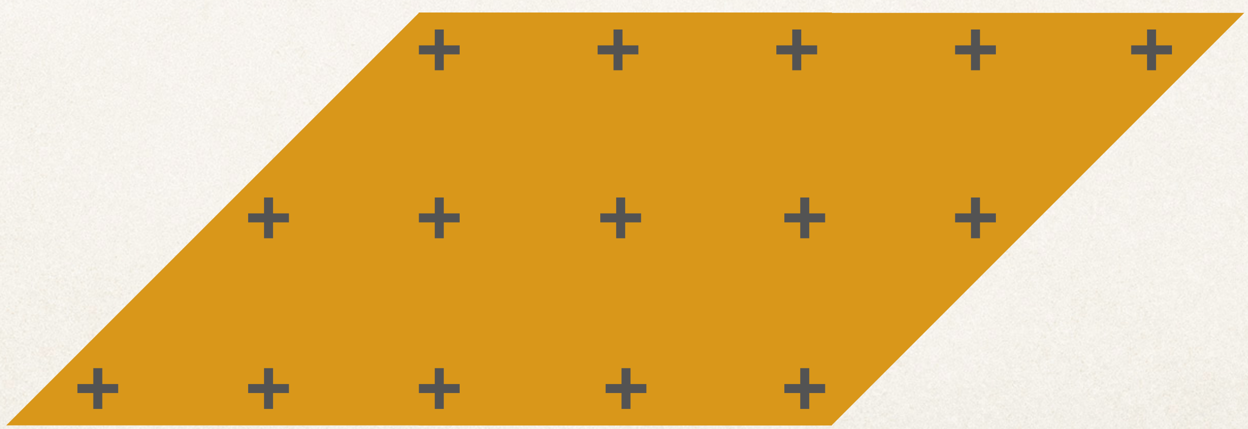
E-Fields on a conductor

- As drops fall, the charge will continue to spread out until it’s spread out evenly and no longer moving (electrostatics)



E-Fields on a conductor

- With an electrostatic state reached, what are the implications for the E-Field?



E-Fields on a conductor

- What is the E-Field on the surface of a conductor, between the charges assuming electrostatics?
    - If the charges are static, then…

$$\overrightarrow{F_{net}} = 0$$

E-Fields on a conductor

- Going back to the relationship between force and the E-Field…

$$\vec{F} = q\vec{E}$$

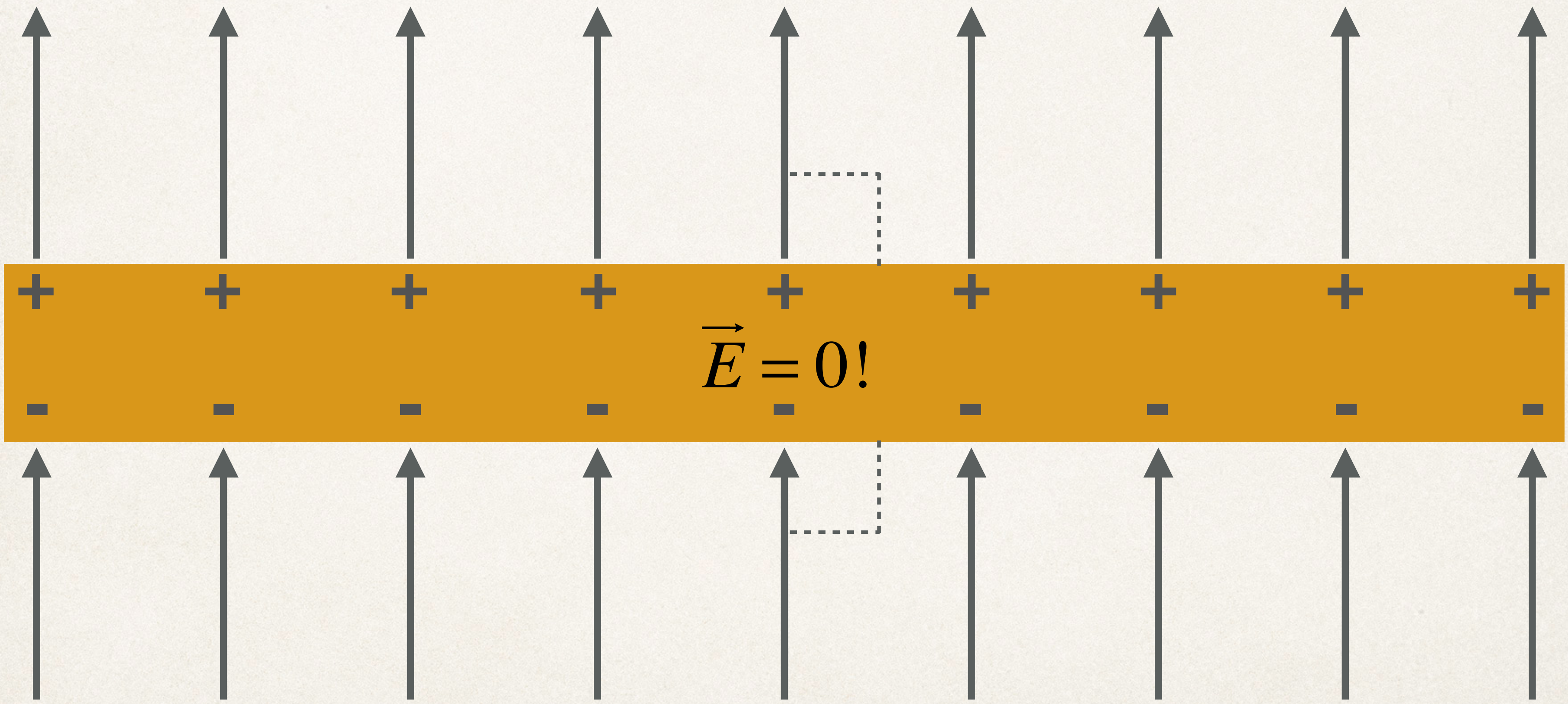
- …but since F=0 then…

$$0 = q\vec{E} \quad \text{(or)} \quad \vec{E} = 0!$$

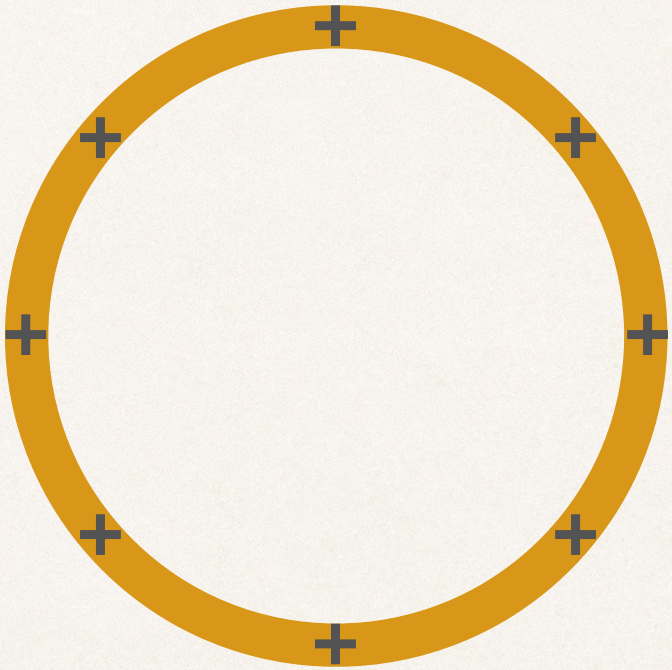
E-Fields in a conductor

- What the electric field associated with a slab of conductor with charge on each surface?

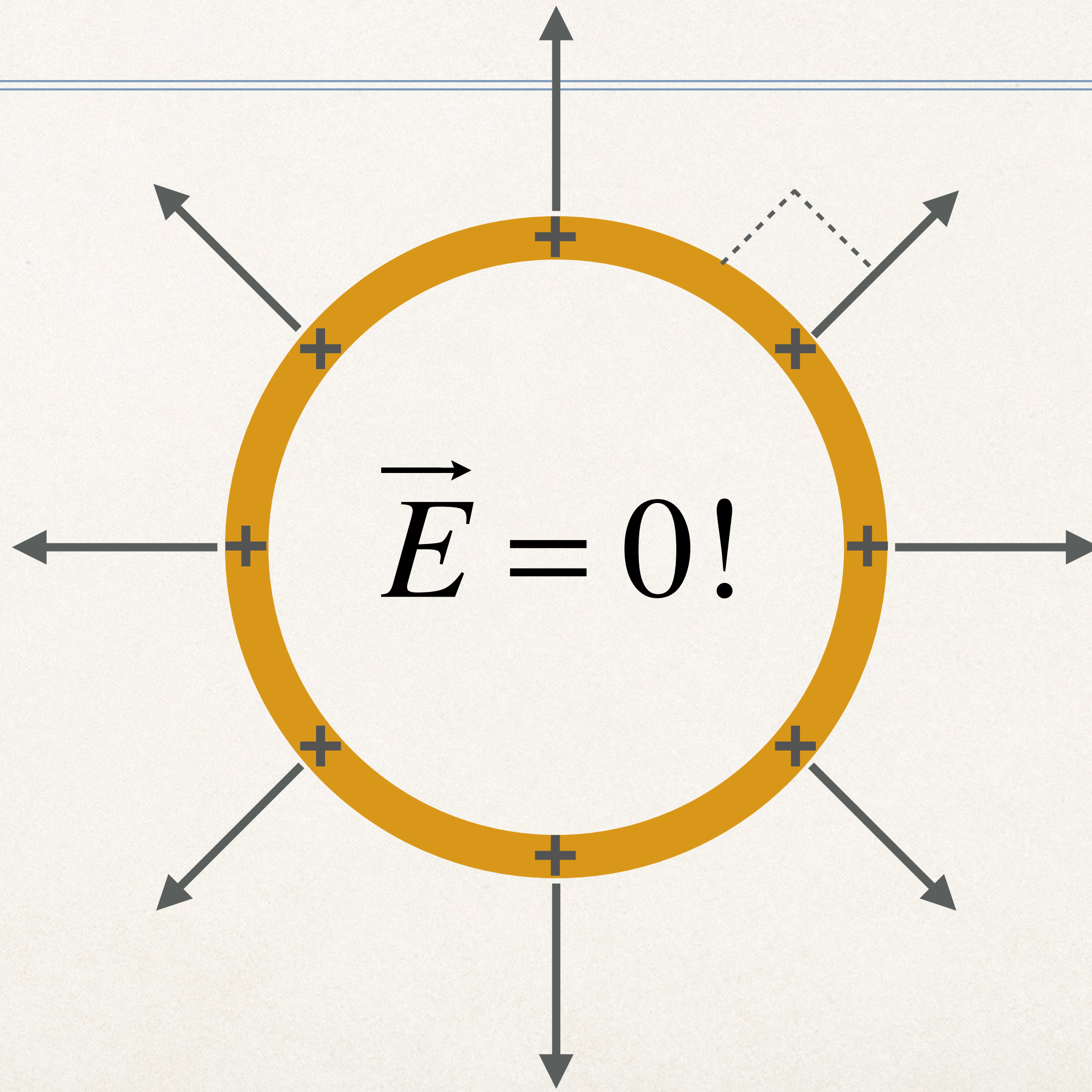
E-Fields in a conductor



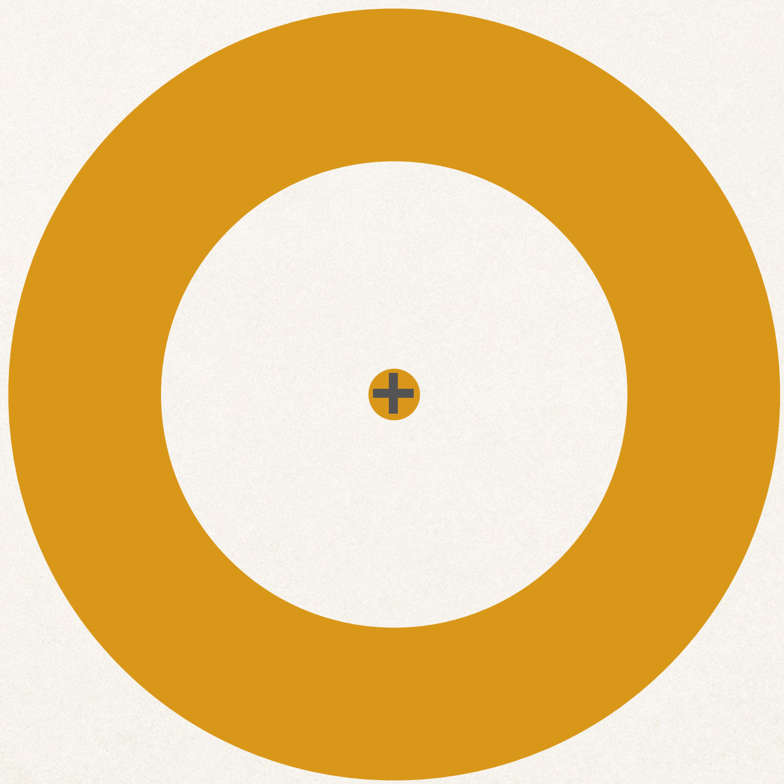
E-Fields for a thin shell ?



E-Fields for a thin shell



E-Fields for a **thick** shell



E-Fields for a **thick** shell