PHYS 2020: College Physics
Manic Monday #1

"One does not, by knowing all the physical laws as we know them today, immediately obtain an understanding of anything much."
~Richard Feynman

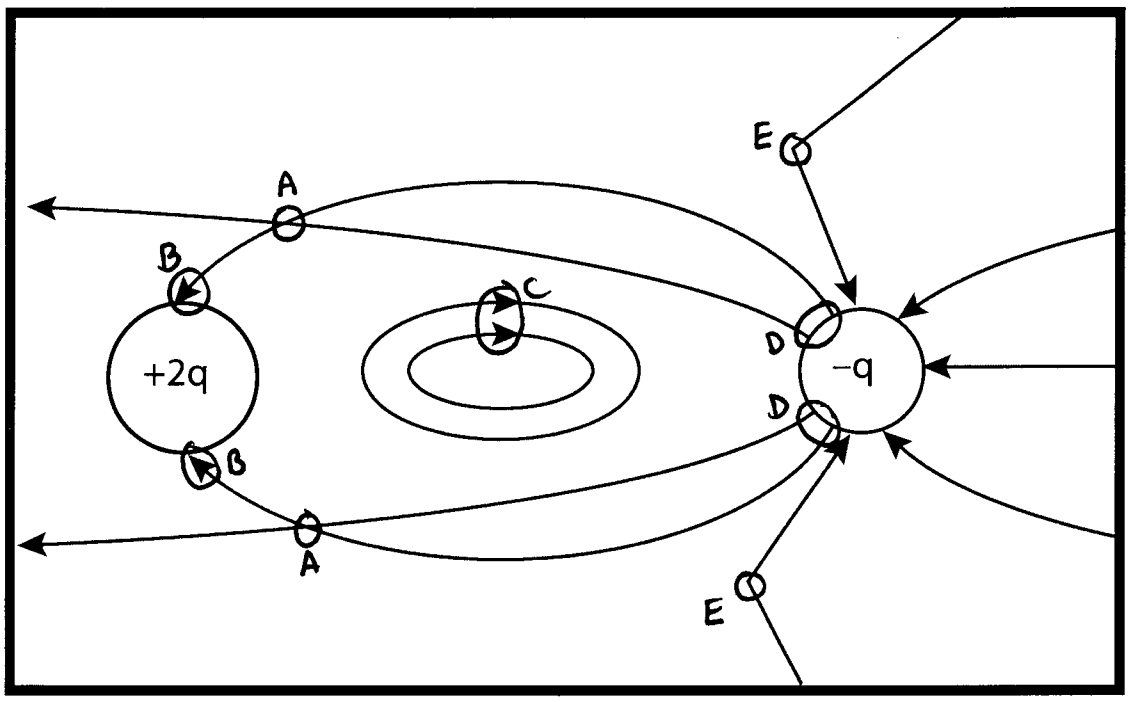
Electric Fields: Near and Far

The concept of the *electric field* was introduced by the English physicist Michael "The Brain" Faraday to simplify our approach to experiments in electrostatics. In addition to this, he was also a chemist, who discovered benzene and invented the bunsen burner. He had little training in the way of higher mathematics (*e.g. calculus*), but was never-the-less one of the most influential figures in scientific history, and is widely regarded as one of the finest experimentalist in the history of science — you want this dude to be your lab partner!

In this exercise, we will practice drawing electric fields; let us recall the rules for electric field line diagrams:

- ▷ At each point, the total electric field vector $\vec{E}$ is tangent to the field line
- ▷ E-field lines *point away* from positive (+) charges, and *point toward* negative (−) charges
- ▷ E-field lines start on positive charges or at infinity (off the edge of your paper)
- ▷ E-field lines end on negative charges or at infinity (off the edge of your paper)
- ▷ E-field lines are densest where the field is strongest; the number of lines leaving a charge is an indicator of the charge strength

A▷ Bad Drawing!
An E-field diagram has been drawn below, but there are several improper things about it. Circle each incorrect feature, label it $(a, b, c, \ldots)$, and explain why the feature is incorrect in the space provided.



A: FIELD LINES DON'T CROSS

B: POINT AWAY FROM POSITIVE

C: END OR START ON CHARGES OR INFINITY

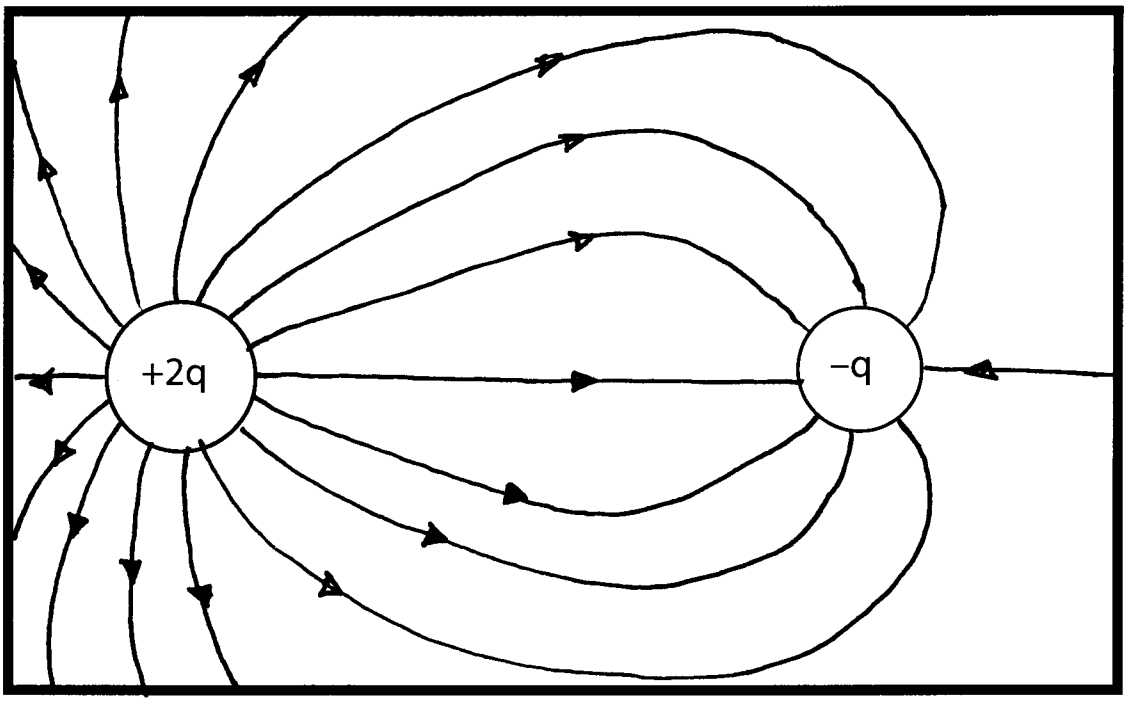
D: POINT TOWARD NEGATIVE

E: NO CORNERS IN FIELD LINES

F: SHOULD BE MORE LINES ON LARGER (+2Q) CHARGE

B▷ Draw Your Own E-field

On the diagram below, draw your very own (*correct!*) representation of the electric field diagram!



B▷ Proximity to Electric Charges

Consider the situation below. You are interested in the electric field at the point A, where the charge on the left is only 1 cm away from A, and the charge on the right is 100 cm away.

▷ Write down the magnitude of the E-field due to each charge at point A. Leave your answer in terms of q and k, but put in values for r in each case.

$$E_1 = \frac{kq}{r^2} = \frac{kq}{(0.01m)^2} = \frac{kq}{10^{-4}m^2}$$

$$E_2 = \frac{kq}{r^2} = \frac{kq}{(1m)^2} = \frac{kq}{1m^2}$$

▷ What is the ratio of the electric field due to the left charge compared to the right charge?

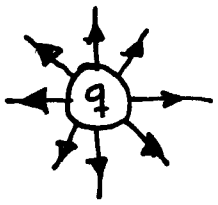
$$\frac{E_1}{E_2} = \frac{kq/10^{-4}m^2}{kq/1m^2} = \frac{1}{10^{-4}} = 10{,}000$$

E_1 is 10000x larger than E_2

▷ At the point A, which is much closer to the left charge than the right charge, can I ignore the right charge? Explain.

At A, the contribution from the distant charge is 10000x smaller than the close charge, so I can effectively ignore the distant charge.

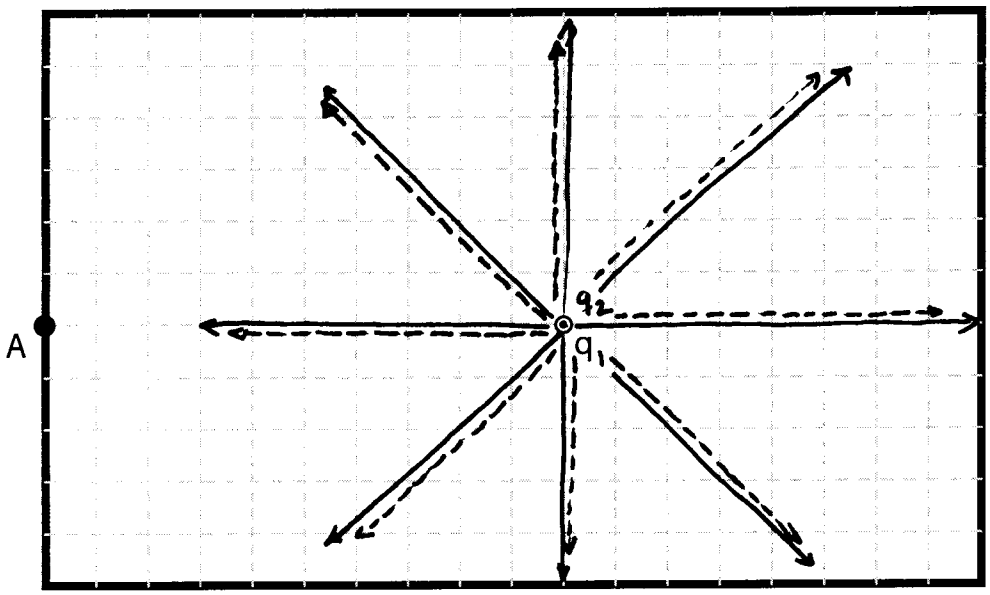
▷ Give your answer to the last question, make a sketch of the E-field very close to the left charge.



VERY CLOSE to the charge it just looks like a point charge.

C▷ Far From Electric Charges

Consider the situation below. You are interested in the electric field at the point A. The two charges are 1 cm apart: only one charge has been drawn on the diagram. Each square is 100 m to a side.



▷ On the sketch, put a dot at the location of the second charge. *Make sure the distance between the charges is correct on the scale of the grid!*

▷ Give the location of the two charges, sketch the electric field lines due to each charge on the sketch. What is the *net electric field* at A?

$$E_{NET} = E_1 + E_2 = \frac{kq}{r^2} + \frac{kq}{r^2} = \frac{kq}{(1000\text{m})^2} + \frac{kq}{(1000.01\text{m})^2} \simeq \frac{2kq}{(1000\text{m})^2}$$

The magnitudes of the Efields E_1 and E_2 are $\simeq$ same at A.

▷ How would your electric field lines look different if one charge had magnitude $+q$ and the other was $-q$? What would the *net electric field* at point A be? Explain.

If q_2 were negative the magnitude of the Efield would be the same as q_1 but it would point in the OPPOSITE DIRECTION so

$$E_{NET} = E_1 + E_2 \simeq E_1 - E_1 = 0$$ So A would see NO FIELD.

D▷ Practice sketches

On a separate piece of paper, sketch the electric field lines for each of the following charge configurations.