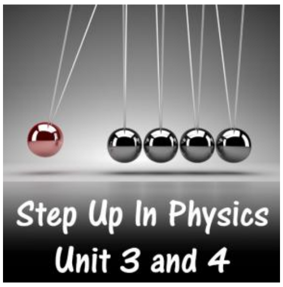
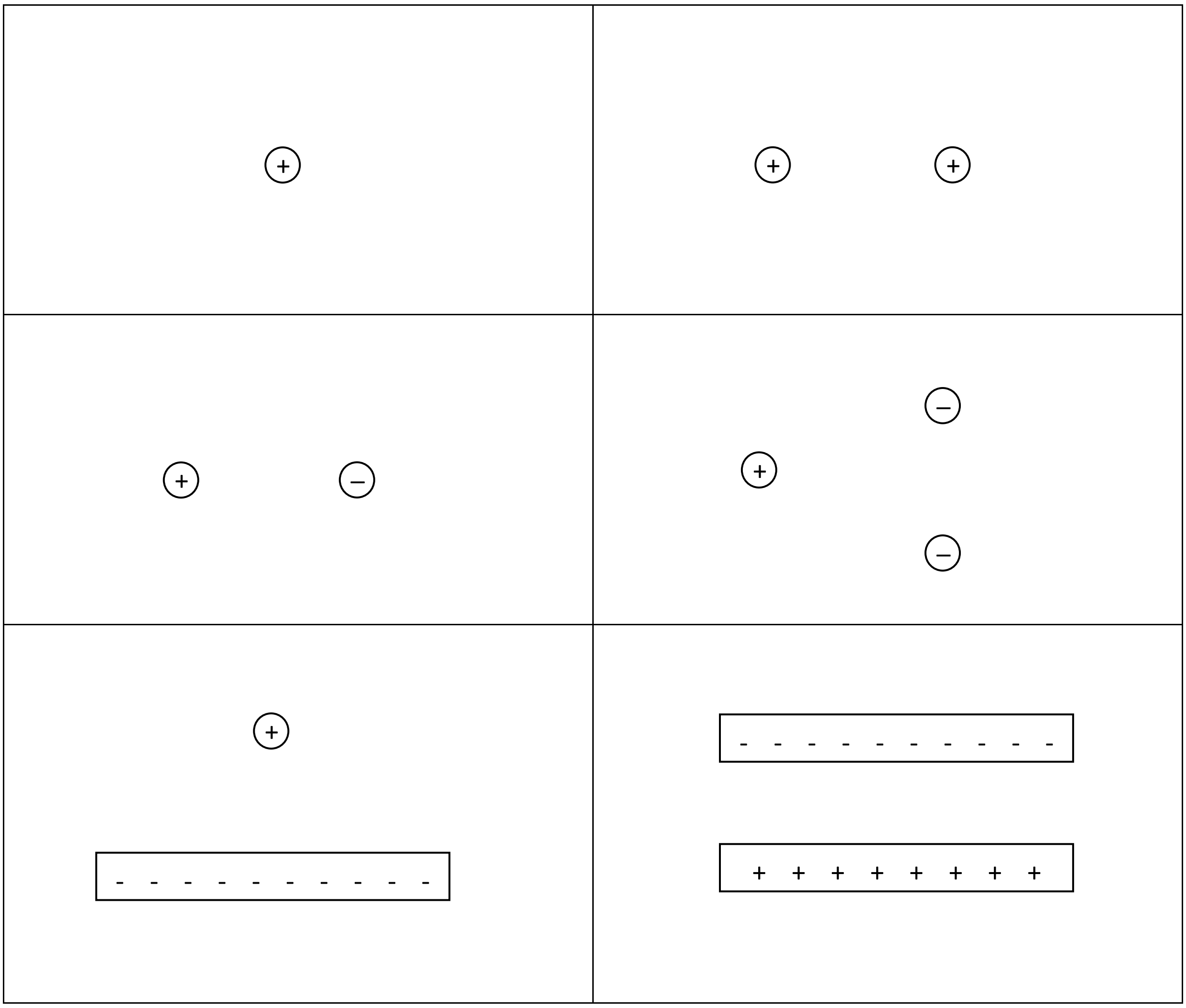
Electric Fields and Coulomb's Law

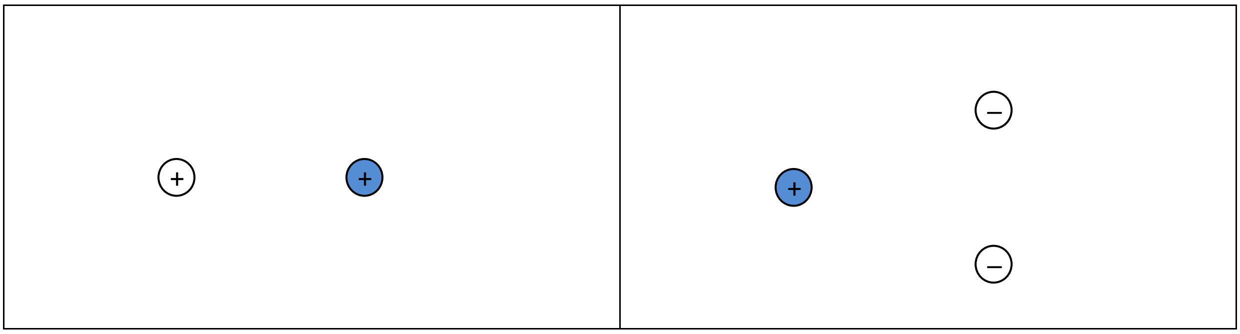
Problems Worksheet

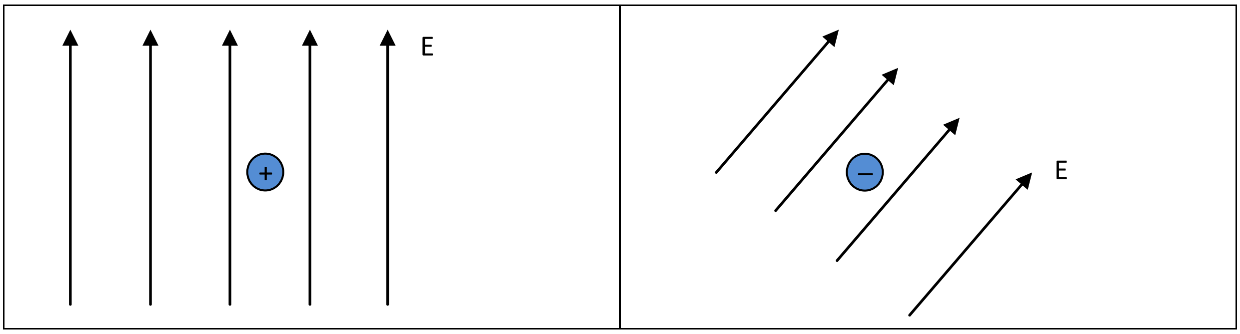


1. Draw the electric field in the regions surrounding each of the charges below.



2. Using a single arrow, indicate the direction of the net force the test charge (which has been shaded) would experience.





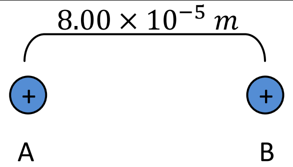
3. Calculate the electric field strength that is capable of applying a 12.0 N force on a (+)3.00 mC charge.

4. A sodium ion has a +1 relative atomic charge which indicates it has one more proton than electron. This ion is placed in a 4.00 NC^{-1} electric field.
   a. Calculate the force applied to a single sodium ion in this electric field.

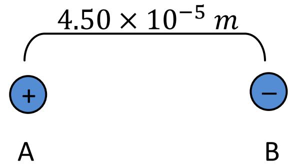
   b. A different ion is placed in the electric field. It moves in the opposite direction to the sodium ion and experiences a 1.28×10^{-18} N force. Calculate the relative atomic charge of the ion.

5. Find the net force acting on point charge A for each scenario below.

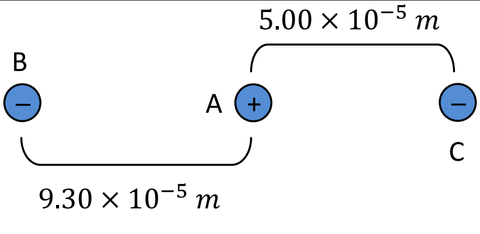
a.

Charge A $(+)2.00\ nC$ Charge B $(+)3.00\ nC$	

b.

Charge A $(+)4.00\ nC$ Charge B $(-)3.50\ nC$	

c.

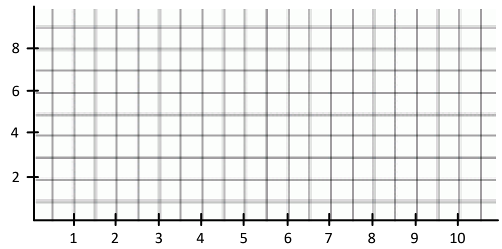
Charge A $(+)4.00\ nC$ Charge B $(-)2.00\ nC$ Charge C $(-)1.50\ nC$	

6. Calculate the electric field intensity in the region of space 20.0 cm away from a (-)125 mC point charge.

7. A test charge 1.00 m from a (+)1.00 C point charge feels a 1.00 N force.

   a. Sketch a graph of the force felt by the test charge as a function of the charge of the point charge.

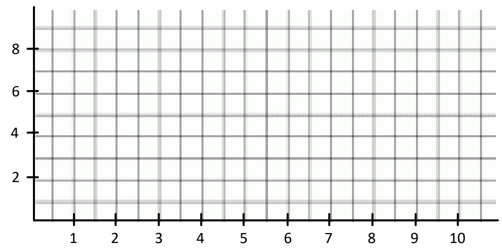
Force (N)



Point charge (C)

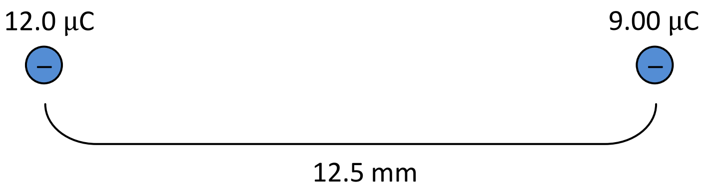
   b. Sketch a graph of the force felt by the test charge as a function of the distance from the point charge.

Force (N)



Distance (m)

8. Where could a point charge be placed between the point charges shown in the diagram below such that it would experience a zero net force?



9. Calculate the electric field strength between two long parallel plates separated by 10.0 cm when a 120 V potential difference is applied to the plates.

10. The electric constant ε (also called the permittivity) of a medium is a measure of the medium's resistance to the formation of an electric field. The electric constant of a vacuum is given the symbol ε_0 and its value is 8.85×10^{-12} Fm^{-1}. The electric constant is used in Coulomb's law to find the force acting between two point charges separated by a distance r.

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

Two students wondered why all the example problems shown by their teacher used the electric constant of a vacuum even when the problem was clearly set on Earth, with air being the medium the electric field forms in. They set out to do an experiment to determine the electric constant of air.

They set up a couple of 8.00 μC objects at various distances apart, separated only by air. The force acting on one of the objects was measured. Their force measurements had a 7% uncertainty. Their raw data is in the table below.

Distance (m)	Force (N)	Force Uncertainty (N)	1/Distance^2 (m^{-2})
0.20	14.4	± 1.0	
0.30	6.7		
0.40	3.3		
0.50	2.3		
0.60	1.5		

a. Complete the table by filling in the missing data

b. Plot the graph of force verses $\frac{1}{Distance^2}$ on the following graph paper. Include a line of best fit and error bars.

c. Using the graph, calculate the gradient of the line of best fit.

d. Using the gradient, determine the electric constant for air.

e. Is it reasonable to use the electric constant for a vacuum when air is the medium that separates two point charges? Justify your response.

