Ch. 22 HW Electrostatics

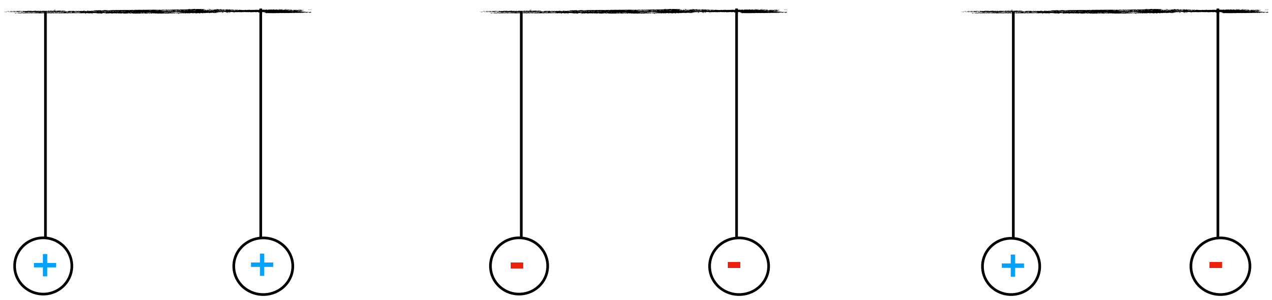
Show **ALL WORK**. You may be randomly selected to solve one of the problems next class which will count towards 20% of your final grade.

1) **(10 pts)** Calculate the force (magnitude and direction) between the point charges $q_1 = -3.0 \times 10^{-6}$ C and $q_2 = 5.0 \times 10^{-6}$ C

   (a) **(5 pts)** when they are placed 1 m apart in the air.

   (b) **(5 pts)** If the distance between them is doubled from 1 to 2 meters

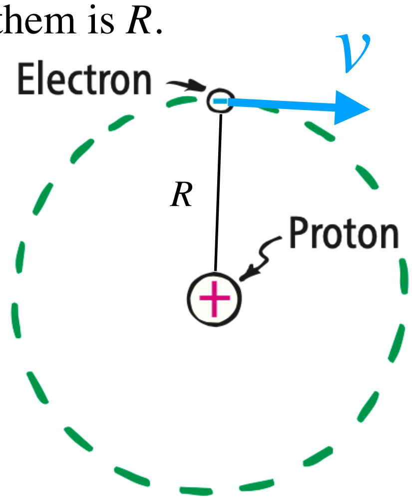
2) **(5 pts)** For each of the charge configurations shown below:



(a) **(1 pts)** indicate whether the force is *attractive* or *repulsive* and draw the the electric force vector that each charge exerts on the other (you may also draw how the final configuration would look like after the interaction, using dashed lines to differentiate them from solid lines)

(b) **(4 pts)** suppose each the charges consist of only a proton and electron with a charge of $q_{\pm} = \pm\, 1.602 \times 10^{-19}$ C. Calculate the magnitude of the electric force between the pair of charges for any of the three configurations if the distance between the charges is $r = 10^{-15}$ m

3) **(15 pts)** A hydrogen atom nucleus consists of a single proton with an orbiting electron with a tangential speed v. The elementary charge is q. The proton and electron mass are m_p and m_e , respectively. The average distance between them is R.



$q = \pm 1.602 \times 10^{-19}$ C

$m_p = 1.67 \times 10^{-27}$ kg

$m_e = 9.10 \times 10^{-31}$ kg

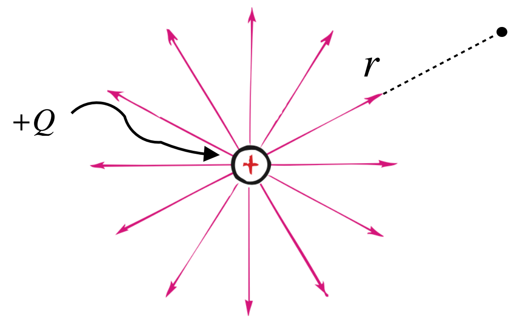
$R = 5.29 \times 10^{-11}$ m

(a) **(5 pts)** Draw the electric force **vector** the proton exerts on the electron and calculate the magnitude of the *electric force*.

(b) **(5 pts)** Calculate the gravitational force F_g of attraction between the proton and electron. How much stronger is the electric force compared to the gravitational force ? (hint: take the ratio of the electric to gravitational force, F_e / F_g). Which is neg

(c) **(5 pts)** Calculate the tangential speed of the electron. (*hint*: for uniform circular motion, there are two forces of attraction in this case; however, one of the forces, as you found in part (b) is negligible.)

4) **(15 pts)** Just as the space around a planet (and around every other massive body) is filled with a gravitational field, the space around every electrically charged body is filled with an **electric field.**



(a) **(5 pts)** Find the general expression for the electric field vector of charge Q at a distance r from the center.

(b) **(5 pts)** If the distance at which the field calculated doubled ($r \to 2r$), would the field get *weaker* or *stronger* compared to the original field and by how much ?

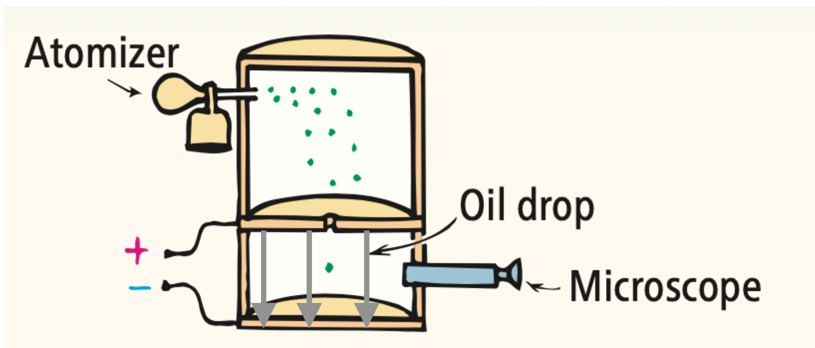
(c) **(5 pts)** If the source charge triples ($Q \to 3Q$), would the field get *weaker* or *stronger* compared to the original field and by how much ?

5) **(10 pts)** Two equal and opposite point charges $\pm q$ are located 30 cm (0.3 m) apart in vacuum. The magnitude of the electric field E at the midpoint O of the line joining the two charges is 2.4×10^6 N/C

(a) **(5 pts)** Draw the configuration described and indicate the direction of the electric field

(b) **(5 pts)** Calculate the magnitude and direction of force experienced by a negative test charge $q = -1.6 \times 10^{-6}$ C placed at O.

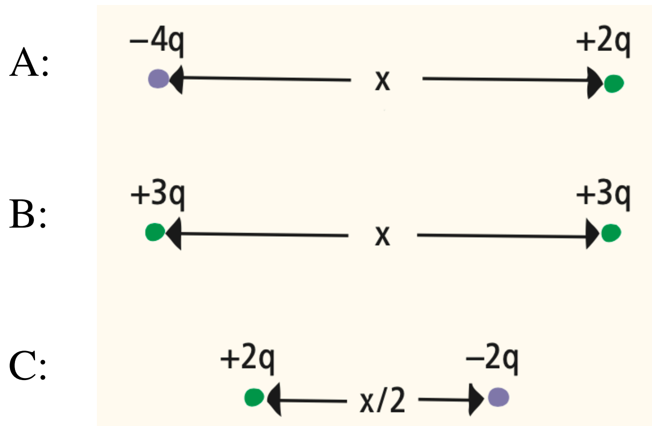
6) **(10 pts)** In 1909, Robert Millikan was the first to find the charge of an electron in his now-famous oil-drop experiment. In that experiment tiny oil drops were sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops were observed with a magnifying eyepiece, and the electric field (shown in gray) was adjusted so that the upward force on some negatively charged oil drops was just sufficient to balance the downward force of gravity. That is, when suspended, upward force qE just equaled mg. Millikan accurately measured the charges on many oil drops and found the values to be whole-number multiples of 1.6×10^{-19} C which turns out to be the charge of the electron. For this he won the Nobel Prize.



(a) **(5 pts)** If a drop of mass $m = 1.1 \times 10^{-14}$ kg remains stationary in an electric field $E = 1.68 \times 10^{5}$ N/C, what is the charge of this drop ?

(b) **(5 pts)** How many extra electrons are on this particular oil drop (the presently known charge of the electron, $1e^{-} \equiv 1.602 \times 10^{-19}$ C)

7) **(10 pts)** Shown are three separate pairs of point charges. Assume the pairs interact only with each other.



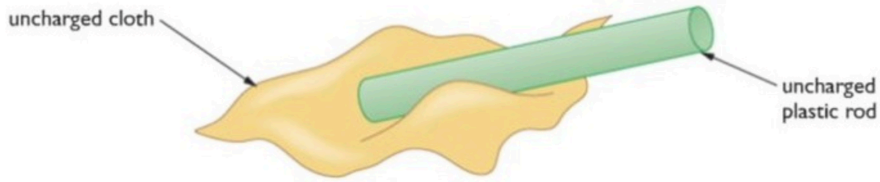
(a) **(5 pts)** Write a general expression for the electric force for each of the configurations above in terms of the variables shown

(b) **(5 pts)** Rank the magnitudes of the force between the pairs from *largest* to *smallest*.

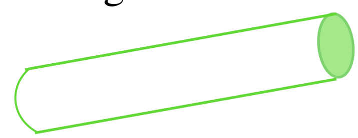
__________ __________ __________

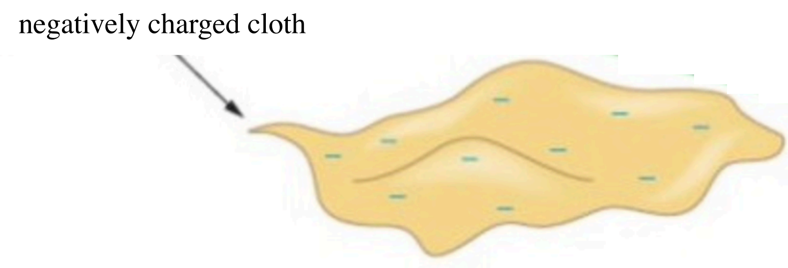
largest *smallest*

8) **(10 pts)** An initially neutral glass rod is charged by __________ by rubbing it with a silk cloth.



(a) **(5 pts)** After charging it, the silk ends up with a net negative charge. Did the rod become charged ? If so, did it acquired a positive or negative charge ? Draw your prediction in the rod figure below.





(b) **(5 pts)** The charged rod from part (a), is now placed near a neutral balloons *without* touching. This is charging by __________. Does the balloon acquire any charge or remain neutral ? Draw how the charges distribute inside the balloon. Does the ballon experience an electric force ? If so, draw the force vector experienced by the balloon.