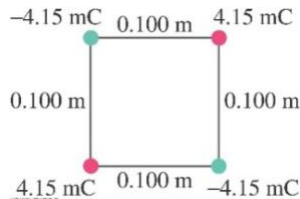


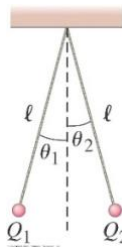
## Seminar 5: Lectures 13-15

### Coulomb's Law:

1. How many electrons make up a charge of  $-38.0 \mu\text{C}$ ?
2. Two negative and two positive point charges (magnitude  $Q = 4.15 \text{ mC}$ ) are placed on opposite corners of a square as shown in the figure below. Determine the magnitude and direction of the force on each charge.



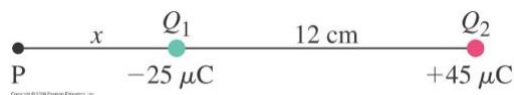
3. Two charges,  $-Q_0$  and  $-4Q_0$ , are a distance  $l$  apart. These two charges are free to move, but do not because there is a third charge nearby. What must be the magnitude of the third charge and its placement in order for the first two to be in equilibrium?
4. Two small charged spheres hang from cords of equal length, as shown in the figure below, and make small angles  $\theta_1$  and  $\theta_2$  with the vertical. (a) If  $Q_1 = Q$ ,  $Q_2 = 2Q$ , and  $m_1 = m_2 = m$ , determine the ratio  $\theta_1/\theta_2$ . (b) If  $Q_1 = Q$ ,  $Q_2 = 2Q$ , and  $m_1 = m$ , and  $m_2 = 2m$ , determine the ratio  $\theta_1/\theta_2$ . (c) Estimate the distance between the spheres for each case.



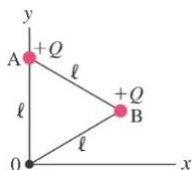
### Electric Field and Field Lines:

5. A downward electric force of  $8.4 \text{ N}$  is exerted on a  $-8.8 \mu\text{C}$  charge. What are the magnitude and direction of the electric field at the position of this charge?
6. Determine the magnitude and direction of the electric field at a point midway between a  $-8.0 \mu\text{C}$  charge and a  $+5.8 \mu\text{C}$  charge  $8.0 \text{ cm}$  apart. Assume no other charge are nearby.
7. The electric field midway between two equal but opposite point charges is  $586 \text{ N/C}$ , and the distance between the charges is  $16.0 \text{ cm}$ . What is the magnitude of the charge on each?

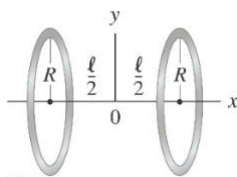
8. Two point charges,  $Q_1 = -25 \mu\text{C}$  and  $Q_2 = +45 \mu\text{C}$ , are separated by a distance of 12 cm. The electric field at the point P (see the figure below) is zero. How far from  $Q_1$  is P?



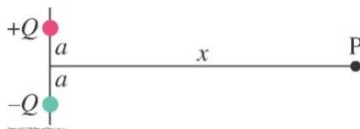
9. (a) Determine the electric field  $\vec{E}$  at the origin O in the figure below due to the two charges at A and B. (b) Repeat, but let the charge at B be reversed in sign.



10. Two parallel circular rings of radius  $R$  have their centers on the  $x$  axis separated by a distance  $l$  as shown in the figure below. If each ring carries a uniformly distributed charge  $Q$ , find the electric field,  $\vec{E}(x)$ , at points along the  $x$  axis.



11. Determine the direction and magnitude of the electric field at the point P shown in the figure below. The two charges are separated by a distance of  $2a$ . Point P is on the perpendicular bisector of the line joining the charges, a distance  $x$  from the midpoint between them. Express your answer in terms of  $Q$ ,  $x$ ,  $a$ , and  $k$ .



12. An electron moving to the right at  $7.5 \times 10^5 \text{ m/s}$  enters a uniform electric field parallel to its direction of motion. If the electron is to be brought to rest in the space of 4.0 cm, (a) what direction is required for the electric field and (b) what is the strength of the field?