Light:
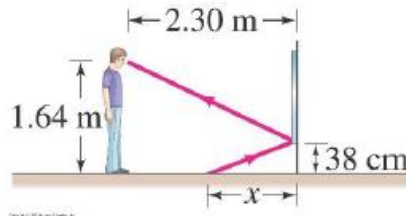
1. A person whose eyes are 1.64 m above the floor stands 2.30 m in front of a vertical plane mirror whose bottom edge is 38 cm above the floor, as shown in the figure below. What is the horizontal distance x to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?


2. A ray of light, after entering a light fiber, reflects at an angle of 14.5° with the long axis of the fiber, as shown in the figure below. Calculate the distance along the axis of the fiber that the light ray travels between successive reflections off the sides of the fiber. Assume that the fiber has an index of refraction of 1.55 and is $(1.40\times10)^{-4}$ m in diameter.
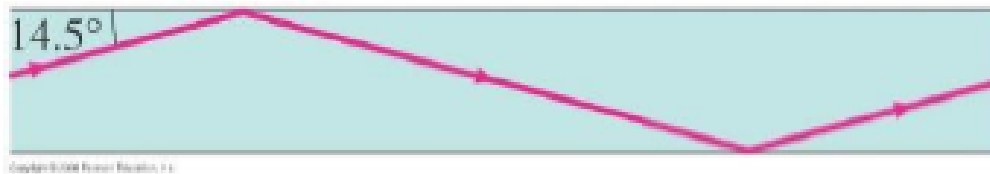

Coulomb's Law:

3. How many electrons make up a charge of -38.0 µC?

4. Two negative and two positive point charges (magnitude Q = 4.15 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.
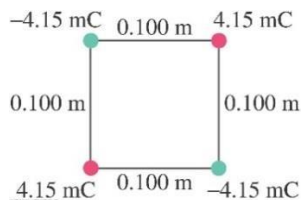
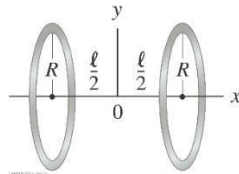## Electric Field and Field Lines:

5. A downward electric force of 8.4 N is exerted on a -8.8 µC 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 µC charge and a +5.8 µC charge 8.0 cm apart. Assume no other charge are nearby.

7. The electric field midway between two equal but opposite point charges is 586 N/C, and the distance between the charges is 16.0 cm. What is the magnitude of the charge on each?

8. (a) Determine the electric field **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.
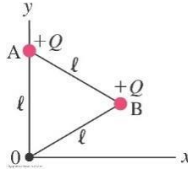

9. Two parallel circular rings of radius R have their centers on the x axis separated by a distance l as shown in the figure below. If each ring carries a uniformly distributed charge Q, find the electric field, $\vec{E}(x)$, at points along the x axis.


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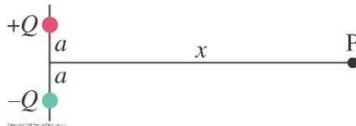
11. An electron moving to the right at 7.5×10^5 m/s enters a uniform electric field parallel to its direction of motion. If the electron is to be brought to rest in the space of 4.0 cm, (a) what direction is required for the electric field and (b) what is the strength of the field?

12. 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?

13. Two small charged spheres hang from cords of equal length, as shown in the figure below, and make small angles θ_1 and θ_2 with the vertical. (a) If $Q_1 = Q$, $Q_2 = 2Q$, and $m_1 = m_2 = m$, determine the ratio θ_1/θ_2. (b) If $Q_1 = Q$, $Q_2 = 2Q$, and $m_1 = m$, and $m_2 = 2m$, determine the ratio θ_1/θ_2. (c) Estimate the distance between the spheres for each case.
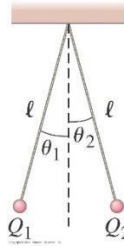
14. Two-point charges, Q_1 = -25 μC and Q_2 = +45 μC, are separated by a distance of 12 cm. The electric field at the point P (see the figure below) is zero. How far from Q_1 is P?
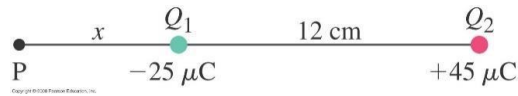
15. The speed of light in ice is $2.29 \times 10^8 \ ms^{-1}$. What is the index of refraction of ice?

16. (a) What is the minimum index of refraction for a glass or plastic prism to be used in binoculars (as shown in the figure below) so that total internal reflection occurs at 45'? (b) Will binoculars work if their prisms (assume n = 1.58) are immersed in water? (c) What minimum n is needed if the prisms are immersed in water?