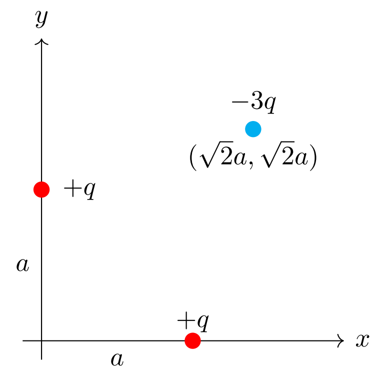
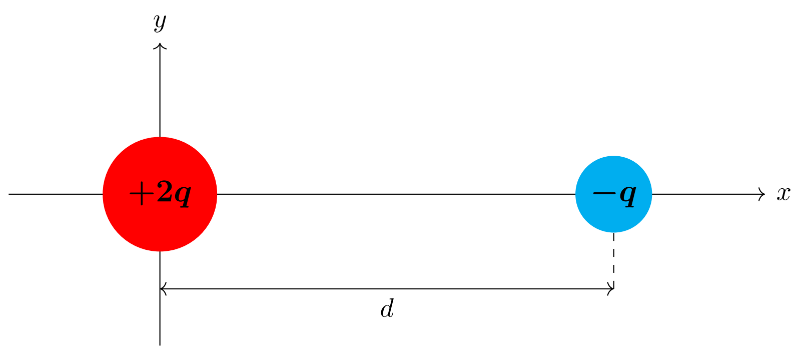
Chapter 23 - Electric Potential

Physics 207

1. Three charges are configured as seen below:
a) Find the electric potential at the origin.
b) Find the electric potential at the arbitrary point (x_0, y_0). You do not need to simplify.

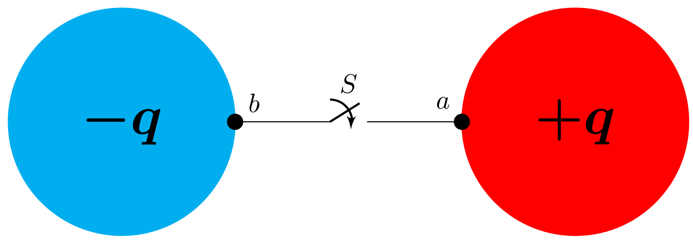


2. A charge of magnitude $+2q$ is fixed at the origin. A second charge, $-q$, is fixed at a distance d away from the origin on the positive x-axis.
a) Find the point(s) on the x-axis where the electric potential is zero.
b) How many points on the x-axis have an electric potential of zero.
c) How many points on the x-axis have an electric field of zero.

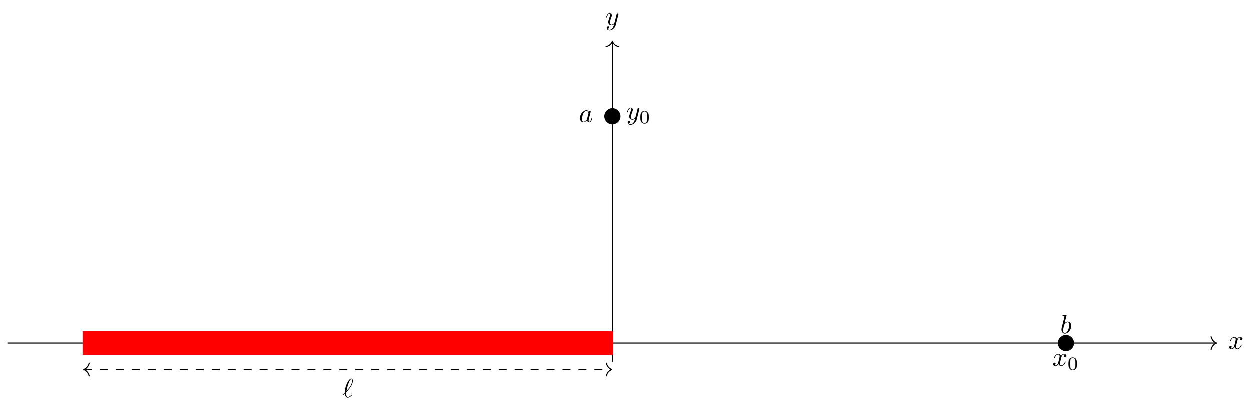


3. Two equal positive charges with charge $+q$ and mass m are initially located at a distance b away from each other. The charges are then moved so that their distance is $b/2$.
a) How much work is done to move the charges to their new positions?
b) Is the work positive or negative?
c) Suppose both charges are released from rest at the $b/2$ separation. How fast are they moving when they reach their initial separation of b?
d) What would happen to the work if one of the charges was replaced with a $-q$? Explain what this means in words.

4. Two hollow conducting spheres, each with radius r, have their centers separated by a distance d. Assume that the spheres have equal and opposite charges distributed evenly across their surfaces. A thin wire with a switch S is connected to the surface of each sphere and the switch is initially open.
a) What is the potential difference between points a and b?
b) If the switch is then closed, what is the charge on each sphere at a time $t \to \infty$.
c) What is the potential between points a and b after the sphere reaches its steady state?



5. Electric charge is distributed along a thin, insulating rod of length ℓ. The charge density follows the formula $\lambda(x) = \lambda_0 \left(x + \frac{\ell}{2}\right)^2$. Taking the potential to be zero at infinity, what is the potential at point a a distance y_0 above the right-hand end of the rod? What is the potential at a point b a distance x_0 to the right of the rod?



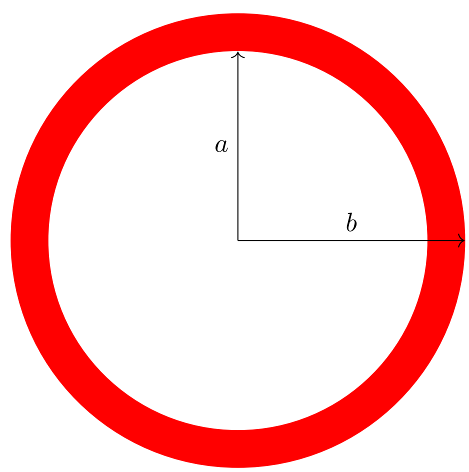
6. An insulating hollow sphere has an inner radius a and an outer radius b. Within the insulating material, the volume charge density is given below where γ is a positive constant.

$$\rho(r) = \frac{\gamma}{r}$$

In the Chapter 22 recitation, you found that the electric field for this situation was

$$E(r) = \begin{cases} 0 & r < a \\ \frac{\gamma(r^2 - a^2)}{2\epsilon_0 r^2} & a < r < b \\ \frac{\gamma(b^2 - a^2)}{2\epsilon_0 r^2} & b < r \end{cases}$$

a) Find the formula for the electric potential as a function of r in all three regions.
b) Plot $V(r)$



7. In the following two parts, you will be given a formula for the electric potential as a function of position. You will then be asked to find some information about the electric field.

a) $V(x, y) = x^2y + 8x - 121y$. Find all positions in space where the electric field is exactly equal to zero.

b) $V(x, y, z) = \frac{1}{10}\sin[10(x^2 + y^2 + z^2)]$. Find the formula that represents the electric field vector.

c) $V(x, y, z) = \sqrt{0.4^2 - \left(0.6 - \sqrt{x^2 + y^2 + z^2}\right)^2}$. Find the formula that represents the electric field vector.

8. Consider a system of identical point charges q that are evenly spaced by a distance d starting at the origin and continuing infinitely along the negative x-axis. The point P is the same distance d to the right of the origin. In the Chapter 21 recitation, you found that the electric field converges to the value given below at point P. Does the electric potential converge to a value at that same point? If so, what is that value? You may need to look online for a convergence value based on a formula you come up with for this geometry.

$$\vec{E} = \frac{kq}{d^2}\frac{\pi^2}{6}\hat{\imath}$$