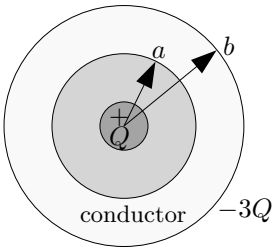
Problem 22.38,42,46; 23.3,17,28 from MasteringPhysics with minor clarifications.

22.38 - Conducting Spherical Shell



A conducting spherical shell with inner radius a and outer radius b has a positive point charge Q located at its center. The total charge on the shell is -3Q, and it is insulated from its surroundings.

This means the net charge on the conductor is $-3Q$, on both the inner and outer surface.

Part A

Derive the expression for the electric field magnitude in terms of the distance r from the center for the region $r < a$.

Part B

Derive the expression for the electric field magnitude in terms of the distance r from the center for the region $a < r < b$.

Part C

Derive the expression for the electric field magnitude in terms of the distance r from the center for the region $r > b$.

Part D

What is the surface charge density on the inner surface of the conducting shell, ρ_{in}?

Part E

What is the surface charge density on the outer surface of the conducting shell, ρ_{out}?

22.42 - Solid Conducting Sphere with Insulating Shell

A solid conducting sphere with radius R carries a positive total charge Q. The sphere is surrounded by an insulating shell with inner radius R and outer radius $2R$. The insulating shell has a uniform charge density ρ.

Part A

Find the value of ρ so that the net charge of the entire system is zero.

Part B

If ρ has the value found in part A, find the magnitude of the electric field, E, in the region $0 < r < R$.

Part C

If ρ has the value found in part A, find the magnitude of the electric field in the region $R < r < 2R$.

Part D

If ρ has the value found in part A, find the direction of the electric field in the region $R < r < 2R$.

Part E

If ρ has the value found in part A, find the magnitude of the electric field in the region $r > 2R$.

22.46 - Conducting Tube

A very long conducting tube (hollow cylinder) has inner radius a and outer radius b. It carries charge per unit length $+\alpha$, where alpha is a positive constant with units of C/m. A line of charge lies along the axis of the tube. The line of charge has charge per unit length $+\alpha$.

Part A

Calculate the electric field in terms of α and the distance r from the axis of the tube for $r < a$.

Part B

Calculate the electric field in terms of α and the distance r from the axis of the tube for $a < r < b$.

Part C

Calculate the electric field in terms of α and the distance r from the axis of the tube for $r > b$.

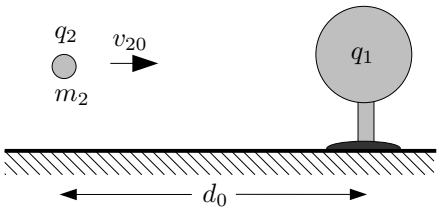
Part D

What is the charge per unit length, α_{in}, on the inner surface of the tube?

Part E

What is the charge per unit length, α_{out}, on the outer surface of the tube?

23.3 - Moving Charges, Energy Methods



A small metal sphere, carrying a net charge of q_1=-3.00μC, is held in a stationary position by insulating supports. A second small metal sphere, with a net charge of q_2=-7.30μC and mass m_2=1.70g, is projected toward q_1. When the two spheres are d_0=0.800m apart, q_2 is moving toward q_1 with speed v_{20}=22.0m/s. Assume that the two spheres can be treated as point charges. You can ignore the force of gravity.

Part A

What is the speed, v_{21}, of q_2 when the spheres are d_1=0.430m apart?

Part B

How close, d_2, does q_2 get to q_1 ?

23.17 - Charge in a Uniform Electric Field

A charge of q is placed in a uniform electric field that is directed vertically upward and that has a magnitude of E.

Part A

What work , W_R, is done by the electric force when the charge moves a distance of x_1 to the right?

Part B

What work, W_U, is done by the electric force when the charge moves a distance of x_2 upward?

Part C

What work, W_{45°, is done by the electric force when the charge moves a distance of x_3 at an angle of 45.0° downward from the horizontal?

23.28 - Electric Potential

At a certain distance from a point charge, the potential and electric field magnitude due to that charge are V= 4.98V and E=12.0V/m, respectively. (Take the potential to be zero at infinity.)

Part A

What is the distance, d, to the point charge?

Part B

What is the magnitude of the charge, q ?

Part C

Is the electric field directed toward or away from the point charge?