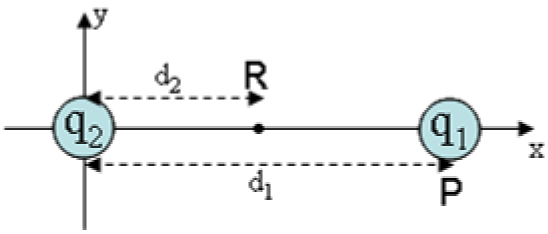
Physics 2220 Homework 5 and 6 Solutions

Potential Energy of Point Charges



A point charge q_2 = -3.4 μC is fixed at the origin of a co-ordinate system as shown. Another point charge q_1 = -0.7 μC is is initially located at point P, a distance d_1 = 9.1 cm from the origin along the x-axis

1)

What is ΔPE, the change in potenial energy of charge q_1 when it is moved from point P to point R, located a distance d_2 = 3.6 cm from the origin along the x-axis as shown?

0.360 J

Our basic formula for potential energy is:

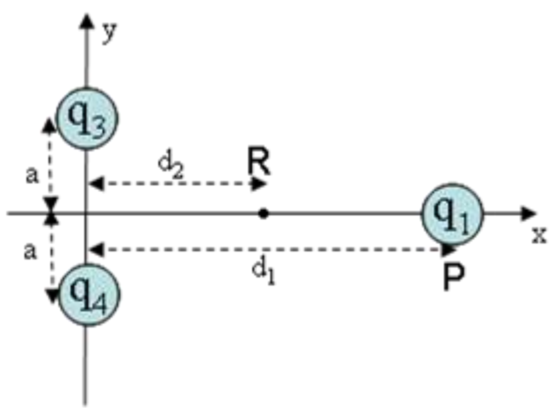
$$U = k\frac{q_a q_b}{r}$$

Note that energy is a scalar and is not affected by direction, just by distance and charge strength. To find the change in Potential energy we take

$$\Delta U = U_2 - U_1 = k\frac{q_a q_b}{r_2} - k\frac{q_a q_b}{r_1}$$

We do this for the above situation noting that only the distance changes.

2)

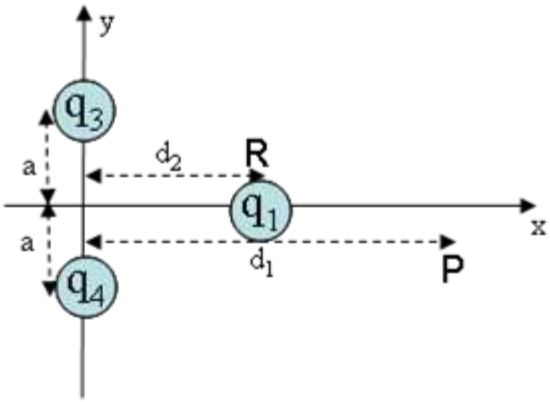


The charge q_2 is now replaced by two charges q_3 and q_4 which each have a magnitude of -1.7 μC, half of that of q_2. The charges are located a distance a = 2.2 cm from the origin along the y-axis as shown. What is ΔPE, the change in potential energy now if charge q_1 is moved from point P to point R?

0.279 J

When finding the potential energy of the system we can add the separate contributions from each of the charge-charge interactions. This problem is just like the previous one except that, because of the y displacement, we have to use the Pythagorean Theorem to find the distances. Also in this particular case since Q_3 and Q_4 have the same charge and distances from Q_1 we can just find the contribution from one of them and double it.

3)



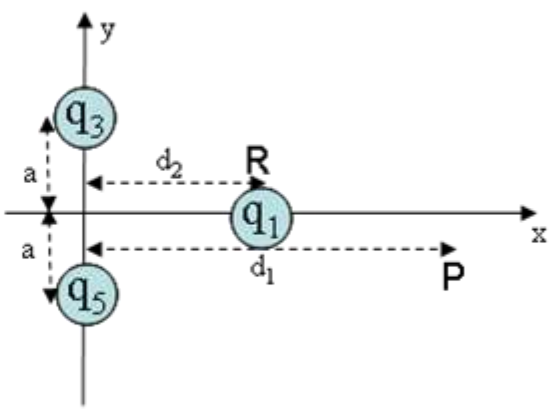
What is the potential energy of the system composed of the three charges q_1, q_3, and q_4, when q_1 is at point R? Define the potential energy to be zero at infinity.

1.099 J

Just use our potential energy equation from before and sum up the different contributions

$$U = k\frac{q_a q_b}{r}$$

4)

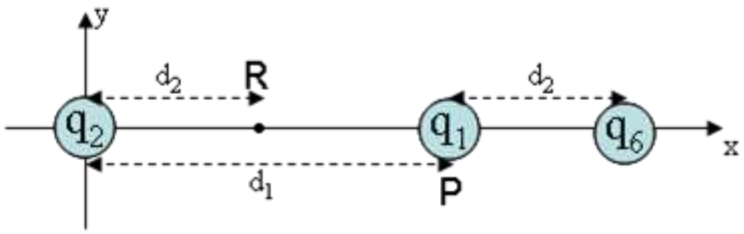


The charge q_4 is now replaced by charge q_5 which has the same magnitude, but opposite sign from q_4 (i.e., q_5 = 1.7 μC). What is the new value for the potential energy of the system?

-0.59 J

Because Q_3 and Q_5 have the same magnitude of charge although the charge is opposite and are at the same distance from Q_1 the their interactions with Q_1 cancel out and we only have to look at the potential between Q_3 and Q_5.

5)

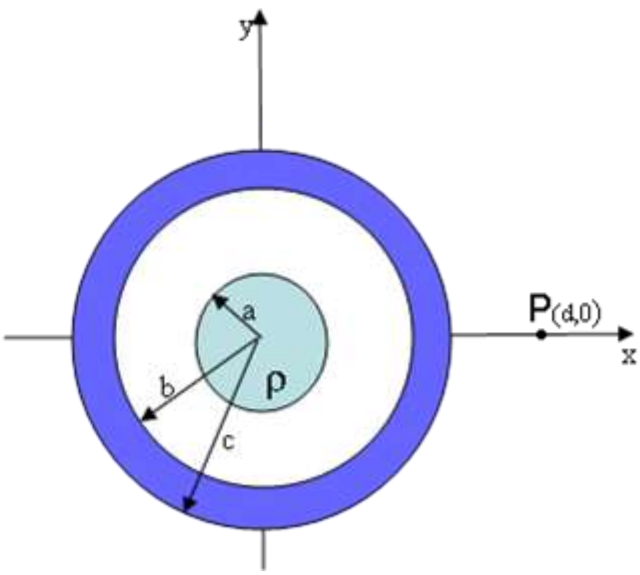


Charges q_3 and q_5 are now replaced by two charges, q_2 and q_6, having equal magnitude and sign (-3.4μC). Charge q_2 is located at the origin and charge q_6 is located a distance $d = d_1 + d_2 = 12.7$cm from the origin as shown. What is ΔPE, the change in potential energy now if charge q_1 is moved from point P to point R?

0 J

We go from a system where, with Q_2 and Q_6 having the same charge, we go from a system where one charge is at a distance of d2 and the other at d1, to a system where one charge is d1 distant and the other d2. Essentially nothing changes and the difference in potential is zero.

Potential of Concentric Spherical Insulator and Conductor



A solid insulating sphere of radius a = 4.5 cm is fixed at the origin of a co-ordinate system as shown. The sphere is uniformly charged with a charge density ρ = -390 μC/m^3. Concentric with the sphere is an uncharged spherical conducting shell of inner radius b = 10.2 cm, and outer radius c = 12.2 cm.