

Holt Physics

Problem 18A**ELECTRICAL POTENTIAL ENERGY****PROBLEM**

What if, instead of an apple, Sir Isaac Newton noticed a charge of 6.0 nC fall on his head from a branch 2.5 m above him. What would have been the change in the electrical potential energy if Earth's electric field strength has a magnitude of 95 N/C and a downward direction?

SOLUTION

Given: $q = 6.0 \text{ nC} = 6.0 \times 10^{-9} \text{ C}$ $E = 95 \text{ N/C}$ $d = 2.5 \text{ m}$

Unknown: $PE_{\text{electric}} = ?$

Choose the equation(s) or situation:

Use the equation for electrical potential energy in a uniform electric field, given on page 667.

$$PE_{\text{electric}} = -qEd = -(6.0 \times 10^{-9} \text{ C})(95 \text{ N/C})(2.5 \text{ m}) = \boxed{-1.4 \times 10^{-6} \text{ J}}$$

ADDITIONAL PRACTICE

- As a child tries to attach a string to a helium-filled balloon, 14.5 nC of charge collects on the balloon's surface as it rubs against her wool sweater. Suppose the child lets go of the balloon before the string is attached. The yellow balloon rises 290 m. What is the change in the electrical potential energy if Earth's electric field strength has a magnitude of 105 N/C and a downward direction?
- After brushing your hair many times, you notice that your hair is attracted to the brush. Suppose a charge of +64 nC is on the brush and a charge of +64 nC is on your hair. What is the electrical potential energy associated with your hair and the brush when you hold the brush 0.95 m from your hair?
- Sparks fly when free atmospheric electrons move fast enough to knock electrons off of an atom with which they collide, causing an electron "avalanche." Suppose the electric field in the air is $3.0 \times 10^6 \text{ N/C}$. If the electron moves $7.3 \times 10^{-7} \text{ m}$, what is the electrical potential energy associated with the electron?
- Sometimes wearing woolen socks while walking on carpet can cause charge to accumulate. You might have noticed this if you felt a spark as you tried to open a door. Suppose a charge of $-42 \text{ } \mu\text{C}$ exists on a doorknob, and your hand has a charge of $63 \text{ } \mu\text{C}$. The electrical potential energy associated with the hand and the doorknob is $-6.92 \times 10^{-4} \text{ J}$. How far is your hand from the knob?

5. Suppose you have a charge of 16 nC and your friend has a charge of 14 nC. As you greet each other, the electrical potential energy associated with you and your friend is 2.1×10^{-6} J. How far are you standing from your friend?
6. A magician holds a charged wand over scattered confetti and the confetti moves to the wand. Suppose the confetti has a charge of -55 nC and the wand has a charge of 77 nC. When the electrical potential energy associated with the wand and the confetti is -1.3×10^{-2} J, how far is the wand from the confetti?
7. The largest electric field measured in a thundercloud is 3.4×10^5 N/C. Suppose the airplane that measured this field flew into this thundercloud at an altitude of 7.3 km. If the electrical potential energy associated with the cloud and the plane is -1.39×10^{11} J, what is the charge on the plane?
8. Suppose you would like to develop a hat that wouldn't fall off someone's head by putting enough charge on the hat so that it would stay no matter how much the wind blew. You begin by rubbing a silk hat against your head so that the same amount of charge collects on the hat as the charge on your head. When you wear the hat ($r = 1.25 \times 10^{-3}$ m), the electrical potential energy associated with the hat and your head is 1.25×10^{-4} J. The hat stays as you walk into the wind.
- How much charge was on the hat?
 - How much charge was on your head?
 - Suppose your friend approaches and puts the hat on. Is the hat likely to stay on your friend's head by charge alone? Why or why not?
9. When you remove clothes from the dryer, a sock clings to a towel ($r = 9.4 \times 10^{-4}$ m). The electrical potential energy associated with the sock and the towel is 8.89×10^{-10} J. Suppose the sock and the towel have equal and opposite charge. Calculate the charges on both.
10. After rubbing a balloon against your hair, the balloon sticks to the wall because they have equal and opposite charge. The electrical potential energy associated with your hair and the wall is 6.3×10^{-6} J when they are 1.25×10^{-6} m apart. What are the charges on the balloon and your hair?