Homework 1 Guide

13.21

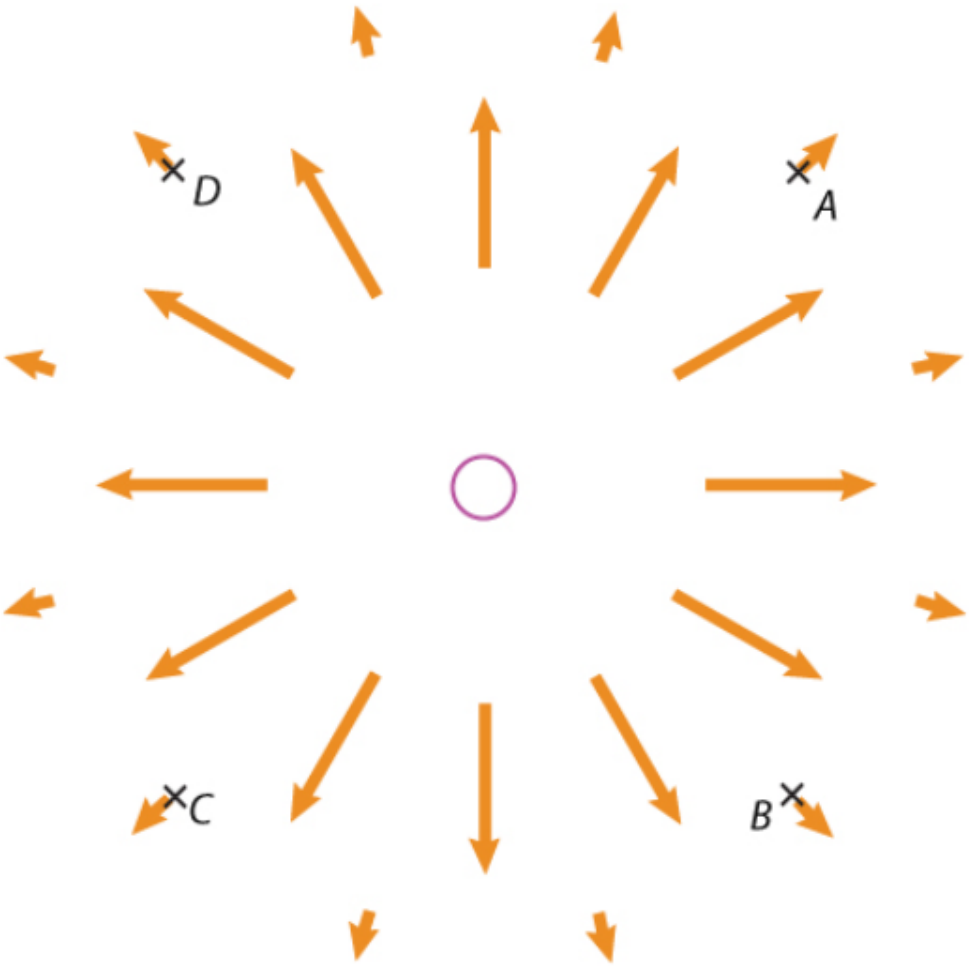
Skills Involved

Vectors

- Direction
- Fields

Electric field due to a point charge

Problem



In the region shown in the diagram above there is an electric field due to a point charge located at the center of the magenta circle. The orange arrows indicate the magnitude and direction of the electric field at the locations shown.

What is the sign of the source charge?

Now a particle whose charge is -7 × 10^{-9} C is placed at location A. Which arrow (a-j) best indicates the direction of the electric force on the -7 × 10^{-9} C charge?

The electric field at location D has the value <-4000, 4000, 0> N/C. What is the unit vector in the direction of $\vec{E}$ at this location?

What is the electric force on the -4×10^{-9} C charge?

What is the unit vector in the direction of this electric force?

Important Information

Objective: Find the sign of the source charge, the direction of the electric force on the charge, the electric field, the electric force, and the direction of the electric force.

Given Information:

- Diagram of point charge and electric field.
- Charge of particle placed at a given location.
- Electric field at location D.

Key Equations:

$$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{< x, y, z >}{\sqrt{x^2 + y^2 + z^2}}$$

$$\vec{F} = q\vec{E}$$

References:

- Figure 13.12 (Matter and Interactions, p. 517)
- Figure 13.19 (Matter and Interactions, p. 520)
- Figure 13.20 (Matter and Interactions, p. 520)
- Definition of Electric Field (Matter and Interactions, p. 517)
- The Physics II Student's Guide to Vectors (computational_activities/Additional_Resources/Vectors_Guide.ipynb)

Things to think about:

- Direction of the electric field for both positive and negative charges.
- Electric forces of postive and negative charges.
- What equation is used for unit vectors? Is it the same equation for the electric field and the electric force?
- Does the unit vector have units?

13.30

Skills Involved

Electric field due to point charge.

Finding the charge of an electron or proton.

Problem

In a hydrogen atom in its ground state, the electron is on average a distance of about 0.5×10^{-10} m from the proton. What is the magnitude of the electric field due to the proton at this distance from the proton?

Important Information

Objective: FInd the magnitude of the electric field due to the proton.

Given Information:

- We are looking at a hydrogen atom in its ground state.
- The average distance of the electron from the proton.

Key Equations

$$|\frac{1}{4\pi\epsilon_0}\frac{q}{|\vec{r}|^2}|$$

References:

- Charged Particles (Matter and Interactions, p. 514)
- Distance Dependance of Electric Field (Matter and Interactions, p. 519)
- Magnitude of Electric Field (Matter and Interactions, p. 520)

Things to think about:

- What does a hydrogen atom look like? Draw it!
- What are the charges of protons and electrons? How many of each are in hydrogen?
  - Note that *ground state* of the hydrogen atom means that it's not in an excited state - all available electrons are in orbitals conducive to the lowest energy state.
- Do charges feel their own fields?
- The equation in the **Key Equations** section is similar to the first part of the electric field vector equation. How is this different? Remember that $\frac{1}{4\pi\epsilon_0}\frac{q}{|\vec{r}|^2}$ isn't *always* equal to the magnitude of the electric field.

  Are magnitudes positive, negative, or can they be either?
- What is the value of k?
- What is $|\vec{r}|^2$? How does this relate to the given information?

13.25

Skills Involved

Finding the charge of an electron or proton.

Finding the mass of a proton.

Problem

A proton is observed to have an instantaneous acceleration of $9 \times 10^{11} m/s^2$. What is $|\vec{E}|$ at the proton's location?

Important Information

Objective: Find the magnitude of the electric field at the proton's location.

Given Information:

- The instantaneous acceleration of the proton.

Key Equations:

$$\vec{F} = m\vec{a}$$

$$\vec{F} = q\vec{E}$$

References:

- Charged Particles (Matter and Interactions, p. 514)

Things to think about:

- What is the charge of a proton?
- What is the mass of a proton?