Chapter C - Problems

Blinn College - Physics 2426 - Terry Honan

Problem C.1

Here we will study the speed v of an electron after it is accelerated from rest across a potential difference of magnitude V.

(a) What is the sign of the change in potential? In other words: Is $\Delta V = +V$ or $\Delta V = -V$?

(b) Using the standard nonrelativistic kinetic energy formula of $K = \frac{1}{2} m v^2$ find the speed.

(c) Find the value for the speed in part (b) when $V = 12\,\text{V}$. The standard nonrelativistic expression for kinetic energy given above only applies to particles with a speed that is significantly less than the speed of light. What fraction of the speed of light is this value?

(d) In the picture tube of a television it is typical to have voltages (potential differences) of $V = 25\,\text{kV}$. Find the speed of an electron after accelerating across this voltage using the nonrelativistic expression. What fraction of the speed of light is this?

(e) The correct relativistic expression for kinetic energy is

$$K = \left(\frac{1}{\sqrt{1-v^2/c^2}} - 1 \right) m c^2.$$

Use this to find the correct speed of an electron after accelerating across $V = 25\,\text{kV}$. What is the percent error in using the nonrelativistic formula?

Problem C.2

A some distance from a point charge the voltage is $-180\,\text{V}$ and the electric field magnitude is $800\,V/m$. Find the charge and the distance from the charge?

Problem C.3

A $5\,\mu\text{C}$ charge sits at the origin and a $-8\,\mu\text{C}$ charge sits at $(2\,\text{m}, -3\,\text{m})$. What is the potential at $(0, -2\,\text{m})$? Compare this to problem A.5, where the electric field at $(0, -2\,\text{m})$ was found.

Problem C.4

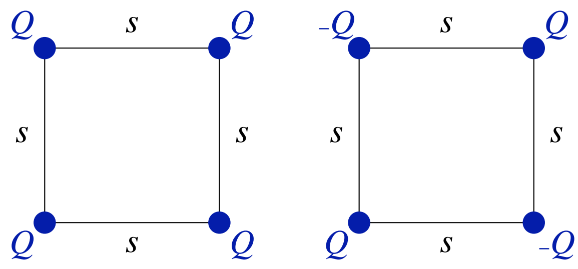
What is the potential at the origin due to a line of charge from x_0 to x_1 along the positive x-axis with a uniform linear charge density (charge/length) of λ. Compare this to problem A.7, where the electric field at the origin was found and where $x_0 \to \infty$.

Problem C.5

Consider a flat annulus in the xy-plane with an inside radius a and an outside radius b and with a uniform surface charge density σ. What is the potential at a point z_0 along the positive z-axis?

Problem C.6

What is the total potential energy of the configuration for each configuration shown?



Problem C.7

Two protons are released from rest from a distance of 1 nm. What is their speed when they are a large distance apart? Both will have the same speed. You may assume all speeds are nonrelativistic.

Problem C.8

Consider a ring of radius R uniformly charged with a charge Q. How much work is required to move a point charge q from a distance z_0 from the center along the central axis to the center.

Problem C.9

The potential as a function of position is $V(x, y, z) = 6x^2 - 5yz^3 - 8x^3z$ in SI units.

(a) Find the electric field as a function of position.

(b) What is the value of the field at (3 m, −2 m, 4 m)? What is the magnitude of the field there?

Problem C.10

Consider a uniform electric field of magnitude $300\,V/m$ in the negative z-direction. A $-20\,\mu\text{C}$ charge is moved from the point $(3\,\text{m},\ -2\,\text{m},\ 5\,\text{m})$ to the origin.
(a) What is the change in the potential for the charge?
(b) How much work is needed to move the charge?

Problem C.11

How many electrons must be removed from a conducting sphere with a $12\,\text{cm}$ radius to give it a voltage of $5000\,\text{V}$?

Problem C.12

Two conducting spheres of radius $6\,\text{cm}$ and $9\,\text{cm}$ are separated by a large distance and connected by a conducting wire. If a total charge of $25\,\mu\text{C}$ is added to the configuration then what charge flows to each conductor? What is the potential of each conductor?

Problem C.13

What is the potential as a function of position for a thin spherical shell of radius R with a uniform charge Q?

Problem C.14

A solid insulating sphere of radius a has a uniform charge Q. This sits inside of a hollow conducting sphere with and inside radius b and outside radius c. The conductor is given a net charge of q. (All spherical surfaces are concentric.) What is the potential as a function of position? Give answers for all cases: $r < a$, $a < r < b$, $b < r < c$ and $r > c$. This is an extension of Problem B.13 from the previous chapter.