3.8: Electric Potential (Summary)

Key Terms

Chapter 3

Term	Definition
electric dipole	system of two equal but opposite charges a fixed distance apart
electric potential	potential energy per unit charge
electric potential difference	the change in potential energy of a charge q moved between two points, divided by the charge.
electric potential energy	potential energy stored in a system of charged objects due to the charges
electron-volt	energy given to a fundamental charge accelerated through a potential difference of one volt
voltage	change in potential energy of a charge moved from one point to another, divided by the charge; units of potential difference are joules per coulomb, known as volt

Key Equations

Chapter 3

Description	Equation
Potential energy of a two-charge system	$U(r)=k\frac{qQ}{r}$
Work done to assemble a system of charges	$W_{12\cdots N}=\frac{k}{2}\sum_i^N\sum_j^N\frac{q_iq_j}{r_{ij}}$ for $i\neq j$
Potential difference	$\Delta V=\frac{\Delta U}{q}$ or $\Delta U=q\Delta V$
Electric potential	$V=\frac{U}{q}=-\int_R^P\vec{E}\cdot\vec{dl}$
Electric potential of a point charge	$V=\frac{kq}{r}$
Electric potential of a system of point charges	$V_P=k\sum_1^N\frac{q_i}{r_i}$
Electric potential of a continuous charge distribution	$V_P=k\int\frac{dq}{r}$

Summary

Work and Energy

- The work done by a force, acting over a finite path, is the integral of the infinitesimal increments of work done along the path, which are given by the dot product of the force and the infinitesimal displacements.
- The kinetic energy of a particle is the product of one-half its mass and the square of its speed (for non-relativistic speeds), and the kinetic energy of a system is the sum of the kinetic energies of all the particles in the system.
- The integral for the net work done on the particle is equal to the change in the particle's kinetic energy. This is the work-kinetic energy theorem.
- For a single-particle system, the difference of potential energy is the opposite of the work done by the forces acting on the particle as it moves from one position to another.

- A conservative force is one for which the work done is independent of path. Equivalently, a force is conservative if the work done over any closed path is zero.
- If non-conservative forces do no work and there are no external forces, the mechanical energy of a particle stays constant. This is a statement of the conservation of mechanical energy and there is no change in the total mechanical energy.

Electric Potential Energy

- The work done to move a charge from point A to B in an electric field is path independent, and the work around a closed path is zero. Therefore, the electric field and electric force are conservative.
- The superposition principle holds for electric potential energy; the potential energy of a system of multiple charges is the sum of the potential energies of the individual pairs.

Electric Potential Energy of Point Charges

- We can define an electric potential energy, which between point charges is $U(r) = k\frac{qQ}{r}$, with the zero reference taken to be at infinity.

Electric Potential

- Electric potential is potential energy per unit charge.
- The potential difference between points A and B, $V_B - V_A$, that is, the change in potential of a charge q moved from A to B, is equal to the change in potential energy divided by the charge.
- Potential difference is commonly called voltage, represented by the symbol ΔV:

$$\Delta V = \frac{\Delta U}{q} \text{ or } \Delta U = q\Delta V.$$

- An electron-volt is the energy given to a fundamental charge accelerated through a potential difference of 1 V. In equation form,

$$1\text{ eV} = (1.60 \times 10^{-19}\text{ C})(1\text{ V}) = (1.60 \times 10^{-19}\text{ C})(1\text{ J/C}) = 1.60 \times 10^{-19}\text{ J}.$$

Electric Potential of a Point Charge

- Electric potential is a scalar, whereas electric field is a vector.
- The addition of voltages as numbers gives the voltage due to a combination of point charges, allowing us to use the principle of superposition: $V_P = k\sum_1^N \frac{q_i}{r_i}$.
- An electric dipole consists of two equal and opposite charges a fixed distance apart, with a dipole moment $\vec{p} = q\vec{d}$.

Common Models of Electric Potential

- Continuous charge distributions may be calculated with $V_P = k\int \frac{dq}{r}$.
- Results are for the electric potential provided for common continuous charge distributions including a line segment, ring, disk, and infinite line.

Contributors and Attributions

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