Physics 161

Lecture 21 Summary

Electrical Potential Energy and Capacitance

November 14, 2017

Lecture 21: learning objectives

You will be able to define electric potential energy, contrast it with electric potential, and apply the work-energy theorem to electric systems.

You will be define the electron volt.

You will be able to describe a capacitor, define capacitance, determine the energy stored by a capacitor and apply this to parallel-plate capacitors.

You will be able to analyse capacitors in parallel and series.

Electric potential

Electric potential energy:
The change in the electric potential energy of a system consisting of an object of charge q moving through a displacement in a constant electric field is given by the (negative of the) product of the charge, electric field and displacement.

$$\Delta E_P = -qE_x\Delta x$$

Electric potential difference:
The electric potential difference between points A and B is the change in the electric potential energy as a charge q moves from A to B divided by the charge q.

$$\Delta V = V_B - V_A = \frac{\Delta E_P}{q}$$

Electric potential for point charges

The electric potential at a distance r from a point charge q is

$$V = k_e \frac{q}{r}$$

Superposition principle:
The electric potential at a single point due to multiple electric charges is the algebraic sum of the potentials due to each charge.

Work done on a charge:
The work done on a charge q to move it from point A to point B in an electric field is the (negative of the) product of the electric potential difference between those points and the charge.

$$W_E = -q(V_B - V_A)$$

Electron volt

Electron volt (eV):
The kinetic energy gained by an electron when it is accelerated through a potential difference of 1 V.

The electron volt is a unit of energy: 1 eV = 1.60×10^{-19} J.

Capacitance

Capacitance:
The ratio of the charge stored in a capacitor to the potential difference between the conducting plates.

$$C = \frac{Q}{\Delta V}$$

$$C_{\parallel} = \epsilon_0 \frac{A}{d}$$

Energy stored in a capacitor:
Energy stored is half the ratio of the charge stored in a capacitor (squared) to the capacitance.

$$E = \frac{Q^2}{2C}$$

$$E = \frac{1}{2} C (\Delta V)^2$$

Capacitors

For capacitors in series, the equivalent capacitance is

$$\frac{1}{C_{\text{equiv}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

For capacitors in parallel, the equivalent capacitance is

$$C_{\text{equiv}} = C_1 + C_2 + C_3 + \cdots$$