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: \(1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}\).
Capacitance:
The ratio of the charge stored in a capacitor to the potential difference between the conducting plates.

\[ C = \frac{Q}{\Delta V} \]

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

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