Workshop 5: Classical Mechanics and Electrostatics

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For a more complete overview of classical mechanics and electrostatics please refer to the detailed notes.

1 Classical Mechanics

Classical mechanics tells us how objects move, provided they are large enough that we don't need to worry about quantum mechanical effects. This applies to almost anything bigger than a hydrogen atom. Some of the key laws and equations in classical mechanics are:

- Newton's First Law: objects only change their velocity when a force is applied.
- Newton's Second Law: the force applied to an object is equal to the rate of change of its momentum.

$$F = ma$$

- Newton's Third Law: every action has an equal and opposite reaction.
- Conservation of Momentum: the total momentum of a collection of particles remains unchanged unless a force acts on them.
- Conservation of Energy: Energy cannot be created or destroyed, only converted from one form to another. These forms include:
  - Work (W): the energy used to move an object a certain distance (d) against a force (F).

    $$W = -Fd$$

  - Kinetic Energy: the energy associated with an object of mass m moving at speed v.

    $$KE = \frac{1}{2}mv^2$$

  - Potential Energy: the energy stored in an object. For example, gravitational energy is the energy stored in an object of mass m at height h above the Earth due to a gravitational field of strength g.

    $$\text{Gravitational Potential Energy} = mgh$$

    There are many types of potential energy, including chemical, elastic, and electrostatic potential energy.

- Angular Motion: motion in a circle means that the object moving is constantly changing its velocity (because its direction constantly changes). Newton's First Law says there must be a force causing this change of velocity - this is called the centripetal force. Different terms are used to describe angular motion - angular momentum instead of momentum, torque instead of forces. These are described in the detailed notes.

2 Electrostatics

Electrostatics describes the interactions between charged particles. The potential energy due to the electrostatic interaction between two charged particles is

$$V = \frac{q_1 q_2}{4\pi\varepsilon r}$$

where q_1 and q_2 are the charges on the two particles, r is the distance between the two particles, and ε is a constant called the permittivity, which depends on what substance is between the two charges and determines how strongly an electric field is felt by a charged particle.

The force between two charged particles is given by

$$F = \frac{q_1 q_2}{4\pi\varepsilon r^2}$$

If the charges of the two particles have the same sign, the force will cause the particles to move apart; if the charges have different signs, the force will cause the particles will move towards one another.