ECE 30
Day 8 Notes

Elijah Hantman

Agenda

- Electric Fields
- Work and Energy
- Electric Potential Energy

Electric Fields

What are Ions?
ions are atoms which have had electrons stripped from them, this causes them to be electrically charged. The vast majority of atoms are neutral normally but we can delibrately charge them for etching.

The human blood has extra ions. This means human fingers are electrically charged.

Charges effect their environment. Many forces like gravity also have seemingly non-local effects. This can be modeled by imagining all of space has a charge value, this is called a field.

The value of the electric field is the force a charged particle would feel at the given point in space. This defines a function from a position to a force which creates a vector field.

$$\vec{\epsilon} \triangleq \frac{\vec{F}_e}{q_0}$$

Where $\vec{F}_e$ is the Coulomb force exerted on a particle with charge q_0. The electro static force is measured in force per unit charge. $\mathrm{N/C}$

An electric field is represented via electric field lines. The field lines are always drawn as arrows which describe the movement of a positive charge. There are some additional rules.

1. Field lines are tangent to the electic field at all points.
2. Direction is same as the force on a positive test charge.
3. The number of lines passing through a surface perpendicular to the lines is proportional to the magnitude of the electrical field.

Something to note is that the electric field is conservative, which means it is the gradient of some potential function. This is intuitive if you imagine creating a surface where the charges represent the height, and everything is continuous. This would be a potential function, and the gradient would be the vector field.

Work and Energy

Work is defined as:

$$W = F \times \Delta x$$

For a constant foce in the direction of Δx. Only the component of work in the direction of Δx contributes to the work. And has units of Nm. Or Joules (J)

Therefore we can also write work as:

$$W = \vec{F} \cdot \Delta \vec{x}$$

Over a curved path you can compute work using a line integral.

$$W = \int_S \vec{F} \cdot d\vec{x}$$

This is the more general form which works for non constant force and a non linear path. This can be analytically solved via a parameterization.

$$W = \int_a^b f(x(t), y(t), z(t)) \sqrt{(x'(t))^2 + (y'(t))^2 + (z'(t))^2} dt$$

This comes from the formula for arc length multiplied by the force at each point. This requires being able to parameterize the line which is usually possible but may be difficult in general.

Work can also be written as:

$$W = \int_a^b mv dv$$

By integrating the above integral we get:

$$W = \frac{1}{2} mv^2 \Big|_a^b$$

Which is by definition the difference in kinetic energy of a particle since kinetic energy is written:

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

Which means:

$$W = \Delta K_e$$

What if there is no change in speed?

Since $W = F_y \Delta y = mg(y - y_0) = mgh$, we can see that work is the potential energy when the speed doesn't change.

Work is the change in potential energy. This works because forces like gravity and electro static forces are conservative.

Energy is defined as the capacity for doing work. Therefore to perform work a body must have energy.

Electrical Energy

Electric Potential:

$$W = \int_a^b F dx = -\int_a^b q\epsilon dx \tag{1}$$