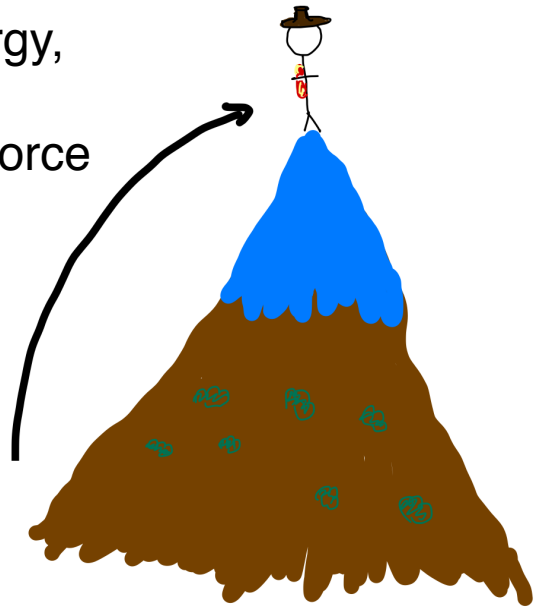
Electric potential and Voltage

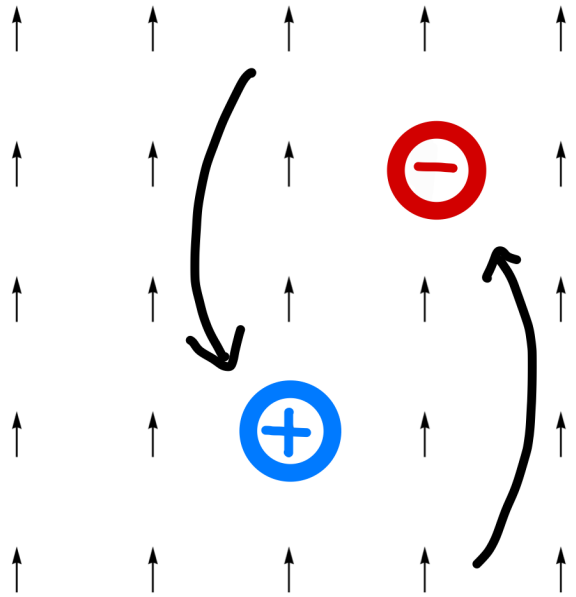
When we studied gravity, we saw that the presence of a force field implies that an object will have a potential energy that depends on its position in space. For gravity, the higher you go, the greater your potential energy becomes.

Similarly, we have found that a charge placed on an electric field will feel a force. This case will also represent a force field. Therefore, there will be some potential energy associated to the electric field and the electric charges.

Going higher increases your potential energy, since the gravitational force is pulling you downwards.



In the case of this particular electric field, bringing a positive charge down increases its potential energy (the electric force pushes it upwards).



For a negative charge, the behavior changes. Moving it up increases its potential energy since the electric force pulls downwards.

Notice that in order to find the potential energy at each point we need the polarity of the charge, its magnitude and a reference value of the energy. For some applications this can be difficult and confusing

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It is then convenient to define a quantity that gives us information about the energy of the electric field without having to know what charge (both polarity and magnitude) will be used. This is called the **electric potential**. It is defined as the potential energy per unit of charge. In other words,

Electric potential = Potential energy / Unit of charge

This removes the dependence on the test charge that we use. However, there is still one more ambiguity left. When we define the potential energy, we have the liberty to choose which point in space corresponds to one value of the energy (in the case of gravity, we usually set the floor to be the height at which U=0). The physical behavior of particles cannot depend on our arbitrary choices.

In order to get rid of this ambiguity, we think that the physical quantity is the **difference between the potential energy at different points**. We can extend our definition of electrical potential in order to deal with this arbitrary choice. This is what we call the **voltage**.

Voltage = **Δ** Potential energy / Unit of charge

or

$$V = \Delta U / Q$$

Homework

Problem 1. It was recently demonstrated on several scientific papers that some insects and spiders use electrostatics to perform different tasks. Do some research on the internet about this. Once that you understand how electrostatics is being used, draw a sketch in which you describe the mechanism and explain with your own words the physics.

Problem 2. Suppose that you have a battery of 1.5V that has pumped a total of 3 Coulomb of electric charge through it. What is the maximum amount of work that can be done by this circuit?

Hint: Recall that $W = \Delta U$.