Jumping a Dead Battery

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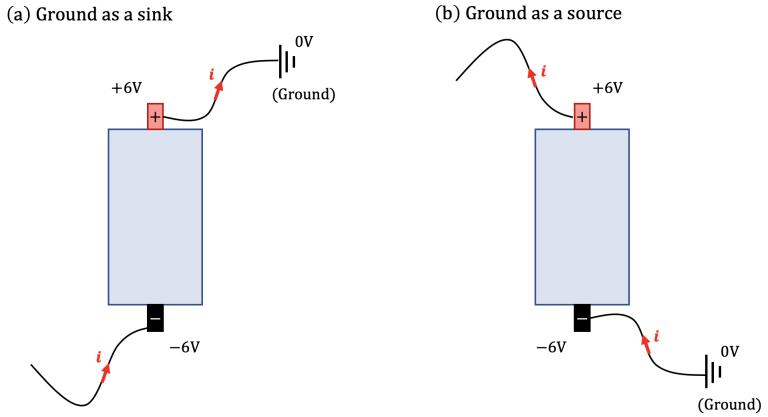
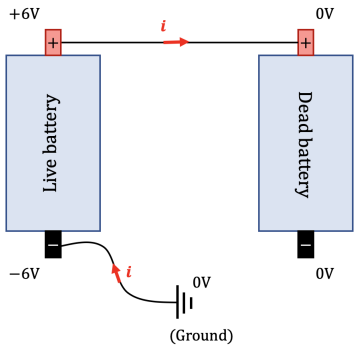
Before we can understand how jumping a dead battery works, we need to understand how a ground works in a circuit. Imagine a battery with a voltage of 12V (the standard voltage of a car battery, for instance). As we discussed in class, all that this means is that the potential difference between the positive terminal and the negative terminal is 12V; that is, the positive terminal is 12V higher in potential than the negative terminal. However, this doesn't tell us anything about what the *actual* potential is at either terminal – in fact, it's impossible for us to know the actual potential anywhere.

So, for convenience, we define the ground to be 0V, all positive terminals to be at a potential greater than 0V, and all negative terminals to be at a potential less than 0V. Using our above example, a 12V battery would have a positive terminal at +6V and a negative terminal at −6V. It's this fact – that positive terminals are always above the ground and negative terminals are always below the ground – that allows the ground to act as both a source and a sink of charge.



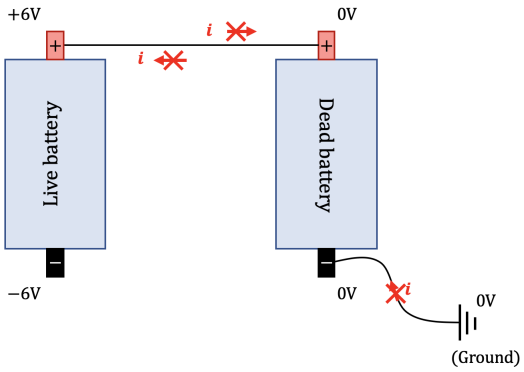
Consider the image above. In figure (a), the ground is shown to be connected to the positive terminal of the battery; the negative terminal of the battery is connected to something else, which is necessary since both the source part and the sink part of a battery must be connected to wires in order to produce current (recall that we covered this in class). Since the positive terminal is at +6V and the ground is at 0V, current will run from the positive terminal to the ground, since current always travels from high potential to low potential. Thus, the ground is acting as a sink in this case.

In figure (b), the ground is instead connected to the negative terminal; as in figure (a), we have to connect the positive terminal to something in order for current to flow. Since the negative terminal is at −6V and the ground is at 0V, current will flow out of the ground and into the negative terminal. Thus, the ground is acting as a source in this case. This figure illustrates how the ground can act as both a source and a sink of current, which is the defining characteristic of the ground.



Now that we've covered what a ground is, we can discuss jumping a dead battery. The set-up is shown in the figure above: the positive terminals of both batteries are connected, while the negative terminal of the live battery is connected to the ground; the negative terminal of the dead battery isn't connected to anything. Since the negative terminal of the live battery, at -6V, is at a lower potential than the ground at 0V, current flows out of the ground and into the negative terminal of the live battery. The dead battery is said to have 0V of potential at each terminal, because it shouldn't be able to pull current out of a ground. This means that the positive terminal of the live battery, at $+6$V, is at a higher potential than the positive terminal of the dead battery, at 0V, and so current flows from the live battery to the dead battery.

As charge builds up in the positive terminal of the dead battery, the potential rises. Due to a chemical reaction within the battery, as the positive terminal charges, the negative terminal will charge as well. Eventually, when the positive terminal reaches a potential of $+6$V, current will stop flowing from the live battery to the (previously) dead battery; note that since the negative terminal charges with the positive terminal, it will be at -6V by this point, so the battery will be fully charged to a voltage of 12V.



What if we were to mess up the placement of the jumper cables, and accidentally grounded the dead battery instead of the live battery, as shown in the above figure? Well, nothing would happen in this case. The three possible currents are shown in the above figure, and each has an X through it for a reason. No current would come out of the ground and into the negative terminal of the dead battery because both the ground and the terminal are at 0V, meaning no movement of charges. There cannot be a current from the positive terminal of the dead battery, at 0V, to the positive terminal of the live battery, at $+6$V, because current can never move from low potential to high potential.

And lastly, current won't flow from the positive terminal of the live battery to the positive

terminal of the dead battery. Remember, in order for current to flow continuously, both the source side and the sink side of a battery must be connected to wires, whereas in this case, only the positive terminal is connected to anything. However, if you had a third cable, you could connect the negative terminal of the live battery to the ground, correcting this problem. Now the negative terminal of the live battery can pull current out of the ground, and the positive terminal of the live battery can send current to the dead battery. Notice, though, that this is identical to the correct way of setting up the jumper cables, just with an extra (useless) cable connecting the negative terminal of the dead battery to the ground. So there's no point in doing it this way.