# Electric Cars – Teacher Notes

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Figure 1 – Hands on project using electricity and mechanics

**Question**

Electricity plays an important role in modern life, imagine how our life would be like if there was no electricity!!! Simply, think how many electric devices we use from when we wake up in the morning until we revisit the bed at night. Our whole life relies on electricity. In recent years we've seen a new revolution in the car industry with hybrid cars (deriving their energy from both electric engines and gasoline engines) and electric cars replacing conventional petrol cars. This is very promising in terms of reducing pollution emitted from petrol engines and in reducing our dependence on non-renewable energy sources.

In this experiment, students will study concepts within electricity such as potential difference and current and how these parameters affect the performance of an electric car powered by D.C. cells. They will vary both the current and voltage and investigate this effect on the performance of the car.

Students should make their hypothesis on how would the number and mode of connecting batteries (whether in series or in parallel) affect the voltage and current in the circuit and how it would affect the performance of the car.

**Plan**

This experiment involves connecting cells in series and in parallel. It also involves measuring the current and the potential difference (voltage). Students need to understand the difference between series and parallel connections and how to connect the ammeter and the voltmeter in the circuit

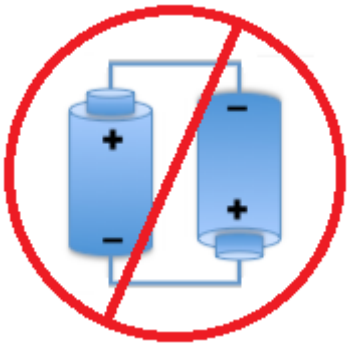
and how to read their values. A useful video clip to watch for series and parallel grouping of cells is https://www.youtube.com/watch?v=mvQe_Z-YpYA&t=17s. For connecting the voltmeter and ammeter a good link is on https://www.youtube.com/watch?v=yE3eQ6q39f4.

Ensure you discuss with students the safety issues associated with the experiment. They will be using AA batteries which are usually safe to use, however students should check if there are any observable leaks. They should avoid heating the batteries or puncturing them and always keep them away from their mouths and eyes.

Students are going to make their own car. They can use sharp tools such as scissors, cutters and spiked tools. Extra caution should be taken to avoid injuries. They should always keep sharp tools, including the skewers and spiked tool, away from their peers' eyes and not throw them.. They should also be very careful while using the hot glue gun to avoid burns.

Ensure the propeller is well fitted to avoid its disconnection and subsequent injuries that could be caused. Always wear safety goggles to protect eyes from the spinning propeller.

Never connect batteries by connecting two batteries positive to negative and negative to positive, this will cause them to overheat and will drain the batteries quickly.



It is important not to overload the motor, i.e. if voltage exceeds the rating of the motor this could burn the motor. This is explained in more detail in the discussion section.

The space used for running the cars should be clear from any glassware or anything fragile.

**Conduct**

This experiment is a mix of prescribed inquiry (students are provided with the question, a method and instructions on how to record results), and open inquiry (students will choose how to analyse the data, formulate conclusions and justify their findings).

Students will construct their own cars according to the provided recipe. According to their age group, extra help and supervision might be required for younger classes especially with cutting the blades and making a hole in the lid.

Students will then connect one battery and observe the performance of the car. They will increase the number of batteries one at a time until they use 4 batteries. The batteries will either be connected in series or in parallel and students will write their observations on how increasing the number of batteries effects the performance of the car in both cases of series and parallel connections. They will connect the ammeter in series between the motor and the batteries (to measure the current) and the voltmeter in parallel with the motor and the batteries (to measure the voltage).

To measure the speed of the car, students will measure the distance covered by the car and measure the time taken to cover this distance using a stopwatch. Then using the formula $Average\ speed = \frac{Distance}{Time}$, they will find the average speed. Make sure they measure the distance in meters and the time in seconds to find the average speed in meters/second. They can tabulate their results as shown in the student notes.

To ensure the experiment is a fair test, all variables should be controlled except the ones being tested.

**Analyse**

After taking their measurements, students will plot their results for the parallel and series connections on the graph paper provided to show the relation between:

1. Number of batteries and voltage obtained.
2. Number of batteries and the intensity of current in the circuit.
3. Number of batteries and the average speed of the car.

It is very important to label the graph correctly including the unit of measurements.

**Problem solving and discussion**

Each team will compare the results obtained to their hypothesis. In case these don't agree, students will need to decide if something went wrong with the measurements or conclude that their hypothesis was incorrect.

Common sources of errors in the measurements are:

1. Not connecting the ammeter in series and the voltmeter in parallel.
2. A burnt fuse in the ammeter specially if it was connected to the circuit in parallel by mistake.
3. A wrong connection, for example one of the batteries is connected in the wrong direction.

A class discussion can be held to clear any misconceptions students may have. An efficient way to identify students' pre-knowledge is by asking questions such as the following:

1. When the cell (battery) is flat, does this mean that it ran out of charge?
2. Is the battery the source of the charge (electrons) that flows through the circuit?
3. Is the charge used up to light the bulb or run a motor?
4. What is the meaning of the potential difference?

Students need to understand that the electric current is a flow of electrons and that these electrons are already present in the conducting material. These electrons are there all the time and they are free to move, in fact they are moving all the time, but because there is no force to move them in one direction, they move randomly in all directions. Once these electrons are forced to move in one direction, we call this an electric current. This force is supplied by an electric field where electrons are forced to move away from the negative end of a battery towards the positive end.

The battery is a source of energy. It provides the electrical energy used by the electrons to transform to other forms of energy such as kinetic energy of a motor, heat energy or light energy in a bulb. This electrical energy is originally transformed from the stored chemical energy within the battery. When we say that the battery is flat, this actually means that the battery has run out of the chemicals which provide the chemical energy for the battery.

It is useful for students to understand that potential difference is actually the difference in electric potential energy between two points. In fact the unit 'Volt' is equivalent to 'joules/coulomb'. When a charge moves between these two points, the potential energy of the charge changes. At the battery side the charges gain potential energy which we call 'voltage rise', and at the resistor side (the load) the charges lose this potential energy which is transformed to any other form of energy (such as heat, motion or any other form of energy), which we call 'voltage drop'. The unit 'ampere' simply means 'coulombs/second', and it measures the intensity of current.

It is important for students to know that the different combination of batteries (i.e. series or parallel) would have different results. In the parallel combination, if all the batteries have the same voltage, then the net voltage is exactly the same as the voltage of one battery. According to Ohm's law,

$$V = IR$$

Where V=potential difference in volts

I = intensity of current in amperes

R = resistance in ohms

If the voltage does not change and the resistance is the same, then the current will not change. It is worth knowing that in the parallel connection, each battery or cell will supply an equal portion of the total current. Hence, the battery life will increase in a parallel connection.

After ensuring that students understand the meaning of the terms they are using, students will need to explain their findings. They should find that by connecting the cells in parallel, as they increase the number of batteries the speed reached is less. The reason for this is that when more batteries are added in parallel, the weight of the car increases while the voltage is exactly the same, therefore more force is required to attain the same speed. The force is mainly dependent on the voltage supplied, so this is why the performance of the car will be less if the number of batteries connected in parallel is increased.

In the case of a series connection, more batteries would yield more voltage. Again, according to Ohm's law, if the voltage increases, the current increases for the same resistance. Here as the number of batteries increases due to the higher voltage, the car performance would be better despite the fact that the car is getting heavier. There is a limit to the number of batteries that can be connected in series because each motor has a certain voltage rating. If this rating is exceeded the motor can simply overheat and burn.

**Conclusion**

Students will mention whether their hypothesis has been supported or not. They can suggest future studies to be done, such as making a combination of parallel and series connections or comparing the time taken for the batteries to run out in the series and parallel connections.

Link to Figure 1 https://www.flickr.com/photos/sno-isle/36190065482/in/photolist-cGQx3S-4MMsdX-7XjLx2-9NJKMw-k6Kace-bmkr3Q-9NC5eF-4LET9t-7Xo1hY-4MyVg4-7Xo1bo-YkNMy4-4MyUz8-7Zqk2u-GgAyxj-Y4k9qN-4MD6Md-7Zn8KV-4MyV3v-biYMSn-e75WxP-kQJb3W-e8pXCz-XjXFyY-cGQx5u-6zNyGP-cGQx1G-4Px64H-bx8bin-9HqkRZ-ddmyPp-e8vBh3-e8vBTC-XjXFMo-e8vAyW-8YHVXx-XAoKm7-7B2xyE-Was8cR-WMPuzu-XjXFDh-WMPuS3-X8Zxyh-XjXFFm-X8ZxCf-Was83H-