

Name/NetID:

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# Module: Getting the Vehicle to Move

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## Module Outline

The motors will tolerate a voltage as high as 12V and as low as ~3V. The speed of the motor can be varied by changing the supply voltage however your final design goal is to have the vehicle move by itself the small car chassis cannot carry the large power supply with it for many reasons. So to be completely autonomous the car will be carrying a battery that only delivers a fixed voltage. As a first step to complete autonomy you will learn to modify the speed using resistors – parts small enough to be included on the protoboard you attached to your car chassis.

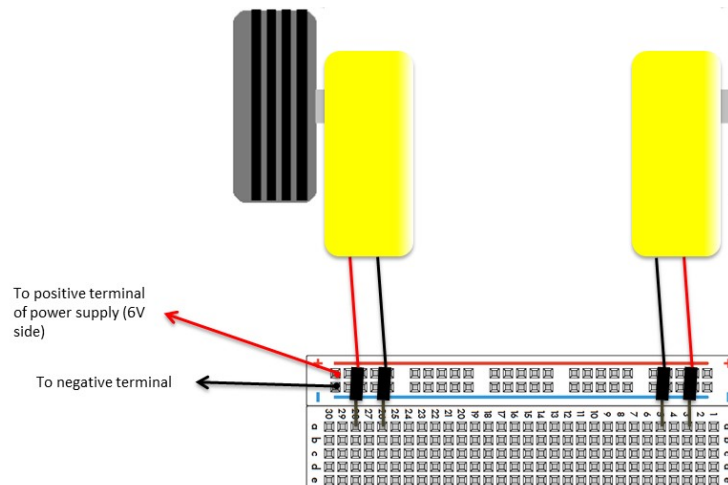
## Using Resistors to Control the Motor Speed

**IN LAB PORTION** – this part of the lab uses the equipment in the lab. Please do this part first before continuing on the section that does not require lab equipment.

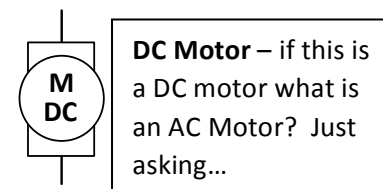
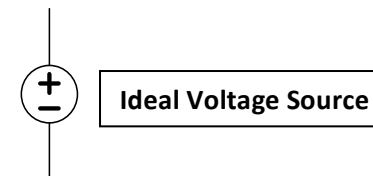
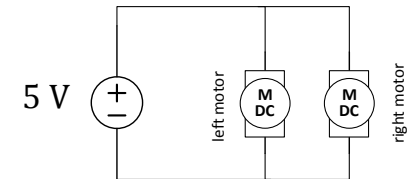
Before testing this with a battery pack with car on the table let's start with the motors connected to the Power Supply. The schematic of the circuit is shown to the right. You will be asked to draw several versions of this schematic as we add components so note the symbols used for the power supply and the motors.

- ✓ Once your chassis is built the motor wires will stick out of the top. Place your protoboard on top but **DO NOT** use the adhesive to connect it to the chassis unless you are really sure of your placement. You can use velcro to attach it temporarily or even some tape.
- ✓ Set power supply into the +6V mode.
- ✓ Connect the positive and negative terminals of the power supply to the protoboard. Put the cable connected to the positive terminal into any of the holes in the long strip of holes labeled in red + near the handy red stripe. Put the cable connected to the negative terminal in any of the holes labeled – in cyan.
- ✓ Set the power supply to 5V (approximately the voltage of 4 AA batteries) and connect to the motor terminals – just to make sure everything is working. It is **ALWAYS** best to start simple. You may place the protoboard anywhere on top of the chassis for these procedures.

**Question 1:** Are the motors turning? They should be – if not try to figure out why. The most common problems are: i) the wires soldered to the motors have snapped off, ii) inserted some of the motor connection wires into the wrong holes on the protoboard. Draw on the physical diagram below the connections you made to get both motors turning.



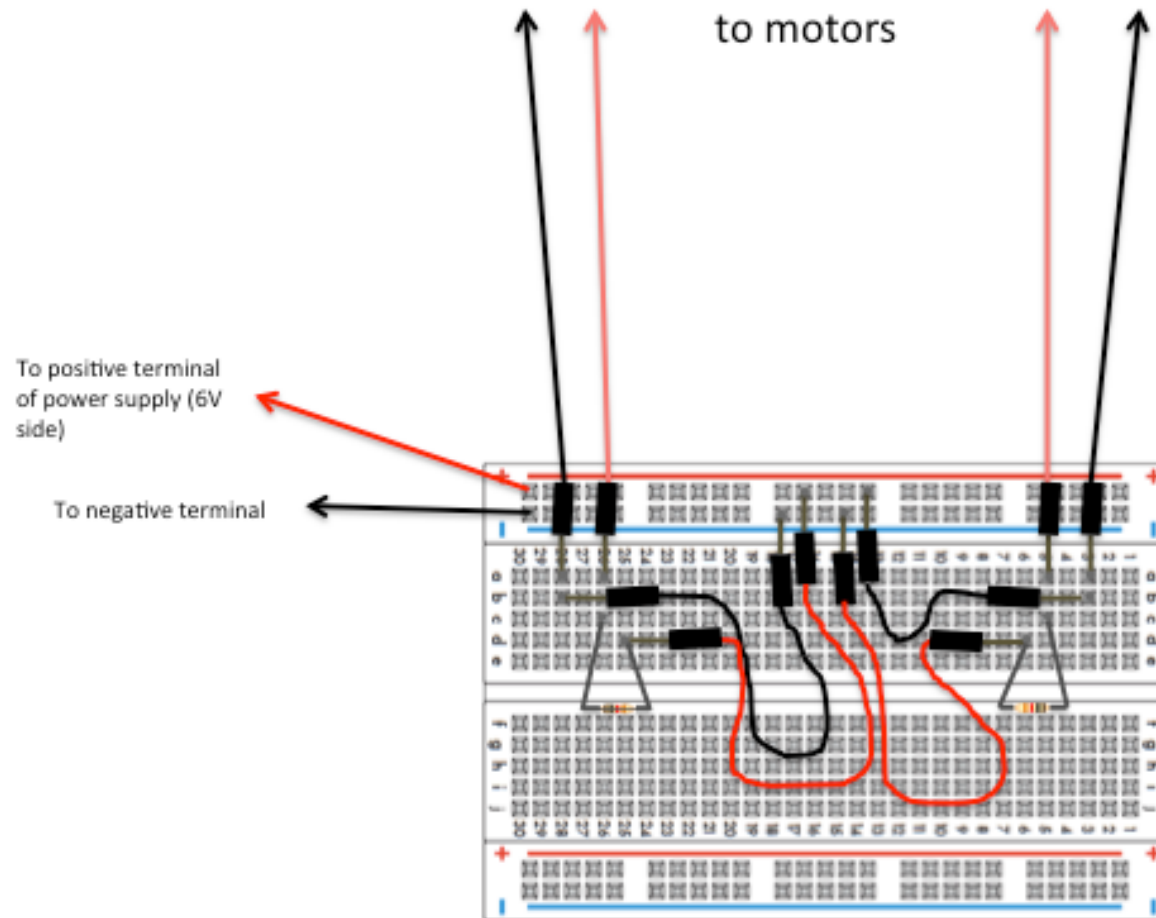
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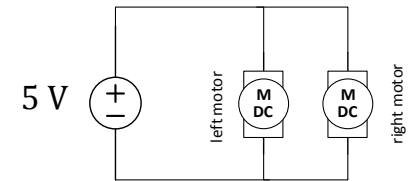
Now let's slow *one* of the motors down using resistors. As a first step you will only be using one resistor whose values was chosen so that the motor will probably not be turning or if so very slowly.

- ✓ Insert a 100Ω resistor in series with one of the motor and power supply. Disconnect the other so as not to be distracting. As you may not understand what "in series" means yet you can refer to the physical diagram below.



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**Question 2:** Using the schematic provided showing how the motors are connected directly to the power supply as a starting point, redraw the schematic to include the resistor – you only need to include 1 motor for now.



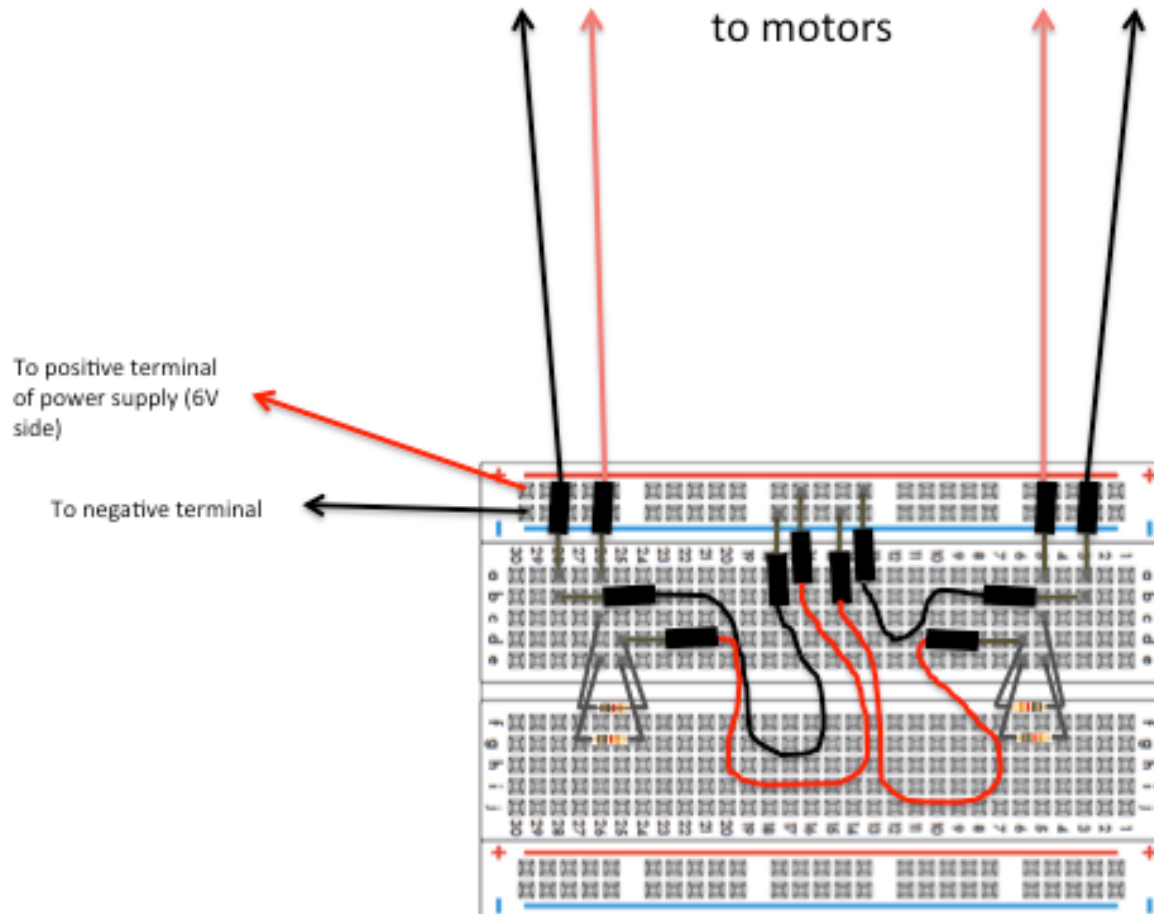
**Question 3:** Is the motor turning? If not try to come up with an explanation. It was definitely turning when connected directly to the power supply.

**Question 4:** Measure the voltage across the motor and the resistor and record these values.

$V_m =$
$V_r =$

Just by adding a resistor you can change the behavior of the motor. Varying the value of the resistance allows you to slow down the motor by differing amounts. When the motor is connected directly to 5V the motor is turning at its maximum speed at that voltage. Adding a 100Ω resistor reduced the voltage across the motor enough that the motor would not turn – you will be characterizing your motors in an upcoming lab where you will determine the voltage needed to get the motors to spin. After that lab you will be able to choose the value of the resistors with knowledge aforethought but for now let's try some other values that are smaller than 100Ω. However, you will not be modifying the circuit by simply choosing a smaller value resistor from your kit but by adding another 100Ω resistor in parallel with the first. Just go with it for now...

- ✓ Now add another 100Ω resistor in parallel with each resistor already in place. Again the physical layout is provided.



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**Question 5:** Draw the schematic of the power supply connected to the motor and resistors – you only need to include 1 motor for now.

**Question 6:** With two  $100\Omega$  resistors in parallel included in the circuit measure the voltage across the motor and resistor network and record them.

$V_m =$
$V_r =$

**Question 7:** How do the recorded voltages in Question 2 and 3 compare? How do the motor rotation speeds compare?

The equivalent resistance of two  $100\Omega$  resistors is  $50\Omega$  and three  $100\Omega$  in parallel have an even smaller equivalent resistance -  $33\Omega$ . You have a comprehensive set of resistors in your kits – Why not just use a smaller value resistor rather than going through the trouble of using multiple resistors in parallel?

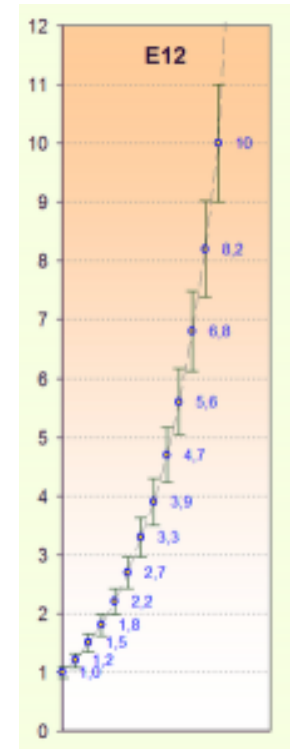
**Question 8:** You actually have a  $1\Omega$  resistor in your kits and you know that when the motor is connected with 5V across the battery terminals with no resistor in series the motors rotates. Do you think it is OK to replace the two  $100\Omega$  resistors with a  $1\Omega$  resistor so that the motor rotates faster? How about a  $10\Omega$  resistor? How about a  $20\Omega$  resistor (hum... there isn't a  $20\Omega$  resistor but a  $22\Omega$  resistor in your package. See the sidebar for the seemingly curious choice of resistor values)? Use what you know of Ohm's law and the power dissipated by the resistors to guide your explanation – this is not a completely straight forward question.

**Question 9:** Since motors are electromechanical devices they usually need to draw more power than any of the other hardware you will use to construct your robot car. Because of the higher energy requirement you must make sure all of the other components connected to the motor can handle it. All resistors have a power rating – a number that indicates the maximum amount of power the resistor can handle. Find the power rating of the resistors in your kit – it is written *somewhere* on outside of the package.

**Question 10:** Explain how connecting resistors in parallel tackles the design constraint addressed in previous question.

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[Standard Resistor Values - Why 47 ohms?](#)



**Question 11:** Hook up the other motor to the supply and a series resistor network. Play with different values of resistances they need not be the same for both motors. There can be even more than two – you can add in some series resistors. Draw schematics for each and indicate how the speed changes for each combination of resistors you used.

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Since the chassis behaves differently when running with a battery and set on the table let's try out the new speed control in autonomous mode.

- ✓ Connect the vehicle to a battery pack so that the car can be run on the big tables.

**Question 12:** Repeat some of the experiments that you performed in Question 3. How does the car behave differently when running on the table as compared to running at the bench supported and connected to the power supply?

**Question 13:** Choose combinations of resistors so the car turns left, right, spins in place. Write down your choices and how the cars behaved.