



### Science Objectives

- Students will explore the parts of a motor.
- Students will discover the relationship between the input voltage and the speed of the motor.
- Students will experiment with the repulsion and attraction of a commutator with magnets arranged around as it spins.
- Students will adjust the number of windings in a motor to change the strength of the electromagnet and the speed of the motor.
- Students will explore the role of the electromagnet in a motor.

### Vocabulary

- |                             |                    |
|-----------------------------|--------------------|
| • RPM                       | • Potential        |
| • DC Motor                  | • Windings         |
| • Electromagnet             | • Permanent Magnet |
| • Commutator                | • Power Supply     |
| • Polarity                  | • Rotor            |
| • Electromagnetic Induction |                    |

### About the Lesson

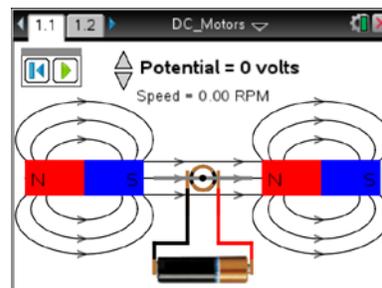
This investigation involves a simple DC motor. The students will explore the parts of the motor and then adjust the voltage or windings in the motor and observe how speed is affected.

As a result the students will:

- Examine the relationship between the voltage of a power supply and the speed of the motor.
- Relate the direction of the spin of the rotor in the motor with the polarity of the power supply.
- Connect the attraction and repulsion of the electromagnet in a motor with the rotation of the rotor.
- Explore the relationship between the number of windings making the electromagnet and the speed of the rotor.

### TI-Nspire™ Navigator™

- Send out the *DC\_Motors.tns* file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to spotlight student answers.
- Quick Poll the class for Formative Assessment.



### TI-Nspire™ Technology Skills:

- Locate and Open TI-Nspire Document
- Open a Document
- Move between Pages
- Use a minimized slider
- Play, Pause, and Reset a Simulation
- Explore hot spots embedded in a simulation

### Tech Tips:

Make sure that participants understand how to adjust the parameters of the simulation.

### Lesson Materials:

#### Student Activity

- *DC\_Motors\_Student.doc*
- *DC\_Motors\_Student.pdf*

#### TI-Nspire document

- *DC\_Motors.tns*



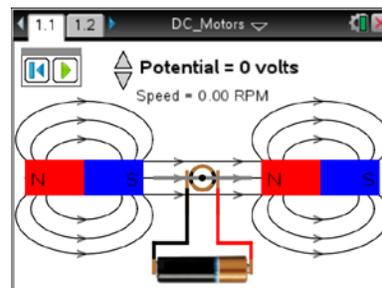
### Discussion Points and Possible Answers

Have students read the background information stated on their activity sheet.

#### Part 1: Exploring the DC Motor

Open the TI-Nspire document *DC\_Motors.tns*.

In this investigation students will explore a DC motor in a TI-Nspire simulation. Initially, they will explore the parts of the motor. Then they will adjust the power supply of the motor to cause the rotor to spin in different directions and at different speeds.

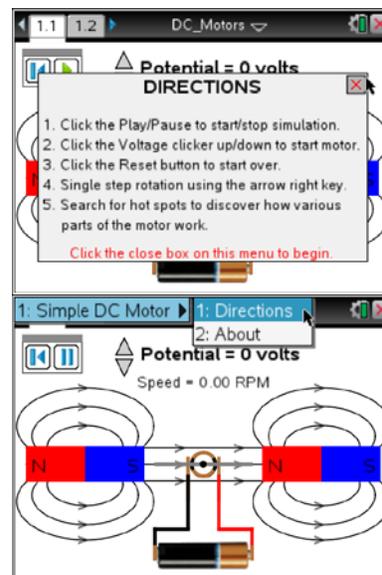


In the second simulation, students will change the strength of an electromagnet to increase or decrease the speed of the rotor.

As students explore the motor they will examine the relationship between the voltage of the power supply and the speed of the rotor.

#### Part 1: Exploring the DC Motor

1. Students are to read the directions explaining how to use the simulation. They can close the pop-up box when they are finished. If needed at any time during the simulation, students can press **menu** if they would like to view the directions again.



2. Now students can explore the hot spots, or different parts, of the motor shown in the simulation. When they move the cursor over the page, the magnifying glass icon  will appear in three places. Students can click to view information about the parts of the DC motor.

Q1. Below, you will see three sets of lines. In the simulation, there are three motor parts indicated by hot spots. On each set of lines below, do the following:

- a) On the top line, write a part of a motor that you observed in the simulation.
- b) Then, write a description of the motor part in your own words.
- c) Draw an arrow from each motor part you listed to its location on the screenshot.

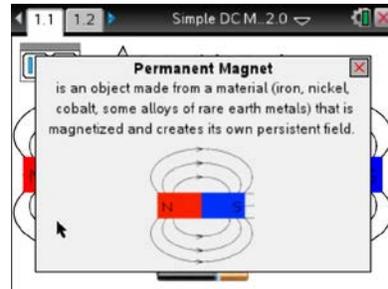
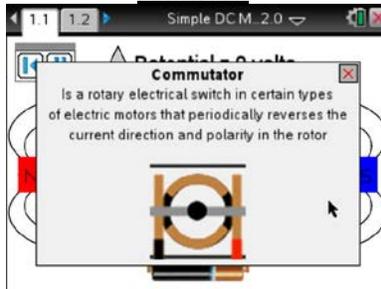
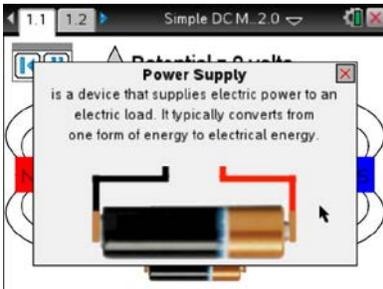


**Commutator**

**Power Supply**

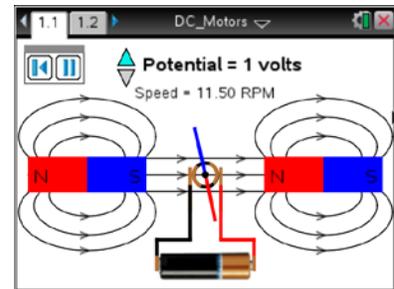
**Permanent Magnet**

**Answers:**



3. Students can press the play button (▶) and adjust the potential (voltage) to observe the effect on speed. Observe the simulation.

To pause the simulation press (⏸). To reset press press (↺).



Q2. What do you observe in this simulation? Write your answer and share this with a neighbor and the class as requested.

**Answer:** As the potential increases, the speed increases. When the potential is positive the spin is clockwise and positive. When the potential is negative, the spin is counter clockwise and negative. The color/polarity of the rotor changes as it moves through the magnetic field.

**Teacher Note:** Use the Notes APP on the Nspire to have the students write their definitions of the hot spots and then use the Navigator Screen shots to collect and discuss in class or just collect the files and read the answers. You could also use Quick Poll Open Response questions to collect this information.



4. For this motor, students are using a power supply to start a rotor rotating and then using the moving rotor in a magnetic field to do work. Have them answer the following questions based on their observations. They can adjust the motor simulation as needed to answer the questions.

Q3. What is **RPM** and what makes the value increase?

**Answer:** RPM means Rotations Per Minute. Increased potential (voltage) makes the speed (RPM's) increase.

Q4. How can you change the direction of the spin of the rotor?

**Answer:** When you change the potential from positive to negative, it changes the direction of spin of the rotor.

Q5. As you play the simulation, watch the colors on the rotor. What happens when blue meets blue? What happens when blue meets red? Why is this interaction important in a motor?

**Answer:** When like colors approach each other, they repel and when opposite colors approach each other, they attract. This oscillating repulsion and attraction causes the spinning of the rotor which makes the motor work.

5. Now students should explore the quantifiable relationship between the voltage of the potential and the speed of the rotor.

Q6. Use the simulation to fill in the missing values in the table below:

**Answers:**

<b>Potential</b>	<b>Speed</b>
-8 volts	<b>-92.00 RPM</b>
<b>-7 volts</b>	-80.50 RPM
-3 volts	<b>-34.50 RPM</b>
<b>2 volts</b>	23.00 RPM
5 volts	<b>57.50 RPM</b>
<b>11 volts</b>	126.50 RPM

Q7. How would you describe the relationship between the potential provided to a motor and the speed at which it runs?

**Answer:** This is a direct relationship. For every one volt change in potential, there is a corresponding change of 11.50 RPM in speed.

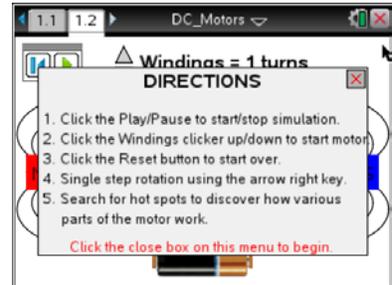


Part 2: Windings and the Motor

Move to page 1.2.

Have students read the background information stated on their activity sheet.

- 6. Have students read the directions box and then close the pop-up menu when they are finished.



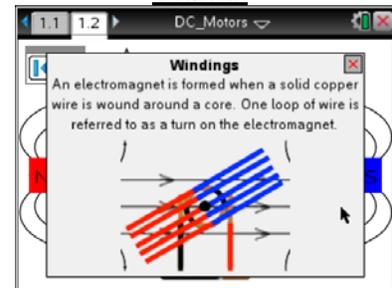
- 7. Now have students explore any the hot spots in this part of the simulations. Students will move the cursor over the page and click when you see the magnifying glass icon

Q8. a. What is the name of the motor part?

b. Write a description of the motor part in your own words.

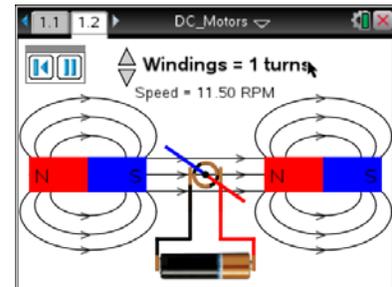
c. Draw an arrow to the motor part's location on the screenshot.

**Answer:**



- 8. Students can press the play button , use the up and down arrows to adjust the Windings, or number of turns, and observe the simulation.

To pause the simulation, press . To reset, press .



- Q9. Describe what you observe as you experiment with the motor on this page. Write your answer and share this with a neighboring student and the class as requested.

**Answer:** As the number of windings increase, the speed of the motor increases.

- Q10. Explore the simulation by increasing the windings. Note what happens to the speed each time you increase the number of turns. Use what you've learned from the simulation to calculate how many turns would be required to get a speed of 632.50 RPM.

**Answer:** 55 turns



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### **Wrap Up**

When students are finished with the activity, collect .tns files using TI-Nspire Navigator or Connect-to-Class. If you used Quick Poll or if you added Questions into the tns file you can save grades to the Portfolio. Discuss the students answers to questions using the Review and look at individual files as a class.