education

MINDSTORMS® GyroBot

In collaboration with NASA

Age 10+

Teacher's Guide

MINDSTORMS® GyroBot

Curriculum Highlights

When students actively build, program, investigate, write, and communicate, they increase their development in numerous ways. The opportunity to integrate subject matter across the curriculum in projects provides a range of contexts for applying concepts, learning new skills, and broadening interests. Specific subject matter is also addressed in the activities.

Science
Focus on kinesthetic energy and Newton's laws of action and reaction.

Technology
Program and create a working model. Interpret 2-D and 3-D illustrations and models. Compare natural systems with mechanical systems. Use software mediato acquire information. Demonstrate your knowledge and operation of digital tools and technological systems.

Engineering
Build, program, and test the models. Add a sensor to enable programs to change speed or to stop. Learn to share ideas and work together to find creative alternative solutions.

Mathematics
Compare the rpms for a model running at different power levels.

Language
Communicate in spoken or written forms using appropriate vocabulary. Prepare and deliver a demonstration using a model. Participate as knowledgeable, reflective members of the group and class.

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Teaching Objectives:

Science
- Forces and motion
- Revolutions per minute (rpm)
- Rotational speed
- Friction
- Mass versus weight
- Newton's laws of motion
- Air resistance
- Pressure
- Scientific investigation

Technology/Engineering
- Using mechanisms
- Assembling components
- Combining materials

Mathematics
- Measuring distance
- Measuring time

Language
- Using spoken, written, and visual language to accomplish tasks.

Materials Required
- 9797 LEGO® MINDSTORMS® Education NXT Base Set or the LEGO MINDSTORMS Retail Set
- MINDSTORMS: GyroBot Teacher Guide from LEGOspace.com
- MINDSTORMS: GyroBot Build Instructions from LEGOspace.com
- Computer loaded with LEGO MINDSTORMS Education NXTVersion 2.1

Vocabulary

- **Angular momentum**
  How an object moves about a fixed point; for example, an ice skater who extends his/her arms to allow for a slower spin and then tucks them inward to spin faster.

- **Centrifugal force**
  An outward force that causes objects to move away from the center of rotation

- **Boom**
  A long beam sticking out from a structure to support or guide an object.

- **Inertia**
  The tendency of an object to resist change in its state of motion; objects in motion tend to stay in motion and objects at rest tend to stay at rest unless acted upon by an outside force.

- **Gyroscope**
  A device for measuring or maintaining orientation rpm: revolutions per minute.

- **Touch sensor**
  A sensor controlled by pressing a button.

- **Ultrasonic sensor**
  A sensor that relies on sound waves to determine distance from an object.

- **Control moment gyros**
  CMGs control the roll, pitch, and yaw of the ISS while keeping it relative to Earth and having the solar panels face the Sun.

Objectives

Learn how a gyroscope will respond in microgravity.

Use the LEGO MINDSTORMS Education NXTGyroBot model to experiment with a robotic gyroscope with light, ultrasonic, rotation, and touch sensors.

Connect

In 1817, Johann Gottlieb Friedrich von Bohnenberger discovered the gyroscope effect. In 1852, Jean Bernard Leon Foucault started performing multiple tests with an object that he named the gyroscope.

Gyroscopes utilize a simple machine – the wheel and axle. They are used for stabilization and navigation in airplanes, space vehicles, robots, ships, helicopters, and other forms of transportation.

Gyroscopic effects can be seen in everyday objects such as bicycles, yo-yos, the Apple® iPhone 4S, Frisbees, the Segway, and gyroscope toys.

What other items can you name that use a gyroscopic effect?
CD/DVD players, spinning tops, motorcycles, race cars, submarines, boomerangs

How do you think the ISS is stabilized in orbit?

Research

Go through Newton's first law – An object at rest will remain at rest and an object in motion will remain in motion unless acted upon by an unbalanced force. This is also known as the law of inertia.

Describe how a gyroscope works.
Gyroscopes work by having an internal wheel or boom/arm assembly that rotates at a constant speed. This constant internal motion causes the object to remain stabilized and resist any outside torque.

What uses would an astronaut have for a gyroscope in space?
Astronauts use gyroscopes for the navigation system of rovers, satellites, space shuttles, the ISS, and many other space vehicles.

Students will complete Step 1 on the worksheet.
Students will build the GyroBot and program it with Gyro On. The Gryo On program should have your GyroBot turn on for 30 seconds at 50% power and then stop with a brake – not a coast.

Students will duplicate the program below using the LEGO® MINDSTORMS® Education NXT software and then download the program onto the NXT. They will then run the program. They should attempt each program at least three times.

To download the program, please return to the website www.legospace.com. Choose Download program under the Gyrobot video

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STEP 1

How does a gyroscope work on Earth? You will make a prediction and then test your GyroBot. Remember to make at least three tests to confirm your data when you complete each step.

1. Describe what you think the GyroBot will do when you run Gyro On.

2. Run the Gyro On program. What did you observe?

Watch the first part of the video.

Watch the first part of the video that shows the GyroBot using the Gyro On program to turn on for 15 seconds and stop with a "hard" brake.

3. Were there any differences in how your model performed on Earth and how the astronaut's model performed in microgravity? Please explain.

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STEP 2

Program your GyroBot to use the program Gyro Touch. The program will make the GyroBot turn on for 15 seconds at 50% power when the touch sensor is pressed. The GyroBot will then coast to a stop.

Students will duplicate the program below using the LEGO MINDSTORMS Education NXTsoftware and then download the program onto the NXT. They will then run the program. They should attempt each program at least three times.

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1. Describe what you think the GyroBot will do when you run Gyro Touch.

2. Run the Gyro Touch program. What did you observe?

Watch the next segment of the video that shows the GyroBot using the Gyro Touch program.

3. Were there any differences in how your model performed on Earth and how the astronaut's model performed in microgravity? Please explain.

4. What did you notice about the coast brake as opposed to the hard brake in microgravity?

5. Why do you think the GyroBot spun in the opposite direction of the spinner in microgravity?

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STEP 3

Program your GyroBot to use the program Gyro Ultrasonic. The program will start the GyroBot when the touch sensor is pressed. The bot will run until an object is placed less than six inches away from the ultrasonic sensor. Then, the GyroBot will coast to a stop.

To download the program, please return to the website www.legospace.com. Choose Download program under the Gyrobot video

1. Describe what you think the GyroBot will do when you run Gyro Ultrasonic.

2. Run the Gyro Ultrasonic program. What did you observe?

Watch the next segment of the video that shows the GyroBot using the Gyro Ultrasonic program.

3. Were there any differences in how your model performed on Earth and how the astronaut's model performed in microgravity? Please explain.

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STEP 4

Program your GyroBot to use the program Gyro Light. The program will make the GyroBot start at 25% power when the touch sensor is pressed. When the touch sensor is pressed again, the power will increase to 50%. When the touch sensor is pressed a third time, the power will increase to 75%. When the touch sensor is pressed a fourth time, the power will increase to 100%. When the touch sensor is pressed a fifth time, the GyroBot will coast to a stop.

Students will have a chart to record data.
Students will need to download the program from LEGOspace.com onto the NXT, using the LEGO MINDSTORMS Education NXT software. They will then run the program. This program is very complex, as shown below, and should be downloaded rather than the student duplicating it by recreating the program in the NXT software.

Through the use of the light sensor's ability to measure reflected light values, there are white LEGOtiles attached to the bottom of the GyroBot's booms. As the booms spin and the white tiles pass over the light sensor, which is pointed up, the light sensor should report a different reflected light value for the white tiles versus the open area when the boom is not over the light sensor.

Because we know that the gyro has two booms, each having white tiles on the bottom, we know that two passes of the white tiles would mean the gyro has completed one full rotation. By measuring and recording the time between rotations, we can calculate rotational speed of the arm compared to the speed/power applied to the motor.

The program is designed so that at the first touch and release of the touch sensor, it will turn the motors on at 25% power and then measure, calculate, and display the rotations of the arm in revolutions per minute (rpm). Each time the touch sensor is pressed and released after the first time, the speed of the motors will increase by 25% and the change in rotation and rpm will be updated on the NXT display. After the speed reaches 100%, the next touch and release of the touch sensor will cause the program to end.

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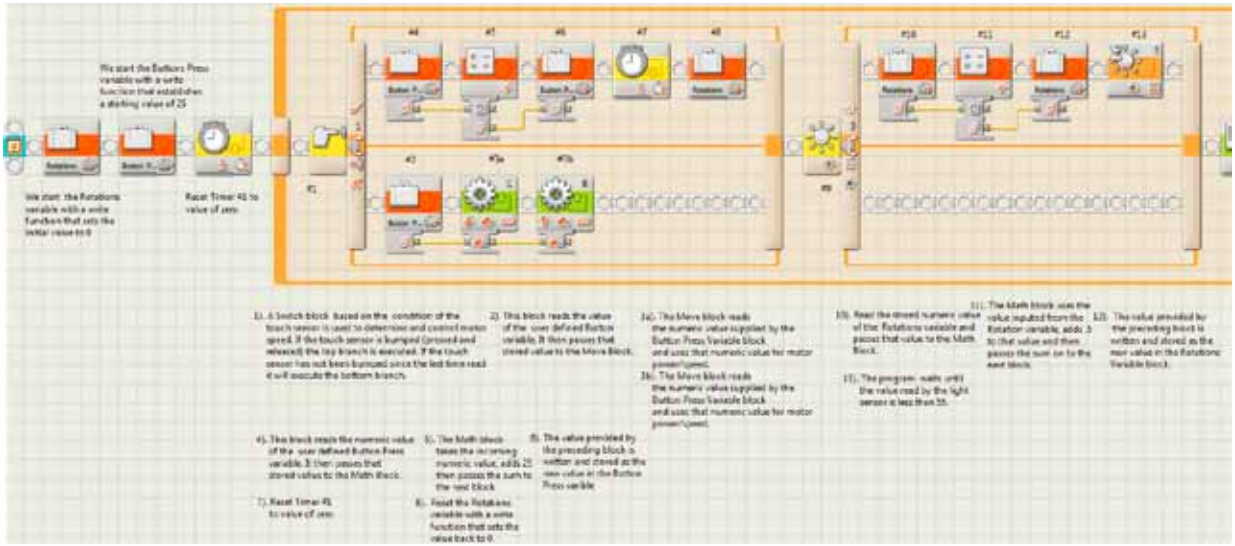
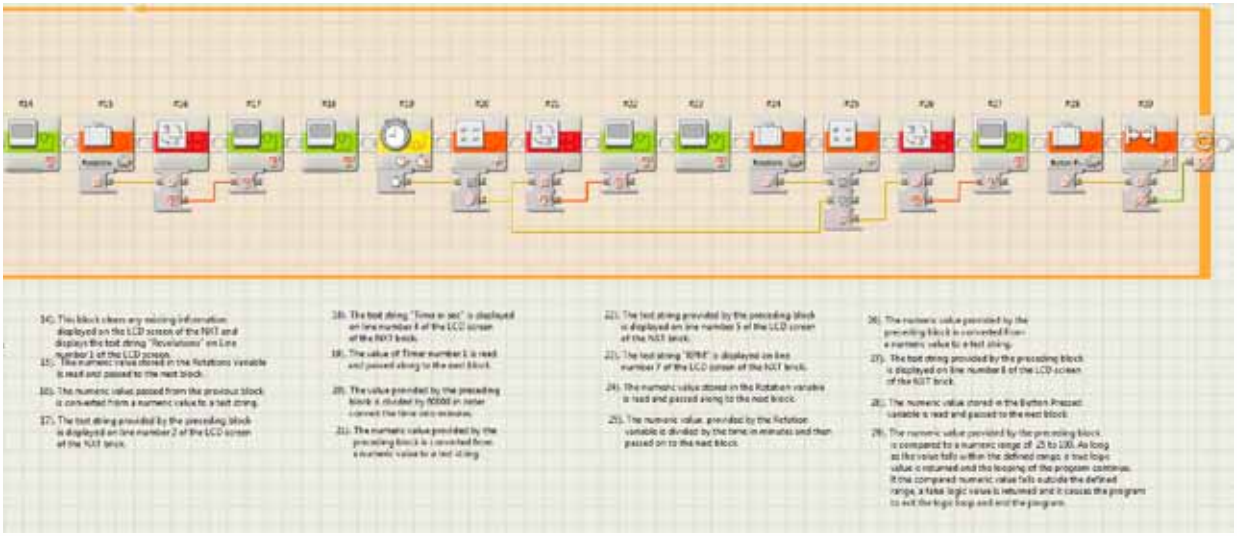
STEP 4





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STEP 4

1. Run the Gyro Light program. Complete the first two columns of the chart. Make sure you use details about what you observe.

2. Watch the next segment of the video that shows the GyroBot using the Gyro Light program.

3. Complete the last two columns of the chart. Make sure you use details about what you observe.

4. How does the power of the motors affect the stability of the gyro? Explain if it is more or less stable at higher power levels and what causes the change in stability.

5. Did the rpms differ between your model and the one on the ISS?

6. Explain to the students Newton's third law – for every action, there is an equal and opposite reaction.

7. How can you prove Newton's third law of motion using the LEGO bricks GyroBot model?

8. Explain to the students Newton's second law: the acceleration of an object is dependent upon two variables – the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object and inversely upon the mass of the object.

9. Create and program a new LEGO MINDSTORMS Education NXTmodel to prove Newton's second law of motion.

EXTENSION:

Change the location of the weights or remove one set of weights on the GyroBotto make the GyroBotunbalanced.

1. Describe what you think will happen when the GyroBot uses the Gyro Light program. Be specific about what you will see at each power level.

2. Run the Gyro Light program. Describe what you observe at each power level. Was that what you predicted?