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LEGO education

Smart Spinner
Age 7+
Teacher’s Notes

In collaboration with NASA
Smart Spinner

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
Trace the transmission of motion and transfer of energy through the machine. Identify the simple machines' mechanisms at work in the models, including levers, gears, and pulleys. Become familiar with complex motion using a cam, worm gear, and crown gear. Understand that friction can affect the movement of the model. Understand and discuss criteria for a fair test.

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

Engineering
Build, program, and test the models. Modify a model's behavior by changing the mechanical system or by adding a sensor to provide feedback. Learn to share ideas and work together to find creative alternative solutions.

Mathematics
Using the Smart Spinner model, measure time in seconds and tenths of a second. Estimate and measure distance in centimeters or inches. Understand the concept of randomness. Compare diameter and rotational speed. Understand and use numbers to represent types of sounds played and the amount of time the motor turns on. Understand how the position of the model is measured by the tilt sensor. Understand and use numbers to measure and score qualitative characteristics.

Language
Communicate in spoken or written forms using appropriate vocabulary. Prepare and deliver a demonstration using a model. Use interview questions to find out information and write a story. Write a script with a dialogue. Write a logical sequence of events to create a story with main characters; add visual and sound effects. Use technology to create and communicate ideas. Participate as knowledgeable, reflective members of the group and class.

Amazing Mechanisms
The Amazing Mechanisms theme focuses on physical science concepts. In Smart Spinner, students investigate the effect of smaller and larger gears on a spinning top.

Students will build and program a spinner mechanism that is motorized to spin and release a top and that uses a motion sensor to turn off the motor when the top is released.
Teacher's Notes

Smart Spinner

Teaching Objectives:

Science
• Trace the transmission of motion and transfer of energy through the machine.
• Identify the gear mechanism and the effect of the gears on the length of time the top can spin.

Technology
• Create a programmable model to demonstrate knowledge and operation of digital tools and technological systems.

Engineering
• Build and test the spinner movement. Modify the spinning behavior by changing the gears to affect the speed of the top and the length of time it spins.

Mathematics
• Understand how the number of teeth and the diameter of the gears affect the speed of the movement.
• Compare the ratio of the smaller and larger gears.

Language
• Communicate in spoken or written forms using the appropriate vocabulary.

Materials Required
• 9580 LEGO® Education WeDo Robotics Construction Set
• Smart Spinner Teacher Notes from LEGOspace.com
• Smart Spinner building instructions from LEGOspace.com or from software
• Stopwatch
Vocabulary

- **crown gear**
a toothed wheel that has teeth out to one side looking like a crown; when meshed with a regular gear, a crown gear transfers the motion through a 90° angle, or perpendicular to the original direction of motion

- **friction**
the resistance met when one surface is sliding over another; e.g., when an axle is turning in a hole or when you rub your hands together

- **gear**
a toothed wheel or cog; the teeth of the gears mesh together to transmit movement; often called a spur gear

- **gear train**
a group of gears mounted on a frame so that the teeth of the gears are meshed together and all gears are moved when the driver is rotated

- **gearing down**
when a small driver turns a large follower, amplifying the force and causing the follower to turn more slowly

- **gearing up**
when a large driver turns a small follower, reducing the force and causing the follower to turn more quickly

- **program**
a set of instructions created on a computer

- **rotation**
turning on an axis

- **speed**
the distance traveled within a specific amount of time; rotational speed is described in rotations per minute, or RPM; the speed of objects is described in distance over time; e.g., kilometers per hour, miles per hour, centimeters per second
Before you start programming, please make sure your connect center (in top-left corner) has the Smart Spinner hardware (motion sensor, hub, and motor) connected.

**Connection Tab:** Record your own sounds and view any Motors, Tilt Sensors, or Motion Sensors.

**Project Tab:** Click to open the menu showing:
- Exit
- Open Project
- New Project

The Canvas is the white working area to where you can drag and drop any Blocks.

The Palette shows all of the programming Blocks.

Click the **Stop button** to stop programs and motors.
Blocks

- Add to Display
- Display
- Motion Sensor Input
- Motor Off
- Motor This Way
- Number Input
- Play Sound
- Repeat
- Wait For
Connect

Mia is learning about the rotation of Earth at school. She explains to Max how Earth rotates on its axis as it revolves around the Sun. To demonstrate, Mia uses a spinning top. She describes how Earth is like a spinning top and rotates on its axis. Unlike a spinning top, however, Earth doesn’t speed up or fall over – it spins at a constant rate due to the conservation of angular momentum.

Max is curious to learn how angular momentum causes the top to continue spinning. He asks Mia to help him test the top to see how long it will spin. Max then wonders if the top would react the same way in space.

Let's help Max and Mia investigate how a spinning top works and if it will spin for the same amount of time in space.

Will the spinning top work the same in orbit as it does on Earth?
Connect

Here are some other ways of connecting:

Take a coin, a pen, or other object and try to spin it on your table or desk.

**How long does it spin?**
Most objects are not stable enough to spin for long and will quickly fall down. The friction of the table or other surface slows and stops the movement. To keep the object spinning, the spinning force must be applied evenly to the center of the object; otherwise, the object will not be balanced and will not spin but will instead move off in another direction.

Pretend you are a spinning top and spin in place.

**What do you do with your body to spin a long time?**
**What do you do to try to spin faster?**
You can stand tall and put your arms out to stabilize your body as you spin. Keep your feet together as much as possible to have a “point” in the center of the spinning movement.

**How do the gears work?**
They mesh together to transmit movement.
Construct

Build the model following the step-by-step instructions.

- To best operate the spinner, make sure the gear train of the handle meshes with the gear of the spinning top when the spinning top is inserted. Do not press the spinner top hard against the surface, but let it spin freely before releasing.

- By programming the spinner top, you are transferring the energy from the computer powering the motor to the crown gear. The crown gear turns the small gear that it is meshed with. On the same axle as the small gear is a large gear, so the large gear also turns. The spinner top is inserted into the handle. On the spinner top is a small gear.

- When the spinner top is inserted and the handle motor is turned on, the handle spins the top.

- When the top is released from the handle, the top keeps spinning. The combination of gears is called a gear train.

- The energy changes from electrical (the computer) to mechanical (physical movement of the gears, spinning the top) energy.

Download Building Instructions at LEGOspace.com.
Construct

Build the model following the step-by-step instructions.

- The program turns on the motor, plays Sound 15 – the Motor sound – and then waits for the motion sensor to see that the spinner handle has been lifted to release the top. Once the handle is released, the program turns off the motor.

- See the LEGO® Education WeDo Software section for the Sound List referencing the Play Sound Block numbers with descriptive names.

- See Getting Started for more examples with the Motion Sensor Input, Motor Off, Motor This Way, Play Sound, and Wait for Blocks.

Download Building Instructions at LEGOspace.com.
Contemplate

Smart Spinner

Set up enough space to experiment with the gears and make notes of your observations.

Draw a data table on a separate sheet of paper. Use the data table to record the changes in the gear positions and the length of time in seconds the top spins with each gear combination.

After investigating the gears, discuss conclusions to the data tables.

For how long did the top spin when the handle had a 24-tooth gear and the top had an 8-tooth gear as shown in the first line of the chart?

Answers will vary. This combination is very fast and stable, so most should run for several seconds. Collect the answers to summarize a range for the class.

When you changed the top from an 8-tooth to a 24-tooth gear as shown in the second line of the chart, did it spin for a longer or shorter time?

Usually this combination spins slower than the combination above because the speed of the top has been reduced. When the top spins slower, it tends to spin for a shorter period of time.

When you changed to the 8-tooth gear on the handle and the 24-tooth gear on the top as shown in the third line of the chart, did the top spin for the longest or shortest time compared to the previous combinations?

Usually this is the slowest-spinning top with the shortest spinning time.
Continue

Watch the Smart Spinner video on LEGOspace.com.

The student worksheet will provide a space for the students to write data presented in the video.

Question: Will the LEGO® Education Smart Spinner spin for the same amount of time in space as it does on Earth?

Research: Has NASA ever experimented with a device like this in space? If so, what were some of the aspects the crew had to consider during testing?

In microgravity, the Smart Spinner top will continue to rotate until acted upon by another force. (Newton’s first law of physics) This holds true regardless of the gear ratio of the handle or the top.

Hypothesis: Do you think the Smart Spinner, using the motion sensor, reacts the same in space as it does on Earth?

Did the results turn out the way you thought they would? Yes □ No □

What connections can you make between what you did on Earth and what the astronaut did aboard the ISS?

Was your hypothesis true □ or false □?

Students will answer questions posed by the astronaut.
The results can be posted to LEGOspace.com.

Questions

1. How long did the spinner top spin on a flat, horizontal surface? How about on a flat, vertical surface?

2. Did the LEGO Smart Spinner work in microgravity the same as it did in your classroom? If not, how was it different? Explain your answer.

3. In your classroom, can you write a program that uses a different sensor with the LEGO Smart Spinner model? If so, describe that program.

4. What other designs could you create that utilize the motion sensor? What about other designs that use a tilt sensor?
Continued

Activity Data Table

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<th>Handle</th>
<th>Top</th>
<th>Top spins this long</th>
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<td>![Gear Icon]</td>
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</tbody>
</table>

Extension Ideas

How do you make something move slower using gears?

Make sure the movement is transferred from a smaller gear to a larger gear. Motion transmitted from a smaller (8-tooth) gear to a larger (24-tooth) gear is called gearing down because speed is reduced.

How do you make something move faster using gears?

Make sure the movement is transferred from a larger gear to a smaller gear. Motion transmitted from a larger (24-tooth) gear to a smaller (8-tooth) gear is called gearing up because speed is increased.