

Gears Rule	Grade 3 and 4	
Lesson Plan	Coding Tool	Scratch
	Time Required	Three Periods
<p>Math Curriculum Connections</p> <p><u>Algebra</u></p> <p>Overall Expectations</p> <p>C1. Identify, describe, extend, create and make predictions about a variety of patterns, including those found in real-life contexts</p> <p>C3. Solve problems and create computational representations of mathematical situations using coding concepts and skills</p> <p>Specific Expectations</p> <p>C1.3 determine pattern rules and use them to extend patterns, make and justify predictions, and identify missing elements in patterns</p> <p>C3.1 solve problems and create computational representations of mathematical situations by writing and executing code, including code that involves sequential events</p>	<p>Science Curriculum Connections</p> <p><u>Grade 3</u></p> <p>Forces Causing Movement</p> <ul style="list-style-type: none"> • Forces cause objects to speed up, slow down, or change direction <p>Overall Expectations</p> <p>3. Demonstrate an understanding of how forces cause movement and changes in movement</p> <p>Specific Expectations</p> <p>3.1 Identify a force as a push or a pull that causes an object to move</p> <p><u>Grade 4</u></p> <p>Pulleys and Gears</p> <ul style="list-style-type: none"> • Pulleys and gears change the speed, direction, and motion of, and force exerted on, moving objects <p>Overall Expectations</p> <p>2. Investigate ways in which pulleys and gears modify the speed and direction of, and the force exerted on, moving objects</p> <p>Specific Expectations</p> <p>3.4 Describe, using their observations, how gears operate in one plane</p>	
<p>Description</p> <p>In this lesson, students will learn to recognize gears as a part of a pattern which allow us to predict how gears interact with one another. With this knowledge, students will create rules for gears using conditional statements and apply those rules using both an unplugged activity and an activity using Scratch.</p>		

Success Criteria

- The 3rd and 4th grade students will be able to identify how gears interact with each other by creating and applying a set of rules
- The 3rd and 4th grade students will be able to demonstrate how gears interact by simulating gears using Scratch

Materials and Media

- Gears Rule Handout
- Gears Rule Teacher Solution
- Gears Rule Assessment
- Gears Rule Coding Guide
- Gear.png
- Pencils, crayons
- Devices with Scratch

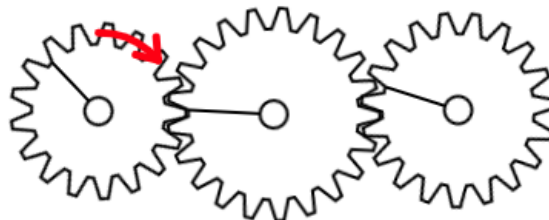
Computational Thinking Skills

This lesson utilizes both an unplugged and an online component to introduce students to block coding while reinforcing the concept of condition statements. In the unplugged part of the lesson, students will use conditional statements to express how gears interact with each other. A conditional statement is used in coding to execute a condition if a statement is true. This allows a computer to achieve an output based on the information it is receiving. We can think of a conditional statement as a rule that must be followed by a computer. For example, If we press the power button on a computer, Then the computer turns on. The computer must follow this rule unless it is coded otherwise. By using multiple conditional statements, a computer can decide which rule best fits the situation and apply it, allowing it to make decisions based on the information it is receiving. The conditional statement that is primarily used in this lesson is the If Then statement, which implies that If an input is received, Then an output is generated.

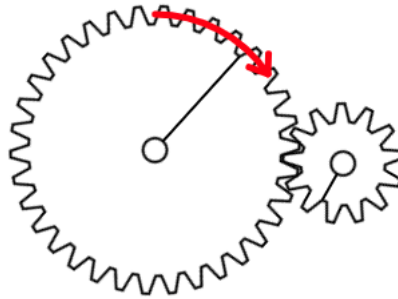
In the Scratch part of this lesson, students will use block coding to simulate gears. In addition to familiarizing themselves with the software, students will use forever (infinite) loops that will allow their program to repeat infinitely unless they decide to shut it down.

Introduction

Patterns are a series or sequence that repeats itself. In math, sequences repeat based on rules and we can use those rules to predict what will happen next or to solve a problem. By this definition, it is possible to look at gears as part of a pattern. Gears interact in predictable ways and by understanding those actions, it is possible to determine exactly how a series of gears (a gear train) will behave. For example, gears in series will turn in alternate directions. Looking at the image below, if the first gear is moving clockwise, then the next gear in series must turn counter-clockwise. The third gear would then turn clockwise and so on. Using this pattern, it's possible to predict what direction a fourth, fifth or sixth gear would be turning if we added it to the series. Have your students predict what direction a sixth gear would turn in this sequence. They should predict counter-clockwise by following the pattern.



When gears are placed in series, they can serve two purposes. One is to change the direction of movement, the other is to change the speed (and force) of an object. When two gears are connected, if the first gear has more teeth (generally bigger) than the second one, then the second smaller gear has to turn much faster to keep up. Alternatively, if the first gear has fewer teeth (generally smaller) than the second one, then the second larger gear moves slower in comparison. The trade-off of a gear moving slower is that it can generate more force. With that in mind, look at the image below. Would the gear to the right be moving faster or slower than the gear on the left? Would it be generating more or less force? Your students should be able to predict that it is moving faster but with less force.

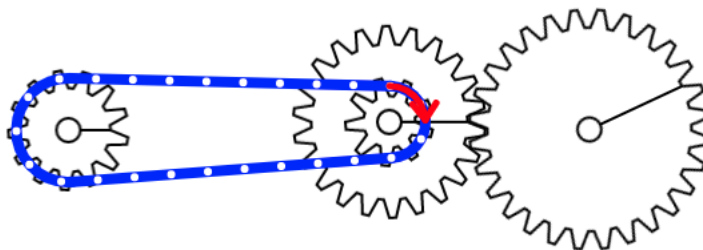


In this lesson, students will expand on their knowledge of gears by following their patterns and creating rules out of conditional statements to better predict how gears in series will behave.

Action

Introducing the Concept

The first part of the lesson uses a free online program called GearSketch which can be accessed by going to the website gearsket.ch. On this website, drawing circles creates gears that can be connected. Adding an arrow to a gear determines the speed (force) that the gear is turning at and multiple forces can be applied. Gears can also be connected using drive belts by drawing a loop around two gears. To see how GearSketch works, simply click on the question mark at the top right of the video to watch a quick tutorial. To start the lesson, give students time to explore GearSketch. There is no right way to do this, simply use the time to discover how it works.



Once students are more familiar with GearSketch, the next part of the lesson requires them to explore more about gears using the *Gears Rule Handout*.

The objective of this handout is for students to write rules for how gears work. They will be writing the rules in the form of an If Then conditional statement. When computer programmers write out code, this is called pseudo-code. An example of a rule that applies to gears using pseudo-code is:

*If a gear has a force applied to it
Then the gear will turn*

The handout included six rules that apply to gears. Students will have to write and draw each rule on the handout. In some situations, they will be required to write the pseudo-code for an opposite condition. For example, if they predict what happens in a series with an even number of gears, they'll have to write what happens with an odd number of gears as well. Have students use GearSketch to test each rule. If students still need some time to learn about gears and the GearSketch program, it is possible to do some of the rules together before allowing them to finish the handout.

The *Gears Rule Teacher Solution* document has the answers for each of the rules.

Applying the Concept

In the next portion of this lesson plan, students will be required to test the rules that they created in the previous section. In a way they are now behaving like a computer which has been coded to understand gears. Like a computer, they will have to look at the gears sequentially, one at a time, to determine how it behaves before moving to the next gear. By moving through the gears one at a time, they will get to the end result which is being able to say what way the final gear in the gear train is moving.

The *Gears Rule Assessment* document has four gear trains of increasing complexity. The student's task will be to predict the direction that the last (right-most) gear is turning as well as its relative speed compared to the first gear. It is recommended that students move one gear at a time, drawing arrows to indicate the direction and relative speed of each gear in the sequence. Alternatively, they can apply some of the rules they used to move directly to the last gear and attempt a prediction, though it may not be as accurate. Once students have predicted the direction and speed of the final gear, they will be able to build the gear train with GearSketch to check their work. In this sense, this activity acts as a form of *assessment as learning* in which students are checking their own work

The last portion of this activity is that students can draw their own gear train on a piece of paper and trade pages with a partner to see if they can predict the direction and relative speed of the final gear. They can use GearSketch to test their gear train or to demonstrate the gear train to their partner. **Note:** When drawing gears, students can draw them as circles to eliminate the need for drawing the gear teeth.

Culminating Math Activity

In the culminating math activity, students will apply what they know about gears to create a gear train in Scratch. To complete the activity, it's best to guide the students through the code for a single gear, then let them determine how to code additional gears in the sequence. The procedure for coding a single gear, as well as the code for the subsequent challenges are all found in the *Gears Rule Coding Handout*. A sample of this type of program can be found here:

<https://scratch.mit.edu/projects/438665696/>

Once you have established how to code a single gear in the program, present students with the following three challenges which will require them to create gear trains with specific conditions:

- 1) Code two gears that are the same size
- 2) Code three or more gears
- 3) Code two or more gears that are different sizes

As students are working on this task, have them show their gears trains once they complete each challenge. Use this as an opportunity to complete some *assessment for learning* to gauge how well students understand the gear concepts they have been taught.

If students finish their challenges early, task them with creating some more complex gear trains, whether using more gears, different sized gears or even a drive belt.

Closure and Assessment

By the end of the lesson, students should have a strong understanding of how gears move in relation to one another. Over the course of lesson, opportunities for assessment were presented. The *Gears Rule Assessment* document was a self-assessed activity in which students could gauge their own understanding of gears, serving as a form of *assessment as learning*. The Math Activity in which students had to code gears using Scratch had three challenges that students could complete. By observing how students perform on this task, teachers can do *assessment for learning* and determine if further learning is required about gears. Finally, the Gears Rule Handout had students complete a series of rules about gears which could be collected as a form of *assessment of learning* based on the accuracy of the students work.

<p>Adaptations</p> <ul style="list-style-type: none"> • Spend more time using GearSketch. Give students simple tasks to accomplish on the program • GearSketch and Scratch can both be used on an iPad or tablet which can be easier for students with limited dexterity • When drawing gears, have students draw them as circles with the understanding that there would normally be teeth • Modify how much of the lesson is guided as opposed to student led learning 	<p>Extensions</p> <ul style="list-style-type: none"> • Each of the activities has an extension to allow for further challenges. • Gears Rule Handout: Have students create a rule of their own based on the observations they made using GearSketch • Gears Rule Assessment: Students can create their own complex gear train and challenge a partner to solve it • Scratch Math Activity: Students can code more complex gear trains, including one with a drive belt
<p>Additional Resources</p> <ul style="list-style-type: none"> • Gearsket.ch • Scratch.mit.edu 	