Get in Gear

Subject Areas	Algebra, measurement, numbers, and operations
Associated Unit	None
Associated Lesson	None
Activity Title	Get in Gear
Header	Insert Image 1 here, right justified to wrap

Image 1

ADA Description: A robot designed by students

Caption: A robot designed by students for the 2009 Brooklyn Borough Competition

Image file name: ActivityImage1.jpg

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Grade Level	7(6-8)
Activity Dependency	None
Time Required	50 minutes
Group Size	4

Insert Image 2 here, centered

Image 2

ADA Description: Gears in a car engine

Caption: Timing gears in a Ford engine

Image file name: ActivityImage2.jpg

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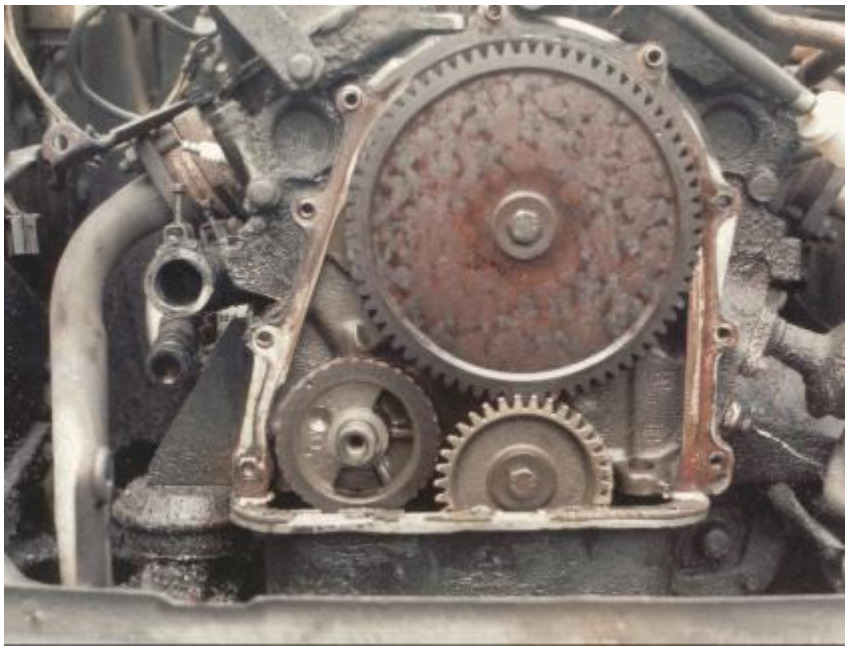
http://en.wikipedia.org/wiki/File:FordtaunusV4front.jpg



Summary
Students are introduced to the idea of gear ratios and how they are used in everyday life and in robotics. Students discover how gears work and how they can be used effectively in robot designs to increase speed or torque. Students quickly recognize that some tasks require a faster robot while others are more suited for slower, more powerful robots. They are introduced to torque and speed, the two traits of the robot affected by using gears. Once the students are introduced to the principles behind gear ratios, they are put to the test in two simple activities. One of the activities is better suited for a quicker robot while the other calls for a more powerful robot. A set of questions follow in the attached worksheet to ensure that the students understand the way gears work and the balance between torque and speed.

Engineering Connection
Sometimes there is a need for a machine to go fast, while at other times it is more critical that the machine produces more torque. These two contrasting situations can be achieved by using different gear ratios (see Image 2). Gears aligned in certain configurations allow for much faster speeds, such as those attained in race cars. In other settings, these same gears arranged differently would produce larger torque, such as needed for a bulldozer.

Engineering Category	Relates math concept to engineering
Keywords	Gear, gear ratio, torque, speed

Educational Standards
- New York science: 1.2, 1.3 [1]
- New York math: 1.1, 1.2, 2.2, 4.3 [1]

Pre-Requisite Knowledge Division, basic concept of a ratio, basic programming skill with Lego Mindstorms software

Learning Objectives After this activity, students should be able to:

- Describe what gears are and how gear ratios work
- Describe how to make a faster robot versus a powerful robot
- Define torque and speed, and know which combination of a large gear and small gear is more suitable for each

Materials List

Each group needs:

- Lego NXT kit with different gear sizes included
- Calculator to calculate the gear ratios

To share with the entire class:

- Colored tape
- A number of different sized books

Introduction/Motivation

Can anyone tell me what a gear is and what type of gears do we experience in our everyday lives? (Give students some time to ponder here. If you draw blank stares, give them some examples of machines that use gears such as clocks, cars, robots, etc). How do gears work? (Answer: Gears transmit motion from motors to other parts of the machine. To help the students understand this, attach a gear to an axle and place another gear adjacent to it so that the teeth of the gears mesh, see Figure 2 in worksheet. Twist the axle to show that motion is transmitted from one gear to the next). Now that we know that motion is transmitted along gears, how does this benefit society? Sure, we can place two gears of exactly the same size next to each other. This strictly transmits motion in the way it was originally intended as an output from the motor. However, we can control the behavior of this motion by using gears of various sizes or gear ratios. A gear ratio is the relationship between the "teeth" of two gears that are meshed together. The teeth of a gear are the pointed edges of the gear that you can count. (Give students a number of different gears and tell them that you want them to count the number of teeth and relay the answer back to you to see if they understand the concept.) In Image 3, displayed in the attached worksheet, the number of teeth on the smaller gear is 13, while the larger middle gear has 21 teeth. The gear ratio is just the ratio of the number of teeth on output gear versus the number of teeth on the input gear (21/13 = 1.62) [2].

Depending upon the situation, gear ratios could be very useful. As we will soon see, certain traits of the machine/robot are affected by using proper gear ratios. These two traits are torque and speed. Can anyone tell me what torque is? (Wait for an answer here. If you don't get one or there is some confusion just simply state they will soon have a better idea of torque following the activity. Answer: Torque measures how hard something is rotated. Using a wrench analogy, amount of torque applied to a bolt depends on how long the wrench is, how hard one pushes down on the wrench, and how well you are pushing it in the right direction.) Now can anyone

define speed for me? (Answer: Speed is the rate of change of distance. In other words, it is the length of distance covered divided by the time it took to travel that distance.) We will now see how torque and speed can be controlled using gear ratios.

Vocabulary / Definitions

Word	Definition
Torque	A measure of how hard something is twisted.
Speed	Rate of change of distance with respect to time.
Teeth	The pointed edges of any gear that one can count.

Procedure

Before the Activity

- Construct and program a Lego NXT robot as outlined in the attached worksheet.
- Download attached robot program onto LEGO Mindstorms and display on an overhead projector so that the class can follow along as you explain the programming section of the activity.
- Copy attached worksheet so that there is one for every two students.

With the Students

1. Divide the class into groups of four.
2. Make sure each group has a LEGO NXT kit complete with various gears, a calculator, and access to a computer for the programming section of the activity.
3. Have each group build the general chassis design from the LEGO Mindstorms Education manual [3] completing up to Step 16.
4. Ask students how would they normally make the robot go faster? (Answer: Increase the power level output of the motors). Have the students program the robot program attached in the worksheet and try different power levels starting from 50. Tell students to write down their observations on their worksheet.
5. Now ask the students if there is any way to make the robot go faster if the motors are already at max power level 100.
6. Redesign the bottom of the chassis using the pieces illustrated in Figure 3 of the worksheet. Have the students choose between placing the small or larger gear as the output gear and come up with a hypothesis.
7. Set up a race between two groups. Each group should have a different setup with regards to the small or large gear being the output gear. Run program and tell the students to record their observations on their worksheet.
8. Now ask students to construct a front bumper for the robot as illustrated in Figure 4 of the worksheet. Next, place some heavy books on the floor that will be pushed by the robot. Have two different groups, again with different setups for the output gear, run the program to see which robot is “stronger” in pushing various books (changing from light to heavy books, or adding additional books). Have the students record their observations on their worksheet.
9. Bring the class back together for a final discussion.

Attachments
Get in Gear Worksheet (WorksheetforGetinGearActivity.doc)

Get in Gear Robot Program (GearRatioActivity.rbt)

Troubleshooting Tips
Build the robot design as illustrated in the worksheet. Test the robot's program before the class.

Investigating Questions
None

Assessment

Pre-Activity Assessment
Gears Name Game: Name the different gears in Figure 1 of the worksheet.

Activity Embedded Assessment
Gear Ratios and 1: Challenge the students to come up with three rules of gear ratios (equal to, less than, or greater than) and the value 1 when it comes to pairing different gear sizes.
Transmission Mission: Challenge the students to think about the role of transmissions in cars. Why is it more efficient to remain in 1^{st} gear when driving up a steep mountain? What about driving in 6^{th} gear when driving on the highway?

Activity Extensions
None

Activity Scaling
- For upper grades, one could have the students begin to explore gears in real-life examples in more detail such as automatic transmissions and car engines.

Redirect URL http://gk12.poly.edu/amps/

Owner Michael Hernandez

Contributors Michael Hernandez, Carole Chen

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References

[1] http://www.jesandco.org/asn/viewer/default.aspx
[2] http://en.wikipedia.org/wiki/Gear_ratio
[3] LEGO MINDSTORMS Education kit 9797 ©2006 The LEGO Group

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