

## ***Topic: Gear Ratio and Torque***

**Teachers:** Laura Scarfogliero and Donna Gobin  
**Genre:** Mathematics  
**Grade Level:** 6-7th grade

**Unit:** Ratios & Proportions  
**Estimated Duration:** 1-2 single period

### **Essential Question**

**(Domain 1: Planning and Preparation-Component 1c: Designing Coherent Instruction)**

- **How are ratios and proportions used to compare two quantities or values? Where can examples of ratios and proportions be found in real life situations?**

### **Background Knowledge**

#### **Background Summary:**

Students are expected to have an understanding on how to solve basic one step equations. They will be introduced to the equation for torque ( $T = fd$ ).

Students will need to have some basic understanding of gears. For example, the force of the output gear will be opposite the force of the input gear. They should also connect the number of teeth and diameter of the gears and that they change proportionally.

The students should understand that ratios can be presented in several ways (i.e. 1:3,  $\frac{1}{3}$ , 1 to 3). This lesson can be used to reinforce or introduce proportional relationships. There are several questions in the worksheet that would flow nicely into a conversation on proportions.

There is also an intercurricular connection in science and simple machines. Students should understand that machines change the direction or magnitude of a force. A discussion can also be made about the similarities between gears and pulleys.

During this unit, students will learn the effects of different types of forces on the motion of objects, through the study of Newton's laws of motion. Newton's laws state: (1) an object at rest will stay at rest until an unbalanced force acts upon it. Every object moves in a straight line unless acted upon by a force. (2) The acceleration of an object is directly proportional to the net force exerted and inversely proportional to the object's mass.  $F=ma$  (3) For every action, there is an equal and opposite reaction. Students will also need an understanding of friction and how it affects a moving vehicle.

#### **Lesson Objective:**

- Students will understand the underlying concept of torque and its effect on car movement.
- Students will identify proportional relationships in a real world scenario.
- Students will make the connection between gear ratios and distance traveled.
- Students will translate their understanding of gear ratios to fractions.

### **Standards**

**(Domain 1: Planning and Preparation- Component 1a: Demonstrating Knowledge of Content and Pedagogy)**

**MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**Common Core Mathematics Standards**

**6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."*

**6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

**6.RP.3a** Make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios

**NYS Science Standards**

**5.1c** An object's motion is the result of the combined effect of all forces acting on the object. A moving object that is not subjected to a force will continue to move at a constant speed in a straight line. An object at rest will remain at rest.

<b>Vocabulary</b> <b>(Domain I: Planning and Preparation - Component 1e: Demonstrating Knowledge of Students.)</b>		<b>Prep Work/Materials</b> <b>(Domain 1 Planning and Instruction- Component 1e: Designing Coherent Instruction, Domain 3 Instruction- Component 3c: Instruction Engaging Students in Learning)</b>	<b>Cross Curricular Connection</b> <b>(Domain I: Planning and Preparation - Component 1a: Demonstrating Knowledge of Content and Pedagogy, Component 1b: Demonstrating Knowledge of Students.)</b>
ratio fraction gear velocity distance speed force	machine torque friction diameter circumference	EV3 robot Extra gears measuring tape pulley attachment weighted blocks tape/sticker (to mark floor)	Technology Engineering
<b>Differentiation</b> <b>(Domain I Planning and Preparation-Component 1e: Designing Coherent Instruction, Domain 3: Instruction - Component 3b: Using Question and Discussion techniques Domain 3: Instruction - Component 3c: Engaging Students in Learning)</b>			
<ul style="list-style-type: none"> <li>• Bodily kinesthetic learners - Hands on Torque Gear Ratio Activity</li> <li>• Audio and Visual learners – Visual representation of activity in the Do Now. The observations collected throughout the activity.</li> <li>• ELL/Low reader - Guided notes printed for those who require them</li> <li>• Technology- Utilizing Lego Mindstorms robot kit and digital program</li> <li>• Enrichment: Conduct experiment adding in the variable of friction</li> <li>• Extended time for those who require it</li> <li>• Small groups</li> <li>• Individual attention from ICT teachers and paraprofessionals</li> <li>• Resource room remediation for those who require</li> </ul>			
<b>Procedure</b> <b>(Domain I Planning and Preparation-Component 1e: Designing Coherent Instruction, Domain 3: Instruction - Component 3b: Using Question and Discussion techniques Domain 3: Instruction - Component 3c: Engaging Students in Learning)</b>			<b>Student Engagement (Teacher Assessment)</b>

<p>1) Introduce the problem of the day (how adding weight to a vehicle will require changes to be made)</p> <p>2) Do Now: Lead a class discussion and brainstorm some of the variables that will affect the motion of a vehicle. (Accommodation: Have toy cars available for students that need an actual model)</p> <p>3) Watch a video clip that will introduce the concept of torque. <a href="http://science360.gov/obj/video/9112c778-48e4-4b75-a09b-2f2d2404da12/science-nfl-football-torque">http://science360.gov/obj/video/9112c778-48e4-4b75-a09b-2f2d2404da12/science-nfl-football-torque</a> .</p> <p>4) Summarize the findings about torque derived from the video</p> <p>5) Introduce the equation for torque (<math>t=fd</math>). Refer to diagram on Torque Gear Ratio Worksheet.</p> <p>6) Have short discussion about friction's role in this system</p> <p>7) Conduct experiment using the Student Activity Directions below.</p> <p>8) Utilize your observations to answer questions on the Torque Gear Ratio Worksheet.</p> <p>12) Extension: Students can conduct additional experiments that include different forms of friction and record the changes in the distance car travels.</p> <p><b>Student Activity Directions:</b></p> <ol style="list-style-type: none"> <li>1. Build a hitch to place on back of Gear Ratio Robot with 1:3 ratio gears.</li> <li>2. Place weighted block in hitch of approximately 3 lbs.</li> <li>3. Place the robot on the flat surface.</li> <li>4. Run program that will move forward.</li> <li>5. Record observations on Torque Gear Ratio Worksheet.</li> <li>6. Change gears on Gear Ratio Robot to 3:1 ratio.</li> <li>7. Repeat steps 2-5.</li> </ol>	
<p><b>Assessment (Formative or Summative)</b> (Domain 1 Planning and Instruction- Component 1e: Designing Coherent Instruction, Domain 3 Instruction- Component 3c: Engaging Students in Learning, Domain 3 Instruction- Component 3d: Using Assessment in Instruction)</p>	<p><b>Student Engagement (Teacher Assessment)</b></p>

Pre-assessment: (Do Now)

Assessment will occur during lesson and after the lesson, by gauging understanding and mastery through student responses to lesson discussion as well as their answers to the in class activity worksheets. We will wrap up by answering the objectives; reviewing in class worksheets, and having the students summarize the lesson activity.

KEY Questions:

Consider the multiple variables in this experiment. Is gear ratio the most important variable?

Describe a real world situation, where the amount of torque an object contains is relevant.

How does change the ratio negate the need to alter motor strength?

Why is a gear a simple machine?

How many representations of a 1:3 ratio can you create with your gear set?

**Additional Resources**