## *Topic: Tug of War*

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**Genre: Science & Math** **Unit: Physical Science**
**Grade Level: 6th -8th grade** **Estimated Duration: 1-2 single period**

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

- **As a culminating lesson, how can we visualize and bring to fruition all the science components that we have learned through the use of the Lego Mindstorm EV3 robot?**

**Background Knowledge**

**Background Summary:**

Students will use skills learned from the previous lessons to reinforce the use of a model to test and modify a tool to achieve an optimal design. This lesson can be used to reinforce prior skills learned over the length of the Lego Robotics EV3 curriculum. There is also an intercurricular connection in science, math and engineering. The robot will examine how manipulation of multiple variables in their system will effect the center of gravity. Those variables will be brick placement, gear ratios, power used, and use of a rear wheel. 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 that the number of teeth and diameter of the gears change proportionally. Students should understand that machines change the direction or magnitude of a force. Students should connect their prior knowledge on the effects of different types of forces on the motion of objects, through the study of the 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 must use their knowledge of the Center of Mass/Gravity to manipulate the brick to various locations and hypothesize what they think will happen when pulling another robot in tug of war. This lesson also reinforces money management skills by having students pay for the parts they add on or change on the robot. This lesson is cumulative and promotes spatial reasoning and encourages critical thinking.

**Lesson Objective:**

- Students will learn the steps involved in the engineering design process by designing a EV3 Lego Robot.
- Students will apply what they have learned about gear ratio and proportions.
- Students will apply what they have learned about energy, friction, velocity, and torque.
- Students will apply what they've learned in real world situations.
- Students will analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success.

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

**MST Standards: Standard 7: Interdisciplinary Problem Solving Key Idea 1:**
The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

**NGSS Standards:**
Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

**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.

**NYS Science Standards:**
5.2a: Every object exerts gravitational force on every other object. Gravitational force depends on how much mass the objects have and how far apart they are. Gravity is on the forces acting on orbiting objects and projectiles.

**Standard 6: Interconnectedness:**
Key Idea 2: Models are simplified representations of objects, structures, or systems used in the analysis, explanation, interpretation, or design.

**Common Core Math State Standards:**
**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.
**7.RP.2** Recognize and represent proportional relationships between quantities.

| **Vocabulary (Domain I: Planning and Preparation - Component 1e: Demonstrating Knowledge of Students.)** | **Prep Work/Materials (Domain 1 Planning and Instruction-Component 1e: Designing Coherent Instruction, Domain 3 Instruction-Component 3c: Instruction Engaging Students in Learning)** | **Cross Curricular Connection (Domain I: Planning and Preparation - Component 1a: Demonstrating Knowledge of Content and Pedagogy, Component 1b: Demonstrating Knowledge of Students.)** |
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| Center of gravity<br>Mass<br>Friction<br>Force<br>Proportional relationship<br>Ratios<br>Sir Isaac Newton<br>Velocity<br>Torque | EV3 robot and kit<br>Laptop/iPad with Mindstorms Education version<br>Different color tape/stickers<br>Measuring tape<br>EV3 Café Menu<br>50 Bot Bucks | Science<br>Mathematics<br>Technology<br>Engineering<br>ELA |

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| Gears<br>Energy<br>Speed | | |

**Differentiation**
**(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)**

- Bodily kinesthetic learners - EV3 robot and Tug of War activity.
- Audio and Visual learners – Visual representation of activity in the Do Now. The observations collected throughout the activity.
- ELL/Low reader - Guided notes printed for those who require them
- Technology- Utilizing Lego Mindstorms robot kit and digital program. See additional resources
- Enrichment: Research Rube Goldberg and use your robots to create an action scenario using 4 simple machines minimum.
- Extended time for those who require it
- Small groups
- Individual attention from ICT teachers and paraprofessionals
- Resource room remediation for those who require

| **Procedure**<br>**(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)** | **Student Engagement (Teacher Assessment)** |
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| 1) Introduce the problem of the day (In true BattleBot fashion, only the best robot will prevail. Students will be building and designing the best robot to win a tug of war contest.) and show students the video below.<br>http://www.discovery.com/tv-shows/mythbusters/videos/torque-tug-of-war/<br><br>2) Class Discussion - Discuss with students the video and explain what the purpose of today's lesson will be. Have students find connections between today's activity and the video above. The teacher will go over the menu and explain the method for purchasing different enhancements. Teacher will review what knowledge is necessary for today and refresh students memory of the prior lessons such as Gear Ratios and Proportions Unit and Center of Gravity.<br><br>3) Ask students prior knowledge questions with content from previous lessons to give students a chance to earn 12 extra Bot Bucks per group. Groups can only earn a maximum of $62 Bot Bucks. **Tug of War Group Worksheet**<br><br>4) Student groups will receive their EV3 Café Menu and $50.00 Bot Bucks to start. They will read it with their group members, discuss their plan of action, and design a sketch on their worksheet of their Tug of War Bot.<br><br>5)Teacher will act as cashier or select a student to run the enhancement store. Student groups will track their enhancements and Bot Bucks used in the section provided on their **Tug of War Group Worksheet.**<br><br>6) Have groups make predictions on their worksheet about how and why each enhancement selected would better. Each group will also explain why these enhancements will allow their robot to win the Tug of War competition.<br><br>7) The teacher will circulate and motivate students to complete the worksheets, document observations, record analysis question responses and use the Tug of War data to make changes to their robot. The teacher will also ask students key questions. It is left at the teacher's discretion to run the competition more than one time.<br><br>8) Extensions:<br>-Students will view the youtube video modeling a Rube Goldberg design. Students will then use their robots to create an action scenario using a minimum of 4 simple machines.<br>https://www.youtube.com/watch?v=IIGyVa5Xftw | |

**Student Data Collection Directions:**

1. Collect EV3 Lego Kit.
2. Build your robot to make sure the body matches the specs in the manual.
3. As a group, complete Do Now to earn Bonus Bot Bucks.
4. Collect your EV3 Café Menu and read it over with your group.
5. As a group, brainstorm Bot Design and sketch it on your worksheet.
6. Use your Bot Bucks to purchase enhancements to your robot. Record Cost of purchases on your worksheet.
7. Make your predictions on your worksheet.
8. Attach your EV3 brick to the computer and sync the EV3 Tug of War program.
9. Place your Robot at the start points your teacher has pre labeled for you, attach your tug of war "rope" between two competing robots.
10. Run EV3 Tug of War Program by pressing the center button on each robot at the extra same time.
11. Observe and record your observation on your worksheet.
12. Discuss your findings and make any adjustments if you have money left over.
13. On your Worksheet, answer all analysis questions.

| **Assessment *(Formative or Summative)*<br>(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)** | **Student Engagement (Teacher Assessment)** |
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Pre-assessment:

Do Now Worksheet

-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.

-Students will also write a reflection identifying all the science and math components that are covered in this Tug of War competition. This reflection will demonstrate the cohesion of most of the robotic lessons covered this year. They will identify the science standard and how it's used to demonstrate understanding.

KEY Questions:
What is gravity?
What is Mass?
How is mass different than weight?
Define Circumference?
What is the difference between the diameter and the radius?
What is the formula to find the Circumference of a circle?
What is proportional relationship?
What principle is being demonstrated by the enhancement added?

**Additional Resources**

**http://www.discovery.com/tv-shows/mythbusters/videos/torque-tug-of-war/**

https://www.youtube.com/watch?v=IIGyVa5Xftw