Level/Course: 8th-12th Grade Physics

General Unit Overview:
The students will have already been introduced to the concept of simple machines and how they can be combined to create more complex machines. Similarly, they will have been introduced to examples of Rube Goldberg machines, which are complex machines that are used to perform very simple tasks (OK Go Rube Goldberg video - This video is a good introduction to the concept of a Rube Goldberg machine. Have students watch the video and identify as many simple machines as possible.). Students should also have introductory knowledge of mechanical advantage and the math skill to complete any calculations.

Project Description :
Form groups of 2-3 students. Each group will design a set-up that will incorporate at least 2 sensors and at least 2 simple machines. This set-up will be used to perform a simple task of each group's choosing (throwing a bottle into a recycling bin, launching a paper airplane, etc.). The sensors will trigger simple machines in different locations in order to perform this task. In addition, students should incorporate normal, everyday items within the set-up to help with the task (dominoes, etc.). The groups will keep a laboratory journal in which they will document their design, building, and programming process. They will refine and perform troubleshooting activities when necessary - which will also be detailed in the laboratory journal. The groups will present their set-ups to the class and explain their use of simple machines. Note that each student should be responsible for one of the simple machines or the steps using everyday objects.

Students in a more advanced Physics course (i.e. those in 10th-12th grade) will keep measurements of their simple machines and calculate mechanical advantage for those simple machines. Students are expected to write out each step in words.

Note: The two sensors should be different types of sensors (light and distance are suggested). A type of simple machine can be reused, but a project must incorporate at least two different types of simple machines. At least one section of the set-up must utilize everyday items.

A possible variation would be to have students connect their respective projects into a much larger Rube Goldberg machine, using extra sensors. For example, one group could include an LED at the end of their project in order to trigger a sensor to start the next group's machine. This could continue until each group's project is linked together to create one larger, more complex Rube Goldberg machine.

Objectives:
- The student will be able to recognize and define the six different simple machines.
- The student will be able to calculate the mechanical advantage of the simple machines.
- The student will be able to create a set-up using simple machines that will act as a more complex machine to perform a task.
- The student will be able to describe their design, building, and programming process in a laboratory journal.
- The student will be able to analyze the efficiency of their design and use troubleshooting strategies in response.

Standards:
- 3.4.10.C1 Apply the components of the technological design process.
- 3.4.10.C2 Analyze a prototype and/or create a working model to test a design concept by making actual observations and necessary adjustments.
- 3.4.10.D1 Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of a final product.
- 3.4.10.D2 Diagnose a malfunctioning system and use tools, materials, and knowledge to repair it.

Instructional Materials:
- Hummingbird Duo Controller
- Hummingbird Kit Components

    - 2-3 sensors (light, distance, sound, potentiometer, etc.)
    - LEDs
    - Servo motors
    - Regular motors
- Laptop (plus programs)
- Cardboard, foam, foam core
- Construction paper
- Markers
- Hot glue gun, tape
- Plastic pieces
- String, wire, rope
- Scissors, Screwdriver
- Everyday objects (dominoes, marble, etc.)

Safety Considerations/Procedures:
- Follow instructions closely.
- Do not pull wires directly out of snap-in slots. Use screwdriver to hold down button and then pull out wires.
- If using exacto knife, be cautious.

Timeline:
- Day 1 and 2: Orientation
    - Students will watch videos explaining the components of the HummingBird Duo.
    - Students will watch videos explaining how to use the basic programming software.
    - Students will become familiar with the software and hardware.
    - Students will be shown example videos of Rube Goldberg projects.
- Day 3: Introduction
    - The student groups will be chosen.
    - The students will begin brainstorming their design and will keep a group laboratory journal to document their design and a running list of materials.
- Day 4 and 5: Research
    - The groups will find videos and online resources about Rube Goldberg machines. They will use this research to aid their design.
- Day 6 and 7: Design
    - The student groups will continue to design their robots based upon their research.
    - The student groups will continue adding their designs to their laboratory journal.
- Day 8,9, and 10: Building
    - The student groups will begin gathering materials and putting together their robot.
    - Any troubleshooting issues will be recorded in their laboratory journals and strategies to combat these issues will be recorded.
- Day 11, 12, and 13: Programming
    - The student groups will begin to program their robots. Note that groups who have no programming experience can use CMU Create Lab, while groups that have a student with programming experience can use a different language.
    - The groups will continue to record troubleshooting strategies.
- Day 14: Presentation
    - The student groups will present their robots to the class.
    - The group laboratory journals will be turned in for assessment.

Rubrics:

Building a Robot

	1 Point	2 Points	3 Points	4 Points
Aesthetic	The set-up has very messy transitions and is not visually interesting.	The set-up has a couple of messy transitions, but is somewhat visually interesting.	The set-up includes mostly neat transitions and is somewhat visually interesting.	The set-up is visually compelling and includes neat transitions between machines.
Components and Materials	Fewer than the minimum number of components have been incorporated. No extra materials have been used appropriately.	The minimum number of components have been incorporated. Few extra materials have been used appropriately.	The minimum number of components have been incorporated. The extra materials have been used appropriately.	More than the minimum number of components have been incorporated (within reason). The extra materials have been used appropriately and creatively.
Plan	The set-up bears little resemblance to the submitted design. There are little-to-no labels present.	The set-up follows the submitted design with some deviation. There are some labels missing and those present are not neat.	The set-up follows the submitted design. There are some labels missing, but those present are neat.	The set-up follows the submitted design. Labels exist where necessary and are neat.
Task	The task was not completed through the set-up that was built.	The task was completed by the set-up with several interventions.	The task was completed by the set-up with a bit of intervention.	The task was completed by the set-up that was built.
Leadership	There were unequal contributions to the project. 1 group member did most of the work.	Most of the group members contributed to the project. 1 or 2 members were responsible for most of the building and	Every group member contributed to the project. 1 or 2 members were responsible for most of the building, but the	Every group member contributed to the project. At least 1 part of the set-up was built by each person.

		programming.	other members contributed heavily in some other area.	
Presentation	The set-up built has nothing to do with the overall topic. The group appropriately explains a couple of the simple machines used.	The set-up built has little to do with the overall topic. The group appropriately explains most of the simple machines used.	The set-up built is a good example of the topic. The group appropriately explains the use of each simple machine.	The set-up built enhances the understanding of the overall topic. The group appropriately explains the use of each simple machine.

Laboratory Journal

	1 Point	2 Points	3 Points	4 Points
Design Process	The design process is detailed in few entries. There is no evolution of design. There are few diagrams and they are unlabelled.	The design process is detailed in a couple of entries. There is little evolution seen in the design. There are few diagrams and few labels.	The design process is detailed in several entries. There is a clear evolution of design. There are some diagrams, which are missing labels.	The design process is detailed in several entries. There is a clear evolution of design. There are diagrams, which are neatly labelled.
Building Process	There are only a couple of entries documenting the building process.	There are few entries documenting the building process. Some materials have been left out of the list.	The building process is documented in several entries. Some materials have been left out of the list.	The building process is documented in several entries. A neat list of materials has been kept.
Programming Process	There are only a couple of entries detailing the programming process. There is no explanation of the sequence being built.	There are a few entries detailing the programming process. Very little explanation is given with regards to the sequence.	The programming process has been detailed by a few entries. The entries are mostly neat. The function of the sequence is somewhat explained.	The programming process has been detailed by several entries. The entries are neat and the function of the sequence is clearly explained.
Troubleshooting	There are no entries	There is little evidence of	There is some evidence of	There are a couple entries that clearly

	documenting troubleshooting procedures.	troubleshooting and refined design.	troubleshooting and refined design.	document evidence of troubleshooting, testing, and refinement.