**Lesson 05: Design and Apply Experiments**

**Problem statement:** In this project you and your group will design, build, test, and improve (if needed) a running car using alternate energy.

This lesson will be targeting the testing phase of the car building process.

**Learning objectives:** Students will apply several pre-designed experiments on their cars to find weight, speed, velocity, and force. They will also design one experiment as a group to test their car.

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS:**

* Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. (MS-PS2-2)
* The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2.A)
* 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-ETS1-3)
* 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. (MS-ETS1-4)

**CCSS:**

* Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (7.EE.B.4)
* Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (7.EE.B.3)

**Materials:**

Stopwatch

Tape Measures or Meter Sticks

Spring Scale

Electronic Balance

Masking Tape

Incline Plane

Graph paper

Test Worksheet

**Lesson preparation:** You will need to have all supplies and worksheets ready when students come in. You will also need to decide whether your class will need a teacher demonstration or if students can handle doing the math on their own. There needs to be an open area for students to test their cars.

**Time required:** 50 mins

**Grouping of students for instruction:** (same as lesson 1)

Students will be placed into groups of 3 and 4 by the instructor. These groups will be mixed skills and mixed grade levels if possible.

Groups will be given the following roles: Secretary (recorder, brainstorming), Materials manager, Project manager (keeping on schedule, keeping on task, etc.), Communications manager

**What is the instruction? Consider the PBL Procedure that is being addressed here:**

1. Handout worksheet to each student, even though they will do it as a group
   1. Display a teacher copy under a document camera and explain the directions.
   2. While they are still listening and not working independently, have them record two observations about how their car runs.
2. Students will find the mass of their car using an electronic balance, You will need to demonstrate how to use one of these if they have never seen it before. Record
3. Then have students find the weight of their car by hanging it off of a spring scale. Record in Newtons
4. Some students will need to record the distance if their car runs for a finite amount of time. Have them use meter sticks to determine this distance.
5. Using the meter sticks, mark off two meters on the floor using masking tape. Each group will need to run their car from start to finish and time the 2 meter interval. Use this time and distance to find average speed of their car.
6. Then have groups split their 2 meter distance into at least 4 equal intervals. They will then use stopwatches or cell phone timers to time each of the intervals. They will need several timers who stop their clocks at the end of each interval. They will repeat this activity 4 times.
7. When their interval chart is filled out, they will use the trials to solve for the average speed during intervals. You will probably need to remind students how to find average. You may also want to do an example on the document camera so all students can see.

**Accommodations:** Teacher modeling for all students. Teams can test and record in front of the class if needed. Students who need extra help should already be teamed with groups who can support them. If there are any students who struggle with math, the teacher will want to check in with them frequently.

**Extensions:** Determine another test to measure some other performance characteristic of the car.

**Assessment:**

Formative:

* Complete the car tests worksheet
  + Each student needs to turn in their own even though they did it with a group

**References/Resources:**

* Car Tests Worksheet