Teacher: Richard Matthews
Unit: Forces and Motion
Physics Lesson Plan
Grade Level: 8

Time Period: Approx. 90 min, (can be completed in two 45 min. sessions).

Pennsylvania Academic Standards for Science and Technology

1. **PA 3.4.7C: Identify and explain the principles of force and motion.**
    - Describe the motion of an object based on its position, direction and speed.
    - Explain various motions using models.
2. **PA 3.1.7E: Identify change as a variable in describing natural and physical systems.**
    - Describe fundamental science and technology concepts that could solve practical problems.
3. **PA 3.2.7B: Apply process knowledge to make and interpret observations.**
    - Design controlled experiments, recognize variables, and manipulate variables.
    - Interpret data, formulate models, design models, and produce solutions.
4. **PA 3.2.7C: Identify and use the elements of scientific inquiry to solve problems.**
    - Design an investigation with limited variables to investigate a question.
    - Communicate appropriate conclusions from the experiment.
5. **PA 3.2.10D: Know and use technological design process to solve problems**
    - Explain the results, present improvements, identify and infer the impacts of the solution.

Lesson Title: Connecting Time, Distance and Velocity (Using the Sonic Ranger)
Lesson Objective: **Instructional Model: Inquiry**[1]
Students will:

- Design an experimental model that will allow for the measurement of distance and time and the calculation of velocity.
- Conduct a controlled experiment that allows the collection of distance/time data.
- Organize and graph data and use a mathematical equation to calculate slope in order to make connections between distance, time, and velocity.
- Describe the motion of an object along a path.
- Communicate experimental data and make real world connection with the facts.
- Students will analyze the motion of a student walking across the room using the Motion Detector. They will also predict, sketch and test position and velocity vs. time kinematics graphs.
- The Motion Detector is used in this lab that qualitatively analyzes the motion of objects that move back and forth. Comparisons are made to catalog objects that exhibit similar motion. Objects analyzed may include pendulums, dynamics carts, students jumping, springs, and bouncing balls.

Misconceptions[2]:

1. For basic understanding of motion students are need only a fundamental understand of mathematical equations. Providing students with numerous opportunities to conduct experiment with motion and to describe motion will help increase measurement and mathematical skills.
2. Students may be limited in their ability to describe motion because they think of motion as movement or no movement. Helping students divide motion into three categories: constant speed, increasing speeding, and decreasing speed may give students an initial framework for discussing motion.
3. Relative motion of an object along a path and vibration in materials, such as, wave's motion or the movement of falling dominoes is not the same.

Lesson Materials:

1. Stop watches
2. Meter sticks, measuring tapes
3. Toy car, toy trucks
4. Thin wooden board or ramp
5. Pasco Motion Sensor
6. Graph paper /pencils
7. Computer installed w/ Logger Pro software

Session 1 (45 minutes)

Procedure:

1. **Pre-Assessment:** Activating Prior Knowledge **(5 minutes**)
   In Whole Group: Teacher will write students responses on large chart paper or board. Charts should remain posted throughout the unit of study.

   Review What Students Need To Know Before Lesson: (see below)
   - An object is in **motion** if it changes position over time in relation to a reference point.
   - **Displacement** is a measurement of how far an object has moved from its original position.
   - **Speed** is the measurement of distance traveled by an object divided by the time the object takes to travel that distance. Speed = distance/time
   - **Velocity** is measurement of distance and direction. Velocity is a measure of an object's displacement over time in a given direction. V= displacement/time
   - **Velocity** can be represented on a graph of distance versus time graph

   Pose Questions:
   1. How do you know an object is in motion?
   2. How do you measure how fast an object is moving?
   3. What do you need to know in order to find velocity?
   4. What variables might affect the velocity of an object over a given time?
   5. What can be done to increase the reliability of experimental data?

2. **Mini-Lesson: Whole Group (10 minutes)**
   Introduce/Review
   - The concepts of experimental design. Tell students that variables are any factors, conditions or events that can be manipulated to affect the outcome of an experiment.

   Teacher Demonstration: Falling Dominoes[3]:
   - Students observe a factor that affects the speed of falling dominoes.
   - Students observe and practice using a stopwatch.

3. **Hands-on Investigation: (20 minutes)**
   Essential Question: How can you design an investigation to demonstrate the relationship between distance and velocity?

   Materials:
   - Display materials where they are readily available to students.

   Instructional Model:
   - Cooperative Group: 4-5 Students
   - Groups should be pre-determined by teacher to reflect varying ability levels in the class.
   - Each group member should have a specific responsibility; e.g., recorder, reporter, materials manager, timekeeper, manager.

   Session 1 Objectives:
   Groups will:
   - Select appropriate materials, design an experiment to investigate and describe the motion of their object along a path.
   - Measure the distance an object travels over time.
   - Develop a system to collect and organize data.

   Some Possible Experimental Designs:
   - Measuring velocity for a battery operated toy car using rulers and stopwatches
   - Measuring velocity of a toy truck moving down an inclined wooden plank, using cardboard attached to the bottom of the car to add friction. Students use rulers and stopwatches for measurements.
   - Measuring the motion of a student walking at a constant pace for a measured distance.
   - **Technology**: Measuring velocity of a moving toy wind up car by video taping its motion, using a meter sticks in the frame as a reference point. Students then view the tape and use the video player freeze-frame (1/30 of a second) to collect distance/time data.

4. **Session 1 Wrap-Up**
   Students clean up and return materials.

5. **Assessment:**
   - Teacher, using a checklist, should note if groups have an organized set of data.
   - Teacher, using a checklist, should note if each group member is actively engaged and on task.

Session 2 (45 minutes)
Procedure:

1. **Pre-Assessment: (5 minute Warm-Up)**
   Worksheet: Calculating slope and plotting points on a graph.

2. **Mini-Lesson: Whole Group (10 minutes)**
   Teacher will review with students how to find:
   - **Slope,** the change in y (distance) over the change in x (time).
   - **Calculate Velocity,** the change in displacement divided by the change in time.

3. **Session 2 Objectives: (20-25 minutes)**
   Groups will:
   - Make a graph of the distance versus time using experimental data.
   - Calculate average velocity and make a graph of the velocity versus time data.
   - Find the slope of the distance graph within a certain time range and compare that to the velocity at the same time range on the velocity graph.

4. **Session 2: Wrap-up (15 minutes, about 3 minutes/group)**
   - Report findings to the whole class as a function of their experimental design.
   - Students will come together as a class and present their findings.
   - Students display data and graph and explain how they demonstrate a relationship between distance and velocity.
   - Students discuss how their experimental design and procedure correlates to their data.

5. **Assessment:**
   Informal Assessment:
   - Groups will be assessed by teacher review of their design and plan for organization of data. Groups should have a written plan for their investigation and including group member assignments. There should be visible evidence of organization of data, such as, charts or tables. Teacher will use a four-point rubric to determine level of mastery.
   - Students will document their individual learning by making entries in science journals. Teacher review of science journals give insight into possible misconceptions that students may have. Teacher should give student individual feedback in journal.
   - Group will be assessed by a review of their data and graphs. Students must demonstrate their ability to make connections between distance and velocity based on a four point rubric (mastery, partial mastery, basic, below basic)

Formal Assessment:

- Students will be given an individual worksheet to assess their understanding of the connection between distance and velocity. Worksheet should also assess student's understanding of scientific vocabulary.

6. **Extensions**:

- **Technology**: If available, students will use the Sonic Ranger to record motion of the same objects, create graphs and find slope to make comparisons with their original experimental distance and velocity data.

Reference:

1. American Association for the Advancement of Science. Benchmarks For Science Literacy, Oxford University Press, 1993, p. 87-90.
2. Ibid. p.12.
3. Holt, Rinehart & Winston, Forces, Motion, and Energy, Austin, Texas 2005, p. 3.