Topic: Data Interpretation of Acceleration

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Genre: Mathematics **Unit: Linear and Nonlinear**
Grade Level: 8-9 th grade **Estimated Duration: 1-2 single period**

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

- **How can we distinguish linear relationships from quadratic and other non-linear relationships?**

Background Knowledge

Background Summary: Students will need to have some basic understanding of linear equations. This should be done after the Data Interpretation of Velocity Lesson. There will be multiple references to the data collected in that activity and the linear equations generated from that experiment.
Speed and velocity are two quantities that seem at first glance to have the same meaning. While related, they have distinctly different definitions. Knowing their definitions is critical to understanding the difference between them. SInce those topics were covered in previous lesson, we will build on this knowledge and introduce acceleration.
During this unit, students will learn 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 will also need an understanding of friction and how it affects a moving vehicle.

Lesson Objective:

- Students will identify linear and nonlinear relationships in multiple representations (equation and graph).
- Students will use the robot to collect data, analyze data and manipulate the values to create multiple representations.

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

NGSS Standards

MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the

direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]

MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]

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.

5.1d Force is directly related to an object's mass and acceleration. The greater the force, the greater the change in motion.

5.1e For every action there is an equal and opposite reaction.

Common Core Mathematics Standards

8.F.B.4 Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

8.F.b.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

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.)**
acceleration nonlinear parabola velocity gravity distance speed linear quadratic standard deviation ultrasonic force circumference	EV3 robot with ultrasonic sensor mounted laptop/iPad with Mindstorms Education version	Science Technology Engineering

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 - Hands on Data Interpretation of Acceleration 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
- Enrichment: Compare data from experimental trials with varying times
- Extended time for those who require it
- Small groups
- Individual attention from ICT teachers and paraprofessionals
- Resource room remediation for those who require

Procedure **(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)**
1) Introduce the problem of the day (how can we use technology to assist us in developing multiple representations of data) 2) Do Now:Reviewing Newton's Law (F=ma), slope-intercept form, finding the slope of a table. *Reference: Distance with Gear Ratio Activity Worksheet* 2a) Watch quick video reviewing vocabulary terms http://www.kidsknowit.com/interactive-educational-movies/free-online-movies.php?movie=acceleration 3) In small groups, direct students to conduct experiment and record data utilizing Student Data Collection Directions. 4) Circulate and motivate students to start their data collection. Asking students key questions as well as to describe what they are observing, and documenting data on worksheet. 5) After performing this experiment and analyzing data, students will complete worksheet making connections to previous lesson on Data Interpretation of Velocity. 6) Extension: Students can run the Deceleration Program and make correlations between findings. **Student Data Collection Directions:** 1. Place the robot about 6 inches from wall. 2. Run the Acceleration Program 3. Connect your robot to the laptop.	

4. In your program, create a new experiment. 5. Upload your data from brick to program.. 6. Press Analyze and pick Selection Analysis.. 7. Move margins around the data set you are using. 8. Press curve Fit and choose Quadratic for the Ultrasonic Sensor, 9. Go into Data Calculation to convert wheel degree to distance 10. Calculate Distance 11. Press Curve Fit and choose Quadratic for the the Calculated data. 12. Record equations on the Data Interpretation Worksheets.	
Assessment *(Formative or Summative)* (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)**
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: How do Newton's laws relate to today's experiment? How can we distinguish linear relationships from quadratic and other non-linear relationships? What is the importance of the data collected and the meaning of obtaining a quadratic formula?	

Additional Resources