Velocity & Variable Relationships

Grade: 8th Grade	**Recommended Timeframe: 13 classes**

Unit Overview: Students will be introduced to the idea of distance, time, and velocity in science class. They will then construct "mouse trap cars" to measure the relationships between time and distance. They will also measure the difference produced by changing a single variable, the lever arm. Students will record their data. After some work with the Coordinate Plane and basic graphing skills, students will use their time and distance data to create graphs in math class. Through their data they will explore the ideas of line of best fit and the broader concept of data interpretation. From there, students will be able understand the purposes of graphing, creating linear graphs, the uses of linear graphs, and the relationships of bivariate data.

This mini unit can also act as a launch into a much lengthier and in depth math unit about linear equations. Students can continue to use Vernier equipment to collect data and discern linear relationships and their presentation as graphs. They will also continue work in science class exploring the relationships of forces and their effects.

Essential Questions	**Major Concept**s
Science: How do we measure motion? Math: How do graphs allow us to interpret data?	Science: Forces & Motion Technology: spreadsheet (Excel), Vernier probes, Engineering: Analyzing data from tests to evaluate a design Math: Linear Relationships

Suggested Lesson Sequence

Prerequisites
This unit is intended to be an introduction to the concepts of force, motion, and linear relationships.

Lesson 1
Math –*Distributive Property* (50 minutes)
Lesson Overview: Students will be able to apply the distributive property in to simplify expressions.

Science –*Motion & Position* (50 minutes)
Lesson Overview: Students will understand position and motion and apply those concepts to measuring motion.

Lesson 2
Math –*One-Step Equations* (50 minutes)
Lesson Overview: Students will be able to use inverse operations to solve one-step equations.

Science – *Speed and Velocity* (50 minutes)
Lesson Overview: Students will understand how to measure speed, the formula for speed, and the

difference between speed and velocity.

Lesson 3
Math – *Solving Two-Step Equations* (50 minutes)
Lesson Overview: Students will be able to solve two-step equations.

Science – Lessons 3-6: *Building Mousetrap Cars* (50 minutes)
Lesson Overview: The students will build their mousetrap cars that they will later use to collect data.

Lesson 4
Math – *Solving Multi-Step Equations* (50 minutes)
Lesson Overview: Students will be able to simplify and solve multi-step equations, including equations with the distributive property and variables on both sides of the equation.

Science – Lessons 3-6: *Building Mousetrap Cars* (50 minutes)
Lesson Overview: The students will continue to build their cars.

Lesson 5
Math – *Solving Inequalities* (50 minutes)
Lesson Overview: Students will solve and graph inequalities with one variable.

Science – Lessons 3-6: *Building Mousetrap Cars* (50 minutes)
Lesson Overview: The students will continue to build their cars.

Lesson 6
Math – *Review—Equations* (50 minutes)
Lesson Overview: Students will review the concepts embedded in solving equations and prepare for an assessment.

Science – Lessons 3-6: *Building Mousetrap Cars* (50 minutes)
Lesson Overview: The students should finish building their cars and making sure that they will actually work.

Lesson 7
Math – *Equations Assessment* (50 minutes)
Lesson Overview: Students will demonstrate mastery of solving equations.

Science – *Manual Data Collection* (50 minutes)
Lesson Overview: The students will collect data using stopwatches and meter sticks and/or tape measures, so that they can calculate the speed of their cars.

Lesson 8
Math – *The Coordinate Plane* (50 minutes)
Lesson Overview: Students will recognize and graph ordered pairs on a coordinate plane.

Science – *Data Collection with Vernier* (50 minutes)

Lesson Overview: The students will collect data using the Vernier Labquest interface and a Vernier motion detector.

Lesson 9
Math – *Scatter Plots & Correlations* (50 minutes)
Lesson Overview: Students will be introduced to the concept of relationships between two variables and will be able to determine the correlation of a set of data.

Science – *Redesign* (50 minutes)
Lesson Overview: The students will spend some time modifying their cars in order increase their velocity.

Lesson 10
Math – *Plotting Data* (50 minutes)
Lesson Overview: Students will create scatter plots based on the data collected observing their mouse trap cars.

Science – *Data Collection* (50 minutes)
Lesson Overview: Students will collect data a final time, both manually and with the Vernier equipment so that they can determine whether or not their modifications made a difference in their car's average velocity.

Lesson 11
Math –Lessons 11-12: *Graphing Your Motion (Vernier Lab)* (50 minutes)
Lesson Overview: Students will recognize and graph ordered pairs on a coordinate plane.

Science – *Data Interpretation* (50 minutes)
Lesson Overview: The students will graph their data and discuss whether modifications changed their rate of speed for their car.

Lesson 12
Math –Lessons 11-12: *Graphing Your Motion (Vernier Lab*) (50 minutes)
Lesson Overview: Students will recognize and graph ordered pairs on a coordinate plane.

Science – Lessons 12-13: *Engineering Work Sample* (50-minute period)
Lesson Overview: Students discuss Engineering Work Sample and begin their own work sample.

Lesson 13
Math – *Walk the Line Lab* (50 minutes)
Lesson Overview: Students will use Vernier Lab to continue exploring relationships between two variables.

Science – Lessons 12-13: *Engineering Work Sample* (50-minute period)
Lesson Overview: Students will continue their engineering work sample.

Materials, Tools, & Technology

- ☐ standard classroom materials
- ☐ Vernier labquests, 1 per group (Lessons 8, 10, 14)
- ☐ Vernier motion sensor, 1 per group (Lessons 8, 10, 14)

Vocabulary

distance
time
velocity
acceleration
lever
variable
coordinate plane
ordered pair
slope
intersection
trend
accuracy
line of best fit
linear
relationship
bivariate data

STEM Professional Involvement Ideas

- Mechanical Engineer

Standards

Science

MS-PS2-2 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-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Technology

6. Technology Operations and Concepts

Students utilize technology concepts and tools to learn.

Students:

Select, use, and troubleshoot tools efficiently.

Transfer current knowledge to learning of new technologies.

Engineering

MS-ETS1-2 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution taking into account relevant scientific principles and potential impacts on people an dthe natural environment that may limit possible solutions.

Math

6.EE.7 Solve real-world and mathematical problems by writing and solving equations in the form of $x+p=q$ and $px=q$ for cases in which p, q, and x are all nonnegative rational numbers.

8.EE.7b Solve linear equations with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.

HS.A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

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

8.F.5 Describe qualitatively the functional relationship between two quantiles by analyzing a graph. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

Notes

Throughout this unit the term "standard classroom materials" is used to describe everyday classroom materials students and teachers would be expected to have: class notebook, pencil or pen, paper, etc. Any items not typically needed for a standard lesson will be denoted specifically.

All handouts and activities provided by Jeff Journigan and Kristen Tompeck unless otherwise acknowledged.

Appendices

Appendix A: Teacher Resources
Appendix B: Student Resources

Distributive Property — Math Lesson 1

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will be able to apply the distributive property to simplify expressions.

Standards:

Math

7.EE.1 Apply the properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients.

Background Information:

A solid foundation in order of operations should be established prior to beginning this unit. The lesson sequence is designed to give students exposure to real life occurrences of relationships between two variables before they begin to explore the concepts of slope and intercepts.

Materials:

- ☐ standard classroom materials
- ☐ student handouts, App. B
- ☐ Exit Ticket, App. B

Vocabulary:

distribute
equivalent expressions
term
coefficient
variable
constant

Resources:

App. B—Lesson 1: Math: Distributive Property Guided Lesson Notes and Distributive Property Sort Activity

Procedures:

1. Distribute lesson notes: allow students to complete Motivation. Review and discuss.
2. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Distribute "sort"; allow students to work in pairs. Each student receives a group of 12 expressions. Each expression is equivalent to three other expressions. Students should sort the expressions into three groups of four equivalent expressions. Once they have double-checked their groups, student can affix their equations to their handout.
4. Wrap up: Distributive Property Exit Ticket

Differentiation:

Supports

Extensions

Distributive Property Sort, second set

Assessment Opportunities:

Exit Ticket, App. B

Citations:

One-Step Equations — Math Lesson 2

Motion & Position — Science Lesson 1

Grade Level: 8th Grade	**Time Needed:** 50 minutes.	**Subjects:** Science

Objective: Learn how to describe an object's motion and position.

Standards:

Science

MS-PS2-2 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.

Background Information:

The location of an object is called its **position** and all **motion** can be described by an object's change in position. The change in an object's position has be be described in relation to another object's position which is called a **reference point**.

Materials:

- ☐ standard classroom materials
- ☐ computer and web address

Vocabulary:

reference point
motion
position

Resources:

- None Provided

Procedures:

1. The students will be asked to define how they know if something is moving. They will then be asked to describe how fast they are currently moving.
2. The class will look online for their speed compared to the center of the Earth (approx 1000 mph), the speed around the sun (approx 66,000 mph), and the speed around the black hole at the center of our galaxy (483,000 mph). Describe how to get to somewhere from their house without naming any specific objects. Discuss the importance of using reference points to describe locations and positions.
3. Have students walk forward while tossing a ball. Have students draw pictures and discuss what they see both as the person tossing the ball and as someone who is sitting nearby watching the motion of the ball.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None Provided

Citations:

- Scale information found at http://astrosociety.org/edu/publications/tnl/71/howfast.html.

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will be able to use inverse operations to solve one-step equations.

Standards:

Math

6.EE.7 Solve real-world and mathematical problems by writing and solving equations of the form x+p=q and px=q for cases in which p, q, and x are all nonnegative rational numbers.

Background Information:

This lesson should be a review of a concept introduced at the 6th grade level. This lesson is intended to be review, something upon which students can build comfort and fluency working with inverse operations.

Materials:

- ☐ standard classroom materials
- ☐ Order of Operations Dice Activity, App. B
- ☐ student handouts, App. B
- ☐ Exit Ticket, App. B

Vocabulary:

isolate
inverse operations
term
coefficient
variable
constant

Resources:

- App. B: Lesson 2—Math: One-Step Equation lesson notes and example problems

Procedures:

1. Begin with Order of Operations Dice Activity. Students work in pairs, roll dice and complete rounds to practice order of operations and computation skills.
2. Distribute lesson notes, allow students to complete Motivation. Review and discuss.
3. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
4. Wrap up: One Step Equations Exit Ticket

Differentiation:

Supports

Extensions

Assessment Opportunities:

Exit Ticket, App. B

Citations:

Exit Ticket adapted from Core Focus on Linear Equations SM^{C} Curriculum, p18

Speed and Velocity — Science Lesson 2

Grade Level: 8th Grade	**Time Needed:** 50 minutes	**Subjects:** Science

Objective: How to calculate an object's speed. How to describe an object's velocity.

Standards:

Science

MS-PS2-2. 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.

Background Information:

Speed describes how far an object travels in a given amount of time and the formula is thus S=D/T where the units of speed (S) are given in the unit of distance (D, any measured distance) over time (T, in any measured unit of time).

Materials:

- ☐ balls
- ☐ stopwatches

Vocabulary:

speed
velocity
acceleration

Resources:

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Procedures:

1. Students see a ball being rolled across the floor at two different speeds.
2. They are asked if and how they know which roll is faster.
3. They use stopwatches to see if they can provide data to compare the actual speeds of the rolls.
4. Class discusses speed and how to calculate it.
5. The students measure balls that they roll on their own at three different speeds.
6. Class discusses the differences between speed and velocity.

Differentiation:

Supports

Working with partners and small groups.

Extensions

Calculate speed of a faster moving object, such as cars that drive by the school.

Assessment Opportunities:

None provided.

Citations:

Solving Two-Step Equations — Math Lesson 3

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will be able to solve two-step equations.

Standards:

Math

8.EE.7b Solve linear equations in one variable with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.

Background Information:

Materials:

- ☐ standard classroom materials
- ☐ student handouts, App. B
- ☐ Exit Ticket, App. B

Vocabulary:

isolate
inverse operations
term
coefficient
variable
constant

Resources:

- App. B—Lesson 3: Math: Two-Step Equations lesson notes and Exit Ticket

Procedures:

1. Distribute Two-Step Equations lesson notes. Allow students to complete motivation. Review and discuss as a whole class.
2. Review lesson handout; have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Wrap up: Two-Step Equations Exit Ticket

Differentiation:

Supports

Extensions

Assessment Opportunities:

Exit Ticket, App. B

Citations:

Exit Ticket adapted from Core Focus on Linear Equations SM^{C} Curriculum, p23.

Building Mousetrap Cars — Science Lessons 3-6

Grade Level: 8th Grade	**Time Needed:** 4-50 minute periods	**Subjects:** Science

Objective: To build a car that is propelled by the power from a mousetrap.

Standards:

Science

MS-PS2-2 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.

Background Information:

Mousetrap cars are powered by attaching a string that goes from the lever arm of the mousetrap to the axle of the car. The string is wound around the axle as the arm is pulled back. The tension in the spring acts as the "powerplant" for the car. When the car is set down and released, the pull of the lever arm on the axle causes it to move forward.

Materials:

- ☐ mousetraps
- ☐ brazing rods
- ☐ CDs
- ☐ balsa wood or cardboard
- ☐ hot glue guns
- ☐ hot glue sticks
- ☐ white glue
- ☐ plastic bottle caps (optional)
- ☐ drill (optional)
- ☐ skewer sticks
- ☐ string, etc.

Vocabulary:

lever arm
potential energy
kinetic energy

Resources:

Design ideas for mouse trap cars:

- http://www.docfizzix.com/topics/construction-tips/Mouse-Trap-Cars/
- https://www.google.com/search?q=mousetrap+car&rlz=1C1PRFC_enUS605US605&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0CAcQ_AUoAmoVChMI-LHlzPmYyAIVDS6ICh0iWA_F

Procedures:

1. Students will discuss ideas about how to power a car from a mousetrap.
2. They will be shown a model of a mousetrap car and will see various images of other types of mousetrap cars.
3. The students will discuss some of the more important features of building mousetrap cars and will be given some hints about how to get their cars to perform well (hints may include: straight wheels, smoothly turning axles, end of lever arm directly above the axle, light weight, etc.).
4. The students will be given the materials and tools and will begin construction of their cars.

5. The teacher will walk around the room giving advice and direction as needed.

Differentiation:

Supports

Students will work in groups.

Extensions

Assessment Opportunities:

None provided.

Citations:

Solving Multi-Step Equations — Math Lesson 4

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will be able to solve multi-step equations.

Standards:

Math

8.EE.7b Solve linear equations in one variable with rational number coefficients, including equations whose solutions require expanding expressions using the distributive property and collecting like terms.

Background Information:

This lesson is meant to synthesis the prior three lessons; it asks students to use their knowledge of distributive property, combining like terms, and inverse operations to solve multi-step equations.

Materials:

- ☐ standard classroom materials
- ☐ student handouts, App. B
- ☐ Exit Ticket, App. B

Vocabulary:

isolate
inverse operations
term
coefficient
variable
constant

Resources:

- App. B—Lesson 4: Math: Multi-Step Equations lesson notes and example problem
- App. B—Lesson 4: Math:Multi-Step Equations Exit Ticket

Procedures:

1. Distribute Multi-Step Equations lesson notes. Allow students to complete motivation. Review and discuss as a whole class.
2. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Wrap up: Multi-Step Equations Exit Ticket

Differentiation:

Supports

Extensions

Assessment Opportunities:

Exit Ticket, App. B

Citations:

Exit Ticket adapted from Core Focus on Linear Equations SM^{C} Curriculum, p29.

Solving Inequalities — Math Lesson 5

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will be able to solve and graph inequalities with one variable.

Standards:

Math

HS.A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Background Information:

This lesson introduces the concept of inequality and graphing on a number line. It is written to meet a high school algebra standard. It can be excluded without affecting the sequence of the mini-unit.

Materials:

- ☐ standard classroom materials
- ☐ student handouts, App. B
- ☐ Exit Ticket, App. B

Vocabulary:

inequality
graph
solution set
inverse operations

Resources:

- App. B—Lesson 5: Math: Inequality lesson notes and example problems

Procedures:

1. Distribute Solving Inequalities lesson notes. Allow students to complete motivation. Review and discuss as a whole class.
2. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Wrap up: "Turn and Talk." Tell your partner the difference between an equation and an inequality. Describe the similarities between solving an equation and an inequality.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Citations:

Review—Equations — Math Lesson 6

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will review the concepts necessary to solve equations to prepare for an assessment.

Standards:

Math

8.EE.7 Solve linear equations in one variable.

HS.A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Background Information:

This lesson included an active review to help students prepare for an equations test.

Materials:

☐ standard classroom materials

☐ student handouts, App. B

Vocabulary:

Resources:

- App. B—Lesson 6: Math: Equations Review activity

Procedures:

1. Explain "Climb the Ladder" procedure. Students should work in pairs, taking turns to answer each problem at each level. Once students have worked out the problem, paying attention to precision, a member may approach the teacher for confirmation and the next step in the ladder.
2. Wrap up: "Turn and Talk." What are the steps to solve a multi-step equation?

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Citations:

"Climb the Ladder" activity and problems adapted from SM^{C} Curriculum supplemental materials.

Equations Assessment — Math Lesson 7

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will review the concepts necessary to solve equations to prepare for an assessment.

Standards:

Math

8.EE.7 Solve linear equations in one variable.

HS.A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Background Information:

Materials:

☐ standard classroom materials

Vocabulary:

Resources:

- None provided

Procedures:

Administer equations test.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Citations:

Manual Data Collection — Science Lesson 7

Grade Level: 8th Grade	**Time Needed:** 50 minutes	**Subjects:** Science

Objective: To manually collect data on mousetrap cars.

Standards:

Science

MS-PS2-2 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-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.

Background Information:

Speed is the distance an object travels divided by the time (S=d/t). Velocity is speed in a given direction. Any unit of distance can be given over any unit of time. The students will measure distance in meters and time in seconds.

Materials:

- ☐ masking tape
- ☐ meter stick
- ☐ stopwatches or tablets with stopwatch app.
- ☐ graph paper (optional)

Vocabulary:

speed
speed formula
velocity
data

Procedures:

The teacher will find a smooth, flat area to test the cars on. A starting line will be marked on the floor with masking tape. Tape will also be placed at 1 meter intervals for a total of 12 meters (this can be longer if the cars are expected to go farther and if there is room.) Students will be placed at each meter interval taped line. The teacher will instruct them that when the teacher says to go, one group of students that is ready to test their car will release it from the starting line. Upon the command, all the students with timers will start their timer. As the car reaches each interval, the students at that tape mark will stop their stopwatch. The group will then go along the line and fill in the times that the car took to go each meter. The students will make a t-chart of their data, and will later graph the data in order to see a relationship.

Differentiation:

Supports

Students will all work together to collect the data.

Extensions

Advanced students may be asked to come up with other ways to measure the speed, and to actually take those measurements to see if they are close to the values that were obtained using this method.

Assessment Opportunities:

None provided.

The Coordinate Plane — Math Lesson 8

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will recognize and graph ordered pairs on a coordinate plane.

Standards:

Math

6.NS.8 Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distance between points with the same first coordinate or the same second coordinate.

Background Information:

This lesson is meant to reacquaint students with the coordinate plane and plotting points. For some students it may be review, for others it may all seem brand new. Using the metaphor of "cross streets" may help students understand a point is located where two number lines intersect and its name actually describes a location.

Materials:

☐ standard classroom materials

☐ student handout, App. B

Vocabulary:

coordinate plane
ordered pair
origin
quadrant
x-axis
y-axis
plot

Resources:

- Appendix B—Lesson 8: Math: Coordinate Plane & Linear Plots

Procedures:

1. Distribute lesson notes, allow students to complete Motivation. Review and discuss.
2. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Wrap Up: Sink the Sir Activity- Sink the Sir is a paper version of the board game Battleship. Students plot five ships on their coordinate plane. Pairs take turns guessing the position of their opponent's ships. When a student correctly guesses the number of points associated with the type of ship, it is "sunk." The object of the game is to "sink" the opponent's five ships first. Students should record their guess and their opponent's guesses as ordered pairs.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Citations:

Data Collection with Vernier — Science Lesson 8

Grade Level: 8th Grade	**Time Needed:** 50 minutes	**Subjects:** Science

Objective: To collect data from mousetrap cars using Vernier motion sensors technology.

Standards:

Science

MS-PS2-2 Plan an investigation to provide evidence that change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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.

Background Information:

Some experience using the Vernier Labquest 2 and motion sensor is helpful.

Materials:

- ☐ mousetrap cars
- ☐ tape
- ☐ Labquest 2 (1 per group if possible, but a couple per class could work)
- ☐ motion sensor
- ☐ printer if available.

Vocabulary:

data
sensor

Procedures:

The students will go to the same place to collect data that they did in the previous lesson, so that the data will be more consistent. Each group will have a Vernier Labquest and motion sensor. They will all start on the same line and will have the motion sensor behind their mousetrap car. They can then start their car and collect data using the Labquest. It is not necessary for all of the students to start at the same time since they will be collecting data each time with the Labquest. After the data is collected, the graph of the data may be printed out, or just saved on the Labquest for further analysis. If it is being saved on a Labquest and there are multiple Labquests, the students will need to keep track of which one their data is stored on. The students will analyze their data to determine the speed of their car from the graph.

Differentiation:

Supports

Students will be working in groups.

Extensions

Advanced students may be asked to look at some of the statistics of the graph and see if they can get a line of best fit for their data.

Scatter Plots & Correlations — Math Lesson 9

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will recognize and graph ordered pairs on a coordinate plane.

Standards:

Math

8.SP.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patters such as clustering, outliers, positive or negative associations, linear association, and nonlinear association.

Background Information:

This lesson is meant to introduce students to the concept of plotting their data on a coordinate plane and informally describing the pattern they observe. The underlying goal is to establish that data in the real world is messy and we need tools to help us interpret data and patterns, which sets the stage for the following lesson: drawing a line of best fit and making predictions.

Materials:

- ☐ standard classroom materials
- ☐ mouse trap car data (from science class)

Vocabulary:

Statistics
data
single-variable data
scatter plot

Resources:

- None provided

Procedures:

1. Review previous day's discussion about linear plots.
2. Introduce the concept of scatter plots. Explain terms:
   Statistics- process of collecting, displaying, and analyzing a set of data
   Single-variable data- shows one type of data
   Two-variable data- two types of data are considered at the same time
   Scatter plot- plotting two variable data set as ordered pairs in order to analyze the relationship between the two variables
3. Model plotting data from mouse trap car data.
4. Have students create scatter plots that include various sets of data from different groups. This will create a fuller picture of the data and prepare students for tomorrow's lesson: drawing the line of best fit.
5. Wrap Up: Ask students to describe other real world situations that would have positive correlations. Then have them discuss situations that would be represented by negative correlations.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Citations:

Redesign — Science Lesson 9

Grade Level: 8th Grade	**Time Needed:** 50 Min	**Subjects:** Science

Objective: Students will redesign their cars to see if their changes improve the speed of their car.

Standards:

Science

MS-PS2-2 Plan an investigation to provide evidence that change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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.

Background Information:

The easiest modification of their car can be in just shortening the lever arm. This can be the only thing changed by the students, or the teacher may allow the students to make other modifications that they think will improve the speed of their car. Each car may have only one modification in between tests, so that the students are able to determine how the particular modification changed the performance of the car.

Materials:

- ☐ mousetraps
- ☐ brazing rods
- ☐ CDs
- ☐ balsa wood or cardboard
- ☐ hot glue guns
- ☐ hot glue sticks
- ☐ white glue
- ☐ plastic bottle caps (optional)
- ☐ drill (optional)
- ☐ skewer sticks
- ☐ string

Vocabulary:

modification
lever arm

Resources:

None provided.

Procedures:

1. After collecting the data from the previous lesson, the students choose one particular feature about their car that they think they can change that will improve the speed of the car over the 5-10 meter distance.
2. They make the change to their car. The students are only allowed to make one modification at a time before they collect data.

Differentiation:

Supports

Students will work in groups.

Extensions

Students may be allowed to make several

	modifications as long as they collect the relevant data after each modification is made.
Assessment Opportunities: None provided.	
Citations:	

Predicting with Lines of Best Fit — Math Lesson 10

Grade Level: 8th grade	**Time Needed:** 50 minutes	**Subjects:** Math

Objective: Students will recognize and graph ordered pairs on a coordinate plane.

Standards:

Math

8.SP.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patters such as clustering, outliers, positive or negative associations, linear association, and nonlinear association.

8.SP.2 Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of data points to the line.

Background Information:

This lesson seeks to combine students' understanding of linear relationships and scatter plots and help them understand data is "messy" but we can still interpret relationships and make predictions based on linear associations.

Materials:

☐ standard classroom materials

☐ student handout, App. B

Vocabulary:

line of best fit
data set
scatter plot

Resources:

- Appendix B—Lesson 10: Math: Predicting with the Line of Best Fit

Procedures:

1. Distribute lesson notes, allow students to complete Motivation. Review and discuss.
2. Review lesson handout, have students annotate as they follow along. Complete model problems using gradual release scaffold.
3. Have students then apply concept of line of best fit to the scatter plots they created the previous lesson. Ask them to make predictions and justify their predictions as well as evaluate the lines of best fit of classmates. Be sure they can justify their evaluations applying the parameters for line of best fit presented in the lesson.
4. Wrap up: Ask students to describe characteristics of a good line of best fit. Then ask for examples of how students could use lines of best fit to make predictions about real world data.

Differentiation:

Supports

Extensions

Assessment Opportunities:

None provided

Data Collection — Science Lesson 10

Grade Level: 8th Grade	**Time Needed:** 50 min	**Subjects:** Science

Objective: Data Collection, both manual and motion sensor.

Standards:

Science

MS-PS2-2 Plan an investigation to provide evidence that change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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.

Background Information:

Students already familiar with both manual and sensor data collection should be able to collect data both ways in the same class period.

Materials:

- ☐ masking tape
- ☐ meter stick
- ☐ stopwatches or tablets with stopwatch app.
- ☐ graph paper (optional)
- ☐ mousetrap cars
- ☐ tape
- ☐ Labquest 2 (1 per group if possible, but a couple per class could work)
- ☐ motion sensor
- ☐ printer if available.

Vocabulary:

Procedures:

The students will collect data for their car's speed using both the manual stopwatch and meter stick method and the Vernier Labquest and sensor method.

Differentiation:

Supports

Students are working in groups.

Extensions

Assessment Opportunities:

None Provided

Citations:

Graphing Your Motion (Vernier Lab) — Math Lessons 11-12

Grade Level: 8th grade	**Time Needed:** *50 minutes x 2*	**Subjects:** Math

Objective: Students will recognize and graph ordered pairs on a coordinate plane.

Standards:
Math

Background Information:
Students will need time to explore the Vernier labs if they have not had a chance to use them previously. This lab is meant to reinforce the concepts of collecting data, plotting scatter plots, informally determining the line of best fit and making predictions based on the data.

Materials:
☐ standard classroom materials
☐ student handout
☐ Vernier Labquests (one per group)
☐ Vernier Labquest #33 handout
"Graphing Your Motion"

Vocabulary:

Resources:
- App. B—Lesson 11-12: Math: Vernier LabQuest #33 "Graphing Your Motion"

Procedures:

Day 11
1. Have students acquaint themselves with the labquests. Facilitate exploration or allow students to explore on their own with guiding notes.
2. Break students into groups (number of groups depends on number of labquests available). Introduce the lab and its objectives. Begin lab if time permits.

Day 12
1. Facilitate "Graphing Your Motion" Lab.
2. The lab actually creates a table and scatter plot of data on the labquest. Have students use the data table to create their own scatter plots and compare. Then have students determine lines of best fit and discuss their meaning.
3. Wrap up: Evaluate with relevant justifications the lines of best fit and inferences based on the data.

Differentiation:
Supports Extensions

Assessment Opportunities:
None provided

Citations:

- Vernier LabQuest #33, Middle School Science with Vernier

Data Interpretation — Science Lesson 11

Grade Level: 8th grade	**Time Needed:** 50 min	**Subjects:** Science

Objective: The students will graph their data and discuss whether modifications changed their rate of speed for their car.

Standards:

Science

MS-PS2-2 Plan an investigation to provide evidence that change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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.

Background Information:

A graph of distance and time is usually given with the time along the x-axis and the distance on the y-axis. The graphs should be labelled with units and a title should be written at the top of the graph.

Materials:

- ☐ standard classroom materials
- ☐ graph paper

Vocabulary:

graph
x-axis
y-axis
velocity

Resources:

-

Procedures:

1. The students will graph data that they have collected and will compare the results of their graphs of both the manual and Labquest data that they collected and the before-modification and after-modification data.
2. They will be asked if their modifications increased or decreased their car's velocity.

Differentiation:

Supports

Students will work in groups.

Extensions

Assessment Opportunities:

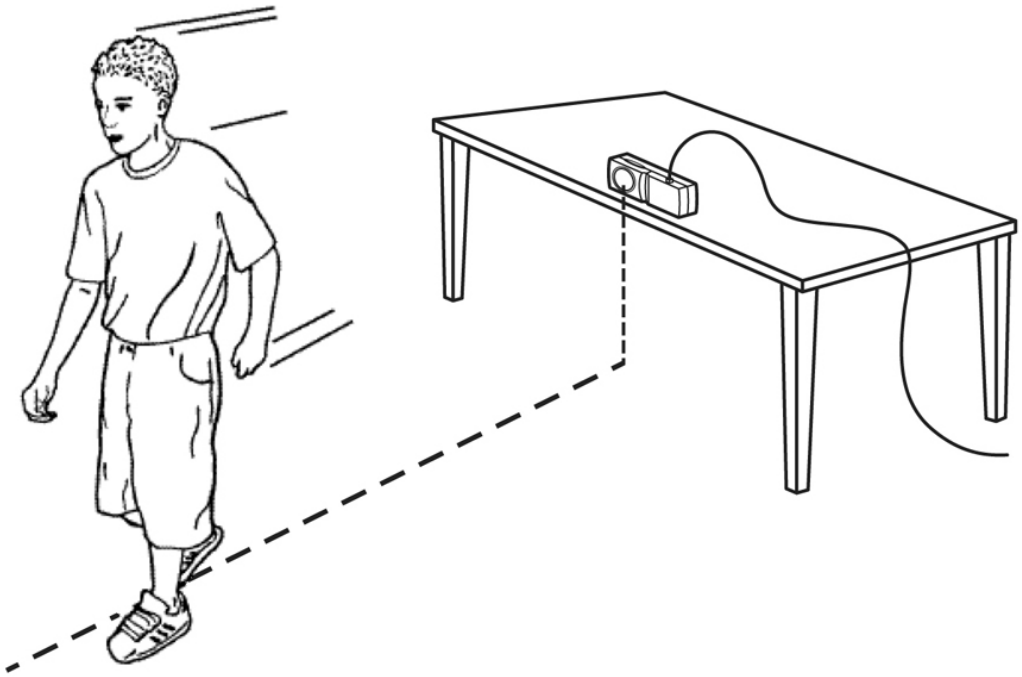
None Provided

Citations:

Walk the Line: Straight Line Distance Graphs— Math Lesson 13

When one quantity changes at a constant rate with respect to another, we say they are *linearly related*. Mathematically, we describe this relationship by defining a linear equation. In real-world applications, some quantities are linearly related and can be represented by using a straight-line graph.

In this activity, you will create straight-line, or constant-speed, position versus time plots using a Motion Detector, and then develop linear equations to describe these plots mathematically.



OBJECTIVES

- Record distance versus time data for a person walking at a uniform rate.
- Analyze the data to extract slope and intercept information.
- Interpret the slope and intercept information for physical meaning.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
CBR 2 **or** Go! Motion, **or**
Motion Detector and data-collection interface

PROCEDURE

1. If your Motion Detector has a switch, set it to Normal, as shown. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. (If you are using a CBR 2 or Go! Motion, you do not need a data-collection interface.)

2. Position the Motion Detector on a table or chair so that the head is pointing horizontally out into an open area where you can walk. There should be no chairs or tables nearby.

3. Choose New Experiment from the Experiment menu. For this experiment, the default data-collection parameters for a Motion Detector will be used (Rate: 20 samples per second; Duration: 5 seconds). The number of points collected should be 101.

4. Stand about a meter from the Motion Detector. When you are ready to collect data, walk away from the Motion Detector at a slow and steady pace and start data collection (). You will have five seconds to collect data.

5. When data collection is complete, choose Show Graph ► Graph 1 from the Graph menu, a graph of distance *vs*. time will be displayed. Examine the graph. It should show a nearly linearly increasing function with no spikes or flat regions. If you need to repeat data collection, repeat Step 4.

6. Once you are satisfied with the graph, sketch or print copies of the graph as directed by your teacher.

DATA TABLE

y-intercept, *b*	
optimized slope, *m*	
optimized line equation	
x_1, y_1	
x_2, y_2	
regression line equation	

ANALYSIS

1. Click any data point and use ► and ◄ to read the values from the graph.

2. The slope-intercept form of a linear equation is $y = mx + b$, where m is the slope of the line and b is the y-intercept value. The independent variable is x, which represents time, and the dependent variable is y, which represents position in this activity. Trace across your graph to the left edge to read the y-intercept. Record this value as b in your data table.

3. One way to determine the slope of your position *vs.* time graph is to guess a value and then check it by viewing a graph of the line. To do this, use the movable line feature of Data & Statistics.
   a. Add a new Data & Statistics page to your document (handheld – Select Insert ► Data & Statistics from the Documents menu; computer – Select Data & Statistics from the Insert menu.)
   b. Add **time** as the variable for the horizontal axis.
   c. Add **position** as the variable for the vertical axis.
   d. Choose Add Movable Line from the Data & Stats Analyze Menu.
   e. Move the cursor over the movable line. Near the center of the movable line, the cursor will appear as a four-directional icon. Away from the center of the movable line, the cursor appears as two arrows in a circular arrangement. Grasp the movable line to translate and rotate it.
   f. Experiment with your movable line to find the best value for *m* and record the optimized value in the data table.

4. Use the values of the slope and intercept to record in your data table the equation of the line that best fits your position *vs.* time data.

5. Another way to determine the slope of a line to fit your data is to use two well-separated data points. Choose two points (x_1, y_1) and (x_2, y_2) that are not close to each other and record them in the data table.

6. Use the points in the table to compute the slope, *m*, of the position *vs.* time graph.

$$m = \frac{y_2 - y_1}{x_2 - x_1} =$$

   Answer Analysis Question 1.

7. You can also use Data & Statistics to automatically determine an optimized slope and intercept.
   a. Choose Remove Movable Line from the Analyze Menu.
   b. Choose Regression ► Show Linear (mx+b) from the Analyze Menu.
   c. Use the parameters *m* and *b* to record the equation of the best-fit regression line in your data table.
   d. (optional) Print your graph.

8. Answer Analysis Questions 2–5.

ANALYSIS QUESTIONS

1. How does this value compare with the slope you found by trial and error?

2. How do the values of the slope and intercept as determined by the calculator compare to your earlier values? Would you expect them to be exactly the same?

3. Slope is defined as change in *y*-values divided by change in *x*-values. Complete the following statement about slope for the linear data set you collected.

   In this activity, slope represents a change in _____ divided by a change in _____.

4. Based on this statement, what are the units of measurement for slope in this activity?

5. The *y*-intercept can be interpreted as the starting position or the starting distance from the Motion Detector. What does the slope represent physically? **Hint**: Consider the units of measurement for the slope you described in the previous question.

Real-World Math with Vernier
Connecting Math and Science

Authors
John Gastineau
Chris Brueninsen
Bill Bower
Linda Antinone
Elisa Kerner

Engineering Work Sample — Science Lessons 12-13

Grade Level: 8th grade	**Time Needed:** Two 50-minute periods	**Subject:** Science

Objective: Discuss Engineering Work Sample and begin their own work sample.

Standards:

Science

MS-PS2-2 Plan an investigation to provide evidence that change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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.

Background Information:

Familiarity with the state scoring rubric for engineering and design is helpful in explaining to the students how they will be graded.

Materials:

Vocabulary:

Resources:

- App A—Lesson 12-13: Engineering Scoring Guide
- App B—Lesson 12-13: Engineering Work Sample Template

Procedures:

1. The teacher will hand out and discuss the state scoring rubric for the engineering and design work sample.
2. The students are given the work sample writing page to fill in for their work sample.

Differentiation:

Supports

Extensions

Assessment Opportunities:

Students will complete an engineering work sample using the template.

Citations:

- **Engineering Design Work Sample Template** http://www.nclack.k12.or.us/cms/lib6/OR01000992/centricity/domain/125/ed_work_sample_template_ms.pdf
- Engineering Design Work Sample Scoring Guide http://www.ode.state.or.us/wma/teachlearn/testing/scoring/guides/2011-12/science_engineering_design_gr6-8_eng.pdf