

K-12 FINAL REPORT

Tennessee Technological University

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STEM in Motion at Tennessee Tech University

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STRIDE

Southeastern Transportation Research,
Innovation, Development and Education Center

UF | Transportation Institute
UNIVERSITY of FLORIDA

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ABSTRACT

The purpose of the STEM in Motion online workshop at Tennessee Tech University was to train high school mathematics and/or science teachers to incorporate transportation-based learning objectives into their classroom lessons. During the workshop, the participating teachers had virtual contact time with both STEM teaching experts and transportation engineers which provided a well-rounded experience. The participating teachers worked both individually and collaboratively through virtual modules. The workshop participants were then able to develop their own standards-aligned transportation related activity to implement in their own classrooms as well as to be shared on the Oakley STEM Center’s website for use by other educators.

Keywords: transportation education, transportation careers, high school teachers, mathematics teachers, science teachers

EXECUTIVE SUMMARY

The STEM in Motion online workshop, developed by Tennessee Tech University, was designed to engage high school mathematics and science teachers in transportation related activities and subsequently encourage them to incorporate transportation topics into their classroom lessons. The workshop was developed to include 10 unique modules that were created by experts in education and civil engineering. Each module included engaging materials both in a virtual format as well as activities which required physical, hands-on learning. All modules required some form of response from participants including data collected from experiments as well as reflections about their classroom practice. Participants worked individually as well as cooperatively via the online platform. The workshop required approximately 20 hours of time to complete.

After completing the workshop modules, the 19 participants created their own transportation related activities, following the same template, which were shared during an online meeting with both the participants and the workshop facilitators. The created activities are housed in both the workshop Google Site as well as the Oakley STEM Center website. By housing the activity plans on the STEM Center's website, they are available to any educator to use in their own classrooms, thus having a greater reach than just the number of participants completing the workshop.

A comparison of the completed pre- and post-surveys show that participants gained both knowledge about transportation topics as well as the teaching of transportation topics in STEM education settings. These results were encouraging in that future workshops, both virtual and face-to-face, can benefit from the materials created in this online setting.

1.0 INTRODUCTION

The purpose of this K-12 project, titled *STEM in Motion*, was to provide teachers with the tools and resources necessary to incorporate transportation topics into their high school science and mathematics lessons. In addition to using a transportation focus to enhance science and math learning via tangible applications, this method attempted to introduce transportation-related career paths to students early on. This approach aimed to achieve the STRIDE goal to enhance the workforce development potential in the transportation field by introducing these topics to high school students. The early introduction of such fields to students may increase the probability of more young people pursuing transportation as a career.

2.0 EDUCATIONAL PROGRAM

STEM in Motion was a high school teacher workshop with the intent to provide high school teachers with knowledge about how to incorporate transportation topics into their mathematics and science lessons.

Workshop Dates: June 22, 2020 to July 2, 2020

Workshop Location: Online (<https://sites.google.com/view/stride-stem-in-motion-ttu-2020/home>)

Number of Participants: 19 Teachers

Participant Contact Hours: ± 20 hours

Tennessee counties Served:

- Cannon County
- DeKalb County
- Hamilton County
- Maury County
- Picket County
- Putnam County
- Van Buren County
- White County

2.1 Narrative

Due to restrictions in place from COVID-19, this workshop was held in a virtual platform utilizing Google Sites. The workshop began on Monday, June 22, 2020, with an introductory Zoom meeting. During this meeting, participants introduced themselves and completed a pre-survey,

facilitators were introduced, and each module was discussed along with overall workshop requirements.

Over a two-week period, participants completed the following modules: Introduction to Transportation in the Classroom, Oakley STEM Center Lending Library Training, Developing Critical Thinking Skills via Current Topics in Transportation, Careers in Transportation, Speed Limits, Problem Based Learning, Weighing a Car, Blind Spot Geometry, Lighting Up Transformations, and Transportation Education Resources. Each module included pre-recorded videos, readings, internet exploration, engaging activities (some virtual and some performed in a physical, hands-on manner), and interactive responses.

Upon completion of all modules, participants used the information gained during the workshop to create a transportation related activity for use with high school students. They used a common template with the following components: overview and purpose, education standards, objectives, materials needed, and activity procedures. These activities were then uploaded to the Google Site for all participants to view.

At the end of the two weeks allotted for working through the materials and creating the activity, participants met together again via Zoom on Thursday, July 2, 2020, for a culminating meeting. At this meeting, each participant shared their activity with the group and then completed a post-survey about their workshop experience.

2.2 Collaborations

This workshop was developed through collaboration between the College of Engineering, College of Education, and the Oakley STEM Center at Tennessee Tech. The development also benefitted from several discussions with the STRIDE management to ensure that the approach was not duplicating other efforts.

2.3 Impacts

An evaluation survey was completed by all participants after the culminating workshop meeting on July 2, 2020. As shown in Table 1, the results were overwhelmingly positive. Please refer to the list of attachments at the end for a compilation of the actual surveys.

TABLE 1 – PROGRAM EVALUATION SURVEY SUMMARY

	Survey Questions	Strongly Disagree	Somewhat Disagree	Neither Disagree or Agree	Somewhat Agree	Strongly Agree
1	The objectives of the training were clearly defined.				3	12
2	Participation and Interaction were encouraged.					15
3	The topics covered were relevant to me.				5	10
4	The content was organized and easy to follow.				6	9
5	The materials distributed were helpful.				2	13
6	This training experience will be useful in my work.				6	9
7	The trainers were knowledgeable about the training topics					15
8	The trainers were well prepared.					15
9	The training objectives were met.				3	12
10	The time allotted for the training was sufficient.		2		3	10
11	I feel confident checking out items at the STEM Center Lending Library.				3	12
12	The Topics covered were relevant to the subject(s) I teach.		1		7	7

2.4 Recommendations

The Google Site created for this workshop will be maintained in its present form to be accessed by the participants of this year’s cohort. In the future, this Site can be duplicated and edited for use with other programs. The same materials would also be beneficial for face-to-face experiences as well.

3.0 EDUCATIONAL PRODUCT

3.1 Narrative

STEM in Motion was a high school teacher workshop with the intent to provide high school teachers with knowledge about how to incorporate transportation topics into their mathematics and science lessons. This online workshop included 10 unique modules that were developed and facilitated by the following personnel:

TABLE 2 – PROGRAM FACILITATORS

Name	Position	Role
Lina Abounsassif	College of Engineering PhD Student	Facilitated session on introducing transportation in the classroom
Dr. Steven Click	Associate Professor of Civil and Environmental Engineering	Created module on Developing Critical Thinking Skills via Current Topics in Transportation
Carlos Galindo	Millard Oakley STEM Center Outreach Coordinator	Marketing and participant recruitment
Dr. Jennifer Meadows	College of Education Assistant Professor	Organized online workshop; created and monitored Google Site to house workshop materials; created template for transportation activities; created modules for the Oakley STEM Center Lending Library Training, Careers in Transportation, and Transportation Education Resources; facilitated both the introductory and closing meetings for the online workshop
Kelly Moore	College of Education Lecturer	Created modules for Speed Limits, Problem Based Learning, and Weighing a Car
Dr. Darek Potter	Millard Oakley STEM Center Director	Organized workshop including recruiting session facilitators, scheduling, and managing logistics
Carey Wilson	College of Education PhD Student	Created modules for Blind Spot Geometry and Lighting Up Transformations

The workshop introductory Zoom meeting included an overview of the modules and the intent of the workshop as a whole. Participants had minimal questions and seemed excited about both learning new content and learning in an online format similar to what they had been

experiencing in the spring with their students. The modules are described below. All teachers developed a transportation related activity at the end of the workshop. The final activities are described briefly in 3.1.11 and are provided in full in the appendix.

3.1.1 Introduction to Transportation Module

The first module was created by Lina Abounsassif, a PhD student in the College of Engineering. This was an introduction to transportation in the classroom. This module included the following topics:

- What is transportation?
- Why is transportation important?
- How do we transport things?
- How do you use transportation?
- What are possible jobs?
- How can “too much” transportation be bad?
- “We Need a Road” Activity

Upon completion of this module, participants answered the following questions using a Google Form:

1. Discuss how information within the presentation is connected to standards taught in your classes.
2. Discuss how the activity "We Need a Road" could be used or modified to be used in your classroom.
3. What do you hope to gain from participating in this STEM in Motion: STRIDE Workshop?

3.1.2 Oakley STEM Center Lending Library Module

In the next module, Oakley STEM Center Lending Library Training, created by Dr. Jennifer Meadows, College of Education Assistant Professor, participants watched a video about how to navigate the Oakley STEM Center’s Lending Library website along with four other videos highlighting specific pieces of equipment available for checkout. To certify that they had watched all videos and understood how to access the website, participants submitted their information to be added to our system via a Google Form.

3.1.3 Developing Critical Thinking Skills via Current Topics in Transportation Module

Dr. Steven Click, College of Engineering Associate Professor, created the third module, Developing Critical Thinking Skills via Current Topics in Transportation. Participants looked at “Rideshare and the Gig Economy” and “Infrastructure Funding Gap” as topics for objective analysis and evaluation to build critical thinking skills. Responses from participants were

collected via Google Forms and Poll Everywhere asking questions such as “What other current issues related to transportation might be of interest to students?”

3.1.4 Careers in Transportation Module

Careers in Transportation were explored in the next module created by Dr. Jennifer Meadows. In this module, participants explored each of the links to the Dream Big Project, a project that encompasses resources and programs designed for students, teachers, engineers, and science centers, including 50+ hands-on activities, girl-centered events, lesson plans, design challenge exhibits, videos, and more. They also watched short videos about specific careers in the transportation field. Afterwards, participants completed a Google Form to share their thoughts about 3 resources that they might be likely to use in their classrooms.

3.1.5 Speed Limits Module

Kelly Moore, College of Education Lecturer, created the Speed Limits module. Dr. Moore shared an activity from a publication of the National Science Teaching Association (NSTA), *It's Debatable*. Here participants explored the question “Should speed limits be lowered to reduce traffic fatalities?” They were asked to use Flipgrid (<https://flipgrid.com/73a1cc3d>) to record their opening statement in a debate over the “need for speed” according to the group they were assigned (truck drivers, parents, business leaders, or police officers) using evidence from selected articles to support their position. Following the original posts, participants then replied to two other participant posts.

3.1.6 Problem-Based Learning Module

In the problem-based learning module, Dr. Moore utilized the National Science Teaching Association (NSTA) text, *Problem-Based Learning in the Physical Science Classroom*. She highlighted Chapter 5: Get Moving. This chapter looked at four problems: Get Me Out of Here, Fastest Human, Constantly Moving, and Good Driver. Participants read excerpts from the text and watched a short video. From there, they were asked to create a Padlet (<https://padlet.com/kellyrheamoore/STRIDE>) post responding to one of the following prompts: Create a convincing argument that Johnson was the fastest runner; Create a convincing argument that Bailey was the fastest runner; or Explain how you could use this activity (or another PBL idea from Chapter 5) in your classroom. Participants were then asked to follow this up with two replies to other participant posts.

3.1.7 Weighing a Car Module

Dr. Moore created the Weighing a Car module where participants explored Newton’s third law, pressure, and unit conversions. They watched a video and then collected data on their own. They were asked to park a car on a smooth, level surface such as a sidewalk or smooth concrete driveway, then placed graph paper closely behind each tire on the cement and carefully rolled the car backwards so that the tires rested fully on the graph paper. They then determined the area of the tire that was in contact with the ground by tracing around the tire as closely as possible to where it met the paper. Next, they determined the air pressure in the tire with a

pressure gauge several times to take the most representative pressure in pounds per square inch. Then they made a crayon rubbing of a section of tire tread, going across the entire surface side-to-side of the tire. They found the recorded weight of the car, either by using an internet search or checking the frame of the driver side door (load information plate), where it sometimes can be found. This data was used to calculate the area of the tire outlined on the graph paper and adjusted by considering the percentage of the tire that was in contact with the ground based on the crayon rubbing. The weight load on the tire was determined by multiplying the tire pressure by the amount of adjusted contact area. This was repeated for all 4 tires. Analysis was to determine the percent error of the accepted/actual weight of the car compared to the experimental weight of the car. Using Google Forms, participants completed the experiment on their own and submitted the results.

3.1.8 Blind Spot Geometry Module

Carey Wilson, a PhD student in the College of Education, created the Blind Spot Geometry module where participants watched a series of videos and complete an experiment about determining blind spots. Participants gained knowledge about blind spots and semitrucks, blind spots and driving motor vehicles, and blind spots and technological advances. Because Carey is a math teacher as well, she incorporated a significant amount of mathematics in this module by having participants practice with proportion statements in order to connect real-world scenarios to mathematics. Participants worked to see how spatial reasoning, similarity, and real-world problems work together to help them determine how to find their respective blind spots. Participants responded to this module by creating a Google Doc with their completed data sheet from the experiment and submitting that through a Google Form.

3.1.9 Lighting Up Transformations Module

Carey Wilson developed the Lighting Up Transformations module where participants were challenged with this question: Which graphical model most closely simulates the flashlight beam (to represent headlights): Linear, absolute, quadratic, cubic or exponential? They were asked to explore the online math tool, Desmos. They also looked at the science behind how headlights work by viewing a video on the subject. This module's main purpose was to help participants connect real-world scenarios to mathematical models. In the context of a flashlight beam (modeling the lights on a vehicle), a quadratic function might be used to model the beam of a flashlight or the absolute value function might be better suited. It really depended on the arguments presented that might make one function better than the other. With the Desmos activity, the participants were introduced to graphical transformations when they used the sliders on Desmos to manipulate the functions. Participants saw how these manipulations changed the equation and the graph at the same time, and they connected that to identifying parent functions and transforming those parent functions. Participants responded to this module by creating a Google Doc with their completed data sheet from the experiment and submitting that through a Google Form.

3.1.10 Transportation Education Resources

The final module for the workshop was Transportation Education Resources, created by Dr. Jennifer Meadows. In this module, participants were asked to explore links to various transportation education resources and think about how they might be incorporated in their classrooms. They then completed a Google Form to share their thoughts about 3 of the links they intend to use in their classrooms. They were also asked to add other transportation education resources they have heard about or used to a Padlet (<https://padlet.com/jennifermeadows7/3y356yauno55cewr>).

3.1.11 Teacher Developed Activities

Each participant created a transportation related activity for a total of 19 activities. These activities are housed both on the Oakley STEM Center website (<https://www.tntech.edu/education/stem/educators-schools.php>) and on the workshop Google Site (<https://sites.google.com/view/stride-stem-in-motion-ttu-2020/home>).

3.2 Collaborations

The following table describes collaborative efforts to develop and implement the STEM in Motion workshop.

TABLE 3 – PROGRAM COLLABORATORS

Group	Contribution
Millard Oakley STEM Center	Marketing and participant recruitment; Organized workshop including recruiting session facilitators, scheduling, and managing logistics
College of Engineering	Created modules on Introducing Transportation in the Classroom and Developing Critical Thinking Skills via Current Topics in Transportation
College of Education	Organized online workshop; created and monitored Google Site to house workshop materials; created template for transportation activities; created modules for the Oakley STEM Center Lending Library Training, Careers in Transportation, Transportation Education Resources, Speed Limits, Problem Based Learning, Weighing a Car, Blind Spot Geometry, and Lighting Up Transformations; facilitated both the introductory and closing meetings for the online workshop

3.3 Impacts

A workshop evaluation form was completed by all workshop participants after presentation of activities at the culminating Zoom meeting. The results of the evaluation survey were overwhelmingly positive. Please refer to the attachments section for all of the completed surveys.

3.4 Recommendations

The online workshop materials from the Google Site will be maintained for use by the participants from this cohort. The materials will be duplicated and edited for use in future workshops either in an online or in-person format.

4.0 CONCLUSION

This online workshop was designed to engage high school mathematics and science teachers in transportation related activities and subsequently encourage them to incorporate transportation topics into their classroom lessons. The online workshop was developed to include 10 unique modules that were created by experts in education and civil engineering. Each module included engaging materials both in a virtual format as well as activities which required physical, hands-on learning. All modules required some form of response from participants including data collected from experiments as well as reflections about their classroom practice. Participants worked individually as well as cooperatively via the online platform. The workshop required approximately 20 hours of time to complete.

The workshop participants included 19 teachers from eight Tennessee counties. After completing the workshop modules, the 19 teacher participants created their own transportation related activities, following the same template, which were shared during an online meeting with both the participants and the workshop facilitators. The created activities are housed in both the workshop Google Site as well as the Oakley STEM Center website. By housing the activity plans on the STEM Center's website, they are available to any educator to use in their own classrooms, thus having a greater reach than just the number of participants completing the workshop.

The online format was viewed positively by the participants and is planned to be used again in the future in a modified form.

5.0 REFERENCE LIST

1. McConnell, T. J., Parker, J., & Eberhardt, J. (2018). *Problem-Based Learning in the Physical Science Classroom, K-12*. NSTA Press. 1840 Wilson Boulevard, Arlington, VA 22201.
2. Zeidler, D. L., & Kahn, S. (2014). *It's debatable!: Using socioscientific issues to develop scientific literacy K-12*. NSTA press.

6.0 ATTACHMENTS

- Online Workshop Google Site: <https://sites.google.com/view/stride-stem-in-motion-ttu-2020/home>
- Appendix A: Transportation Related Activities Created by Participants
- Appendix B: Workshop Pre-Surveys
- Appendix C: Workshop Post-Surveys

Appendix A – Transportation Activities Created by Participants

The following activities can also be found at <https://sites.google.com/view/stride-stem-in-motion-ttu-2020/transportation-activities>

Where is my Cookie

Teacher: Dusty Ragland

Adapted from Stuart Lenz - Mid-America Transportation Center

Date: 06/29/2020

Overview & Purpose

Students will work with equations and graphing of lines. Concepts of slopes, slope-intercept form, degrees, and coordinates are all covered.

Education Standards

8.EE.B.6 Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; know and derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b .

8.EE.C.8 Analyze and solve systems of two linear equations. a. Understand that solutions to a system of two linear equations in two variables correspond to points of intersection of their graphs, because points of intersection satisfy both equations simultaneously. b. Solve systems of two linear equations in two variables algebraically, and estimate solutions by graphing the equations. Solve simple cases by inspection. For example, $3x + 2y = 5$ and $3x + 2y = 6$ have no solution because $3x + 2y$ cannot simultaneously be 5 and 6. c. Solve real-world and mathematical problems leading to two linear equations in two variables. For example, given coordinates for two pairs of points, determine whether the line through the first pair of points intersects the line through the second pair.

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.G.A.2 Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates

Objectives

1. Students will graph lines from equations and will plot points from degree readings on a protractor and draw a line that connects the points
2. Students will write equations from lines drawn between coordinates
3. Students will plot coordinates on a map from latitude and longitude
4. Students will use triangulation, directions and coordinates to find their package

Materials Needed

1. Protractors, rulers, yarn or Wiki Stix, compass
2. Handouts
3. Projector
4. Map of major nearby city
5. Object to hide on campus

Activity Procedures

Warm up activities

- Review equations of lines. Students will complete a warm-up activity by finding the equation of a line given two points
- Display a map of Tennessee, and briefly discuss latitude and longitude and how to convert Latitude and Longitude coordinates to decimal degrees
- Find distance between two points on a map using the distance formula or Pythagorean theorem after converting to decimal degrees

In class activity

- Teacher will provide a map of the school and hide an object somewhere in the school.
- Students will be given clues about the direction and location of the object. Some clues will be given as equations, some will be given as directions and some will be given as coordinates.
- Students will locate the object on the school map

I usually do this activity after Algebra II EOC testing as something fun for my students. I usually stretch it out for two days. I try to cover as many math concepts as I can that we covered throughout the year. Mostly, I just want them to have fun. I don't have a true lesson plan for it. I have tried to write one for this activity, but usually the students and I just go with it. They love to try and be the first ones to find whatever it is that I have hidden, it's always a favorite treat of theirs. I give the students a copy of the blueprints of our school on a grid when doing this activity. I cannot upload it to this google form because it is in my classroom and we cannot go into the building right now. Any blueprint would work. I bring in my Garmin GPS handheld.

I also show videos about Geocaching and Latitude and Longitude:

Introduction to Geocaching 101 <https://youtu.be/V9Wg38rn0q8>

How to find latitude and longitude: https://youtu.be/ztzNh4bzL_M

Kinetic Energy of Travel

Teacher: Stephen Dotson

Date: 06/30/2020

Overview & Purpose

Students will be measuring their kinetic energy to get to school. This will be related to the movement of atoms.

Education Standards

- Science: PSCI.PS3 Energy 5) Investigate the relationship among kinetic, potential, and total energy within a closed system (the law of conservation of energy)
- Math: Measurement and Data: A. Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects

Objectives

1. Refresher on what Kinetic Energy is and how it is calculated. (many students think of this only as a physical science/physics topic)
2. Learn how Kinetic Energy of atoms and molecules are calculated.

Materials Needed

1. Worksheet
2. Scale (1 at a time)
3. Paper and writing utensils (because half of them didn't bring one)
4. Calculators (30)

Activity Procedures

- Teachers job is to keep people on task, answer questions, and ask questions to those groups that are stuck are doing it wrong in order to help guide them.
- Break the students into groups so they can help each other if they get stuck.
- Have students get their mass on the scale. (they will have to convert to metric which is conversions is another standard to hit)

- Assume that the bus is going 70 miles per hour and calculate your kinetic energy. (they can't copy each other's numbers because it is unlikely 2 people weigh the same)
- Ask why some people have more energy than others.
- Relate this to an atom of carbon that is traveling at a given speed and have them calculate and compare the difference.
- Ask questions about comparison of the 2 numbers.

Name _____

Dotson KE Worksheet

Kinetic Energy

Everything that moves has energy, today you will be estimating how much energy it took to get you to school.

1. Obtain your weight on the scale _____

(now convert to kg) _____

2. Assume that the vehicle that brought you here was going 70 miles per hour _____

(now convert to m/s) _____

3. Calculate the kinetic energy (KE) you had at that time (m = mass and v = velocity)

$$KE = \frac{1}{2}mv^2$$

Why do some people have larger numbers?

What would happen to the Kinetic Energy if the bus went faster?

Atoms have energy just like you.

4. Calculate the KE of an oxygen atom going 464 m/s.

a. Calculate the mass of O_2 molecule _____

b. You are given the velocity _____

c. Calculate the KE of the O_2 molecule _____

What two things of the molecule or atom affect the kinetic energy?

Why is an atom's kinetic energy so different than you traveling on a bus?

Graphing Speed and Acceleration

Teacher: Ms. Beasley

Date: 06/30/2020

Overview & Purpose

Provide a brief description about the content addressed in the activity. The scope of this lesson (activity) is to compare and contrast speed, velocity, and acceleration. In order to bring real world understanding of speed, velocity and acceleration, student will view several videos related to transportation and the jobs of that industry.

Education Standards

- PSCI.PS2: Motion and Stability: Forces and Interactions
- 1) Use mathematical representations to show how various factors (e.g., position, time, direction of force) affect one-dimensional kinematics parameters (distance, displacement, speed, velocity, acceleration). Determine graphically the relationships among those one-dimensional kinematics parameters.
- 2) Algebraically solve problems involving constant velocity and constant acceleration in one-dimension.

Objectives

1. **Learning objectives** define **learning outcomes**:

In this lesson, students will learn to compare and contrast between speed, velocity, and acceleration, this part of the assignment will require 2 days. The 3rd day of the assignment students will utilize a faster method to accomplish their task. The first method supports critical thinking in that students are able to calculate values and plot their data as opposed to the second method in which a computer does it for them. Understanding what the values mean in the first task will add to a greater understanding of the second method.

Day 3 after Veiner Lab is completed students will view several transportation videos to gain a better perspective as to the role transportation engineers and managers play and the many jobs available in the transportation industry. Students will select 3 of the below resources and write a short paragraph for each contribution linked to the very roads they travel daily.

Materials Needed

1. See attached lab for Motion (ramp, timer, meter stick, calculator) **Day 1-2**

Loaners from Oakley STEM Center Lending Library Graph paper

Veiner Lab and accessories Day - 3

2. 14 Veiner tracks
3. 7 cart fans
4. 7 motion detectors
5. 7 Lab Quests

Activity Procedures Day 1 - 2

- Describe each step-in detail about how to lead this activity.
 - Include teacher and student actions.
 - Include formative assessment throughout the activity.
- Teacher - Role
- Teacher passes out lab activity and informs students of expected behavior and must be present for the first 30 minutes of class time for lab activities
 - Teacher places students into groups no more than 4 per group

- Each group consists of a leader, technician, timer, and a recorder
- Teacher goes over lab activity with students and takes Q & A
- Teacher model track set up with students and takes Q & A
- Turn in the below activity

<https://1.cdn.edl.io/33eJtleBpypgoHCxLDaZ8UsdHJu0rIWw2MI5MR1GCWWtezVP.pdf>

Day – 3 Veiner Lab

- Teacher will provide students with a video demonstrating the Veiner track and accessories
- Teacher will assemble the track including the cart fan, and motion detector, along with demonstrating the use of the Lab Quest
- Teacher will assign student groups (4/group)
- Teacher will then navigate the classroom for Q & A as students assemble their Veiner set up.
- Students will then perform dry runs with the equipment 2x
- Students will participate in 4 different trials whereby each student rotates through starting position and operating Lab Quest
- Students will then analyze their data to determine speed, velocity, and acceleration along with manipulating their graphs to print out and place in their lab note book.

DAY 3 – TRANSPORTATION RESOURCES

Resources for above transportation industry links:

Civil Engineer - <https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=17205100>

Mechanical Engineer -

<https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=17214100>

Computer Engineer -

<https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=15113100>

Transportation Manager -

<https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=11307101>

Urban and Rural Planners -

<https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=19305100>

Going Further – These links will be assigned to students as homework or for early finishers when all of the above assignments are completed.

Seven Major Myths about Speed

<https://docs.google.com/document/d/1-Ft-UQm-OnKtKu0t5cgH5AX-zlpQobuMTxG1GwvMWw8/edit?usp=sharin>

Facts Sheet

https://docs.google.com/document/d/1ZAMs56Q846KPTz8NmrLt66WiF6TjhdqGJcZvRKa_j7k/edit?usp=sharing

Safety: As Speed Limit Rise So Does Death Toll

<https://docs.google.com/document/d/1igqNdeB6orkgjZKq6vaZEhoOm5gw2gY7yP0IR2aZFKo/edit?usp=sharing>

Article 4 “Speed Kills”

https://docs.google.com/document/d/1tQ_57qsEfCzobUbtPXNdSHOFzqEpRD26U7Z3_ADcbPk/edit?usp=sharing

Deaths, Injuries Increase With Higher Speed Limits

<https://docs.google.com/document/d/1Y0ZD5aF2pBYxLoNOS2wAGgcCpKaok836UwuUEM2MhW8/edit?usp=sharing>

Speed, Velocity and Acceleration Lab

Name _____

In this lab, you will compare and learn the differences between speed, velocity, and acceleration. You will have two days to complete the lab. There will be some graphing and conclusion questions near the end, but be sure to work quickly to collect your data first so that you make sure there is enough time to complete the lab. Be sure to read all parts of the lab as you go through it.

SPEED vs. VELOCITY

Suppose you are running a race and you want to impress a friend by telling them about it. If you only tell your friend that you ran your race in 20 minutes, that's not enough information for them to know if you ran fast or slow. You would also need to tell your friend how far the race was. A 5 kilometer race in 20 minutes is pretty fast, but a 100 meter dash in 20 minutes is....just sad. What your friend wants to know to see if you ran well is your speed. They will need two things to find your **speed**: 1) the distance you traveled and 2) the time it took you to finish. **Speed** is calculated by dividing your distance by your time.

$$\text{Speed} = \text{Distance} / \text{Time}$$

Now imagine that you are trying to impress a friend by saying that you once swam 100 meters in 65 seconds in a really fast-moving river. This is pretty impressive, considering the world record for a 100m swim is 45 seconds! But wait...if the river was moving fast, were you swimming into the current or with it? I mean, swimming with the river current, anybody can do that! This is an example of when the direction matters. **Velocity** is speed of an object in a particular direction. If your velocity was moving INTO the current, then you're pretty awesome, but if it was in the same direction as the current, you're just...normal. ;) Velocity is calculated in the same way as speed, except you must include the direction.

$$\text{Velocity} = \text{Distance in a direction} / \text{Time}$$

***Most times, a forward speed is expressed as positive velocity, and a backwards speed is a negative velocity. Try a few calculations for **speed** and velocity below. Round to the nearest 10th:

- 1) You run 100 meters in 15 seconds. What is your speed in m/s?
- 2) In a race, you run 3000 meters east in 21 minutes. What is your velocity in Km/min?
- 3) You walk forward 10 meters, backwards 5 meters, and then 10 meters forwards in 15 seconds. What is your overall velocity FORWARDS in m/s?

ACCELERATION

Many times in sports, people can run fast, but it may take them a while for them to get to their top speed. If you are chasing after a soccer ball, but you are not very quick, you may not get to it first. The rate that you can change your speed/velocity is called the **acceleration**. Just like velocity, acceleration must have a direction. Speeding up is a positive acceleration, slowing down is a negative acceleration.

$$\text{Average Acceleration} = \frac{\text{Final velocity} - \text{Starting velocity}}{\text{Time}}$$

Many times, we can see this with car advertisements that say, "This car can go from 0-60 in 4.2 seconds!" The Final velocity is 60, the starting velocity is 0, and the time is 4.2 seconds.

- 1) What would the average acceleration be for a car at a stoplight that speeds up to 20 m/s in 10 seconds (in m/s^2)?
- 2) Imagine that a car traveling at 100 m/s must slam on the brakes to avoid hitting a racoon. If it takes 4 seconds for the car to slow down to a stop, what is its acceleration (in m/s^2)?

VELOCITY MINI-LAB

Question: How does the height of a ramp affect the velocity of a car rolling down it?

Write your own if-then **hypothesis** below:

Investigation:

1. Gather one ramp, one car, one timer, and five books.
2. Measure the length of your ramp in cm to the nearest 10th of a centimeter and write it here. _____ cm
3. Set up a ramp using one book to elevate your ramp. Measure the height of the ramp and record it here. _____ cm
4. Set the car at the top of your ramp.
5. Start the timer and release your car at the same time. Stop the timer once the car touches the table.
6. Record the time in Table 1.
7. Use the Distance of the ramp and the time to find the velocity of the car (in cm/s).
8. Repeat steps 3-7 with 2 books, 3 books, 4 books, and 5 books.
9. Graph the Height of the ramp against the velocity and make your conclusion.

Table 1

Ramp Height (cm)	Time (s)	VELOCITY (cm/s)

1. Independent Variable _____ Dependent Variable _____

ACCELERATION MINI-LAB

Question: What is the acceleration of a car that travels down a ramp and eventually stops?

Observation: Acceleration of most solid falling objects is around 9.8 m/s^2

Write your if-then **hypothesis** here:

Investigation:

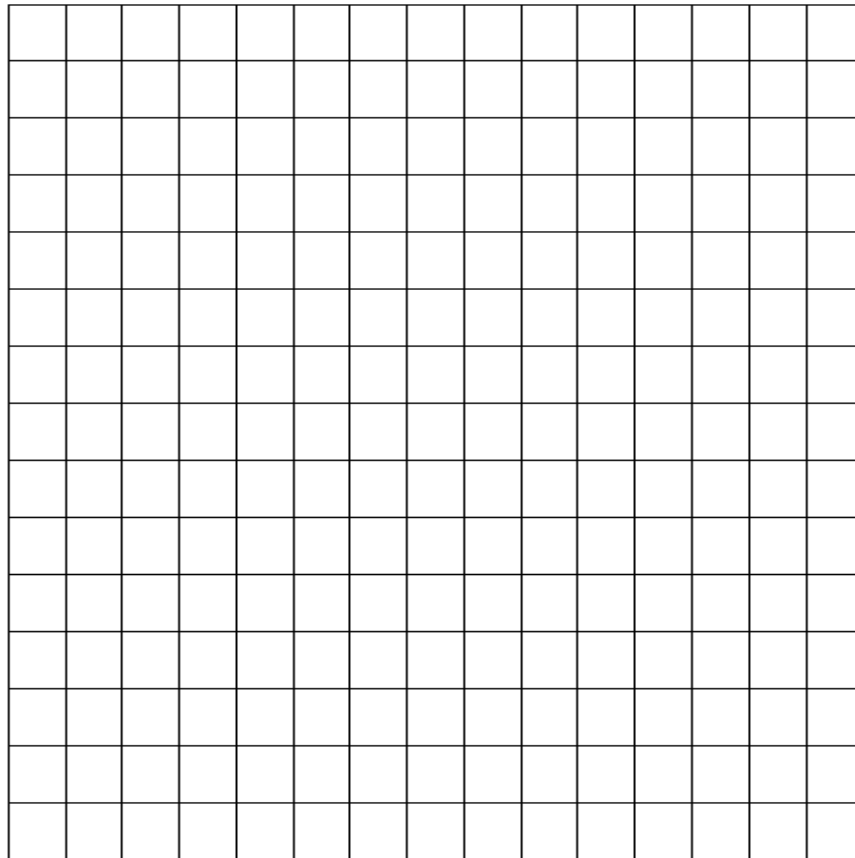
1. Set up a ramp using 5 books. Measure out another meter from the end of the ramp, and mark out every 50 cm using a piece of tape on the ground. Measure the total distance and record it here. _____cm
2. Have three people with three stopwatches and one person be in charge of releasing the toy car.
3. Assign one timer to stop at the end of the ramp, one timer to stop at 50 cm, and one timer to stop at 100 cm.
4. On a count of three, have all three timers begin and the car release from the top of the ramp.
5. Record the times that it took the car to reach the end of the ramp, 50 cm, and 100 cm.
6. Repeat steps 4 and 5 two more times and record in Table 1. Calculate the average times and record in table 2.
7. Calculate the velocity of the car at the beginning of the ramp (HINT: it's sitting still), at the end of the ramp, 50 cm, and 100 cm.
8. Graph the velocities of the car at each of the 4 parts of the ramp system in a line graph.

Table 1

Distance	Trial 1	Trial 2	Trial 3	Average time
End of ramp				
50 cm				
100 cm				

Table 2

Location	Actual Distance (cm)	Time	Velocity= Distance/time
Top of Ramp	0 cm	0 s	0 m/s
End of Ramp			
50 cm			
100 cm			



Questions/Conclusion

1. Independent Variable_____ Dependent Variable_____

2. Calculate the average acceleration between the top of the ramp and the bottom of the ramp. Show your work.

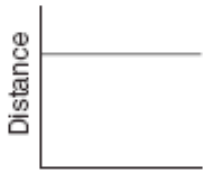
3. Calculate the average acceleration between the bottom of the ramp and the end of the 100 cm mark. Show your work.

4. What are some things that may have caused bias in your experiment? Explain at least 1 example well.

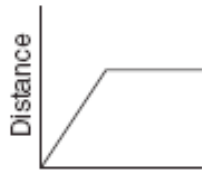
REVIEW:

Match up graphs 1-4 with the correct description of the motion of the object for section one, and then use the section two graph to complete questions 5-7.

Graph 5



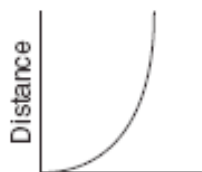
(1)



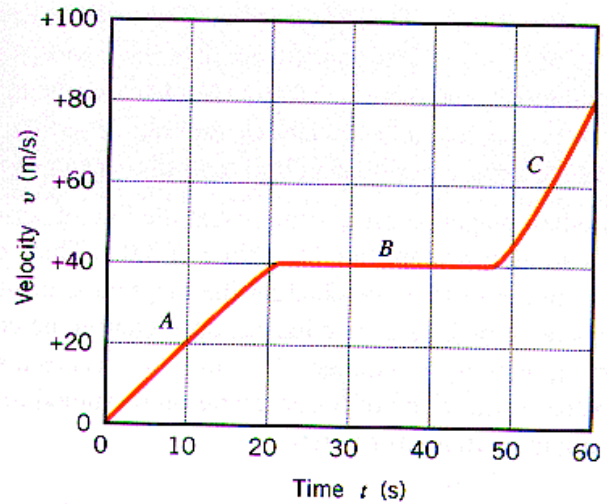
(3)



(2)



(4)



1. _____ Object is staying in the same place.
2. _____ Object is moving at a constant velocity
3. _____ Object is accelerating.
4. _____ Object is moving at a constant velocity and then stops/stays in the same place.
5. _____ Which section(s) of the graph show(s) an object accelerating?
 - a) A b) B c) C d) A and C
6. _____ Which section(s) of the graph show(s) an object moving at a constant velocity?
 - a) A b) B c) C d) A and C
5. _____ Which section(s) of the graph show(s) an object accelerating at a rate of about 2 m/s²?
 - a) A b) B c) C d) A and C

It's a Bird. It's a Plane. It's a Drone.

Teacher: Maxine Dawson

Date: 06/30/2020

Overview & Purpose

The purpose of this activity is to use drones to review trigonometry and to use that to introduce vector diagrams.

Education Standards

- PHYS.PS2: Motion and Stability: Forces and Interactions (4.) Use free-body diagrams to illustrate the contact and non-contact forces acting on an object. Use the diagrams in combination with graphical or component-based vector
- PSCI.PS3: EnergyStudents should be able to understand that by similarity, side ratios in right triangles are properties of angles in the triangle. Students should use this understanding to explore and understand the definitions of trigonometric ratios for acute angles. The instructional focus is for students to have opportunities to explore different right triangles that have and do not have proportional side lengths to understand that corresponding sides of right triangles with the same acute angle measure will be proportional in length.
- G.SRT.C.8b Know and use the Law of Sines and Law of Cosines to solve problems in real life situations. Recognize when it is appropriate to use each.

Objectives

1. **Students will analyze the movement of the drones.**
2. **Students will solve problems involving trigonometry**
3. **Students will recognize the angle of elevation**
4. **Students will research and understand the use of drones in industry particularly product delivery. They will get a feel of the advantages and problems with the use of drones.**

5. Students will make the connection between the drawing of the right triangles and vector diagrams.
6. Students will be able to make simple vector diagrams.

Materials Needed

1. 12 drones--work one for each group of two or 3
2. 2 extra charged batteries for each drone
3. clinometers-made from protractors, straws and string.
4. Rulers
5. Graph paper
6. Tape measure
7. Calculators
8. 12 Envelopes to deliver to porch
9. Painters tape

Activity Procedures: Three day activity

Day 1:

- Review right triangle trigonometry
- A review of how to do this is found here
<https://mathbitsnotebook.com/Geometry/Trigonometry/TGTrigSides.html>
- Explain what a clinometer is. (have these already made

<https://www.instructables.com/id/Basic-Clinometer-From-Classroom-Materials/>)

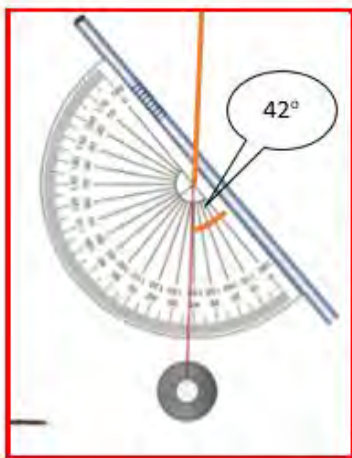
- Go over how to use a clinometer (hypsometer)
- <https://www.youtube.com/watch?v=5XpWfJdjzdM>

Start out by holding the clinometer so that the straw is parallel to the ground.

Slowly tilt the straw up until you can see the very top of the object through the straw.

Have your partner record the angle measure that the string stops at.

Recall, since you start the string at 90 degrees, you must subtract the recorded angle measure from 90 to get the angle of elevation .



So the angle of elevation is $90 - 42 = 48$

Now that you know how to use the clinometer, use it to solve the

- As a class find the height of the wall in the classroom using right triangle trigonometry and the clinometer.
 1. Draw a right triangle
 2. Find the angle of elevation--then label it on the drawing
 3. Find the distance to the base of the wall--include this on the drawing
 4. Use the trigonometric function to find the height of the wall. Show work
- Formative assessment: Use a clinometer to find the height of the gym wall, cafeteria wall (or any trees and flagpoles)

Day 2:

- Introduce the drones with short power point
- Students will research how drones are used in business
- Students will work in groups of 2 or 3 to learn how to fly the drones
- Advanced students will use droneblocks to program drones

Day 3:

- Review work done with clinometer and right triangle trigonometry.
- Work in groups of 2 or 3. Each group will have a drone, clinometer, calculator, graph paper and tape measure
- Students will go to the football field and take turns seeing how high they can fly the drone. The students that are not flying the drone will calculate the height of the drone. When that is done they will switch until each student has flown the drone and each student has completed calculations.
- Assign this challenge problem: An airplane climbs at an angle of 18° with the ground. Find the ground distance the plane travels as it moves 2500m through the air. Give your answer to the nearest 100m.

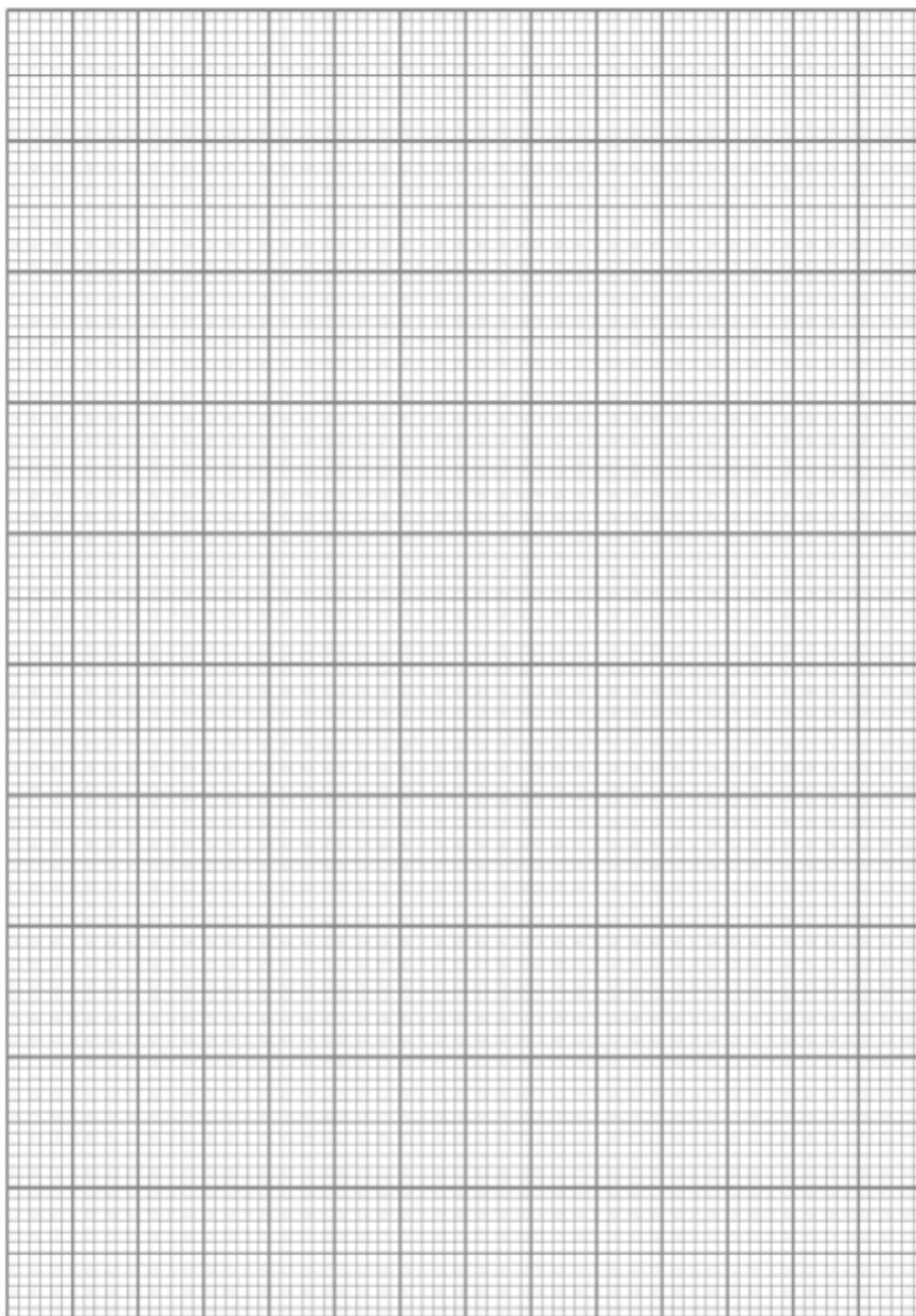
Day 4

- Place markers on the ground around the porch in front of the school. Mark with painters tape.
- Students will find the angle of elevation from that spot to the door.
- Students will calculate the height they need to raise the drone so they can deliver the envelope. The angle needed to find the height to get under the porch and the angle needed to the spot where they will lower the drone and deliver the envelope. Students need to discuss the movement of the drone. Note: the drones will fly up and down; right and left so how are you going to fly you drone. What are the distances?
- Assessment: This will include detailed calculations and diagrams for this activity.

Day 5

- Review vectors and vector diagrams.
- Go over student work and discuss the right triangles drawn. Make the connection between the right triangles and displacement vectors. Emphasize that the hypotenuse is resultant of the two displacement vectors.
- Give students their delivery work and have them draw the movement of their drone as a vector diagram.

- Hand out 3 x 5 cards with the name of a location in the school and then have the students fly the drones to that location while creating a vector diagram of the trip.
- As a final step the students will have to find the resultant of the diagrams.



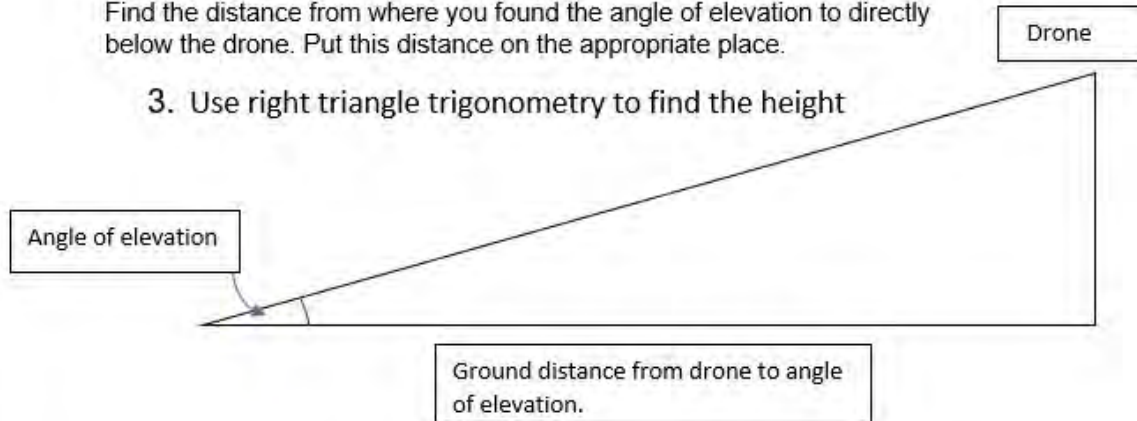
High Flyin'

Each student will fly a drone. Your teammates will calculate how high your drone flew.

1. Draw a right triangle
2. Find the angle of elevation—put this on the sketch of the right triangle

Find the distance from where you found the angle of elevation to directly below the drone. Put this distance on the appropriate place.

3. Use right triangle trigonometry to find the height





It's a bird, it's
a plane, it's a
drone



Dublin, March 25, 2020 (GLOBE NEWSWIRE) -- The "[The Drone Delivery Report 2019-2024](#)"

The Drone Delivery Market, Forecast to 2024 - Drone Deliveries Will Be the Fastest Growing Application Within the \$43+ Billion Global Drone Market

- The Drone Delivery Report finds that the global drone market will grow from \$14 billion in 2018 to over \$43 billion in 2024 at a CAGR of 20.5%. Drone deliveries will be the fastest growing application method within that market.

The Last Mile

- The last mile of a delivery is often the most expensive
- Drones can ensure each delivery, is carried out safely and quickly to the correct address, securing high levels of customer satisfaction even as costs are reduced.

<https://gcelogistic.com/drone-delivery-for-shipping/>





Obstacles to Overcome

- Drones are still relatively light-weight and can handle short flight durations of 15-30 minute flights with 10-15 pound payloads.
- Drones also still represent an expensive investment for many companies, while promises of savings are great in theory.
- Dealing with the air traffic requirements of controlling flying objects.

<https://gcelogistic.com/drone-delivery-for-shipping/>



Some resources

- <https://www.araglegal.com/individuals/learning-center/topics/home-and-property/six-ways-drone-delivery-could-be-a-game-changer>
- <https://jungleworks.com/how-future-delivery-drone-will-deliver-your-packages/>
- <https://www.dronezon.com/drones-for-good/drone-parcel-pizza-delivery-service/>
- <https://www.businesswire.com/news/home/20200612005352/en/Global-Drone-Delivery-Service-Market-2030-->
- <https://www.youtube.com/watch?v=ptKah5WR14g>

Roundabouts: Do they really help?

Teacher: Mrs. George

Date: 06/30/2020

Overview & Purpose

For students to examine the design of intersection roundabouts and when they are most effective for an area.

Education Standards

- M3.G.C.B.4 Find the area of a sector of a circle in a real-world context.
- M3.G.MG.A.2 Apply geometric methods to solve real-world problems.

Objectives

1. Students will investigate the pros and cons about the construction of an intersection roundabouts and their effectiveness.
2. Students will create a media presentation when the use of roundabout intersections are most effective and cite existing ones that work effectively while acknowledging those times when they are not as effective.

Materials Needed

1. Laptop or tablets to research
2. [All About a Roundabout](#)
3. [Roundabouts 101: Basic Design Principles for Improved Intersection Safety](#)

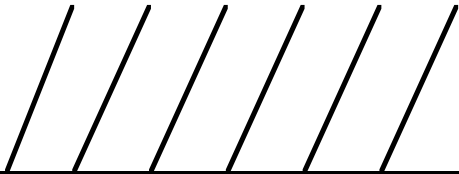
Activity Procedures

- Teacher will open the lesson with a brief discussion about students' knowledge of a roundabout. Students may talk about the roundabout in Spring Hill, TN or downtown Columbia.
- Teacher will explain to the class that this transportation STEM activity is to help students begin the Unit of Circles and their real life impact of Roundabouts.

- Teacher may have the City Mayor or City Planner be a guest speaker as the project begins and invited back when groups present their findings.
- Students will work in groups of 3 to 4 to compare and contrast the differences of a conventional 4-way stop and a roundabout. They will then research the overall effectiveness of roundabouts and when they work most efficiently. What factors are impacted positively when using a roundabout?
- Teacher will pass out a grading rubric for students to follow for grading purposes.
- Teacher will move around the groups asking thought provoking questions to encourage “outside the box” creative thinking and use of analytical skills.
- Teacher will propose the idea of creating an even better and more efficient intersection design to help ease the flow of traffic and decrease accidents.
- Student groups will create a media presentation to give to their classmates.
- Students will also grade each group presenting based upon the rubric.
- Students and any Teachers present to watch students’ presentations will have the opportunity to vote on the best overall presentation. This winning group will be able to enter into the Maury County’s STEM Expo in March 2021.

Scoring Rubric for Presentations

Write each student's name above a score column. For each presentation trait, rate each student using the scale shown.



1	2	3	4	5
Strongly disagree				Strongly agree

Score						Presentation Trait
						<input type="checkbox"/> Quality of information and organization: Presentation main points are clear and well developed; information is linked to presentation topic; information is organized.
						<input type="checkbox"/> Nonverbal communication: Speaker appears comfortable and confident; speaker maintains good eye contact and posture; speaker shows engaging and inviting presence; speaker uses body motions and gestures effectively; speaker utilizes room effectively via movement.
						<input type="checkbox"/> Quality of verbal communication: Speaker's voice is confident, steady, strong and clear; speaker uses inflections to emphasize key points or to create interest.
						<input type="checkbox"/> Visual tools: Visual aids are creative, clear and easy to read; tools enhance the effectiveness of the presentation.
						<input type="checkbox"/> Appropriate use of terminology: All terms are included in the presentation; terms are used in unique and creative ways; terms are used in context.
						<input type="checkbox"/> Precision and detail in documents produced: Documents are clear, well constructed, accurate and show attention to detail; care has been taken in the production.
						<input type="checkbox"/> Overall presentation effectiveness
						<input type="checkbox"/> Total Score

Scoring Rubric for Presentations – Instructions

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 – Poor
Information Quality and Organization	<ul style="list-style-type: none"> Main points are very clear and very detailed Information is directly linked to presentation topic Information is very organized 	<ul style="list-style-type: none"> Main points are clear and detailed Information is linked to presentation topic Information is well organized 	<ul style="list-style-type: none"> Main points are somewhat clear but could use more detail Most information is linked to the presentation topic Information is organized 	<ul style="list-style-type: none"> Main points are not clear and lack significant detail Some information is linked to the presentation topic Information is loosely organized 	<ul style="list-style-type: none"> Presentation lacks main points and related details Information lacks connection to the presentation topic Information is not organized
Nonverbal Communication	<ul style="list-style-type: none"> Speaker appears very comfortable and confident Speaker consistently faces the audience and maintains good eye contact Speaker consistently appears to be engaging with the audience Speaker uses body motions and gestures very effectively Speaker utilizes the room very effectively via movement 	<ul style="list-style-type: none"> Speaker appears fairly comfortable and confident Speaker generally faces the audience and maintains good eye contact Speaker generally appears to be engaging with the audience Speaker uses body motions and gestures well Speaker utilizes much of the room via movement 	<ul style="list-style-type: none"> Speaker appears generally at ease and confident Speaker sometimes faces the audience and maintains eye contact Speaker sometimes appears to be engaging with the audience Speaker's body motions and gestures neither support nor detract from presentation Speaker moves about some of the room 	<ul style="list-style-type: none"> Speaker appears uneasy and somewhat insecure Speaker rarely faces the audience or makes eye contact Speaker rarely appears to be engaging with the audience Speaker uses few body motions or gestures or has gestures or movements that distract the audience Speaker is mostly stationary 	<ul style="list-style-type: none"> Speaker appears very uneasy and insecure Speaker faces away from the audience or makes no eye contact Speaker appears disengaged from the audience Speaker lacks any body motions or gestures or demonstrates consistently distraction body motions or gestures Speaker is completely stationary
Quality of Verbal Communication	<ul style="list-style-type: none"> Speaker's voice is very confident, steady, strong, and clear Speaker consistently uses inflections to emphasize key points or to create interest Speaker's talking pace is consistently appropriate 	<ul style="list-style-type: none"> Speaker's voice is steady, strong and clear Speaker often uses inflections to emphasize key points and create interest Speaker's talking pace is mostly appropriate 	<ul style="list-style-type: none"> Speaker's voice is generally steady, strong and clear Speaker sometimes uses inflections to emphasize key points and create interest Speaker's talking pace is appropriate 	<ul style="list-style-type: none"> Speaker's voice is frequently too weak or too strong Speaker rarely uses inflections to emphasize key points and create interest or speaker sometimes uses inflections inappropriately Speaker's talking pace is often too slow or too fast 	<ul style="list-style-type: none"> Speaker's voice is consistently too weak or too strong Speaker fails to use inflections to emphasize key points and create interest or speaker often uses inflections inappropriately Speaker's talking pace is consistently too slow or too fast

Scoring Rubric for Presentations – Instructions

Traits	5 – Excellent	4 – Very Good	3 – Adequate	2 – Limited	1 – Poor
Visual Tools	<ul style="list-style-type: none"> • Visual aids are very creative, clear, and easy to read • Presentation is consistently enhanced by the visual tools 	<ul style="list-style-type: none"> • Visual aids are usually creative, clear, and easy to read • Presentation is often enhanced by the visual tools 	<ul style="list-style-type: none"> • Visual aids are reasonably creative, clear, and easy to read • Presentation is sometimes enhanced by the visual tools 	<ul style="list-style-type: none"> • Visual aids have limited creativity or clarity or are sometimes difficult to read • Presentation is not enhanced by the visual tools 	<ul style="list-style-type: none"> • Visual aids demonstrate no creativity or clarity and are often difficult to read • Presentation is weakened by the visual tools
Appropriate Use of Vocabulary	<ul style="list-style-type: none"> • All terms are included in the presentation • Used in unique and creative ways • Used in context 	<ul style="list-style-type: none"> • All terms are included in the presentation • Used effectively • Used in context 	<ul style="list-style-type: none"> • Most terms are included in the presentation • Generally used appropriately • Generally used in appropriate context 	<ul style="list-style-type: none"> • Several terms are included in the presentation • May or may not be used appropriately • May lack context 	<ul style="list-style-type: none"> • Few or no terms are included in the presentation • May or may not be used appropriately • Lacks context
Precision and Detail in Documents Produced	<ul style="list-style-type: none"> • Documents are clear, well constructed, accurate and show attention to detail • Extra care has been taken in the production 	<ul style="list-style-type: none"> • Clearly evident that documents are correct, detailed and accurate • Care has been taken in the production 	<ul style="list-style-type: none"> • Evident that documents are correct and show a general attention to detail and accuracy • General care has been taken in production 	<ul style="list-style-type: none"> • Documents may have some errors and show some detail • Some care has been taken in production 	<ul style="list-style-type: none"> • Documents have numerous errors and lack detail • Little care taken in the production
Overall Presentation Effectiveness	<ul style="list-style-type: none"> • This was an exceptional presentation and extremely effective • I'd give you a 10 	<ul style="list-style-type: none"> • This was a very good presentation and very effective • I'd give you an 8 or 9 	<ul style="list-style-type: none"> • This presentation was good and effective • I'd give you a 6 or 7 	<ul style="list-style-type: none"> • This presentation was average and somewhat effective • I'd give you a 3, 4 or 5 	<ul style="list-style-type: none"> • This presentation was weak and not effective • I'd give you a 0, 1, or 2

Supplementary Angles in Car Accidents

Teacher: Christine Rivers

Date: 06/30/2020

Overview & Purpose

Learn about the relationship between supplementary angles in car accidents as it is used by transportation engineers (ex: need for guard rails). Addresses transportation systems, infrastructure planning management, and regulation.

Education Standards

- M1.G.CO.A.1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, plane, distance along a line, and distance around a circular arc.
- M1.G.CO.C.9 Prove theorems about lines and angles.
- G.MG.A.2 Apply geometric methods to solve real world problems.
- Standards for Mathematical Practice 3: Construct viable arguments and critique the reasoning of other.
- Standards for Mathematical Practice 4: Model with mathematics

Objectives

1. Students will learn how geometry concepts can appear in their everyday lives.
2. Students will learn about the role of math in the career of transportation engineering.

Materials Needed

1. Individual white boards for each group (approximately 10-12 depending on class size)
2. Hot Wheels cars (10-12)
3. Dry erase markers for each group (10-12)
4. Protractors (10-12)

5. Meter stick/ruler for each group (10-12)
6. *optional: hard surface to set up as an incline/ramp for launching the cars could possibly make it easier
7. Copies of data collection sheet for each student (approximately 30)
8. Necessary equipment/device to play video(s).

Activity Procedures

- Have students work in groups of 3. Each group needs a car, white board, dry erase marker, and protractor. Each student needs their own copy of the data sheet and a pencil/pen to write with.
- Students will measure various angles and launch their Hot Wheels car at the wall following the measured angle. They will record the angle the car travels away from the wall after impact.
- Students will discuss their findings and the importance of transportation engineers knowing this information.

CAR CRASH ANGLES OF IMPACT ACTIVITY SHEET

This assignment should be completed in groups of 3 (your teacher will assign you to a group).

Materials

(One per group)

White Board
Dry erase marker
Hot Wheels Car
Protractor
Ruler/meter stick

(One per person)

Activity sheet
Pencil

Instructions

Take a white board and draw the following angles on them:

30, 60, 90, 120, 150, 180

Make sure to extend the lines to the end of the board.

Set your white board right up against the wall. Then take a hot wheel car, and from each angle, run it into the wall five times. Record your findings in the table below. The shaded angles (along the top of the grid) are the angles you begin with; the un-shaded column on the left is the resulting angle given when the car bounces off the wall.

	30	60	90	120	150	180
30						
60						
90						
120						
150						
180						

Results

Describe your findings below. What did you notice about the angle the car approached the wall before impact when compared to the angle it traveled away from the wall after impact?

Why do you think it is important for transportation engineers to know about the angles of impact vs. the angle the car travels after impact?

Exploring Horizontal Curves in Railroad & Highway Design

Teacher: Christi Root

Date: 06/30/2020

Overview & Purpose

Students will study horizontal curve design in railroads & highway design by exploring the importance of mathematical concepts when creating new roads and railways. Students will watch videos about civil engineering, basic highway design, and horizontal curve geometrics, then apply what they've learned to create new roadways or find missing information (length of a road or curvature) using high school mathematics.

The design process is simplified in contrast to actual roadway design, but hopefully, students will see the connection of algebra/ geometry skills and road design. This lesson is student-driven and the teacher should provide guidance and help if needed.

This lesson is designed for students in **Integrated Math III or Geometry** that have mastered constructions and circle theorems.

Education Standards

- **EVSC.ETS2: Links Among Engineering, Technology, Science, and Society**
 - 1) Engage in argument from evidence on the role engineering and technology play in a sustainable human society.
- **M3.G.CO.A.1: Make geometric constructions**
 - Make formal geometric constructions with a variety of tools and methods.
- **M3.G.C.A.2: Understand and apply theorems about circles**
 - Identify and describe relationships among inscribed angles, radii, and chords
- **Standards for Mathematical Practice**
 1. Make sense of problems and persevere in solving them.
 2. Reason abstractly and quantitatively.
 3. Construct viable arguments and critique the reasoning of others.

4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.

Objectives

1. Students will be able to identify the type of curves used in designing roadways.
2. Students will be able to describe the difference in a horizontal and vertical curve and explain why each is vital to the road design process.
3. Students will be able to match geometry terms (*central angle, arc, circumscribed angle, etc.*) to engineering terminology.
4. Students will apply algebra techniques to find missing information given a diagram of a horizontal curve.
5. Given an angle measurement and radius, students will construct an example of a simple horizontal curve.
6. Given a map, students will create a new roadway (lines and simple horizontal curves only) using a compass, pencil, and ruler.
7. Students will reflect upon their learning by writing a journal entry or making a video about the importance of mathematics & engineering in regards to transportation in our daily lives.

Possible Extensions:

- Students can design a new roadway but with environmental and budgetary restrictions. Students should aim to keep from cutting down trees or building over waterways, while also trying to save as much money as possible. (*The teacher will either need to provide examples of cost, or have students research and find the cost themselves.*)
- Students can find missing parts of the horizontal curve using trigonometry.
- Students can extend their learning by exploring different types of horizontal curves (*simple, reverse, compound, and spiral*), and practice constructing each one.

Materials Needed

1. Paper & pencil
2. Compass
3. Ruler

4. Computer with Internet access

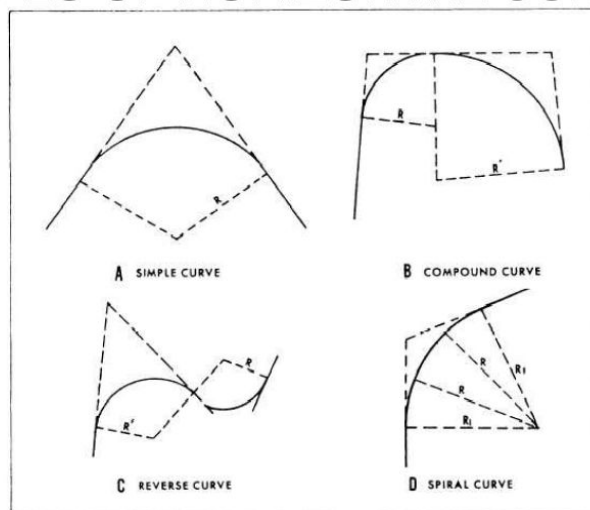
Activity Procedures

Introduce the activity by showing the YouTube video "[What Does a Transportation Engineer Do?](#)". The teacher can extend the video by talking about Civil Engineering in general. At this point, students can do a little research on civil engineering, then specifically transportation engineering. At the end of the research period, students can share anything they learned or found particularly interesting.

The teacher will now focus on a specific part of a transportation engineers job, roadway design. To gain student interest, the teacher can ask "*What do circles have to do with roadway design?*" A student might mention a "roundabout" but it is unlikely anyone will know that curves in roads are designed using circles.

Horizontal Curves are one of the two important transition elements in geometric design for highways (along with [Vertical Curves](#)). A horizontal curve provides a transition between two tangent strips of roadway, allowing a vehicle to negotiate a turn at a gradual rate rather than a sharp cut. The design of the curve is dependent on the intended design speed for the roadway, as well as other factors including drainage and friction. These curves are semicircles to provide the driver with a constant turning rate with radii determined by the laws of physics surrounding centripetal force. (Source: [Wikibooks.com](#))

TYPES OF HORIZONTAL CURVES



The teacher will now introduce visuals of a horizontal curve in roadway design. The teacher will pass out a copy of the "Horizontal Curves" PDF or provide access to it online. The lesson will not use all of these formulas, but the students may find it interesting to see the different formulas and how they've been transformed for this real-world application.

Students can view a Youtube video called "[Highway Alignment](#)". This video shows a 3D rendering of different possible horizontal and vertical curves, but is presented as a desirable or undesirable design. Students don't need to watch the entire video, but it will give the kids an idea of how the curves behave and "feel" while driving.

Next, the teacher will tell the students "After watching a few videos, you will be able to create your own horizontal curve using circles and tangent lines, and ultimately design a roadway given a map. You will share your design with the class when finished."
(Teachers can modify the lesson and not include the roadway design, and only have students recreate a horizontal curve. For a regular math class, the teacher could let the students try to design their own roadway on a blank piece of paper to promote creativity.)

The students should watch & take notes on the YouTube video "[Highway Design](#)". This video introduces students to the most basic parts of roadway design. The teacher should have pairs of students take turns explaining the difference in a horizontal curve and vertical curve. The teacher can ask a volunteer to address the class on the different types of curves, then have another student summarize, but in a different way (if possible).

Students will then work on their own and watch this series of videos. Students should take notes on the design and key terminology of horizontal angles. The narrator mentions "stations" and how to notate them, but it is not the focus of this lesson.

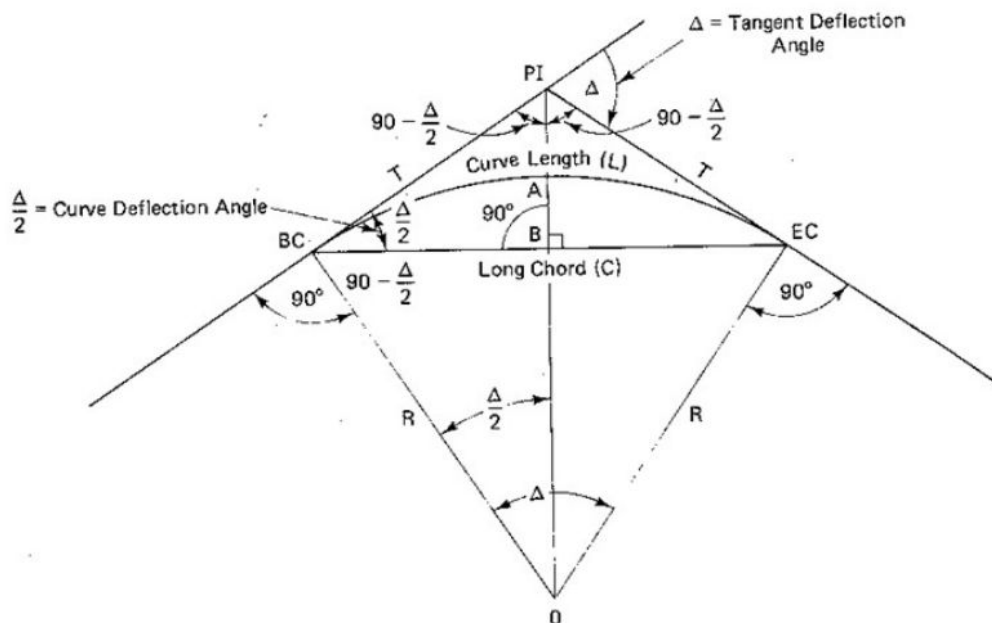
- "[Advanced Geomatics: Horizontal Curves: Part 1](#)" *This video introduces the concept of street design and will not include any calculations. He mentions "stations" or "stationing" which is not important to this lesson, but will help understanding in the next three videos. **This video is optional.***
- "[Advanced Geomatics: Horizontal Curves: Part 2](#)"
- "[Advanced Geomatics: Horizontal Curves: Part 3](#)"
- "[Advanced Geomatics: Horizontal Curves: Part 4](#)"

Comparison of Terms

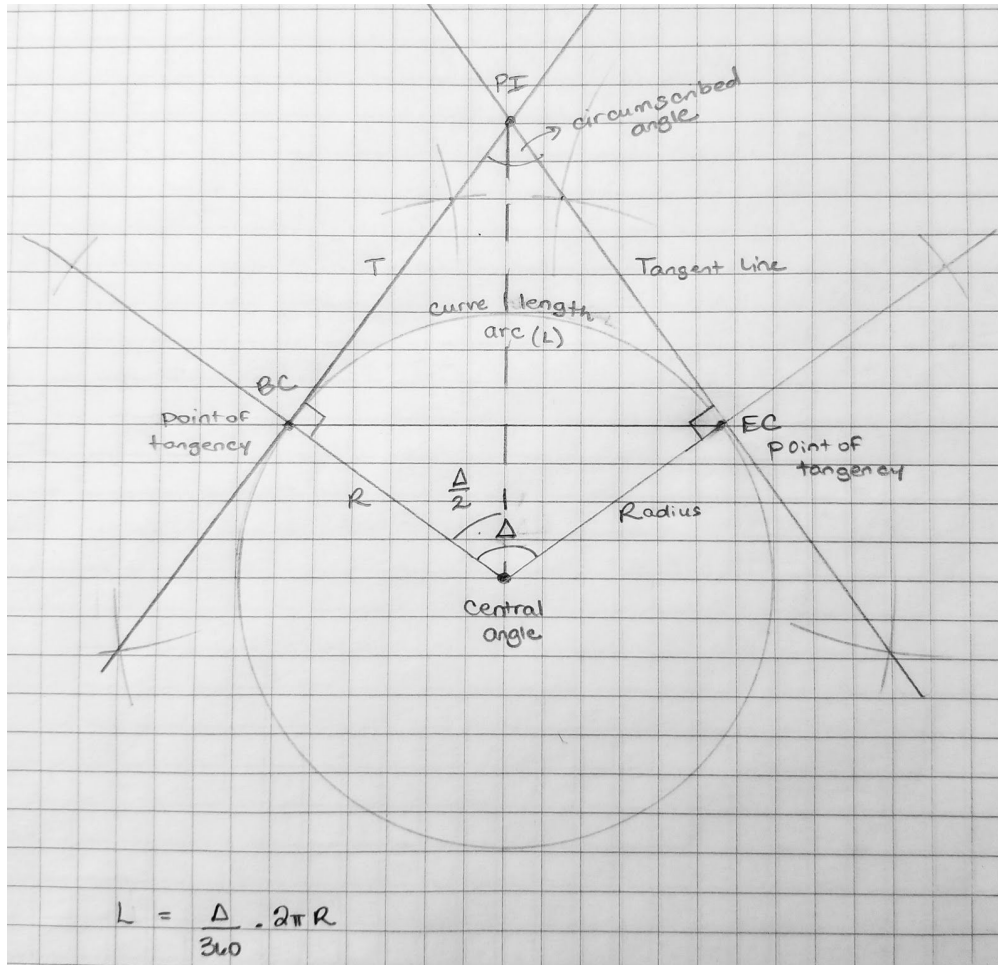
Mathematical Vocabulary/Description	Engineering Terminology
Intersection of tangent lines	Point of Intersection (PI)
Arc	Length of Curve (L)
Point of Tangency (left side)	Beginning of Curve (BC)
Point of Tangency (right side)	End of Curve (EC)
Tangent segment	Tangent Line (T)
Central Angle	Interior Angle (Δ)
Radius	Radius (R)

After watching all the videos, students can now practice drawing horizontal curves of different sizes on scrap paper. When they get the hang of it, each student should draw a large enough horizontal circle that can be labeled with all of the engineering terms listed above. The figure below is an example of a simple horizontal curve. This is used in engineering, so extra information is included.

Circular Curve Geometry



Possible modification: Teachers can either require the curve to be drawn with constructions only, or they can allow students to estimate the tangent lines.



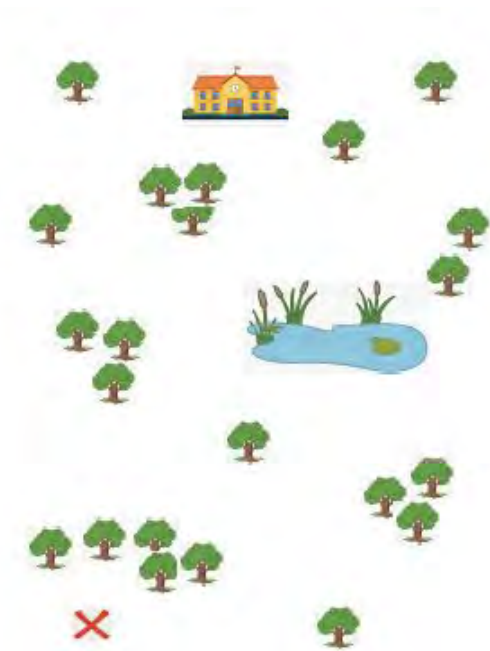
Once the students are familiar with drawing and labeling horizontal curves, they can start working on finding missing parts of the diagram using mathematics. This section can be modified to include trigonometric equations or to find the area of a sector.

Example Questions

1. Find the curve length if the radius is 200 feet and the internal angle (Δ) is 100 degrees. Round your answer to the nearest foot. **Answer: 349 feet**
2. What degree is the internal angle (Δ) if the radius is 500 feet and the curve length is 1,000 feet. Round your answer to the nearest tenth of a degree. **Answer: 114.6 degrees**

3. If given the length of the radius and tangent segment (T), do you have enough information to find the distance between the Point of Intersection (PI) and the Internal Angle (Δ)? If yes, describe in detail how you would solve this problem. If not, state which information is needed. **Answer: Yes, you can find the missing length by using the Pythagorean Theorem. The radius and tangent would be the legs, plug those values into the formula, then solve for c.**

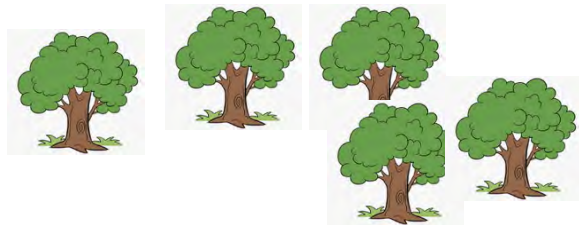
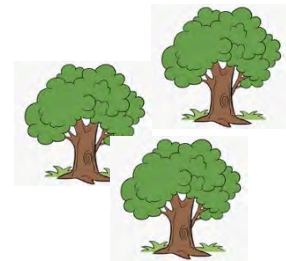
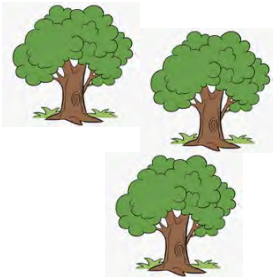
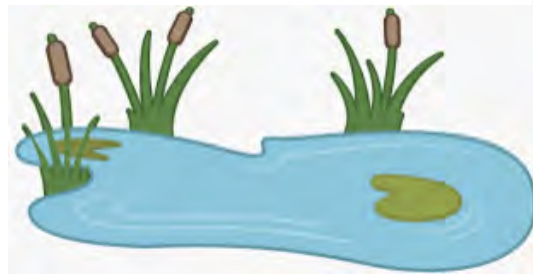
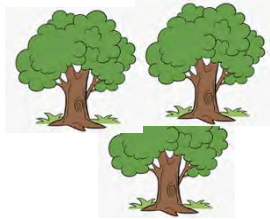
Teachers can choose to extend this lesson to include geometric proofs (congruent triangles) or practicing rearranging formulas for a specific variable.



Students can either work individually or in small groups to complete the next worksheet. Using simple or reverse horizontal curves, students should design a new road from "X" to a school. Students should try to avoid water and trees.

Students can post their new roadmaps on the wall. Different groups can travel around the room leaving positive comments or constructive criticism. *Teachers can make this into a competition and give a small award to the best roadway.*

Students will finish the lesson with a journal entry or video (student choice). Students will talk about what they learned, and describe in detail, using key terminology, how mathematics and engineering is used to create roadways in today's society.



Names: _____

Match the Graph: Using Vernier Motion Detectors to Model Technology Used in Traffic Enforcement

Teacher: Mrs. Burch

Date: 07/01/2020

Overview & Purpose

This activity will introduce students to the similarities between Vernier motion detectors and the LiDAR guns used by law enforcement to catch speeding motorists. Students will then apply their understanding of how these detectors work to match a series of position-time and velocity-time graphs using their bodies and handheld detectors.

Education Standards

- PSCI.PS2: Motion and Stability: Forces and Interactions
- M1.F.IF.B.3 Interpret functions that arise in applications in terms of the context.

Objectives

1. After completing this investigation, students should be able to look at a position-time or velocity-time graph and describe the motion of an object.
2. Students should also be able to look at the motion of an object and sketch a position-time or velocity-time graph representing that motion.

Materials Needed

1. LabQuest 2 (per group of 3-4 students)
2. Motion Detector (per group of 3-4 students)
3. Student Handouts (per student or per group of 3-4 students)

Activity Procedures

- Students would complete the [pre-lab videos](#) and read the [article](#) to answer the pre-lab questions to learn how the motion detectors used by law enforcement compare to those they will be using.
- The teacher would lead a discussion to review some answers and highlight topics from the videos.
 - SHOULD police officers be required to understand the science behind their detectors in order to use them?
 - What is the major difference between our motion detectors and LiDAR?
 - Does either type of detector actually measure speed?
- Students would work in groups of 3-4 to complete the graph matching investigation with the motion detectors.
- The teacher would sign off on satisfactory graphs created by each group.

Match the Graph

Pre-Lab:

1. LiDAR stands for _____.
2. List two of the main considerations for law enforcement before implementing LiDar in a particular area.
 - a. .
 - b. .
3. How does the distance of an officer from the side of the road relate to speed measurement?
4. Why is it important for law enforcement to establish “tracking history” before measuring speed with tools such as LiDAR guns?
5. List two advantages of LiDAR guns over the previously used radar guns.
6. The lidar gun does not actually measure speed; it measures the _____ to a vehicle multiple times to calculate a speed.
7. The formula for speed is _____ / _____.
8. What is the “time of flight?”
9. Review the data below for a LiDAR gun that transmits at 100 pps. Calculate the speed of the car in ft/sec and convert to mi/hr. Show your work!
 - a.

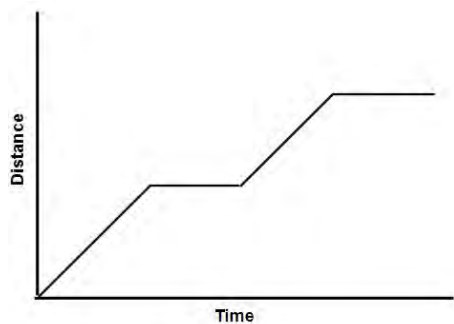
Pulse	Distance to Car (ft)
1	500
2	498.5
3	497
4	495.5
5	494
100	350

10. Why is it important for LiDAR guns to calculate speed on a series of predictable pulses?
11. Rather than determining distance by “watching” for light to return to the lidar gun, how do our motion detectors determine the distance to an object?
12. What two types of graphs will be displayed when you collect data?
13. How do you change your display to show only the position-time graph?
14. Summarize how ultrasonic sensors work.
15. When might an ultrasonic sensor be preferable to a light-based or radar sensor?

Procedure:

- Study each graph below, paying careful attention to the y-axis, to determine what motions will be necessary to re-create the given shape.
- Carefully describe all motions necessary to achieve that shape. Your lines must be proportional to the given scenario (ex. the length of time spent walking away vs. the length of time spent standing still)
- Attempt to match the graph as many times as needed. If you have trouble with a particular graph, skip it and come back at the end.
- Get your teacher to initial when you have successful data.

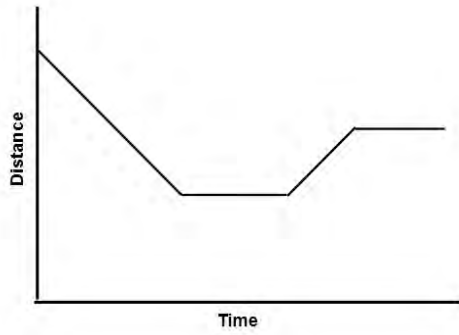
Graph 1:



Motion description: _____

Teacher initials: _____

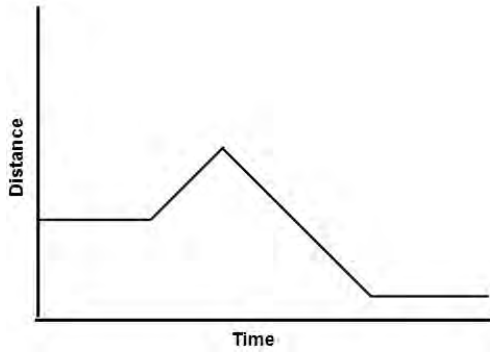
Graph 2:



Motion description: _____

Teacher initials: _____

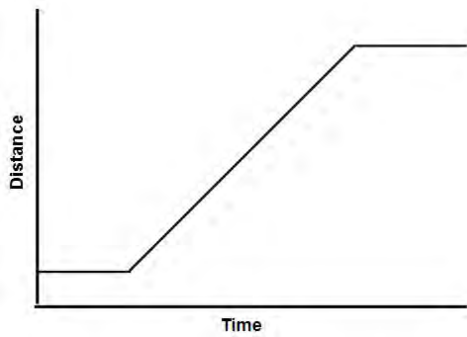
Graph 3:



Motion description: _____

Teacher initials: _____

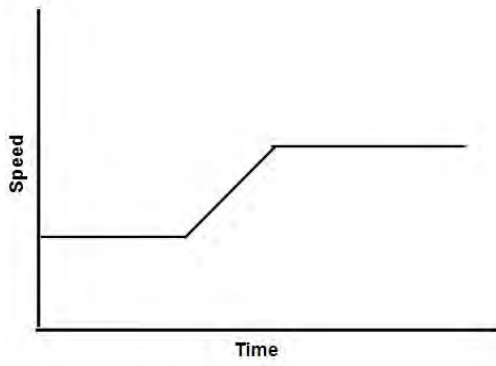
Graph 4:



Motion description: _____

Teacher initials: _____

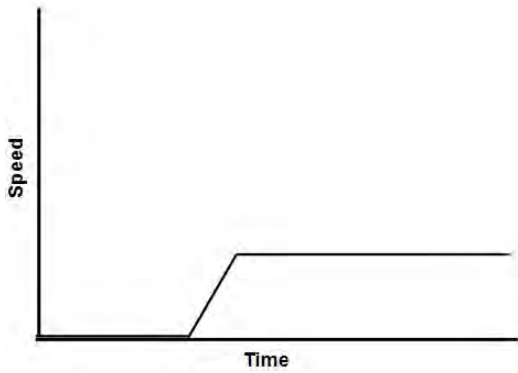
Graph 5:



Motion description: _____

Teacher initials: _____

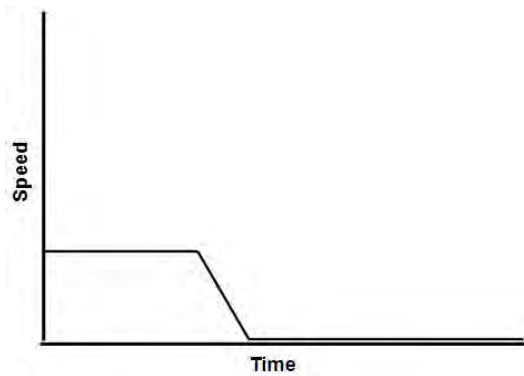
Graph 6:



Motion description: _____

Teacher initials: _____

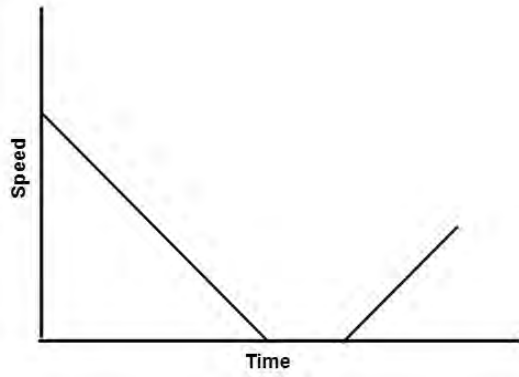
Graph 7:



Motion description: _____

Teacher initials: _____

Graph 8:



Motion description: _____

Teacher initials: _____

Tire size...What a “revolution”!

Teacher: Mrs. Mills

Date: 06/30/2020

Overview & Purpose

In this activity students will be asked to determine the number of revolutions a tire makes per minute when traveling at a given speed. To calculate the number of revolutions, students will first need to determine the circumference of a tire, this can be done by taking students outside to measure or asking students to measure a tire at home prior to the day of the activity. Students will think about how changing the size of the tire affects the speed at which the car is traveling and the accuracy of the speedometer. During the activity, students will be required to convert between units using dimensional analysis.

This activity uses standards found within Bridge Math, but can be used with other grade levels and subject areas.

Education Standards

- B.G.C.A.1 Apply a variety of strategies to determine the area and circumference of circles after identifying necessary information.
- B.N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- B.N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

Objectives

1. Students will calculate the number of tire revolutions per minute when a car is traveling at a given speed.
2. Students will determine how changing the size of a tire affects the speed at which the car is actually traveling and compare that with the speedometer reading.
3. Students will convert between a variety of units using dimensional analysis.

Materials Needed

1. Student activity page
2. Measuring tape
3. Calculator
4. Technological device--if allowing students to conduct research

Activity Procedures

- Prior to conducting the activity, teachers can access the following links to research topics covered within the activity:
 - [You Tube: "How will my speedometer be affected if I increase tire size?"](#)
 - [You Tube: "Example: Determine the Number of Revolutions Per Second of a Car Tire"](#)
 - ["How to Calculate Wheel Speed"](#)
 - ["Speedometer Calibration Calculator"](#)
- Students should be placed with a partner or in a small group.
- Provide each group with an activity sheet and a measuring tape.
- Provide each group with an opportunity to measure the diameter of a tire in inches. (If taking all students outside is not feasible, have students measure the diameter of a tire prior to arriving in class.)
- After groups have measured their tire, they should begin working through the attached activity sheet.
- As students are working, teachers should assist groups, as needed, with their calculations and remind groups to pay attention to their unit conversions.
- As groups finish their first calculation and begin working on the follow-up questions, teachers should help facilitate meaningful conversations.
 - Question 3: If needed, allow students time to research this question on the internet, or access some of the above teacher resource links as a class.

3. The speedometer of a car measures the number of revolutions tires make, meaning cars are engineered to make a given number of tire revolutions when traveling at given speeds. When cars are designed, they are engineered to perform at an optimal level when paired with a specific tire size, often referred to as “stock” size. Will changing the size of your tire from “stock” size affect your speed? *Provide reasoning with your response.*

4. For this activity, assume that the tire you measured in problem one was the “stock” size tire and that the number of revolutions per minute found in problem 2a is the appropriate number of revolutions for your vehicle when traveling 45 mph. (a.) Suppose you increase the size/diameter of the tire by 2 inches, compare the speedometer reading of 45 mph with your actual speed? (*Remember: revolutions=speed/circumference; pay attention to your units!*)

(b.) Suppose you decrease the size/diameter of the tire by 2 inches, compare the speedometer reading of 45 mph with your actual speed?

5. After seeing how tires that are not considered “stock” size affect the accuracy of your speedometer, would you consider changing to a different size tire? Or if you know that you have different sized tires on your vehicle, would you go back to standard sized tires because of the inaccuracy in the speedometer? Explain your reasoning.

Fuel-Conscious Car Salespeople: How does your car compare?

Teacher: Mrs. Britney Gulley

Date: 06/30/2020

Overview & Purpose

With so many fuel options today, it's not always easy to make a choice about what vehicle type to purchase. In this activity, students investigate cars that run on different types of fuels: gasoline, sunlight, ethanol, electricity, biodiesel, natural gas, propane, hydrogen, etc. Students work together in small teams to develop an initial sales pitch about a new model car that runs on a particular fuel type. The pitches will be given to the whole class in a presentation format, and individual students work to collect information about "the competition". Then, students will update their pitches with information that compares their type of vehicle to other fuel vehicles. The purpose of this activity is to develop critical thinking skills, Internet research skills, chemical content knowledge, and communication skills of students in high school Chemistry II classes.

Education Standards

- CHEM2.PS2.10 Obtain, evaluate, and communicate information about how carbon's structure and function are used and have influenced society.
- CHEM2.PS2.13 Investigate models and explore uses of electrochemistry (batteries and electrochemical cells).
- CHEM2.PS2.15 Explain common chemical reactions, including those found in biological systems, using qualitative and quantitative information.
- Cross Cutting Concept(s): Structure and Function
- Science and Engineering Practice(s): Engaging in Argument from Evidence, Obtaining, Evaluating, and Communicating Information

Objectives

1. **Identify** and **describe** a variety of fuel types for vehicles.

2. **Compare and contrast** vehicles that run on different fuel types on the basis of chemical history, reactions, and processes; fuel economy; price; and environmental impact.
3. **Explain** the common chemical reactions and processes used to fuel cars.

Materials Needed

1. Devices (e.g., laptops, Chromebook, iPads, etc.) with Internet access and presentation software capabilities (e.g., PowerPoint, Google Slides, Keynote). One device per student is recommended, but one device per team could be used.
2. Variety of Resources on Fuel Types and Current Model Vehicles in the U.S. You can limit these to particular resources you have compiled as the teacher or leave this open for students to conduct research and evaluate online resources that they find on their own. Allowing students to view YouTube videos and access appropriate text and website resources is recommended.
3. Classroom whiteboard and expo markers.
4. Projector and Projector Screen

Activity Procedures

- Ask students the following opening question to engage students in the topic for this activity: "What do cars run on?" If students can only think of 1 or 2 fuel types, prompt them to think of more. Help students recognize that there are lots of fuel choices today. Ask students: "What would you want to know about a particular fuel type before purchasing a vehicle that runs on that fuel?" Record student answers to these questions on the classroom whiteboard for all students to see (e.g. fuel economy, cost, environmental impacts).
- Share the lesson objectives with students. Explain the purpose of this activity to the students.
- Divide the students into groups of 3-4 team members and randomly assign each group a particular vehicle fuel type to research and "sell".
- Provide students with guidelines for the activity and/or the rubric for presentation evaluation. (See Sample Rubric Below)
- Provide time for students to conduct research and assemble their presentations. The amount of time needed will vary by class. This is a great website to help

students get started with their research:

<https://www.fueleconomy.gov/feg/current.shtml>

- In order to hold individual students accountable, require students to turn in an individually constructed list of resources/URLs that they compiled during research time and include their name in the speaker notes for the slide(s) that he or she created in the presentation.
- Formative Assessment #1: Schedule marketing team meetings with each team when students have finished research and are creating their sales pitch presentations. During these meetings, check for accuracy in the explanation of chemical reactions and processes and address any questions that students have. Meetings should be at least 5-10 minutes in length.
- Require students to present their findings to the class. All students must listen and take notes as their peers present. Prompt students to listen carefully and to think critically about how their car fuel type compares to the others.
- Explain to students that during sales, clients often ask questions to help them decide which type of car to purchase. Pose the question to the class: "How does your car compare to cars that run on other fuel types?"
- Formative Assessment #2: Ask students to update their sales pitch presentations to include information that compares their vehicle to vehicles that run on other fuel types. Students should cite specific evidence from other teams' presentations.
- Ask students to turn in their research resources or notes, fellow team presentation "competition" notes, and final presentations with updates to you via Email or Google Classroom. Grade student presentations based on the rubric.

Fuel-Conscious Salespeople Presentation Rubric

Component	1	2	3	Score
Original Sales Pitch Length	Under 3 minutes or over 7 minutes	3-5 minutes	5-7 minutes	
Equitable Work	It is evident that 1 or more group members did not participate.	All students (1) conduct research, (2) create slides, and (3) have speaking parts during the presentation.	All students (1) conduct research, (2) create slides, and (3) have speaking parts during the presentation.	
Car with Fuel Type	Students identify a current model car that can be purchased in the United States and uses the assigned fuel type. The presentation does not include the fuel economy, environmental considerations, or price of the selected car.	Students identify a current model car that can be purchased in the United States and uses the assigned fuel type. The presentation includes most of the following: the fuel economy, environmental considerations, and price of the selected car.	Students identify a current model car that can be purchased in the United States and uses the assigned fuel type. The presentation includes the fuel economy, environmental considerations, and price of the selected car.	
Explanation of Fuel Type (Chemical Reactions and Processes)	Students vaguely explain or do not explain the chemistry behind their assigned fuel type.	Students explain the chemistry behind their assigned fuel type but leave the audience with major questions about chemical history/development and chemical reactions/processes.	Students thoroughly and completely explain the chemistry behind their assigned fuel type including chemical history/development and chemical reactions/processes.	$\underline{\hspace{1cm}} \times 2$ $= \underline{\hspace{1cm}}$
Comparing and Contrasting	Students do not address the question "How does your car compare?" with any evidence from other teams' presentations.	Students address the question "How does your car compare?" with evidence from at least 1-2 other teams' presentations.	Students thoroughly address the question "How does your car compare?" with evidence from at least 3 other teams' presentations. (e.g. environmental impact, fuel economy, price)	$\underline{\hspace{1cm}} \times 2$ $= \underline{\hspace{1cm}}$
Total				/21

Animals Crossing

Teacher: Mrs. Allison Ayers

Date: 06/30/2020

Overview & Purpose

In this activity, students will brainstorm and design a passage for animals to cross highways and interstates safely to prevent motor vehicle crashes.

Education Standards

- **ECO.ETS2.2** Research and communicate information on a career in ecology. Analyze the role of engineering, technology, and science in that career.
- **ECO.ETS2.1** Engage in argument from evidence regarding the impact engineering and technology have on biodiversity.
- **ECO.LS4.7** Research and evaluate the effectiveness of strategies for maintenance of biodiversity.
- **G.MG.A.2:** Apply geometric methods to solve real-world problems.
- **G.MG.A.2:** Apply geometric methods to solve real-world problems.
- **G.GPE.B.5:** Know and use coordinates to compute perimeters of polygons and areas of triangles and rectangles.
- **A1.N.Q.A.2:** Identify, interpret, and justify appropriate quantities for the purpose of descriptive modeling.
- **HS3.VA.Cr1.A** – Envision and hypothesize creative risks and their implications while determining plans and directions of art-making.
- **HS3.VA.Cr3.A** – Reflect upon, revise, and refine works of art or design, considering relevant traditional and contemporary criteria as well as personal artistic vision

Objectives

1. Students will research highways or interstates with high numbers of animal related vehicle crashes.
2. Students will analyze and interpret data.
3. Students will use engineering and mathematical skills to design a scale model.

Materials Needed

1. Student electronic device
2. Handouts
3. Graph paper
4. Projector/Interactive board

Activity Procedures

Introduction:

- Students will be shown before and after pictures depicting the construction of highways and interstates.
 - The teacher will lead a short discussion by asking students questions such as, "What are some of the potential issues that could arise from urbanization and the construction of new roads?"
- After the discussion, the whole class will watch a short clip introducing the concept of animal bypasses and underpasses.
 - Video: <https://www.youtube.com/watch?v=Xs0NCY5ex-Y>

Class Activity:

- Teacher will provide students with graph paper and handouts containing guiding questions to be answered with research data.
- Students will follow the handout directions and questions to choose a(n) highway/interstate to build an animal bypass over or underpass underneath.
- Using research data, students will choose an animal species to create and design a bypass or underpass for.

- Students will start the design and engineering process by graphing the animal transportation route chosen. The graphical design should be scaled to real life measurements.
- Once students have graphed their bypass/underpass, they will construct a tangible version of their graphical model.
 - Students will choose how they want to present their model, such as presenting a web design or a physical scaled model.

Extra Resource for Students:

- If students become stuck during the activity, the following link describing the function and purpose of various types of animal bypasses and underpasses could be helpful.
 - Article link:
<https://www.nationalgeographic.com/animals/2019/04/wildlife-overpasses-underpasses-make-animals-people-safer/>

Animal Crossings Direction and Research Handout

Use your device to research highways and interstates in your area that have a high number of animal related motor vehicle crashes. Choose one of the highways/interstates to use for the activity.

1. What is the name of the highway/interstate you have chosen?
2. Looking at the highway/interstate data, what animal species is involved in the majority of motor vehicle crashes?
3. Which structure would be most effective in helping the animal species in question 2 cross the highway/interstate safely?

Brainstorm and write/draw in the space below your ideas for the bypass/underpass. Things to consider: how big does the structure need to be, what materials will be used, etc.

Now that you have an idea of how to design and create your bypass/underpass, use the provided graph paper to graph the dimensions and measurements of your structure. Please be as realistic as possible.

Once your graphical model is complete, you may construct a model of your bypass/underpass. You may choose the mode of how you want to present it.

Help! Get Me Out of This Traffic!

Teacher: Mrs. Maxwell

Date: 07/01/2020

Overview & Purpose

Our school is looking to better the flow of traffic in the mornings and afternoons. The purpose of this activity is to design a better flow of traffic to relieve congestion for our students and parents.

Education Standards

- STEM Foundations 1: 8. Given a real world problem, identify several possible solutions using both engineering design process and scientific inquiry.
- STEM Foundations 1: 9. Analyze solutions to a real-world problem collaboratively, to identify critical factors of the steps of the design process.

Objectives

1. Students will design a flow pattern for traffic around the school that is most likely to ease traffic congestion.
2. Students will discuss and debate each design and vote on which they believe is the most efficient.

Materials Needed

1. Graph Paper
2. Ruler
3. Pencil
4. Colored Pencils (optional)
5. Piece of String (about 15 in.)
6. Diagram of present traffic lanes in and out of school.

Activity Procedures

- Introduce the students to engineering design by completing the activity “We Need a Road” from https://www.asce.org/civil_engineering_club/.
- Discuss their findings from the activity in an open discussion.
- Next students will be given a diagram of the school traffic flow and have them using the graph paper design improvements to the current flow.
- Make sure the students include areas where they think signs, crosswalks, or traffic lights need to be included.
- Students need to think about the difference in morning traffic flows as compared to afternoon traffic flows. Differences need to be recorded between the two times and students need to see if one pattern is going to work for both times or if they need two patterns.
- Student groups will design their patterns and present to the class and give their reasoning behind these designs.
- Students will vote by ballot on the design that they think is the best. This design will then be presented to the Principal.

Do You Speak Math?

Learning to Use the Language of Mathematics to Represent Real-World Situations

Teacher: Mrs. Jones

Date: 06/30/2020

Overview & Purpose

This activity will guide students through modeling a real-world situations involving distance using equations.

Education Standards

- **M3.A.CED.A.1** Create equations and inequalities in one variable and use them to solve problems.
- **M3.A.CED.A.2** Create equations in two or more variables to represent relationships between quantities
- **M3.A.CED.A.3** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Objectives

1. Students will gain experience in manipulating formulas to solve for the desired variable.
2. The activity page and teacher will aid students in setting up and solving an equation to answer a transportation related question involving distance, rate, and time.

Materials Needed

1. Student activity page
2. Measuring tape or ruler
3. Stopwatch

4. Calculator
5. Device with map application, such as Google Maps

Activity Procedures

- Prior to the activity, the teacher should mark off a measured distance for students to use in calculating speed. As it is set up currently, I suggest 50 feet on the track, but this can be changed to fit a particular teacher's situation.
- Students will be put in pairs and each given an activity sheet to read and begin completing. In the event there is an odd number of students, the activity could be modified to allow groups of three students.
- Student groups will need a stopwatch. I suggest they use their phones if no stopwatches are available and school policy allows.
- Student groups will need calculators to perform computations.
- Student groups will need a device with a map application, such as Google Maps. Again, students may use their phones for this if school policy allows.
- As students are working, the teacher should provide assistance as needed, paying careful attention to the formulas that are derived. If these are incorrect, everything will be!
- Students will likely need more help with the construction of the equation. Depending on how much exposure they have previously had with this concept, it can be very challenging.

Do You Speak Math?

Learning to Use the Language of Mathematics to Represent Real-World Situations

Oh, no...a word problem! I thought math was about numbers, and here I am having to read a whole paragraph. I don't even know what this is talking about. Can't someone just tell me what to do?

Most math students have said something similar at some point in their study of mathematics, or at least heard a classmate say it. But truthfully, what good would math be in the real-world if we couldn't apply it to the situations we encounter? Today we are going to do a simple application exercise to guide you through some of the thought processes for applying mathematics to real life situations.

Part 1: How Fast Are You?

You and your partner are going to time each other walking or running the 50-foot distance I have marked off on the track. Use the stopwatch to see how long it takes each of you to get from one end to the other.

- Note your time in seconds. _____
- Remember the formula $d = rt$? How can we rewrite that formula to find your rate (speed) in feet/second? Hint: Solve for rate, so your formula will start with $r =$ _____
- Plug your distance (50 feet) and time into the formula and calculate your speed in feet/second. _____
- Now that you know your speed, assuming that you can maintain it for 5280 feet (one mile), how long would it take you to travel that distance? Again, you will be using the formula $d = rt$, but this time you will rewrite

that formula to find your time. Hint: Solve for time, so your formula will start with $t =$ _____

- e. Plug your distance (5280) and rate into the formula and calculate the time in seconds it would take. _____
- f. Convert that time to minutes (Divide by 60) _____
- g. Now convert to hours (Divide again by 60) _____
- h. Now express your speed in mph. (use the formula you derived in step b)

Part 2: Where Will You Meet?

Using Google Maps, plug in two significant addresses to you and your partner and find the distance in miles between the two. You could find the distance from your house to your partner's house, from your house to the school, from the school to McDonald's...whatever you choose!

- a. Make note of the distance between the two locations by completing the following statement: According to Google Maps,
_____ is _____ miles from _____.
- b. Using the speed you calculated in Part 1, how long would it take you to get from one location to the other on foot? Again, you will be using the formula $d = rt$, but this time you will rewrite that formula to find your time. Hint: Solve for time, so your formula will start with $t =$ _____
- c. Plug your distance and rate into the formula and calculate the time in hours it would take. _____ If it seems more reasonable, you could multiply by 60 to see how long it would take in minutes. _____
- d. Repeat step c for your partner. Plug distance and rate into the formula and calculate the time in hours it would take. _____ If it seems more reasonable, you could multiply by 60 to see how long it would take in minutes. _____
- e. What if you were each at one of the locations and you wanted to leave at the same time and meet each other somewhere in the middle? What

would be the location of the meeting point if you both maintained this consistent speed that you calculated? How long would it take you both to reach that point? Let's think this through...the time you travel will be the same since you are leaving at the same time and meeting. So based on the formula you derived in step b, your distance divided by your rate will equal your partner's distance divided by his or her rate. Use the variable d for your distance. Your partner will only have to travel the distance you found in Google Maps minus d , the distance you will travel. For example, if there are 6 miles between you, your distance will be d , and your partner's will be $(6 - d)$. Be sure to set this equation up by dividing those distances by the individual speeds you calculated for you and your partner and setting them equal to one another. Then you will be ready to cross multiply and solve the equation for d and answer the questions we asked.

What would be the location of the meeting point if you both maintained this consistent speed that you calculated?

How long would it take you both to reach that point?

What other scenarios and questions can you think of that could be answered with formula manipulation and equation construction and solving?

Paper Fold to the Moon

Teacher: Ms. Anderson

Date: 06/30/2020

Overview & Purpose

When someone is asked how far and how long it would take to get to the moon, I am sure the automatic thought is that it depends on how fast rocket ships are. What if there was a way to transport to the moon through folding a single piece of paper? This activity gives students a hands-on chance to see how things grow exponentially..so much that it grows to 384,000 kilometers!

Education Standards

- **F.LE 1.** Recognize that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.2. Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a table, a description of a relationship, or input-output pairs. 3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly.
- **F.IF 3.** For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship
- **M1.N.Q.A.2** Identify, interpret, and justify appropriate quantities for the purpose of descriptive modeling.

Objectives

1. Graph exponential functions and identify the key features
2. Compare linear functions to exponential functions
3. Recognize that exponential functions grow by equal factors over equal intervals
4. Calculate how many folds it would take to get to the moon

Materials Needed

1. Multiple sheets of paper
2. Activity sheets
3. Pencil
4. Ruler
5. Calculator

Activity Procedures

- To start the activity and to strike students' interest, ask the question, "Assuming you had a VERY large sheet of paper, how many times do you think you would have to fold it to reach the moon? and "Do you think it would even be possible to fold it enough times to transport to the moon?"
- As students start making guesses, write the huge numbers on the board, so the class can reference them as the activity is completed.
- Students will also ask questions that are necessary to solving such as:
 - How thick is a sheet of paper? **A sheet of copy paper is 0.01 cm thick**
 - How far is it from the earth to the moon? **It is about 384,000 km from the earth to the moon.**
 - How do you convert from cm to km? **1 km=1000 m & 1 m=100 cm**
- Students can complete the activity individually, with partners or groups. Either way, activity sheets and extra paper need to be distributed.
- To show what a linear function would look like, students will look at Table A on the activity sheet. They should know what the height will be because they know the height of an individual sheet of paper, but students can also physically stack and use their ruler to measure. Students will then use the table to graph the linear function.
- To introduce exponential functions, students will start filling out table B. Students will then start folding paper, using their calculator and ruler to find the height. Eventually the paper cannot be folded anymore, so students will have to double the height each time with their calculator.

- They will continue filling out the table and graph until they realize that it only takes 42 folds to transport to the moon.
- Students then will answer the questions on the back of the handout to discover the formula and their meaning.
- As students are working, the teacher should be walking and observing the work that is done. It may be beneficial and necessary to ask them probing questions that will force them to think about why the graphs and equations are so different.

Additional Information:
 Thickness of a sheet of paper= 0.01 cm
 Distance to the moon 384,000km
 100 cm = 1 m 1000 m = 1 km

Complete table A as if you were STACKING paper to the moon, one piece on top of the other.

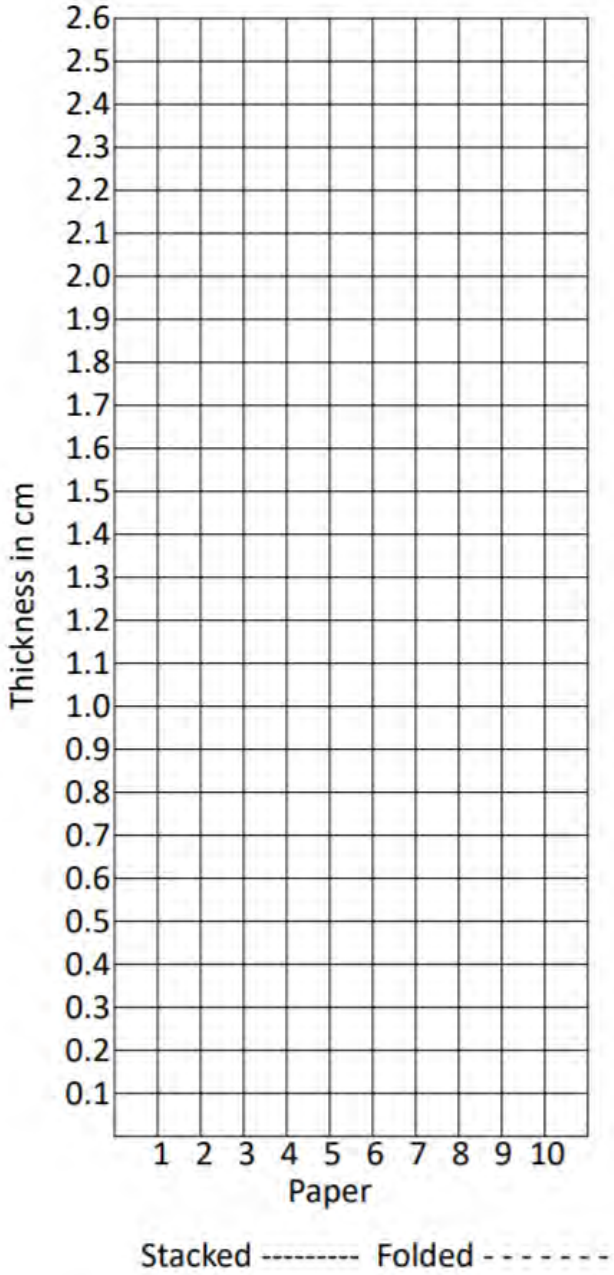
Complete table B as if you were FOLDING a piece of paper, and it is doubling in thickness each time.

Table A

Number of pieces of paper	Thickness in cm
0	0
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table B

Number of times folded	Thickness in cm
0	0.01
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	



Additional Information:
 Thickness of a sheet of paper= 0.01 cm
 Distance to the moon 384,000km
 100 cm = 1 m 1000 m = 1 km

1. If we continue the patterns in both tables, which table is going to get to the moon faster? Why?

2. Create a linear equation in the form $y=mx+b$ from the data in table A.

3. Create an exponential equation in the form $y = ab^x$ from the data in table B.

4. Continue to find the thickness of the paper for Table B.

Table B

Number of times folded	Thickness in ??
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	

Table B

Number of times folded	Thickness in ??
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	

Collisions, Momentum, & Math

Teacher: Emily McDonald

Date: 07/1/2020

Adapted from a [Teach Engineering](#) Activity

Overview & Purpose

In this activity, students simulate vehicle collisions using three different size balls and examine how the balls react when colliding with different surfaces. Students will learn how to calculate momentum, and understand the principle of conservation of momentum. This activity incorporates skills from Algebra 1 (or Integrated Math 1) and Physical Science.

Education Standards

TN Mathematics Standards:

- **A1.A.REI.B.2** (or **M1.A.REI.A.1**) Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Next Generation Science Standards (NGSS):

- **HS-PS2-2** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Objectives

1. Students will **understand** that momentum depends on both mass and velocity.
2. Students will **recognize** that different surfaces and materials promote different types of collisions.
3. Students will **collect data** to solve equations.
4. Students will **learn** that understanding material properties is an important aspect of engineering design.
5. Students will **generalize** the activity simulation to apply to a vehicle collision.

Materials Needed

Each group will need the following:

1. Three different sized balls (suggestions: ping-pong ball, tennis ball, racquetball, golf ball, baseball, super ball, clay, billiards ball)
2. Three different bouncing surfaces (suggestions: tile floor, linoleum floor, carpeted floor, wooden block, cinder block)
3. Kilogram or gram scale
4. Meter stick
5. [Bouncing Balls Worksheet](#) (one per student)

Activity Procedures

Launch

- Video: [Understanding Car Crashes: It's Basic Physics](#)
 - Start Video: 0:00 (beginning) Stop Video: 4:15
- Today, we will simulate vehicle collision by using three different sized balls to represent different size vehicles that are “crashing” into an obstruction.
- Momentum can be thought of as mass in motion and is given by the expression:

$$p = mv$$

Momentum = mass · velocity

- The amount of momentum an object has depends both on its mass and how fast it is going. For example, a heavier object going the same speed as a lighter object would have greater momentum. Sometimes when moving objects collide into each other, momentum can be transferred from one object to another.

Explore

- In order to complete this activity, you will also need to have an understanding of the motion of an object. Following are the Kinematics equations:

$$d = (V_f + V_i) \cdot t$$

$$V_f = V_i + a \cdot t$$

$$d = V_i \cdot t + \frac{1}{2} \cdot a \cdot t^2$$

$$V_f^2 = V_i^2 + 2 \cdot a \cdot d$$

Where d is the displacement of an object, V_i is the initial velocity of the object, V_f is the final velocity, a is the acceleration of the object, and t is the interval of time the object traveled.

NOTE: If the value of acceleration is not given but the object is in free fall, this means its acceleration is that of gravity (9.81 m/s^2).

- Students should measure and record the following on the [Bouncing Balls Worksheet](#):
 - Determine the mass in kilograms of each ball and record it on the data sheet.
 - Drop each ball from a distance of 1 meter onto the surface and record how high it bounces in meters (example: 0.46 meters).
 - Repeat steps 1, 2 and 3 for the two other surfaces.
 - Calculate the velocity for each ball right before it bounces (question 2) and right after it bounces (question 3).
 - Calculate the momentum for each ball right before it bounces (question 4) and right after (question 5).
 - Calculate the percentage of momentum lost for each case (question 6).
- [Activity Demonstration](#) - Video

Summarize

Class Discussion:

- Why did all of the balls lose momentum?
- What happened to the momentum that was lost?
- How did the mass of the ball relate to the momentum of the ball?
- How does this simulation with three balls apply to single-car vehicle collisions?

Teacher Resources

- [Bouncing Balls Worksheet](#) (doc) - editable
- [Bouncing Balls Worksheet](#) – Answers (pdf)
- This activity is best done in groups, because while one person drops the ball, another person must watch the ball and meter stick to note how high the ball bounces. Additional team members could hold the meter stick steady and/or record the data. It is difficult to get an accurate measurement for how high the ball bounces since it is in constant motion. Therefore, have students drop each ball on each surface several times, or until they have a consistent measurement.

Name:

Date:

Collisions, Momentum, & Math – Bouncing Balls Worksheet



Data

Ball Types:

Surface Types:

Ball 1: _____

Surface 1: _____

Ball 2: _____

Surface 2: _____

Ball 3: _____

Surface 3: _____

1. Based on the **Height** of the bounce for each ball, is the collision more elastic or inelastic? Fill in the table accordingly.

Case	Ball	Surface	Mass of Ball (kg)	Bounce Height (m)

Name:

Date:

Calculations and Results

2. Calculate the **velocity** of each ball right **before** it hits the surface (Starting Velocity). Why do you only have to perform this calculation once?

3. Calculate the **velocity** of each ball right **after** it hits the surface (Ending Velocity).

4. Calculate the **momentum** of each ball **before** it hits the surface (Starting Momentum).

5. Calculate the **momentum** of each ball **after** it hits the surface (Ending Momentum).

Name:

Date:

6. Calculate the change in momentum and the percentage of momentum that was lost for each case.

Fill in the Table below with your answers:

Case	Starting Velocity (m/s)	Ending Velocity (m/s)	Starting Momentum (kg*m/s)	Ending Momentum (kg*m/s)	Change in Momentum (kg*m/s)	Percent of Momentum Lost

Investigating Urban Trees

Teacher: Ms. Geist

Date: 06/30/2020

Overview & Purpose

There are many disturbances to the environment that are caused by transportation, this activity will investigate how trees could help with this issue. Trees provide ecological services, such as habitats for wildlife and food sources. Trees also remove common pollutants from the air, improving air quality. Trees also prevent erosion and cut down on the amount of runoff entering surrounding water sources. These are just a few ways the trees, especially in urban areas, can improve the surrounding environment. The purpose of this activity is to enhance internet research skills, develop critical thinking skills, and to get to students thinking about the different ways that technology and transportation affect the environment. This will be a research project and presentation.

Education Standards

- BIO1.LS4:3 Identify ecosystem services and assess the role of biodiversity in support of these services. Analyze the role human activities have on the disruption of these services.
- Crosscutting concepts: Cause and effect, and Stability and change of systems
- Science and Engineering Practices: Asking questions (for science) and defining problems (for engineering) to determine what is known, what has yet to be satisfactorily explained, and what problems need to be solved.
- Science and Engineering Practices: Obtaining, evaluating, and communicating information from scientific texts in order to derive meaning, evaluate the validity, and integrate information.
- ECO.ETS2.1 Engage in argument from evidence regarding the impact engineering and technology have on biodiversity.

Objectives

1. **Identify** and **describe** the effects technology and transportation have on biodiversity and the environment.
2. **Explain** ecosystem services, such as soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.

Materials Needed

1. Devices (e.g., laptops, Chromebook, iPads, etc.) with Internet access.
2. CER (claim, evidence, reasoning) graphic organizers
3. Projector and Projector Screen
4. Document camera

Activity Procedures

- Give students 60 seconds to write down all the ways that trees affect the environment. Encourage them to write until the timer goes off and to think critically! Then give them time to share a few of the points they jot down with their table partner.
- Go around the room and ask students what they have written down, write each new idea/answer on the whiteboard.
- As a class, watch <https://www.youtube.com/watch?v=zarll9bx6FI> this video will introduce students to the topic and help them think of more ways that trees affect the environment, especially in urban areas. Discuss any new ideas that come up after watching the video.
- Share the lesson objectives with students. Explain the purpose of this activity to the students. Provide students with the CER graphic organizer, explain this is how they will be assessed during this lesson. (See sample found below)
- Give students the question, What effect do trees have on the environment in an urban area?
- Ask students to come up with a claim, the claim can be anything relating to urban trees and the effect they have on urban areas. Let the students be creative here in the investigation!
- Give students time to write a strong claim and guide students during this time, asking them to explain their claim or their thoughts if they have not written a claim yet. (This time will vary between classes)
- Students must fill out the CER graphic organizer as a formative assessment. Students must have the teacher check off on the graphic organizer. For students to be successful in writing a CER response, they must be able to make connections between their claim and evidence. Make sure to check that students

claim is clear and direct. There should be three pieces of evidence and three pieces of reasoning.

- The students will then share their CER graphic organizers with the class on the document camera. All students must listen and take notes as their peers present.

Question:		
Claim: (Write a statement that responds to the question.)		
Evidence: (Provide scientific data and/or information to support your claim. Your evidence should be appropriate (relevant) and sufficient, enough to convince someone that your claim is correct.)		
Evidence #1	Evidence#2	Evidence#3
Reasoning: Use scientific knowledge that you have about why your evidence supports your claim. In other words, explain how your data proves your point.		
Reasoning #1	Reasoning #2	Reasoning #3

Question: What effect do trees have on the environment in an urban area?

Claim:

Evidence: Provide scientific data and/or information to support your claim. Your evidence should be appropriate (relevant) and sufficient (enough to convince someone that your claim is correct).

Evidence #1

Evidence#2

Evidence#3

Reasoning: Use scientific knowledge that you have about why your evidence supports your claim. In other words, explain how your data proves your point.

Reasoning #1

Reasoning #2

Reasoning #3

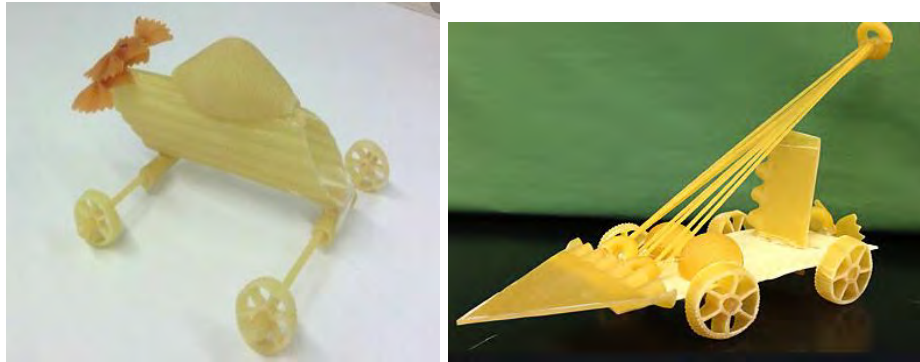
Spaghetti Soapbox Derby

Teacher: Ms. Bethany Stevens, Cookeville High

Date: 06/30/2020

Derived from: https://www.teachengineering.org/activities/view/ucd_derby_activity1

This is an extremely fun activity for my freshmen!



Overview & Purpose

Student pairs design, build and test model vehicles capable of rolling down a ramp and then coasting freely as far as possible. The challenge is to make the vehicles entirely out of dry pasta using only adhesive (such as hot glue) to hold the components together. Creativity is encouraged and different types of pasta are provided to support different functions such as round pasta for wheels and sheet pasta for the chassis. Students become familiar with the concepts of gravitational potential energy, kinetic energy and rolling resistance. Teams follow the steps of the engineering design process as they design, test and redesign their small-sized vehicles, working within the project's material constraints.

The activity requires students to think about using a familiar food product as a building material. The primary challenge of the activity is the pasta material constraint. The material is both fragile and not designed to function as a material for a rolling vehicle. Similar to how real-world engineers must find solutions within design constraints such as material, weight and cost limitations, students learn how challenging this can be. For example, mechanical engineers may yearn to design a car frame with the lightest, yet strongest material available, but doing so would cost so much that the car would be unaffordable! Engineers strive to find an acceptable balance, such as creating a strong, safe and relatively lightweight frame, while keeping the material and production costs affordable for the manufacturer and end consumer. In the activity, students also experience the steps of the engineering design process as they brainstorm, prototype, test, evaluate and modify their designs to evolve them into successful solutions.

Imagine riding in a car made entirely of pasta! Well, you won't be driving this car any time soon, but you will have a chance to design a model vehicle made from this popular cuisine. Your task is to design a vehicle made entirely of dry pasta that is able to roll down a ramp and coast freely as far as possible. I bet you are already imagining a number of challenges that you might face in attempting to make pasta roll!

As you create your vehicle, you will follow the universal steps of the engineering design process. These are the same steps that real engineers use to design all the types of products in our world and every one of those products, structures and projects must meet its own unique design constraints. Design constraints are the requirements (criteria) and limitations that the solution must meet.

For this challenge, your main design constraint is that all components of the vehicle must be constructed of some form of dry pasta. Here's a tip: Before you start putting any pieces of pasta together, think about how each part of the vehicle will function. It is always a good idea to discuss your ideas with everyone on your team and sketching out ideas helps you to explain your ideas and remember them. Once you have decided what each component needs to do—such as the chassis, wheels and axles—find pasta pieces that seem the most suitable for those purposes. For example, how far might your car coast if you use a square piece of pasta for the wheels? That's right—not far at all!

Remember that it is highly unusual for a design to be perfect on the first attempt. When you test your prototype pasta cars, look at every vehicle component and see if it is doing its job well. If one car design does not work, that does not mean the entire car is a failure. Examine each piece and decide whether or not it was a good design choice. Take what you learn from testing each design iteration and incorporate the components that worked into the next version, making improvements on the parts that didn't work as well. Doing this is a big part of the engineering design process: examining what works and what does not, without getting discouraged so you can make changes for improvement.

Real-world engineers may not build cars made from pasta, but the idea of selecting the best material for the task—such as the shape/type of pasta in this activity—is a process that engineers all go through when they design vehicles—or anything! And, every vehicle that engineers design must meet its own design constraints on its properties, everything from weight and size to speed, power, time and cost.

Education Standards NGSS Standard

ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

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.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Objectives

- Identify the type of energy a vehicle has at the top of a ramp.
- Explain that gravitational potential energy is how the car gains speed.
- Explain the logic of changes made to a design after a prototype test.
- Explain what is meant by a design constraint.

Materials Needed

Each group needs:

- a supply of dry pasta in a variety of shapes to serve as vehicle building material, such as large and flat lasagna noodles for car chassis, spaghetti for car axles, rotelle for wheels, penne to serve as bushings, etc.
- hot glue and glue gun; hot glue is the recommended adhesive because of the surface irregularities of pasta; alternatively, provide the instructor's choice of adhesive
- paper and pencil, for sketching designs
- (optional) a small wheeled vehicle, such as a toy, for a quick demo, to let run down the ramp with different amounts of weight to demonstrate the resulting differences in distance traveled
- (optional) access to a computer with Internet access, for students to research example pasta cars OR for the teacher to find the same pictures in advance to print out to show the class
- ****test ramp for testing the pasta cars; such as a ramp composed of a 36 x 24-inch (91 x 61-cm) sheet of thin plywood, foam core board or similar materials that is raised on one side to a height of 13 inches (33 cm), perhaps propped on books or boxes secured with tape
- masking tape
- meter stick, yardstick or measuring tape

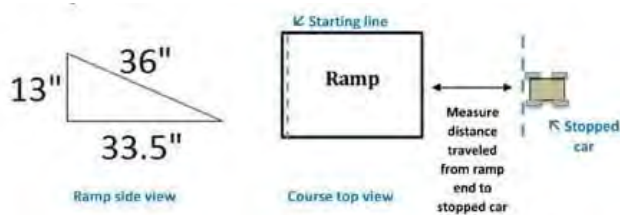
***** Could use a Vernier cart track Kyle talked about for STEM lending library???? Use the accompanying accessories somehow? Ideas?

Activity Procedures

Before the Activity

- Acquire enough dry pasta for all the participating groups, providing enough variety in pasta type to successfully build functioning vehicles. For example, make sure each group at least has some round pasta to use wheels and spaghetti to use as axles.

- Decide how you want to distribute the dry pasta, for example, provide each group with a set assortment of pieces or let teams choose what they want from all pasta at one classroom location.
- (optional) Make an example pasta car to give students an idea of what they are attempting to build.
- (optional) Decide whether or not you want students to conduct their own online research to find examples of pasta cars, or if you want to find some examples in advance to show them, or if you want to conduct the activity without this sort of research input.
- Construct a testing ramp. Refer to the rules, judging instructions and Figures 2 and 3 for suggested dimensions and course layout. Use books/boxes and masking tape to prop up the ramp securely, so it does not change between trials. Use masking tape to mark the starting line at the top of the ramp and a test area on the floor, leaving a stretch of open space at the bottom of the ramp for the little cars to run until they stop.



Suggested vehicle testing ramp and course layout.

With the Students: Background Concepts and the Challenge

- Review with the class the concepts of kinetic and potential energy, as well as the law of conservation of energy.
- **Gravitational potential** is the stored energy due to an object's height above the ground. It is dependent on the object's distance from the ground and its mass (if the concept of mass has not been taught, equate mass to weight). To illustrate the dependence on mass, ask students if they would rather have a brick or a piece of foam fall on their toes? Then ask students: If a brick was dropped on your foot, would it hurt more if it was dropped from a centimeter above the foot or if it dropped from a meter off the ground? Depending on the class math level, introduce the equation for potential energy: $PE = m \times g \times h$ where m is the mass, g is gravitational acceleration and h is the height above the ground. Then enter some numbers for the different variables to show that if g and h are fixed, all you can change is m .
- **Kinetic energy** is energy associated with an object's motion. It is dependent on how fast an object is traveling and the object's mass (if the concept of mass has not been taught, equate mass to weight). **Quick demo:** Let a small wheeled vehicle (perhaps a toy, not made of pasta) run down the ramp numerous times, adding more and more weight to the car each run to show the resulting differences in distance traveled.

- The vehicle's kinetic energy as it rolls down the ramp is a result of the **conversion** from the gravitational potential energy the car had at the top of the ramp. Thus, at the start of each trial, all of the energy a car possesses is from its gravitational potential.
3. Present to the class the Introduction/Motivation content. This introduces the idea of designing a vehicle made entirely of dry pasta. Make sure students are clear about the basics of the activity such as: the vehicle must be able to roll down a ramp and coast freely as far as possible.
 4. As necessary, clarify the definition of a design constraint. Sometimes it helps to tie the idea into real-world examples. Make sure students realize that the biggest constraint in the challenge is that the vehicle must be built entirely of dry pasta and glue.
 5. Spend time going over the anticipated challenges as a class, so students can begin thinking of how they would like to try and solve them.
- Demonstrate how easy it is to break the pasta as a way to make sure students know that dry pasta is fragile and needs to be handled carefully. Advise students to consider the fragility of the material in their designs.
 - Introduce the idea of rolling resistance. Explain the concept by asking students to consider how much force is required to push a vehicle a certain distance. For example, a car that rolls smoothly and can travel a long distance with a single push has a low rolling resistance while one that stops soon after a push has a high rolling resistance.
 - (optional) Show an example of completed pasta car to give students an idea of what they are attempting to build.
 - Emphasize that the engineering design process is about testing and learning from mistakes and not to let a failed design discourage students from trying more.

With the Students: Research, Brainstorming, Design and Construction

1. Divide the class into student pairs.
2. Have students conduct some research related to the challenge. This might include letting them research some pasta car designs on the Internet, showing them some (already found) pictures and/or giving them time to examine and experiment with the given materials. (15 minutes)
3. Direct the groups to brainstorm, sketch and discuss together the ideas they have for a team design.
4. Have each team agree to a design they will attempt to build. Require them to sketch the design, specifying the types of pasta they wish to use for each component. (15 minutes)
5. Distribute the pasta supplies to each team or have students choose the dry pasta materials they need from a central classroom location. (60 minutes for the remaining steps)
6. Review with students the different techniques for attaching different pieces of pasta with the provided adhesive. Depending on the type of adhesive used, supervise or provide assistance, especially if hot glue is used.

7. Advise students to experiment and test partially built vehicles and/or sub-assemblies often to make sure they roll and can survive the ramp. Making the effort to test and troubleshoot periodically throughout the engineering design process prevents students from spending too much time building non-functional vehicles. With the Students: Final

Testing/Competition

1. One by one, have teams bring their final prototype vehicles to the test ramp. Expect 30 minutes to be enough time for a class of ~30 students working in pairs to test their pasta cars.
2. A run consists of holding a pasta car at the top of the ramp with the rear wheels touching the starting line, then releasing the car and letting it roll freely down the ramp and coast until it comes to a stop.
3. Prior to the final competition run, review as a class the judging instructions. Judging is done by measuring the perpendicular distance from the bottom of the ramp to the closest part of the stopped pasta car.
4. Time permitting, let teams make adjustments to their vehicles after their first tests and then re-test for the final competition.

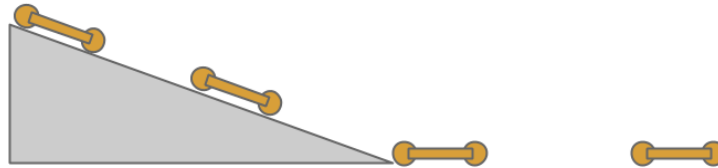
With the Students: Review and Reflect (20 minutes)

1. Based on the class results, have the entire class examine in more detail the vehicles that performed best. Lead a class discussion to explore why the top pasta cars worked well. Encourage all students to provide ideas.
2. Ask students to share their stories about making design changes based on what they learned from their interim and troubleshooting tests.
3. Have each group discuss together what they would change in the team design given what they observed during the class runs.
4. Administer the pre-quiz, as described in the Assessment section.

Name: _____ Date: _____ Class: _____

Spaghetti Soapbox Derby Quiz

- Which of the following activities will increase the gravitational potential energy of an object? Circle all that apply.
 - Change the object's color by painting.
 - Increase the height of the object above the ground.
 - Add more mass to the object.
 - Push the object so it travels faster along the ground.
- In the diagram below, label the position of the pasta car that correspond to the following:
 - The highest kinetic energy
 - The highest potential energy



- You are tasked to design a new car for the XYZ motor company. Your manager tells you that the vehicle must weigh less than 2,000 lbs. and be shorter than 13 feet in length. The engine and the seats inside have already been designed by other engineers. Given these instructions, what is one design constraint that **you** must follow?
- Will any two objects traveling at the same speed have the same kinetic energy? Why or why not?
- Would changing only the rolling resistance of a vehicle change the amount of potential energy it has at the top of the ramp?

Biodiesel Preparation

Teacher: Mr. Anderson

Date: 7/2/2020

Overview & Purpose

Biodiesel is a renewable diesel fuel which is made by a process called transesterification. This process involves combining a natural oil (such as cafeteria fryer oil) with an alcohol and a catalyst. Large batch (40 gal) mixers are available for purchase, and I have used one in our school greenhouse. But due to equipment limitations and safety concerns, this activity will involve only a mathematical calculation of alcohol amounts and a lab determination of catalyst amounts.

The purpose of this activity is to learn about biodiesel as a possible fuel source, to learn the chemistry behind its production, and to determine the amount of reactants needed to process 20 gallons of fryer oil.

Education Standards

- CHEM2.PS1.14 - Conduct titrations with standard solutions and an appropriate indicator and/or a pH probe to determine the concentration of an unknown acid or base...
- CHEM1.PS1.3 - Perform stoichiometric calculations involving the following relationships: mole-mole; mass-mass...

Objectives

1. The student will learn about biodiesel as a possible alternative fuel source.
2. The student will learn the chemistry behind its production.
3. The student will conduct a titration to determine the amount of catalyst needed.
4. The student will calculate the amount of alcohol needed for a large batch production.

Materials Needed

For 30 students working in pairs:

~50 ml of cafeteria fryer oil

~450 ml isopropyl alcohol (91-95%)

Titration glassware (burettes, beakers, stands, etc.)

2 g NaOH, solid

Phenolphthalein indicator and pH paper

Activity Procedures

1) Prepare the titrant by adding 2.0 g of solid NaOH and enough water to make 2000 ml of solution

2) Hand out the lab sheet/questionnaire and introduce the concept of biodiesel by watching this video:

https://www.youtube.com/watch?time_continue=134&v=BjwXRHIDI3k&feature=emb_logo

Students answer questions from the video on their papers.

3) Then show the first 2 minutes of this video:

<https://www.youtube.com/watch?v=1Gs6191FLBE>

This video discusses the basic chemistry of the transesterification. Students answer questions from the video on their papers.

4) You may want to remind them of the titration procedure by watching this video:

<https://www.youtube.com/watch?v=sFpFCPTDv2w>

5) Students follow the instructions on part 2 of the lab sheet. They will arrive at 3 volumes of titrant used and average them.

- 6) Students follow part 3 of the lab sheet to calculate how much NaOH and methanol will be needed to add to a 20 gallon supply of cafeteria fryer oil.
- 7) If you have the proper equipment, you could actually make the biodiesel. Be aware that it should be done in a well ventilated area such as outside or a shed or greenhouse and a washing (with water) and separation step follows.

Part 1 - watch the video "Making Biodiesel Fuel at UConn" and answer the following:

- 1) What are the 2 main reactants required to make biodiesel?
- 2) What is the waste product of biodiesel production?
- 3) Compare the carbon footprint of biodiesel to that of petroleum diesel.

Now watch the first part of the video "The Molecules of Biodiesel Reaction" and answer the following questions:

- 1) What is another name for oil?
- 2) What is the mole ratio of alcohol to oil?
- 3) What 2 alcohols can be used in biodiesel production?

Suppose everything from the cafeteria tastes like fish and the school cafeteria decides to change oil in the fryers. Now we have 20 gallons of used fryer oil to make some biodiesel for the school busses. Parts 2 and 3 will walk us through how to determine the amount of remaining reactants.

Part 2

Procedure

- 1) Titrant preparation - this is done. I added 2.0 g of NaOH to distilled water to make 2000. ml of titrant. You will find it on the front table.
- 2) Analyte preparation - place 1.0 ml of fryer oil into a beaker and add 10.0 ml of isopropyl alcohol.
- 3) Place 20 to 30 ml of titrant into your buret; record your initial reading to 10ths of a ml (i.e. 24.7 ml).
- 3) Put 3 drops of phenolphthalein into your flask of analyte. It should remain clear.
- 4) Titrate until a light pink color appears and stays. Then measure the pH with indicator paper. Ideally it should be in the 8 to 9 range. If it is still below this, continue adding titrant.
- 5) Record the final buret reading, to within 1/10 of a ml.
- 6) Rinse out flask and repeat for 2 more trials.
- 7) Calculate the amount of titrant used in each trial, as well as an average amount used.

Data

	Trial 1	Trial 2	Trial 3
V of analyte (ml)	11.0	11.0	11.0
Initial V of titrant(ml)	_____	_____	_____
Final V of titrant (ml)	_____	_____	_____
V of titrant used (ml)	_____	_____	_____
pH	_____	_____	_____

Calculations

NaOH - most recipes for making biodiesel require 3.5 g of NaOH for 20 gallons of cooking oil. But an additional amount is needed, which you determined by titration. This additional amount is:

1 gram of NaOH for each milliliter of titrant, per liter of oil

Determine how many grams of NaOH would be needed for our 20 gallons of oil by making the following calculations (show your work in the space provided).

a) convert 20 gallons of oil to liters of oil (1 gal = 3.78L)

b) multiply that number by the avg # of milliliters of titrant in your titration

c) add to that number 3.5 g

_____ g of NaOH

methanol - most recipes for making biodiesel require a certain amount of methanol to be added to the oil. That amount is:

210 ml of methanol per liter of oil

Calculate how many ml of methanol would be needed for our 20 gallons of oil (show your work in the space provided).

_____ ml of methanol

Engineering Car Crash Safety with Newton's Third Law of Motion

Teacher: Mr. Gobble, Mark

Date: 06/30/2020

Overview & Purpose

Combine Newton's third law of motion with engineering design in one fun lesson! Your students will learn about equal and opposite reaction forces as they design and build a bumper to protect a toy car during a crash.

Education Standards

NGSS Alignment

This lesson helps students prepare for these [Next Generation Science Standards](#) Performance Expectations:

- **MS-PS2-1.** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- **MS-ETS1-4.** 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
- Tennessee State Standards:
- 8.PS2.5 Evaluate and interpret that for every force exerted on an object there is an equal force exerted in the opposite direction.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Developing and Using Models. Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.</p>	<p>PS2.A: Forces and Motion. For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).</p> <p>ETS1.B: Developing Possible Solutions. A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.</p> <p>ETS1.B: Developing Possible Solutions. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.</p>	<p>Structure and Function. Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.</p>

●

Objectives

1. I can construct an explanation for how forces acting on an object cause changes in the motion of an object.
2. I can demonstrate how forces act on an object to cause changes in the motion of an object.
3. I Can Use the engineering design process to iteratively design, build, and test a product

4. I Can Apply knowledge of Newton's third law to explain what happens in a car crash

Materials Needed

This is an engineering design project, so there is not a specific list of required materials. You can make different materials available to your students, or allow them to bring materials from home. In general, recycled items, craft supplies, and office supplies work well. At a minimum, make sure your students have materials available to make and connect the main parts of the car.

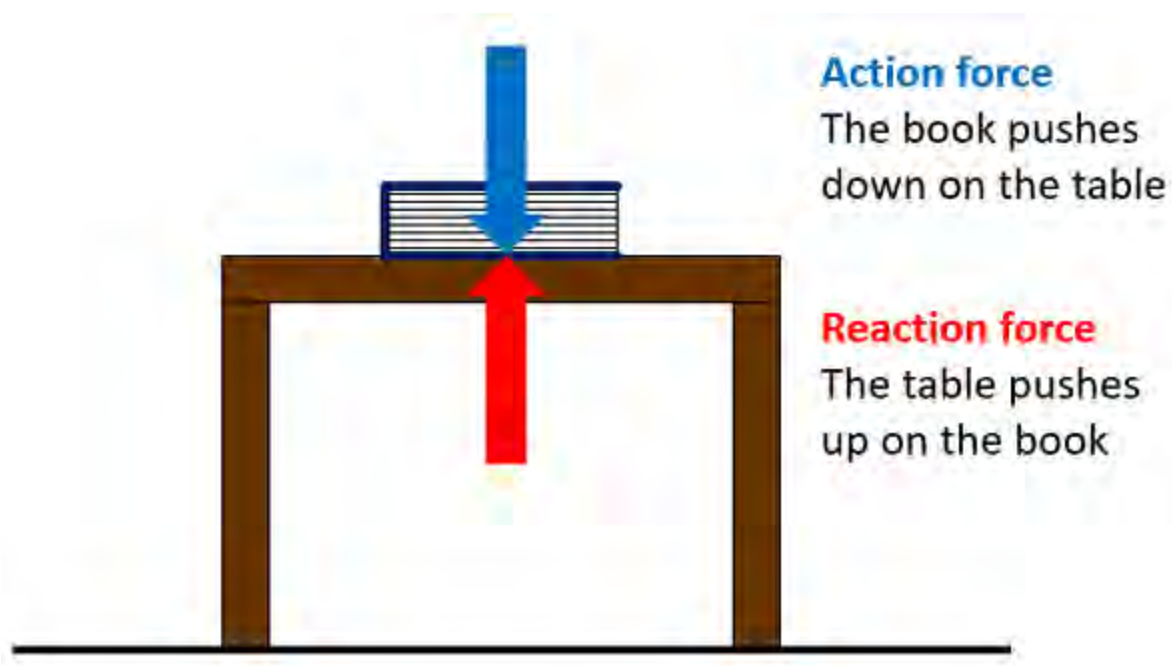
- Wheels: round objects like bottle caps or CDs, or you can cut your own wheels from foam board
- Axles: straws, pencils, wooden skewers, paper rolled into tubes, etc.
- Chassis (body): plastic bottles, cardboard boxes, Styrofoam®, cardboard, etc.
- Other construction supplies: scissors, tape, glue, rubber bands, paper clips, etc.

You will also need materials to build a ramp to roll the cars down:

- Wooden board, large piece of corrugated cardboard, or foam core board, at least 1 foot wide and 3 feet long
- Small box or stack of books to prop up one end of the ramp, at least 1 foot tall

Activity Procedures

- *The teacher will begin the lesson with a discussion of Newton's third law of Motion.*
- Newton's third law of motion states "For every action, there is an equal and opposite reaction" ("reaction" here refers to a force, which is a push or pull). For example, when you put a book on a table, the weight of the book pushes down on the table (the action). The table pushes back on the book (the reaction), with an equal force that acts in the opposite direction. This force is what prevents the book from falling to the floor (Figure 1).



-
- this concept can be confusing for students, and several misconceptions exist. For example, students might ask why the two equal and opposite forces don't just cancel each other out. This is because the two forces act on different objects (e.g. in Figure 1, the action force acts on the table, and the reaction force acts on the book). Equal and opposite forces only cancel each other if they act on the *same* object. Students may associate exerting a force with things that can move, such as a person pushing a box across the floor, or a snow plow pushing a pile of snow. It can be difficult to grasp how an inanimate object can push. For example, if you say "When you push on a wall, the wall pushes back on you," students might ask "How can a wall push if it can't move?" The lesson will help you address some of these misconceptions with students.
- In this lesson plan, The teacher will illustrate Newton's third law by crashing model cars that the students build themselves. When two cars crash at a high enough speed, both cars are usually damaged (Figure 2). For example, think about one car rear-ending another car that is stopped at a red light. When the cars collide, the moving car exerts a force on the stationary car, which can damage the rear end of the stationary car. However, the moving car comes to a stop, and its front end is also damaged. You can observe that something must have exerted a force on the moving car.



-
- **Figure 2.** Example of a car crash where one car rear-ended another and both cars are damaged.

According to Newton's third law, when the moving car exerted a force on the stationary car, the stationary car exerted an equal and opposite reaction force back on the moving car. If a single car crashes into a sturdy, stationary object like a wall or building, the stationary object also pushes back on the crashing car with an equal and opposite force (Figure 3). Again, you can observe the existence of this force because you observe the car slow down and become damaged.

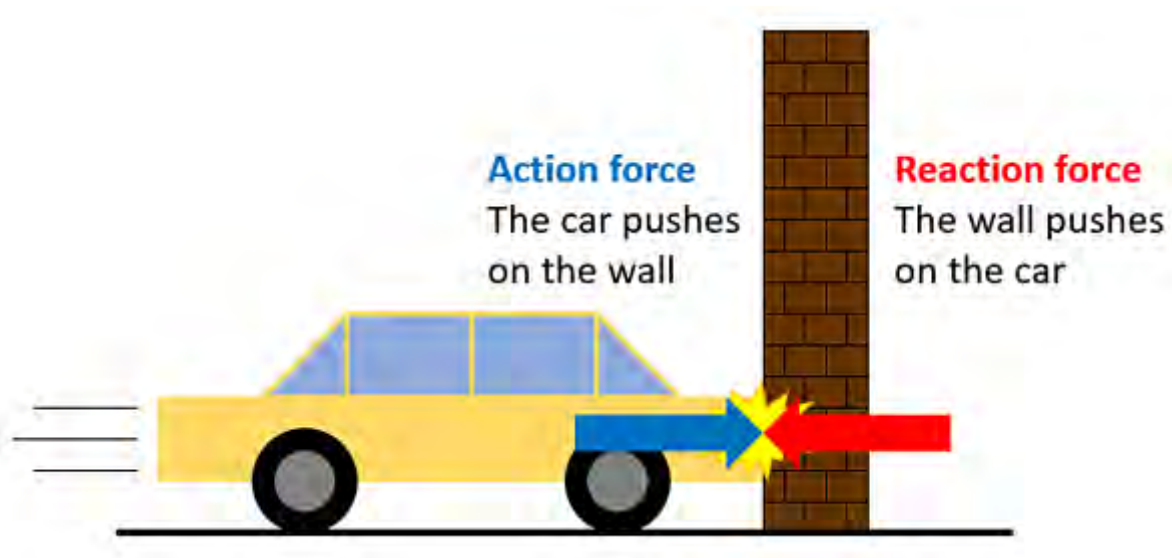


Figure 3. Diagram of action and reaction forces for a car crashing into a wall.

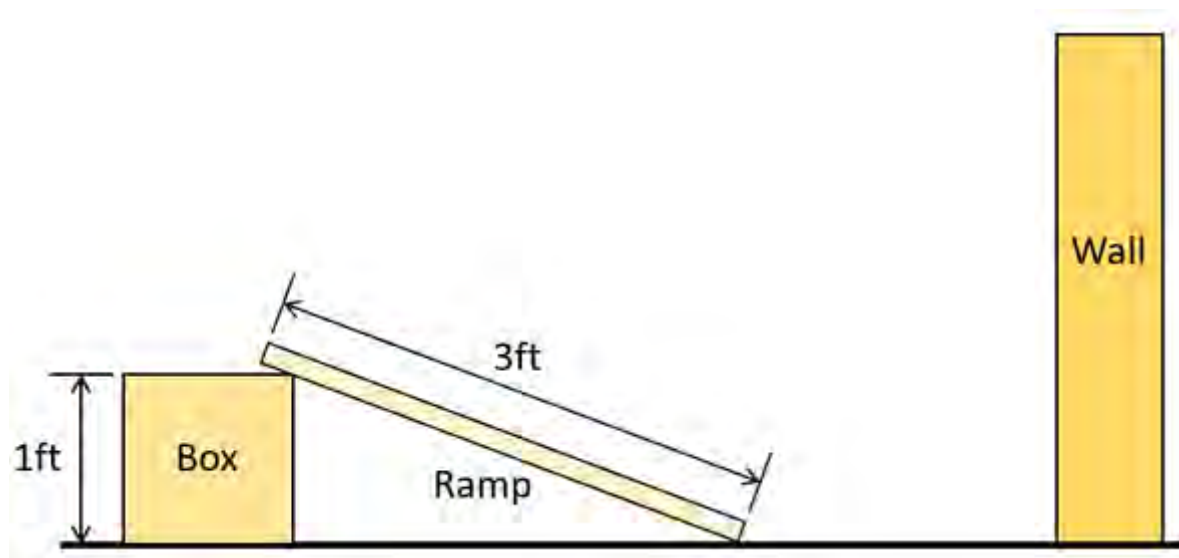
Cars have bumpers designed to protect the body of the car from minor damage during low-speed collisions. In higher-speed collisions, the impact forces will be higher (this comes from Newton's second law—see Additional Background section). The "crumple zone" protects the occupants of the car, because

the body of the car itself absorbs the force of impact and crumples (in Figure 2, notice how the trunk of the yellow car is smashed, but there is little damage near the door and rear passengers seats). In this lesson, your students will design and build toy cars, and perform crash tests on their cars by rolling them down a ramp into a wall. They will use the engineering design process to design and build bumpers to protect the main parts of their car from damage, and use their knowledge of Newton's third law to explain what they observe.

Note: this lesson is written for the NGSS Performance Expectation related to Newton's third law of motion. You can also adapt this lesson to teach about Newton's first and second laws of motion, or kinetic and potential energy. See the [Variations](#) section for details.

Prep Work (5 minutes)

- Set up one or more ramps that your students can use to crash-test their cars by rolling them into a wall. You can do this by propping one end of a wooden board or large piece of cardboard up on a box or stack of books, and aiming the other end at the wall (Figure 4). In order to give your cars enough speed, your ramp should be at least three feet long and one foot high. Starting the cars at the same position on the ramp (as opposed to letting students push the cars into the wall) will allow students to perform their crash tests at approximately the same speed each time.
- Note: this exercise works best if there is visible damage to your students' cars, such as the chassis being crumpled or the wheels/axles falling off. If there is no damage to the cars, they are either too light or not going fast enough. In general, a bigger ramp will work better. If you don't have room to make a big ramp, you can increase the weight of the cars by taping weights to them, like coins or large rubber erasers.



- **Figure 4.** Recommended minimum dimensions for ramp.

Additional Background

- [Newton's Third Law](#), The Physics Classroom
- [Bumper Cars](#), Annenberg Learner
- [How Crumple Zones Work](#), HowStuffWorks
- [Push Harder—Newton's Second Law](#), Science Buddies
- [The Engineering Design Process](#), Science Buddies

Engage (45 minutes)

1. Show your students Figure 2. Prompt students to think and ask questions about what happened in the picture to cause the result that they see. For example, what do you think was happening immediately *before* this picture was taken? How could we explain what we see in this picture with physics?



Figure 5. Two cars after an accident.

2. Explain that today students will build and crash-test their own cars. Now they will get started building their own cars in small groups. The goal for now is to quickly build a working car that can smoothly roll down a ramp, not to optimize or improve the car.
 1. Introduce the materials your students have available to work with.
 2. Show how students can build an axle, which is generally the most difficult part of the car to build. You can show your students this video, or demonstrate how to build one yourself.
 3. <https://youtu.be/STI3JCwdOIY>
 4. Each individual student should make a list of materials and sketch of their car design on their [worksheet](#).
 5. Students within each group should compare their designs and agree on what design they will build. It can be a single design, or a combination of two or three students' designs.

Students should be careful to pick a design they think will *work* the best, not just what they think looks the coolest!

6. Each group should build a prototype of their car.
3. Let each group roll their car down the ramp and crash it into the wall. The whole class can observe each test. Each group should record observations about what happened to their car on their worksheets. What happened during the crash? What does the car look like after the crash?
4. Have a brief discussion about Newton's third law of motion; but don't start out by telling students what the law says!

What made our cars come to a stop? What caused the damage to the cars?



The cars came to a stop because they crashed into a wall. The collision with the wall caused damage to the car.

How does the wall stop the car? Can a wall "push"?



Students might say that a wall cannot push, because they associate the act of "pushing" with things that can move (like a person or a snow plow). Let students experience how a wall can push.

1. Ask students to press their hands against a wall. What do they feel?
2. Does what they feel change if they press against the wall harder? What if they lean against the wall with both hands?

Did your answer change? Can a wall push?

Yes; even though a wall cannot move, it can still push. You can feel the wall pushing back on your hand when you press against the wall. When you press harder, the wall presses back harder.

Now apply what you just learned to your car instead of your hand. What happens when the car pushes on the wall?

The wall pushes back on the car.

What force makes the car stop and causes damage to the car?

The force of the wall pushing on the car.

2. Explain that students just demonstrated Newton's third law of motion. Formally, the law states that "For every action, there is an equal and opposite reaction." "Reaction" refers to a force (a push or a pull). This means that when you push on the wall, it presses back on you with a force that is exactly equal in size, but points in the opposite direction. Now students will design a bumper to protect their car during a crash. It is OK if the bumper itself is damaged during the crash and needs to be repaired or replaced. The goal is to protect the main parts of the car (chassis, wheels, and axles) from damage.

Explore (45 minutes)

1. As a group, students should repair any damage to their car from their crash test, or make a new car if needed.
2. Prompt students to brainstorm how they could build a bumper to protect their car from damage when it crashes into the wall. The design should focus on a bumper that is an addition to the existing car, and does not require totally rebuilding the car. Each student

should sketch a design and make a list of materials on their worksheet. They will need to apply their knowledge of Newton's third law to the design of their bumper (when the car pushes on the wall, how will the wall push back on the car?). They will also need to think about the properties of different materials that they have available. Would some be better than others for building a bumper?

3. Within each group, students should compare their designs and decide what they will build. Again, they can pick the best parts of different designs and combine them to make a single, better design. A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.

4. Each group should build a prototype of their bumper and attach it to their car. When they are ready, they can come to the ramp to test it, observe what happens, and record their observations.

5. Bring the class together for a discussion. Explain that the engineering design process is *iterative*. It is not like a math problem where there is usually a single "right answer." Multiple designs might all be good, and there might be an even better design that no one has thought of yet. Sometimes, ideas can look great on paper, but things do not always go as planned or do not work on the first try. Engineers usually have to repeatedly test and re-design something to make it better.

6. As a class, decide how you will test the bumpers to compare them and find out which ones work the best to protect the car it is attached to. There is more than one way to do this, which may depend on the available height of your ramp. For example:

a. Which car can survive a crash from the highest starting position on the ramp, with no damage to the chassis or wheels/axles (works well for larger ramps)?

b. Which car can survive the most repeated crashes from the same height, with no damage to the chassis or wheels/axles (works well if your ramp height is limited)?

7. Now, students will need to **test and improve their bumpers** in order to meet this goal. While students can make minor modifications and repairs to their cars if necessary to affect how they attach the bumper, the main emphasis at this point should be on designing the bumper and not totally redesigning the car. Any modifications should be documented. Each group should go through at least two iterations of their bumper and record their observations/improvements on their worksheets.

8. After all groups have finalized their designs, perform the final tests one group at a time, while the whole class watches. Record the results for each group (e.g. the number of crashes or highest height on the ramp it took to damage their car). How do the results compare to when they crashed cars without bumpers?

Reflect (15 minutes)

1. Discuss the results of your engineering project as a class. Which bumper designs worked the best? Did they have anything in common? Did the design of the car itself affect the performance of the bumper?

2. Circle back to the picture you saw at the very beginning of class.

Can you explain what you see in the picture in terms of Newton's third law?

3.

The picture shows two cars that are damaged because the front of one car crashed into the back of the other one. Both cars are damaged because they exerted equal and opposite forces on each other when they crashed.

4.

Can you explain what happened to your car when it crashed in terms of Newton's third law?

5.

When your cars crash into the wall, they exert a force on the wall. The wall exerts an equal and opposite force back on the car, which can break the car. A bumper helps absorb that force and prevent damage to the main parts of the car.

Assess

- Collect students' [worksheets](#) and use them to assess their use of the engineering design process.

For example:

- Did students make clear sketches for their design ideas?
- Did students record their observations?
- Did students make a causal link between their observations and changes they could make? For example, "The bumper fell off when it crashed, so I will use more tape to attach it."
- Ask each group to make a poster or do a brief presentation about their car and their bumper design. Ask them to include Newton's third law in their poster or presentation.

Make Career Connections

Discussing or reading about these careers can help students make important connections between the in-class lesson and STEM job opportunities in the real world.



- **Automotive Engineer** Automotive engineers design all the systems, like crumple zones, airbags, bumpers, and seat belts, that help keep passengers safe during a real car crash. If you liked building and testing cars, and thinking about how to make them safer during a crash, you should learn more about automotive engineering



● **Mechanical Engineer** Did you like building and (crash) testing things, but maybe you don't like cars that much? Mechanical engineers build and test many other types of machines, from airplanes to boats to spaceships. They use the engineering design process to improve these machines and make them safer for people.

9.

- Include teacher and student actions.
- Include formative assessment throughout the activity.

Engineering Car Crash Safety with Newton's Third Law

Name: _____

Date: _____

Student worksheet

Directions: Use this worksheet to record your designs and observations as you use the engineering design process.

Car Design

1. Come up with your own idea for a car design.
 - a. Draw a picture of your design.
 - b. Label the main parts of your design (wheels, axles, chassis).
 - c. Make a list of the materials needed for your design.

Engineering Car Crash Safety—Page 3

Name: _____

Bumper Design

1. Come up with your own design for a bumper that can protect your group's car during a crash.
 - a. Draw a picture of your design (the bumper attached to the car).
 - b. Make a list of the materials needed to build your bumper (you do not need to re-list the materials for the car).

Engineering Car Crash Safety—Page 4

Name: _____

2. Talk to your group and agree on a single bumper design that you will build. This can be a combination of two or more designs.
 - a. Draw a picture of the design.
 - b. Make a list of the materials needed to build the bumper (you do not need to re-list the materials for the car).

Engineering Car Crash Safety—Page 5

Name: _____

Testing

1. Test your bumper, and use this table to record your observations and the changes you made to make your bumper better.

Test #	Observations	Changes you made before the next test
1		
2		
3		

2. If you had more time or materials, what other changes would you make to your car's bumper? Briefly explain why you would try these changes.

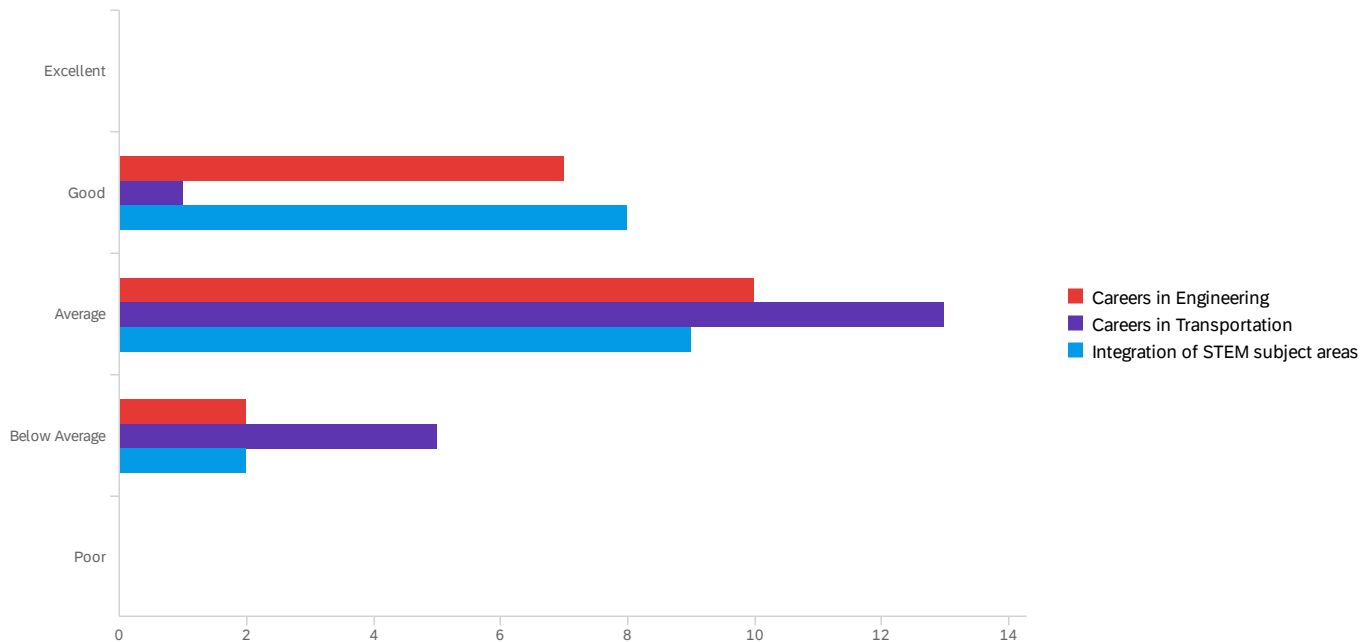
Appendix B – Workshop Pre-Surveys

Default Report

STRIDE 2020 Workshop Pre Survey

September 30, 2020 1:32 PM MDT

Q1 - What is your current knowledge of the following topics:

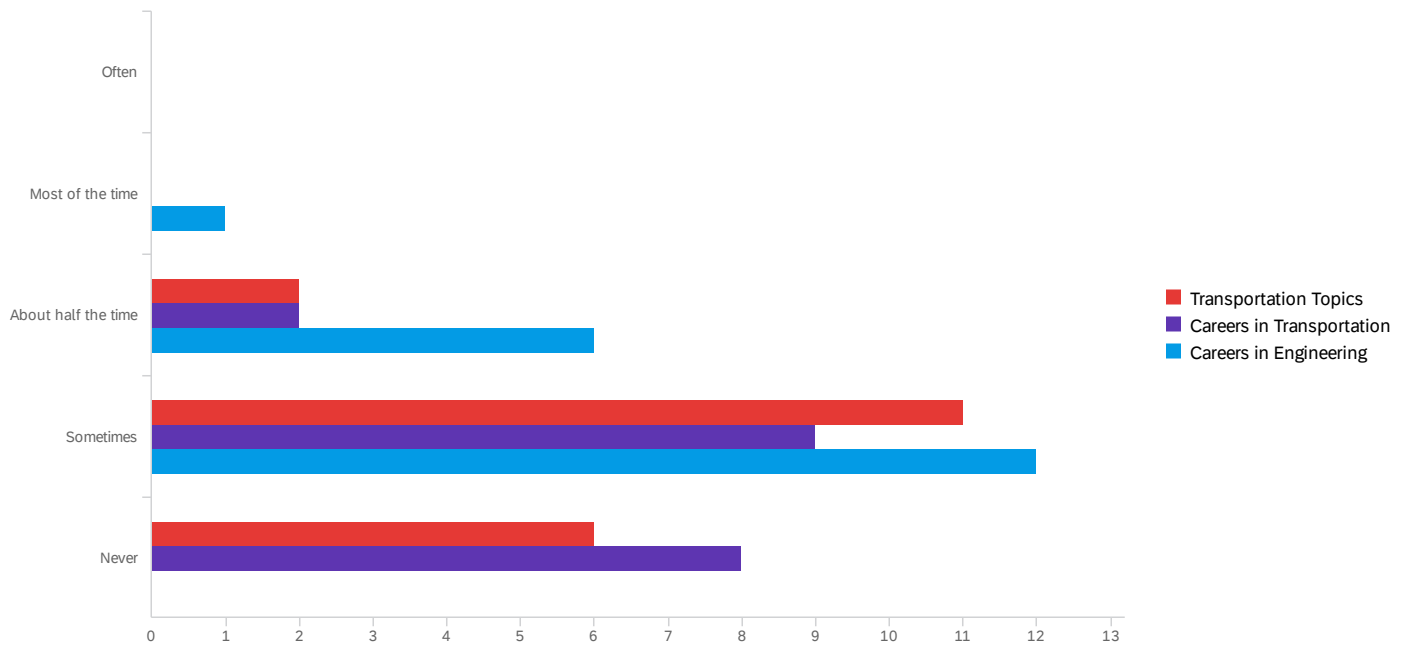


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Careers in Engineering	2.00	4.00	2.74	0.64	0.40	19
2	Careers in Transportation	2.00	4.00	3.21	0.52	0.27	19
3	Integration of STEM subject areas	2.00	4.00	2.68	0.65	0.43	19

#	Field	Excellent	Good	Average	Below Average	Poor	Total
1	Careers in Engineering	0.00% 0	36.84% 7	52.63% 10	10.53% 2	0.00% 0	19
2	Careers in Transportation	0.00% 0	5.26% 1	68.42% 13	26.32% 5	0.00% 0	19
3	Integration of STEM subject areas	0.00% 0	42.11% 8	47.37% 9	10.53% 2	0.00% 0	19

Showing rows 1 - 3 of 3

Q2 - How often do you incorporate the following concepts in your classroom:

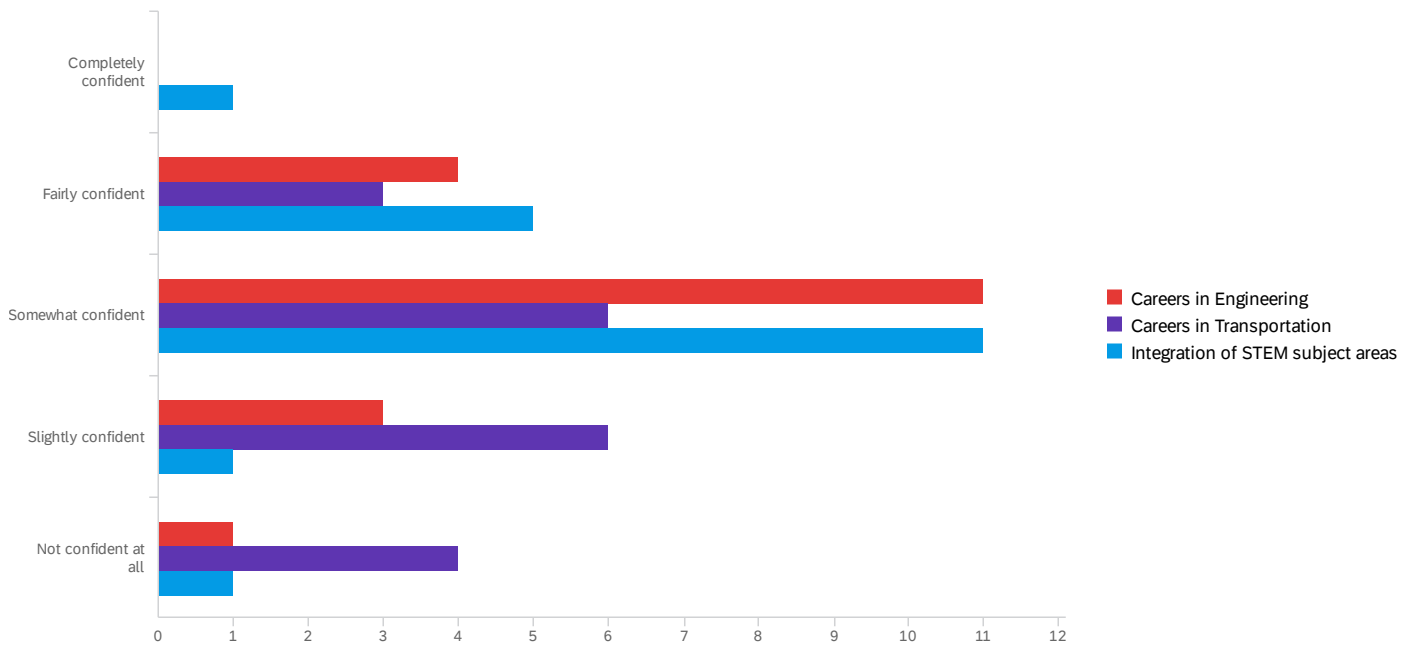


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Transportation Topics	3.00	5.00	4.21	0.61	0.38	19
2	Careers in Transportation	3.00	5.00	4.32	0.65	0.43	19
3	Careers in Engineering	2.00	4.00	3.58	0.59	0.35	19

#	Field	Often	Most of the time	About half the time	Sometimes	Never	Total
1	Transportation Topics	0.00% 0	0.00% 0	10.53% 2	57.89% 11	31.58% 6	19
2	Careers in Transportation	0.00% 0	0.00% 0	10.53% 2	47.37% 9	42.11% 8	19
3	Careers in Engineering	0.00% 0	5.26% 1	31.58% 6	63.16% 12	0.00% 0	19

Showing rows 1 - 3 of 3

Q3 - How confident do you feel teaching the following concepts in your classroom:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Careers in Engineering	2.00	5.00	3.05	0.76	0.58	19
2	Careers in Transportation	2.00	5.00	3.58	0.99	0.98	19
3	Integration of STEM subject areas	1.00	5.00	2.79	0.83	0.69	19

#	Field	Completely confident	Fairly confident	Somewhat confident	Slightly confident	Not confident at all	Total
1	Careers in Engineering	0.00% 0	21.05% 4	57.89% 11	15.79% 3	5.26% 1	19
2	Careers in Transportation	0.00% 0	15.79% 3	31.58% 6	31.58% 6	21.05% 4	19
3	Integration of STEM subject areas	5.26% 1	26.32% 5	57.89% 11	5.26% 1	5.26% 1	19

Showing rows 1 - 3 of 3

Q4 - What would increase your level of comfort in teaching the topics mentioned in the previous question?

What would increase your level of comfort in teaching the topics mentioned...

More knowledge and on the job training Practice. .

Participating in a workshop like this one and having available resources to teach the topics.

Concrete examples of how other teachers are incorporating those topics and help to design my own lessons that incorporate those topics.

More knowledge on the topics mentioned would make me feel more confident in teaching these topics. I hope I gain this knowledge from this workshop.

I would like to be provided with specific ways to incorporate the topics into my curriculum, and would like to be able to provide my students with more, specific information on careers in engineering and transportation. I would like more knowledgeable about how to pursue a career in transportation so that I could pass that on to my students.

I honestly don't know much at all about transportation related careers so exposure to them through this program/workshop will go a long way in improving my comfort level.

I need to learn more about the types of jobs in the transportation field. I would like to learn more about the educational requirements, job availability, and wide array of engineering jobs. I can always use subject integration advice/methods to aid in my teaching.

Additional information that can be gained from YouTube and increase knowledge from experts in the field of engineering. Also, ideas of how and when to apply additional resources in the classroom.

Creating more hands on learning like this Workshop, so that we get to practice our craft before having our students perform these tasks.

I think what would make me more comfortable is having guidance and examples in front of me to go by, which I am hoping to get through this workshop.

More access to resources and materials, knowing where to find them, etc.

To see lesson plans and examples from other participants/instructors, to know how to specifically do that.

Interaction with professionals that have "real experience" in the field. Field visits, lab tours, anything that would help give a concrete experience to teachers. It's hard to confidently introduce kids to careers and topics that you've only self-taught by reading or watching videos about. If only teachers could be experts on everything!

More knowledge about those areas and specific examples on how to incorporate activities into my lessons and how they can apply to Algebra II.

I think exposure-- such as this workshop will increase my understanding.

Exposure to different types of jobs in those fields via videos and/or presentations by people working in those fields. I would also like to know how they integrate high school math into their jobs.

I think having examples that are aligned to HS mathematics may be helpful. Or, having warm-up lessons, stories, etc. that launch a lesson.

What would increase your level of comfort in teaching the topics mentioned...

I would love ideas that makes it real to students . I think when they can relate to their everyday life, it becomes real to them and more interesting.

Increased knowledge in how topics are taught in the classroom and more knowledge in transportation.

Q5 - What subject(s) do you teach?

What subject(s) do you teach?

8th science and social studies

AP Environmental Science, Biology, Ecology, Physical Science, and Science ACT Prep

Chemistry, Honors Chemistry, Scientific Research, ACT Science Prep

9th-grade biology

Integrated Math III

Math, primarily integrated math 2 honors and integrated math 3.

Chemistry, Biology, Physical Science, STEM

Physical Science Honors and standard Chemistry Honors and standard

Geometry, Dual Credit Statistics and Personal Finance

Integrated Math 1 and Integrated Math 3

Integrated Math III

Physical Science and Honors PS

Physical Science, Chemistry

Algebra II, ACT Prep, co-teach Physics

Physics DE statistics STEM (?)

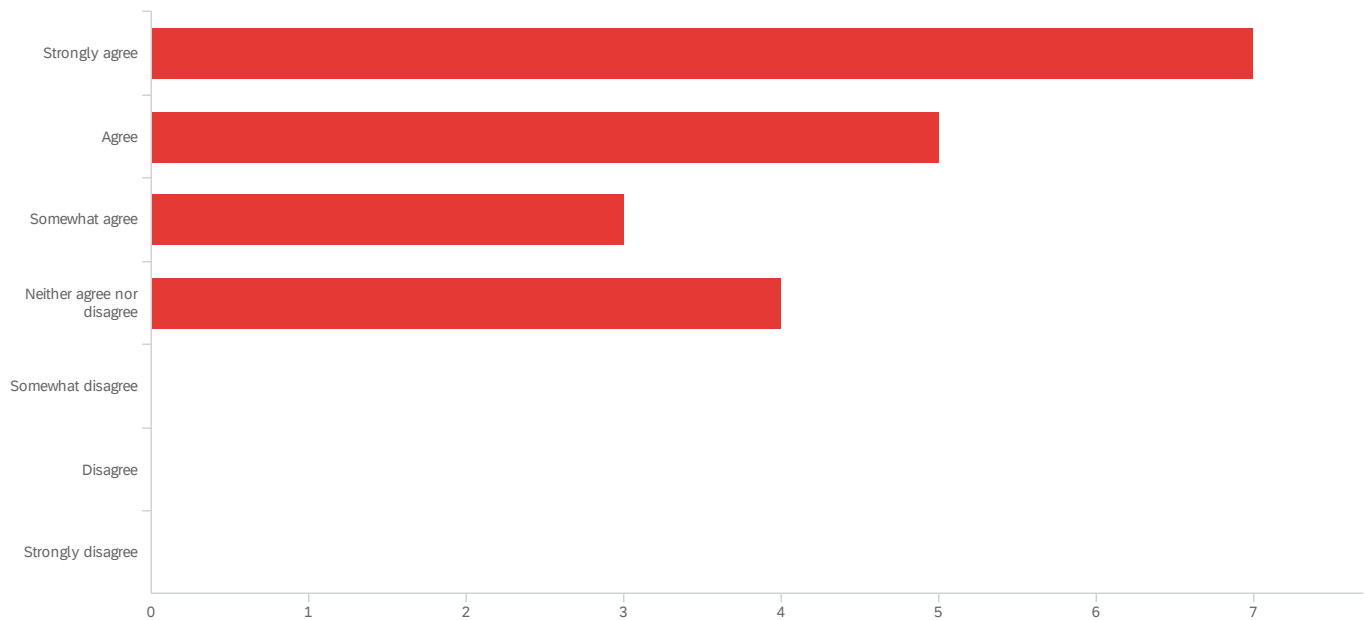
math 3, SAILS, and statistics

High School Mathematics (Algebra 2, Calculus, DE Probability & Statistics)

Chemistry, Physics, STEM 1

Chemistry, Chemistry honors, AP Chemistry

Q6 - The topics covered were relevant to the subject(s) I teach?

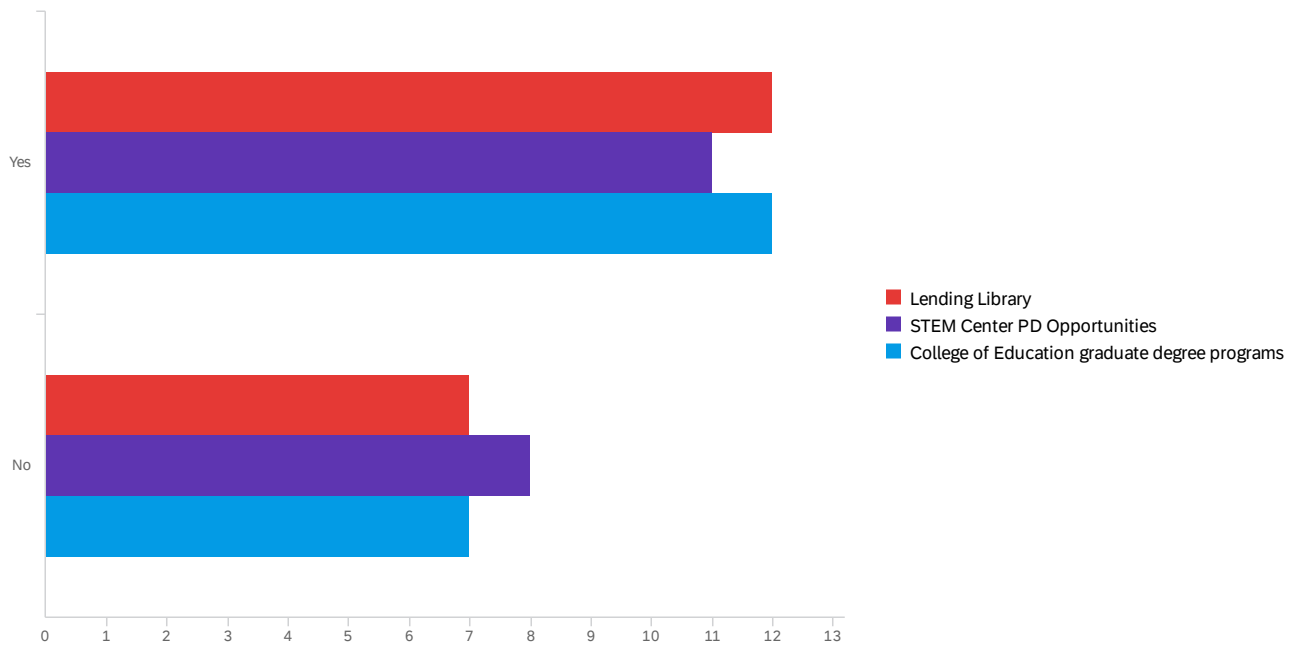


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The topics covered were relevant to the subject(s) I teach?	1.00	4.00	2.21	1.15	1.32	19

#	Field	Choice Count
1	Strongly agree	36.84% 7
2	Agree	26.32% 5
3	Somewhat agree	15.79% 3
4	Neither agree nor disagree	21.05% 4
5	Somewhat disagree	0.00% 0
6	Disagree	0.00% 0
7	Strongly disagree	0.00% 0
		19

Showing rows 1 - 8 of 8

Q7 - Are you familiar with the following resources at TN Tech:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Lending Library	1.00	2.00	1.37	0.48	0.23	19
2	STEM Center PD Opportunities	1.00	2.00	1.42	0.49	0.24	19
3	College of Education graduate degree programs	1.00	2.00	1.37	0.48	0.23	19

#	Field	Yes	No	Total
1	Lending Library	63.16% 12	36.84% 7	19
2	STEM Center PD Opportunities	57.89% 11	42.11% 8	19
3	College of Education graduate degree programs	63.16% 12	36.84% 7	19

Showing rows 1 - 3 of 3

End of Report

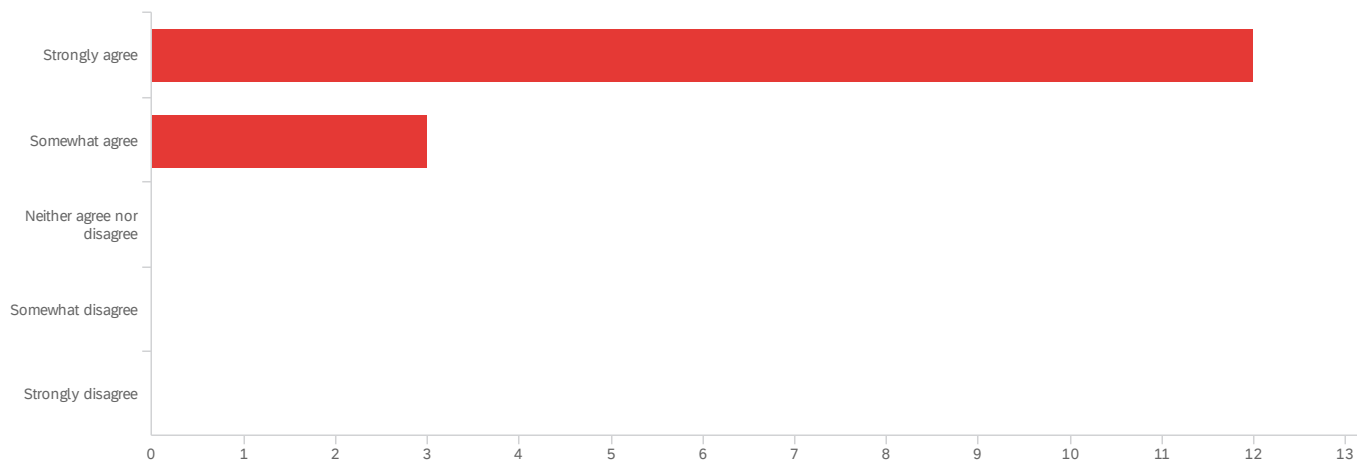
Appendix C – Workshop Post-Surveys

Default Report

STRIDE Workshop 2020 Post Survey

September 30, 2020 1:35 PM MDT

Q1 - The objectives of the training were clearly definded.

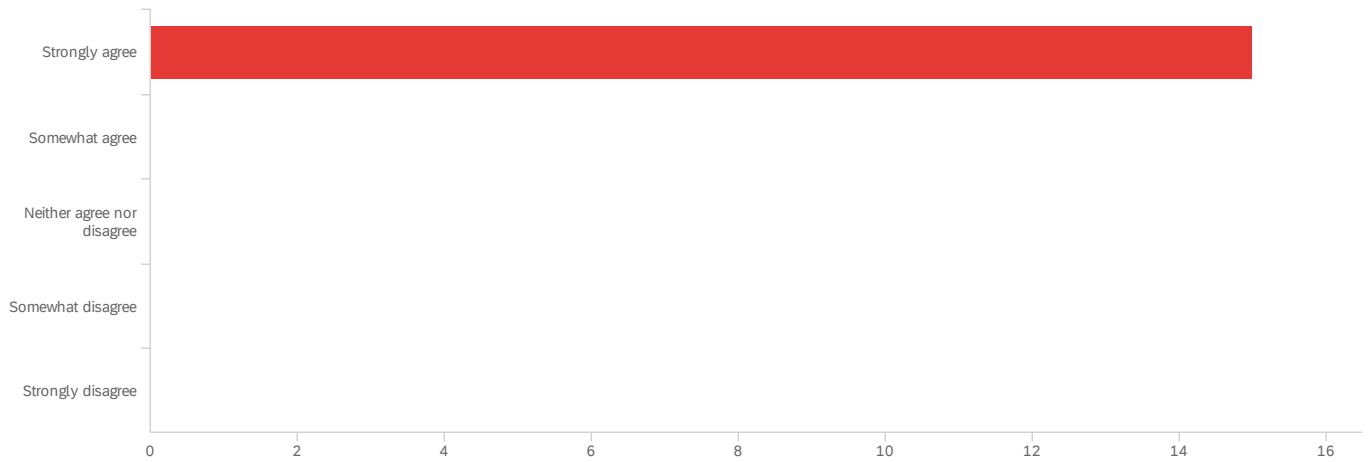


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The objectives of the training were clearly definded.	1.00	2.00	1.20	0.40	0.16	15

#	Field	Choice Count
1	Strongly agree	80.00% 12
2	Somewhat agree	20.00% 3
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q2 - Participation and interaction were encouraged.

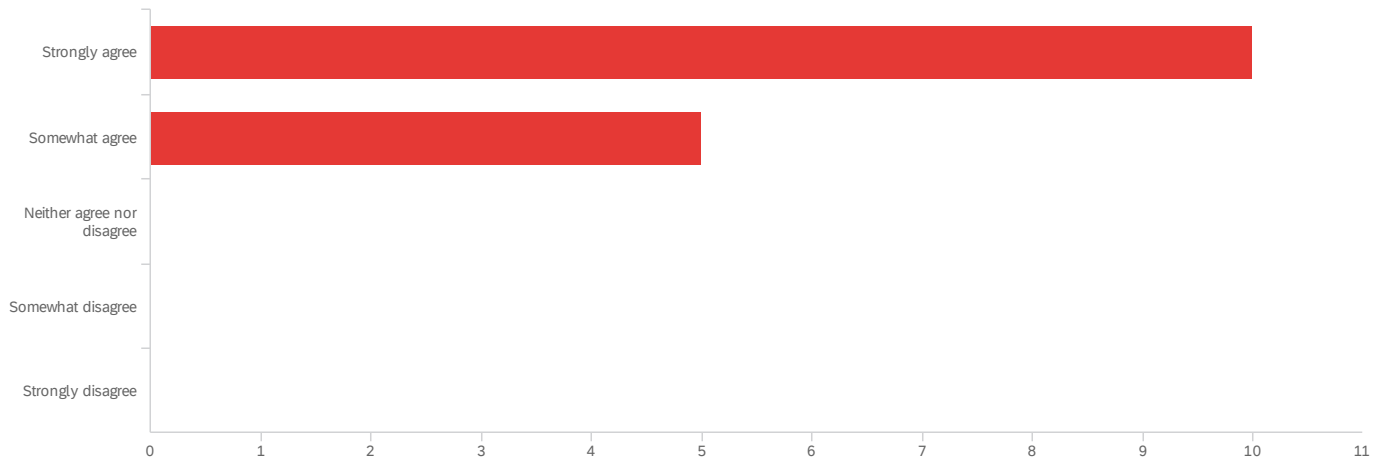


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Participation and interaction were encouraged.	1.00	1.00	1.00	0.00	0.00	15

#	Field	Choice Count
1	Strongly agree	100.00% 15
2	Somewhat agree	0.00% 0
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q3 - The topics covered were relevant to me.

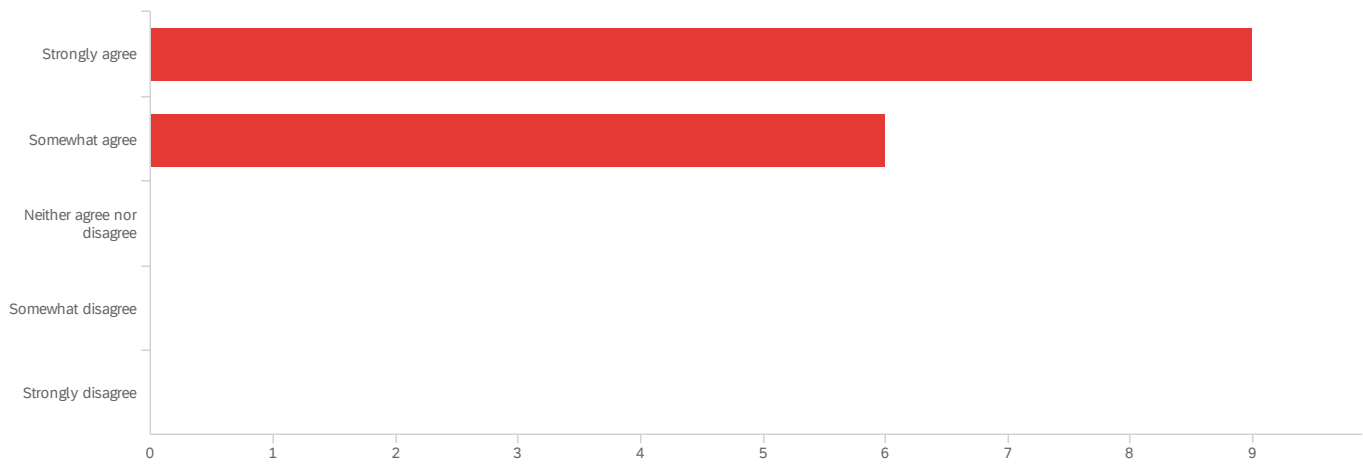


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The topics covered were relevant to me.	1.00	2.00	1.33	0.47	0.22	15

#	Field	Choice Count
1	Strongly agree	66.67% 10
2	Somewhat agree	33.33% 5
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q4 - The content was organized and easy to follow.

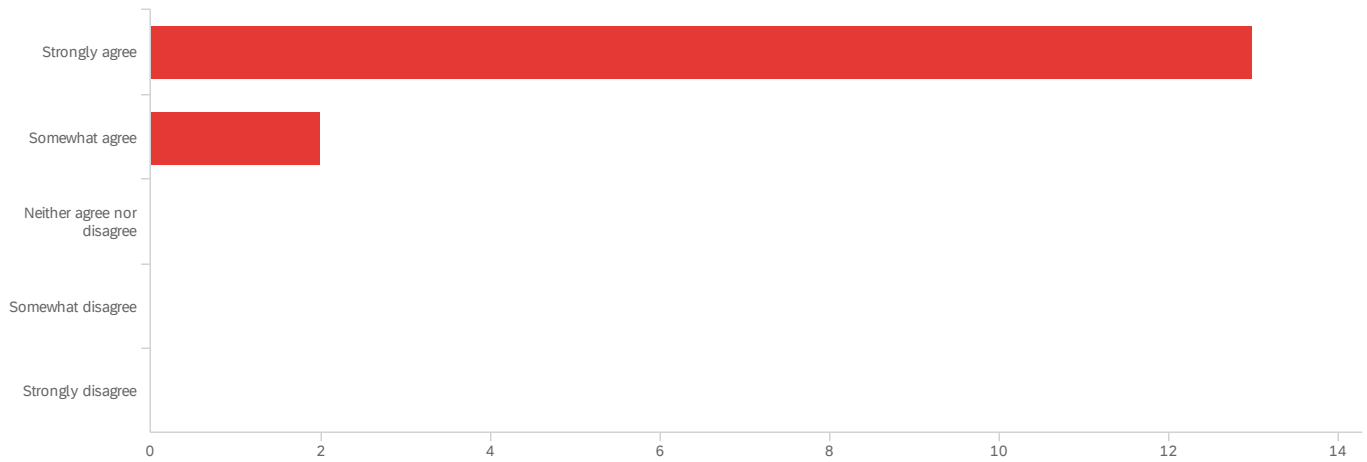


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The content was organized and easy to follow.	1.00	2.00	1.40	0.49	0.24	15

#	Field	Choice Count
1	Strongly agree	60.00% 9
2	Somewhat agree	40.00% 6
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q5 - The materials distributed were helpful.

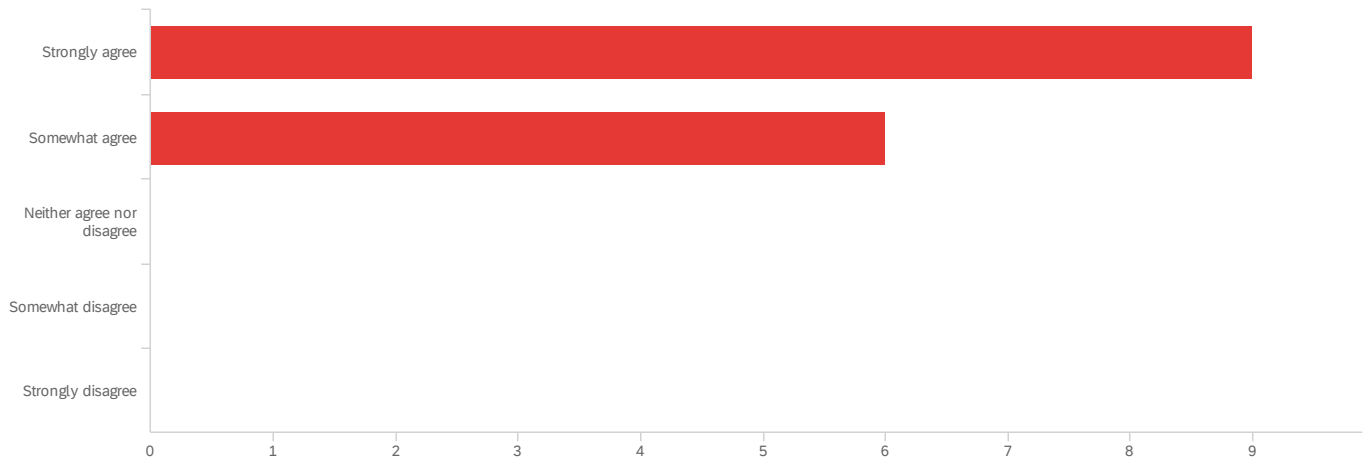


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The materials distributed were helpful.	1.00	2.00	1.13	0.34	0.12	15

#	Field	Choice Count
1	Strongly agree	86.67% 13
2	Somewhat agree	13.33% 2
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q6 - This training experience is helpful in my work.

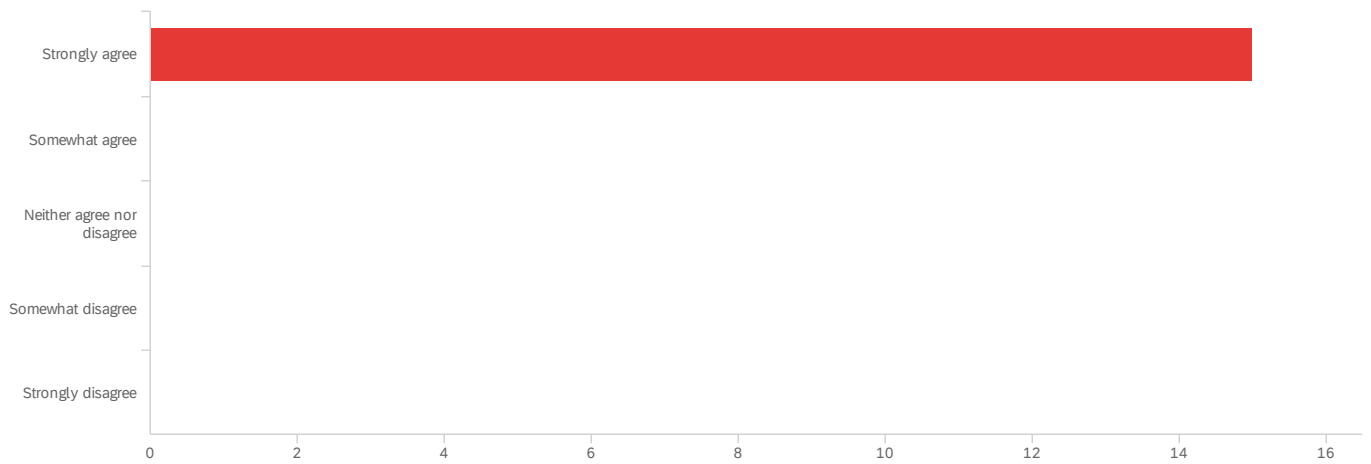


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	This training experience is helpful in my work.	1.00	2.00	1.40	0.49	0.24	15

#	Field	Choice Count
1	Strongly agree	60.00% 9
2	Somewhat agree	40.00% 6
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q7 - The trainers were knowledgeable about the training topics.

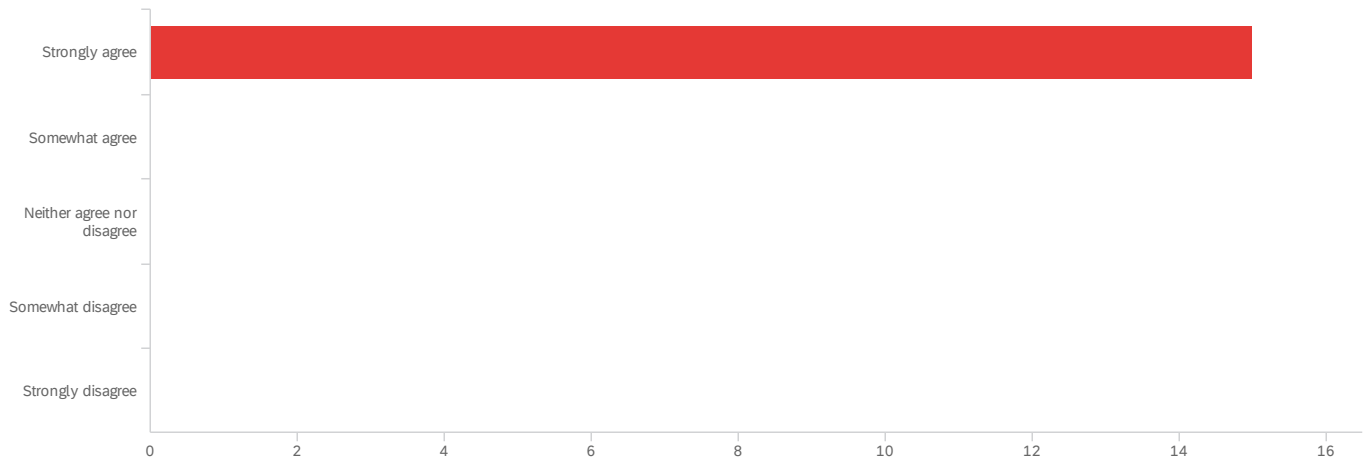


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The trainers were knowledgeable about the training topics.	1.00	1.00	1.00	0.00	0.00	15

#	Field	Choice Count
1	Strongly agree	100.00% 15
2	Somewhat agree	0.00% 0
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q8 - The trainers were well prepared.

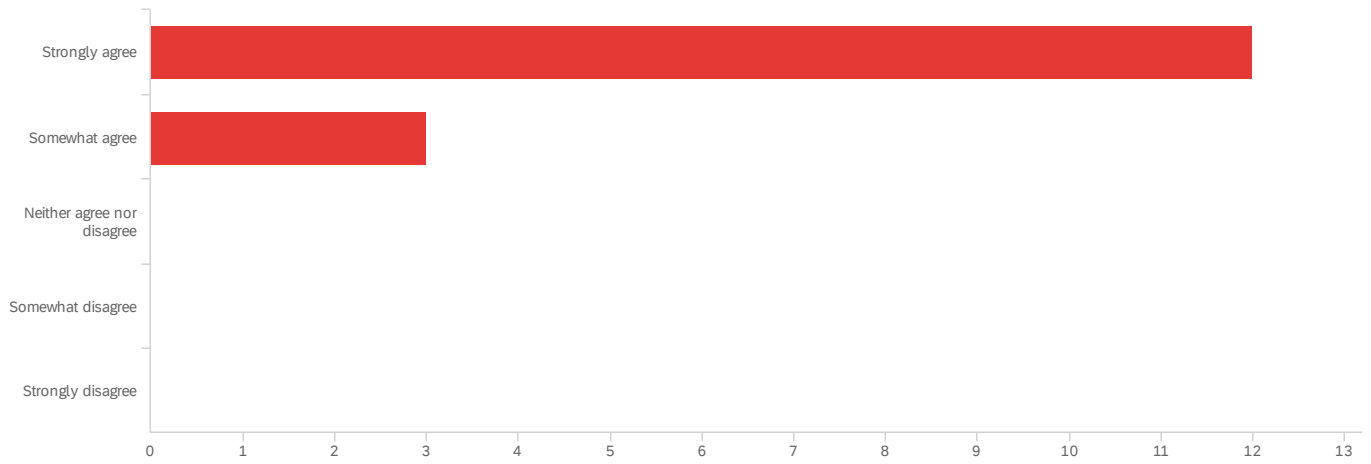


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The trainers were well prepared.	1.00	1.00	1.00	0.00	0.00	15

#	Field	Choice Count
1	Strongly agree	100.00% 15
2	Somewhat agree	0.00% 0
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q9 - The training objectives were met.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The training objectives were met.	1.00	2.00	1.20	0.40	0.16	15

#	Field	Choice Count
1	Strongly agree	80.00% 12
2	Somewhat agree	20.00% 3
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q10 - The time allotted for the training was sufficient.



Data source misconfigured for this visualization.

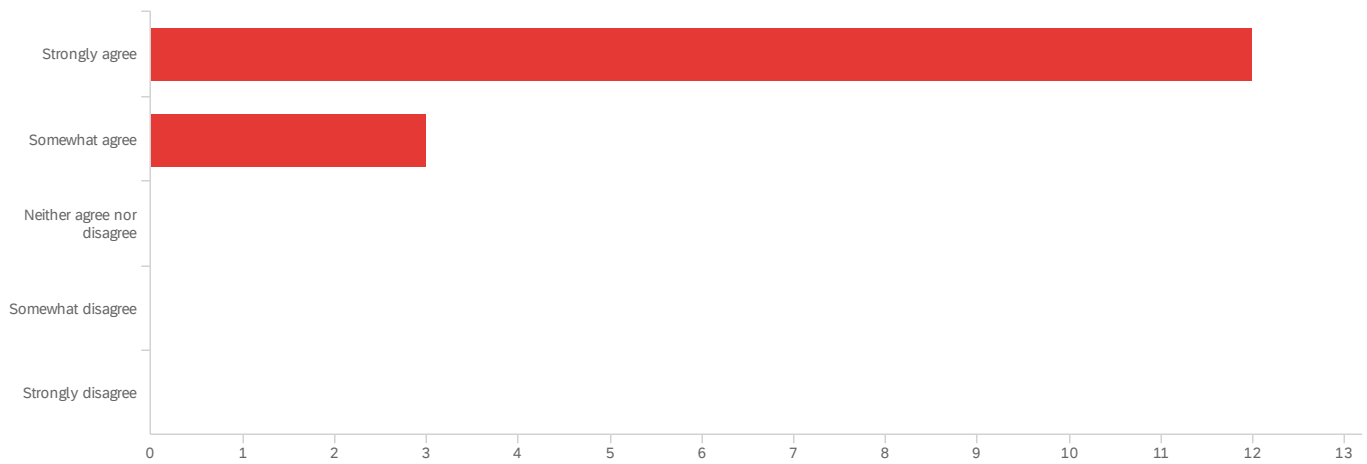


Data source misconfigured for this visualization.



Data source misconfigured for this visualization.

Q11 - I feel confident about checking out items at the STEM Center Lending Library.

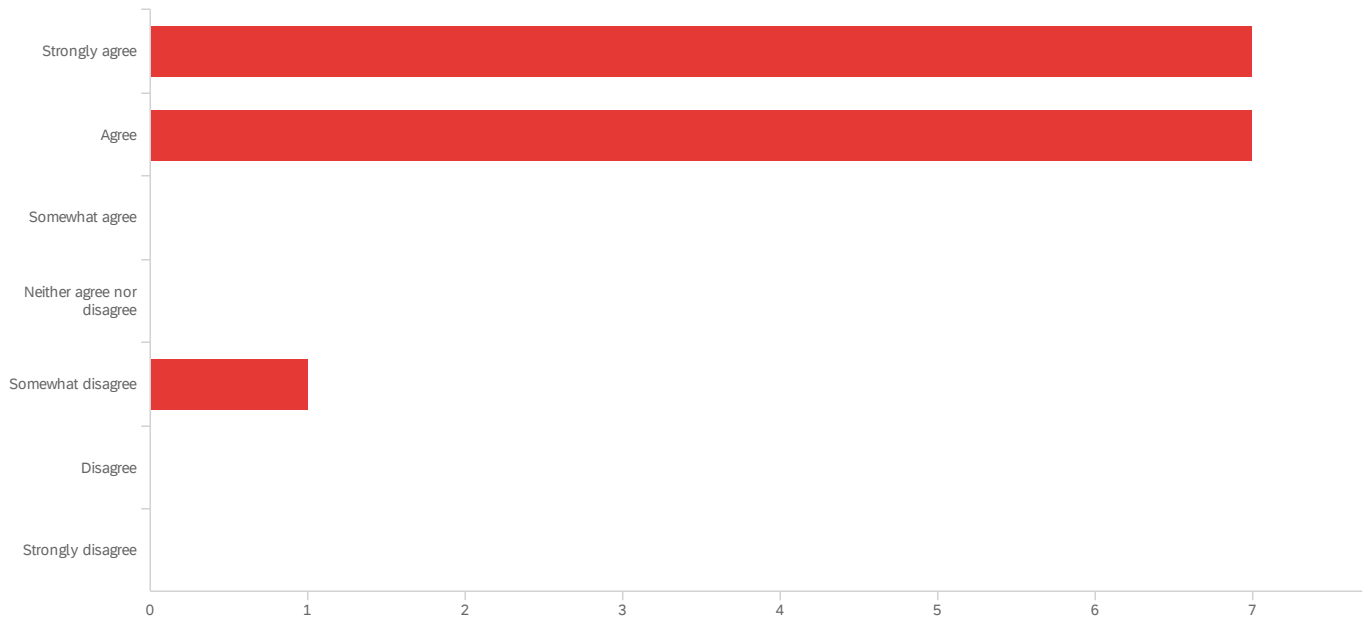


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel confident about checking out items at the STEM Center Lending Library.	1.00	2.00	1.20	0.40	0.16	15

#	Field	Choice Count
1	Strongly agree	80.00% 12
2	Somewhat agree	20.00% 3
3	Neither agree nor disagree	0.00% 0
4	Somewhat disagree	0.00% 0
5	Strongly disagree	0.00% 0
		15

Showing rows 1 - 6 of 6

Q25 - The topics covered were relevant to the subject(s) I teach?

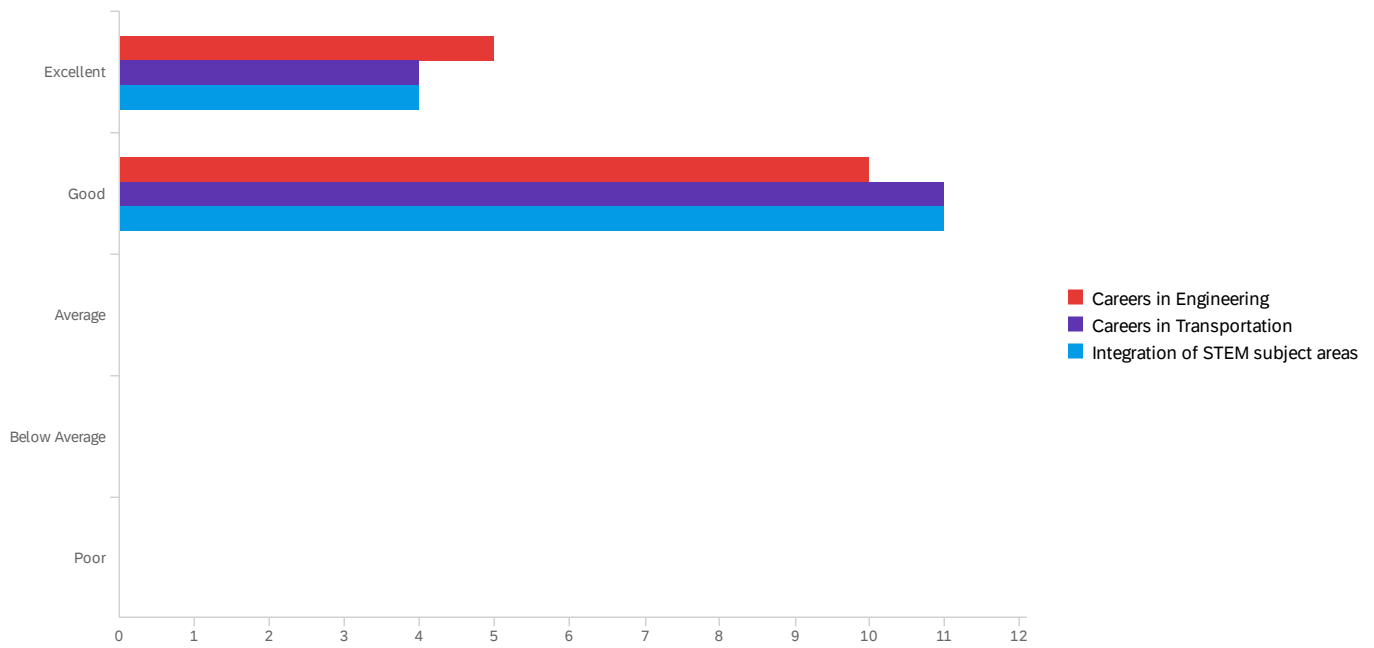


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The topics covered were relevant to the subject(s) I teach?	1.00	5.00	1.73	1.00	1.00	15

#	Field	Choice Count
1	Strongly agree	46.67% 7
2	Agree	46.67% 7
3	Somewhat agree	0.00% 0
4	Neither agree nor disagree	0.00% 0
5	Somewhat disagree	6.67% 1
6	Disagree	0.00% 0
7	Strongly disagree	0.00% 0
		15

Showing rows 1 - 8 of 8

Q19 - What is your current knowledge of the following topics:

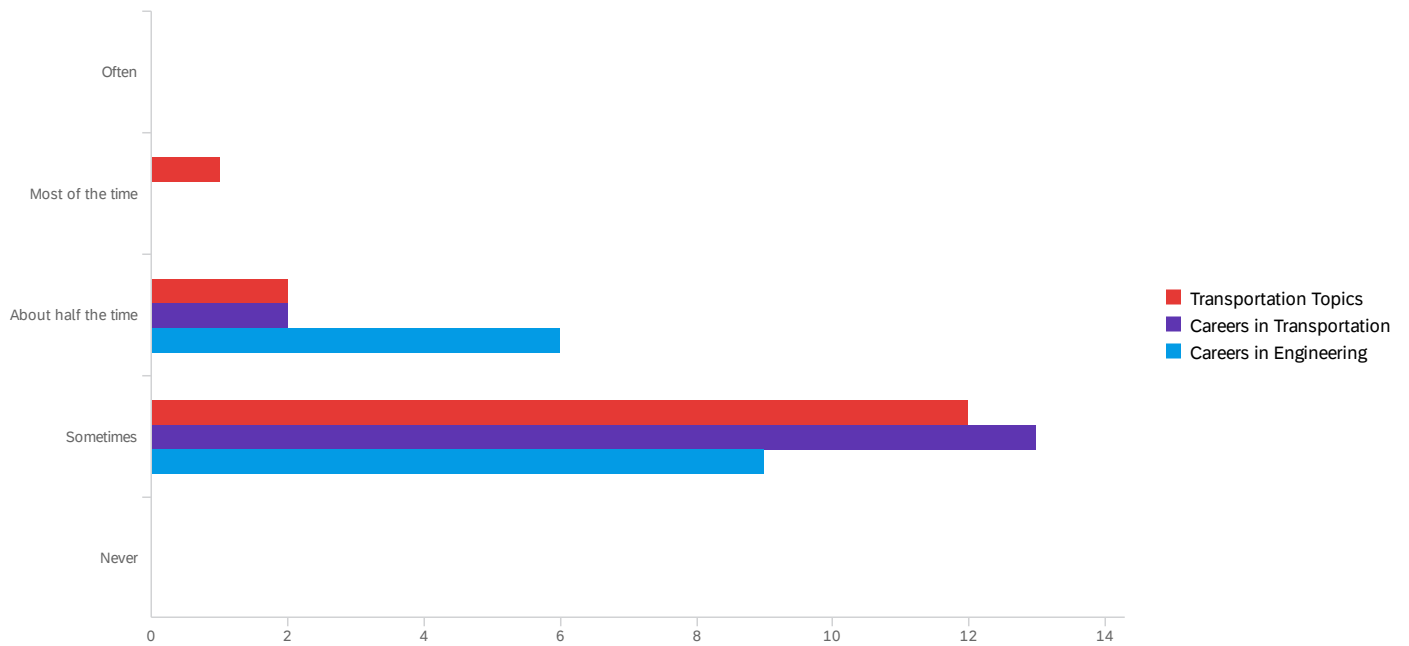


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Careers in Engineering	1.00	2.00	1.67	0.47	0.22	15
2	Careers in Transportation	1.00	2.00	1.73	0.44	0.20	15
3	Integration of STEM subject areas	1.00	2.00	1.73	0.44	0.20	15

#	Field	Excellent	Good	Average	Below Average	Poor	Total
1	Careers in Engineering	33.33% 5	66.67% 10	0.00% 0	0.00% 0	0.00% 0	15
2	Careers in Transportation	26.67% 4	73.33% 11	0.00% 0	0.00% 0	0.00% 0	15
3	Integration of STEM subject areas	26.67% 4	73.33% 11	0.00% 0	0.00% 0	0.00% 0	15

Showing rows 1 - 3 of 3

Q21 - How often do you incorporate the following concepts in your classroom:

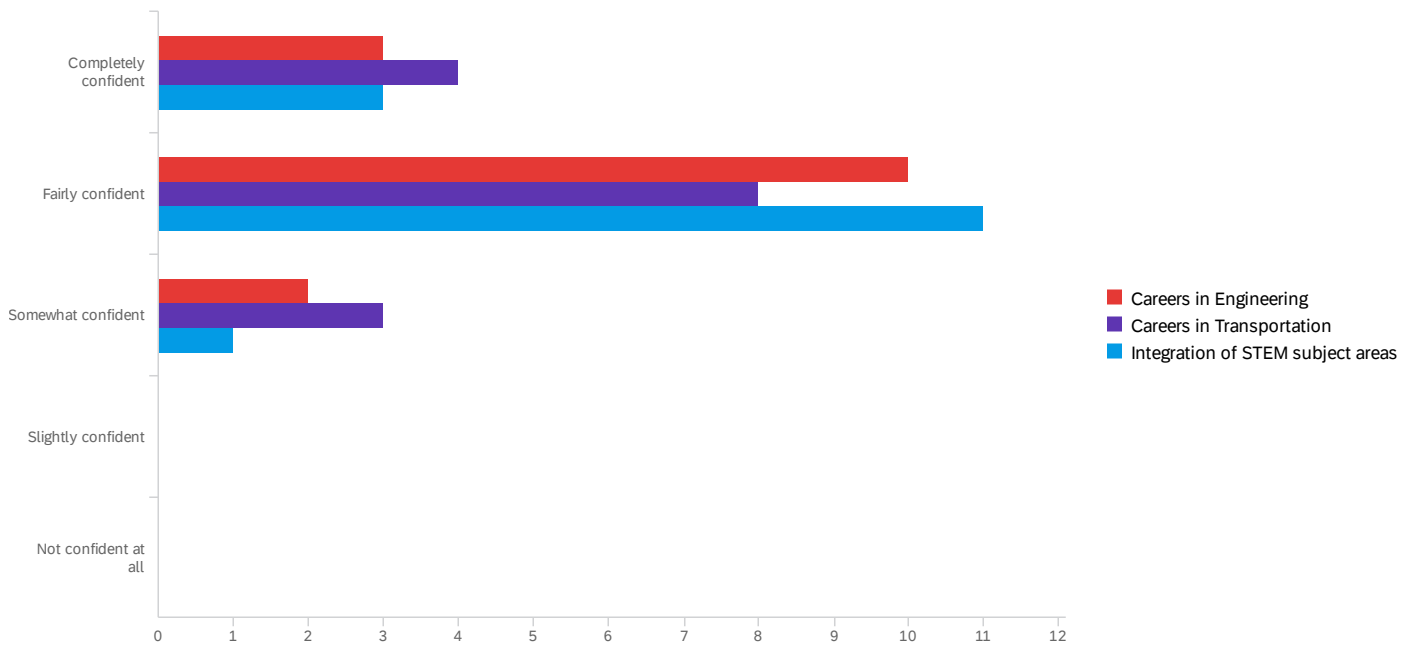


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Transportation Topics	2.00	4.00	3.73	0.57	0.33	15
2	Careers in Transportation	3.00	4.00	3.87	0.34	0.12	15
3	Careers in Engineering	3.00	4.00	3.60	0.49	0.24	15

#	Field	Often	Most of the time	About half the time	Sometimes	Never	Total
1	Transportation Topics	0.00% 0	6.67% 1	13.33% 2	80.00% 12	0.00% 0	15
2	Careers in Transportation	0.00% 0	0.00% 0	13.33% 2	86.67% 13	0.00% 0	15
3	Careers in Engineering	0.00% 0	0.00% 0	40.00% 6	60.00% 9	0.00% 0	15

Showing rows 1 - 3 of 3

Q23 - How confident do you feel teaching the following concepts in your classroom:

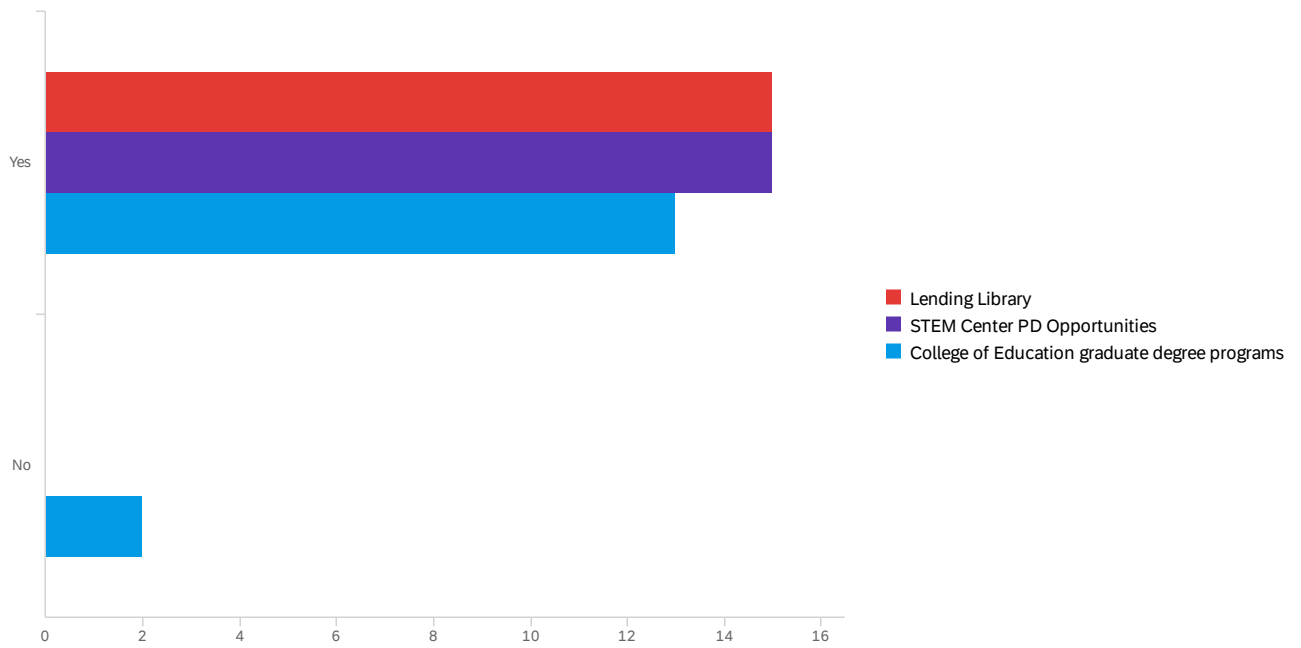


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Careers in Engineering	1.00	3.00	1.93	0.57	0.33	15
2	Careers in Transportation	1.00	3.00	1.93	0.68	0.46	15
3	Integration of STEM subject areas	1.00	3.00	1.87	0.50	0.25	15

#	Field	Completely confident	Fairly confident	Somewhat confident	Slightly confident	Not confident at all	Total
1	Careers in Engineering	20.00% 3	66.67% 10	13.33% 2	0.00% 0	0.00% 0	15
2	Careers in Transportation	26.67% 4	53.33% 8	20.00% 3	0.00% 0	0.00% 0	15
3	Integration of STEM subject areas	20.00% 3	73.33% 11	6.67% 1	0.00% 0	0.00% 0	15

Showing rows 1 - 3 of 3

Q27 - Are you familiar with the following resources at TN Tech:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Lending Library	1.00	1.00	1.00	0.00	0.00	15
2	STEM Center PD Opportunities	1.00	1.00	1.00	0.00	0.00	15
3	College of Education graduate degree programs	1.00	2.00	1.13	0.34	0.12	15

#	Field	Yes	No	Total
1	Lending Library	100.00% 15	0.00% 0	15
2	STEM Center PD Opportunities	100.00% 15	0.00% 0	15
3	College of Education graduate degree programs	86.67% 13	13.33% 2	15

Showing rows 1 - 3 of 3

Q12 - What did you like the most about this training?

What did you like the most about this training?

I liked the activities that we could do at home and take picture of our process and papers and then submit them.

I now have ideas on how to incorporate transportation topic lessons in my classroom.

I really liked the activities that we worked through.

I liked that it was autonomous, and we were free to research on our own time and find resources relevant to classes we teach.

I enjoyed working through the math activities, and I was happy to obtain a number of resources that I can either use as is or adapt for use in my classroom.

This workshop was one of the better professional development trainings I have attended. The lessons presented were either directly related to my standards or required students to think critically and problem solve, something I also work on in my room. I appreciate that the modules were designed with in a way that the lessons are ready to use without me having to modify. I appreciate the materials being posted on a website that I can access as needed. I enjoyed being exposed to different learning platforms, such as Padlet and Flip Grid.

I enjoyed having access to a plethora of resources.

I enjoyed that this training was virtual to accommodate summer schedules. The first week I had another PD so I appreciated having this one virtual and flexible. I appreciate that the lessons exposed teachers to different tech tools (i.e. Flipgrid, Desmos Activity, etc.). Also, I liked doing the "at-home" experiments that expanded my understanding of transportation issues. Having this workshop offered virtually helped me be a participant. I would not have been able to participate in this workshop if it had been on-site (in-person) in Cookeville due to the travel distance, pet care, hotel cost, etc. Although deadlines for assignments were stated, I appreciated having some flexibility in turning in assignments due to other summer commitments during the same time.

The training introduced me to Flipgrid and Padlet, they will be incorporated into my lesson plans. Also, multiple ideas on STEM projects for the future along with a great lesson plans. It was great to train with professors that add to vertical learning and gain an idea as to what colleges are expecting from high school teachers.

I liked the subject and the fact that I could develop an activity that I could use in class.

I really enjoyed the activities. They made me see things from a student's perspective when I wasn't really sure what I needed to be doing. The resources offered are very relevant to my students and their lives whether they want to be an engineer or a truck driver.

Gave me a lot of resources to share with the teachers at my school

Loved interacting with our teachers and co-participants

I liked the flexibility of the training being virtual. I also liked the variety of approaches from the different presenters in terms of how they addressed transportation topics.

I liked that we were exposed to lots of different resources and different ways to incorporate resources. I liked that the activities focused on getting students to think beyond how to solve a single problem and into thinking about the ways that STEM subjects impact society and their lives and future careers.

Q13 - What aspects of the training could be improved?

What aspects of the training could be improved?

None that I know of.

Nothing, I think it was great!

I think the pacing of the lessons should've been more staggered.

Directions on multiple slides were somewhat hard to follow as we had to go back and forth between them and our own projects. Altogether on one sheet / project would be less cumbersome.

I very much enjoyed the training. My only suggestion would be to spread out the due dates. I know it was said that the schedule was flexible, but not having several modules due at the same time would have been nice.

More time to finish the activities would be nice.

I think the training was great, and you all shared SO MANY great resources to explore! No suggestions for improvements.

The time allowed was not adequate for the task load especially with this being a distant learning project. More time is needed for teachers to process tasks and return Q & A.

Of course meeting in person would be nice but this was a good alternative. It is also a nice alternative when transportation is difficult for one reason or another.

Spread the due dates out. I felt strapped for time when the bulk of the activities were due in just a few days of starting the training. Possibly give three due dates instead of two.

Make sure that links work before participants get there (easily fixed but annoying).

I had no problem completing all the activities during the week, but those that might have been working full-time might have had difficulty with time allotted.

Unsure.

I think it would have helped to have more chemistry-based resources and activities incorporated into this training.

Q14 - How do you hope to change your practice as a result of this training?

How do you hope to change your practice as a result of this training?

I hope to use some of these resources to add to my topics in the STEM class that I teach.

Do more activities involving transportation in my STEM class.

I will use more engineering when teaching circles, and talk about different types of engineers more often in class.

I love real-world contextual problems and when my students really engage and persevere. There are several interesting activities throughout the modules that I think might encourage this.

I hope to be able to provide my students with the real world activities and lessons that we were presented with.

I hope to incorporate more engineering topics into my lessons.

As a result of this training, I am more confident in incorporating other STEM fields and concepts in my high school math lessons. I am excited to incorporate more real-world problems and activities that I've learned about through this training. Also, the transportation lessons that participants made are a great resource!

I will include more STEM projects in my teaching along with providing students with more time for Q & A.

I will definitely incorporate more transportation topics.

I want to become more comfortable introducing and teaching topics that the students will enjoy instead of the same old boring math.

I'll include more transportation topics. I think the students can easily relate to them.

I plan on finding more STEM and Career speakers for more hands on teaching which I love to do anyhow.

I'd like to incorporate some of the lessons developed by other participants, and I feel better prepared to share real-world connections with my students in terms of career options in transportation and engineering.

I hope to incorporate activities where students have to think about issues or problems from multiple perspectives or have to incorporate new information into their thinking in order to improve their arguments.

Q15 - What additional STEM focused training would you like to have in the future?

What additional STEM focused training would you like to have in the future?

Energy.

I would like to have more of any type of training that connects math to real-world jobs and learning. I love being able to tell my kids how they can use a skill in real life and not just in a classroom!

Open to anything!

I would like to have more technology training.

If I was asked this question before this training, transportation would have never been something I would have suggested or thought to suggest. However, this training was great and very helpful! I'm glad it was about the vast issues and matters related to transportation. I'm interested in any of the following trainings for STEM fields: Medical, Food Service, Coding, 3D printing and makerspaces/manufacturing

I teach chemistry, I would enjoy STEM projects for chemistry.

I think it would be nice to explore the various types of energy used in transportation and our current lifestyle.

Medical field focus and agriculture focus.

How to get the students to plan their own builds.

I would like to continue to doing the activities as an continual online learning group. Like my students, I learn more by doing! Great job!!

Unsure at this time.

Problem-based learning in Chemistry. Sometimes I need help connecting the specificity of the chemistry standards to the bigger picture in an authentic STEM-type learning opportunity for my students.

Q16 - Please share any additional comments here.

Please share any additional comments here.

None at this time.

I enjoyed the workshop and activities. I just wish more time was allowed to complete the activities.

Thank you for hosting the training virtually. It was great!

Thank you for this very stimulating opportunity to work with some of the finest college professors.

Thank-you so much. I enjoyed using some apps that I may need to use for my classroom this year if there are any shutdowns. I appreciate your hard work.

I know that due to Covid-19 we were not able to meet in person, but I really missed the ability to collaborate with other teachers. We learn so much from each other when we are together.

I enjoyed this. Thanks.

I have been training all summer for online teaching and STEM and found this training the most fulfilling of the summer. Great job Tennessee Tech!!

This was an interesting PD opportunity that helped me learn about lots of career resources. Thank you!

End of Report