TEAM PROJECT REPORT

“Reducing Freeway Emissions Via Ramp Metering Control”

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“Reducing Freeway Emissions Via Ramp Metering Control”

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Abstract

Traffic congestion on the freeways leads to higher emissions of greenhouse gases and particulate matter. Ramp meters placed on the entrance ramps allow traffic to merge onto the freeway without disrupting the free flow on the mainline. Traffic that flows at an optimal speed (55mph to 65mph) without slowing down and accelerating, emits lesser emissions. The goal of this research project is to study freeway and ramp emissions at a site with an active ramp meter. Data will be gathered using a GPS tracker to study the flow of traffic, a PM 2.5 sensor to gather emissions data and traffic volume counts will be taken by using tally clickers. The results of the study lead the researchers to conclude that a rubric needs to be developed to evaluate potential study sites which show optimal conditions of traffic congestion and safety of study. Participation in the project gave the researchers a hands-on experience with the Engineering Design Model, which will be shared with their students. The researchers were able to design and redesign a study goal with the assistance of the faculty and graduate students of the University of Cincinnati and with the aid of the university equipment.

Keywords

Traffic flow theory, ramp meters, freeway congestion, vehicular emissions, particulate matter

1 Introduction

Traffic Flow Theory measures the performance of a road in terms of speed, rates of flow, spacing between vehicles and density. (Hall, 1996) Traffic Flow Theory can be used to determine if areas are congested, by measuring the density and speed of traffic on the road. Traffic flow patterns can be studied using dual loop detectors that produce a relationship between the time spent on the loops, vehicle speed and vehicle length. Radar and video sensors are also used to gather this information. Ramp metering is used on the entrance ramps to allow traffic to merge onto the freeway without disrupting free flow on the mainline. The principle behind ramp meters is that by separating cars entering the freeway, slowdowns due to the difficulty of merging can be minimized. By minimizing these slowdowns, shockwaves in traffic flow can be reduced, keeping traffic flow consistent. Determining the optimal density of a highway is based on studying traffic at peak usage times.

By lessening the congestion of the freeway, emissions resulting from restoring acceleration after slowdowns can be avoided. A vehicle that is operating without having to speed up and/or slow down emits less exhaust emissions. Typical emissions from vehicles that have been determined to be hazardous are carbon monoxide, carbon dioxide, nitrogen oxides, benzene, unburned hydrocarbons and particulate matter. The EPA has developed a computer software to measure emissions from vehicles - MOVES. MOVES stands for Motor Vehicle Emissions Simulator. MOVES contains the largest database of vehicles and their emissions of greenhouse gases and particulate matter. It works by gathering data on traffic flow using a GPS tracker that can then be uploaded into the program. Once the traffic information is uploaded, a variety of factors then can be selected to increase the accuracy of the data. MOVES allows the user to choose vehicle types, time period, geographical areas, pollutants, vehicle operation characteristics and road type. (http://www.epa.gov/oms/models/moves) This software can be used to study the freeway emissions related to the utilization of a ramp meter. The effectiveness of the ramp meter on North Bend Eastbound I-74 ramp in reducing emissions during the morning rush hour starting at 6.30 am, will be the focus of the research study.

2 Literature Review

2.1 Ramp meters effectiveness in reducing traffic congestion

Ramp meters are used on the entrance ramps as effective tools to allow a smooth flow of traffic onto freeways that have a history of heavy congestion. The addition of ramp meters has shown benefits in reducing travel time, fuel consumption and accident rates while increasing travel speed, freeway capacity and safety. Studies indicate that ramp meters are effective in reducing congestion allowing commuters to travel at optimal speeds. (Arnold, 1998)

A study of the Madison Beltline concluded that ramp meters did improve traffic flow: citing a 3% to 18% improvement depending on direction and time of day. (Kim, et. al. 2004) “A survey made for the FHWA of seven ramp metering systems in the U.S. and Canada revealed that average highway speeds increased by 29% after ramp metering was installed. Even when delays on ramps were included, speeds still increased by 20% and travel times decreased by 16.5%” (Arnold, 1998).

2.2 Ramp meters effectiveness in reducing emissions

Numerous studies have been conducted across the world to analyze the effect of ramp meters on lowering emissions. Results show a decrease in emissions on the highway mainline with an increase in emissions on the ramp meter. Also utilizing a ramp meter resulted in extended wait times for vehicles to be able to enter the freeway and that alternate routes were being used to avoid the wait times due to the metering. A study conducted in Genova, Italy concluded that, when a two-class local ramp metering strategy was applied, a reduction in emissions was evident with a reduction in the congestion on the freeway. The method used to determine emissions reduction was an average speed model called the PI-ALINEA (Cecilia Pasquale et. al. 2014).

In Southern California the Comprehensive Modal Emissions Model (CMEM), which has a large database of vehicle types and which compares power demand to determine fuel consumption and emissions produced, reported a possible 7% decrease in CO_2 emissions. The model assumes that traffic would maintain a flow of 60mph which could be accomplished with the help of ramp metering systems (Barth et. al. 2008).

A study in Korea conducted by Bae, Heo and Ryu (2012) concluded that when ramp meters are used, the emissions on the freeway mainline are reduced by 818.4 kg/h. The method used to gather the information was Traffic Software Integrated System (TSIS) that analyzes vehicle category, fuel type and model year to predict the CO_2 emissions. The traffic on the freeway mainline maintained a steady flow when the ramp meters were in use (Bae et. al. 2012). A study conducted in Atlanta, Georgia in 1999 reported a similar result with a reduction in emissions on the mainline (Dixon et. al. 2000).

3 Goals and Objectives

The goal of this RET project is to evaluate the effectiveness of a ramp meter at reducing freeway emissions. To achieve this goal there are four objectives.

- The first objective is understanding Traffic Flow Theory, Queuing Theory and Shockwave Theory as it applies to freeway ramps. An understanding of these theories will lead to a high level of comprehension of wait times on ramps in relation to congestion.

- The second objective is understanding the functions and operations of a ramp meter. This understanding will explain how the use of a ramp meter affects traffic.
- The third objective is to collect GPS data and PM 2.5 data from North Bend Eastbound I-74 ramp. Data will be collected when the ramp meter is active and inactive.
- The final objective is to compare the data collected to determine if freeway emissions are lessened with the use of a ramp meter. Ideally, the degree to which emissions are decreased will also be determined.

4 Research Study Details

4.1 Scope of the Study

Congestion on freeways leads to many problems from loss of time, higher fuel consumption and higher emissions due to acceleration. Ramp meters have been shown to lessen the congestion of traffic allowing traffic to flow at a constant speed by regulating the number of vehicles that enter the freeway at a given time. The focus of this research is to study ramp meter areas to analyze emissions. Data from before, during and after the ramp meter usage time will be collected. GPS data will establish the speed of vehicles to analyze the number of accelerations while driving the ramp and freeway. Emissions data will be taken with a PM 2.5 sensor that will register voltage spikes due to increased particulate matter. Vehicles will be counted using a hand held tally counter; distinguishing between trucks and cars. The data will then be input into MOVES to analyze the amount of emissions. The area to be studied will be the North Bend Eastbound I-74 ramp.

4.2 Equipment Used

This research study made use of the following equipment.

a. GPS Device: A GPS device manufactured by Q-STARZ (Figure 1) was utilized to record GPS coordinates every second to keep a track of the motion of the vehicle. The GPS coordinates recorded would be used to calculate acceleration and slowing down on the particular route that was followed.

Figure 1: GPS Handheld Device

b. Hand Tally Counters: Hand tally counters were used to manually keep traffic counts. Trucks and cars were counted separately using these hand tally counters. (Figure 2)

Figure 2: Hand Tally Counters

c. PM 2.5 Sensor: A PM 2.5 sensor was assembled and was programmed using Arduino software. This device would record voltage spikes whenever there is an increase in PM 2.5 concentration. (Figure 3)

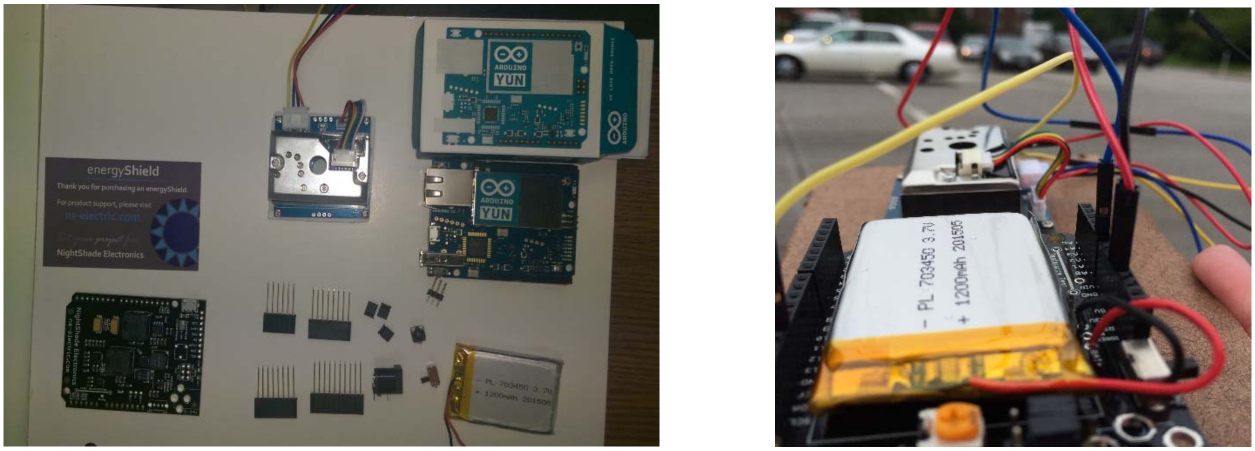

Figure 3: PM 2.5 Sensor

4.3 Equipment Calibration and Validation

4.3.1 GPS Devices:

On July 6, 2015, researchers' walked 1 kilometer around the University of Cincinnati to calibrate the GPS device and to collect data output from the device. The data output was viewed on Google Earth showing outliers due to mis-triangulation of the tracker, from not having a clear view of the sky. (Figure 4)

Figure 4: Calibration of GPS devices

4.3.2 Hand Held Tally Counters:

Hand held tally counters were used on July 6, 2015 to practice counting vehicles on Martin Luther King Drive near the UC campus (Table 1). On July 9, 2015 they were used to practice counting cars and trucks as separate types of vehicles on the Interstate 75 Southbound (Figure 5 & Table 2). This was done to eliminate errors in manual counting.

Table 1: Counter Practice to eliminate errors in counting on Martin Luther King- vehicles traveling westbound; 5:00 p.m.

Time Interval	Gina's Count	Melissa's Count
1 minute	47	48
1 minute	29	29
1 minute	27	27
1 minute	22	22
1 minute	44	44
5 minutes	157	156
5 minutes	119	119
10 minutes	269	268
10 minutes	224	224

Figure 5: Location on I-75 where traffic counts were taken to eliminate errors in counting

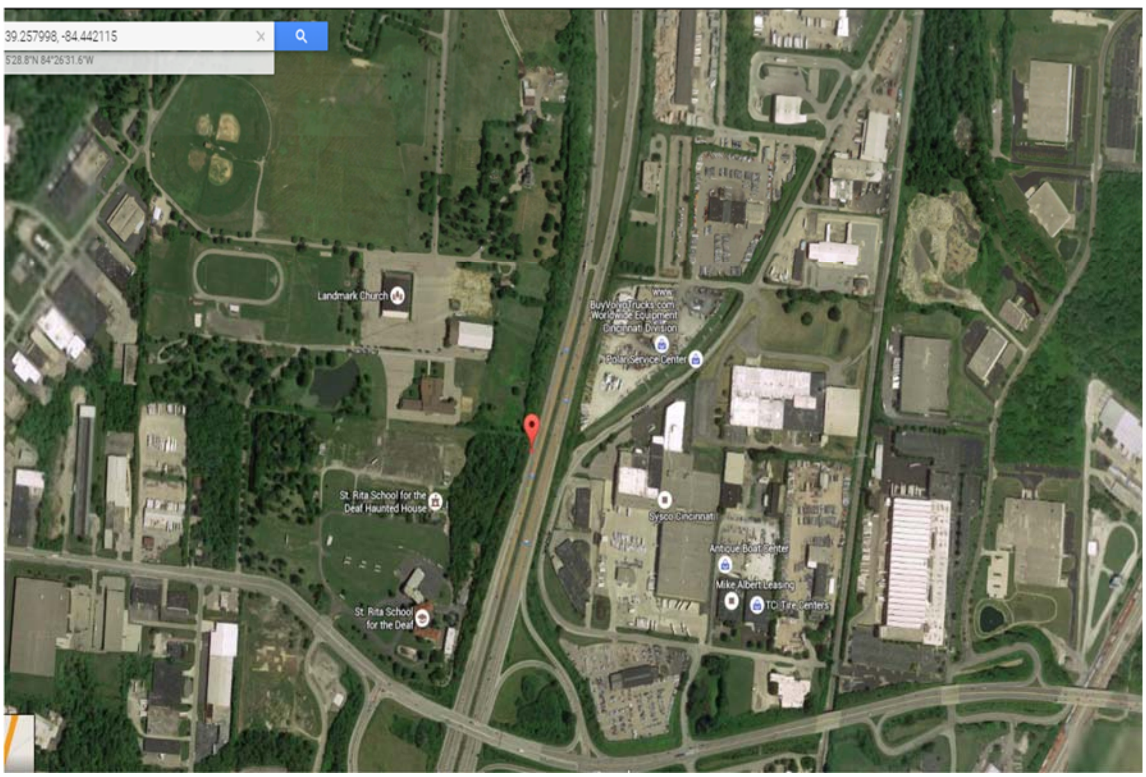

Table 2: Counter Practice on Southbound Interstate 75 to reduce counting errors (latitude, longitude = 39.257998O, -84.442115O) July 9, 2015, 2:30 PM

Time Interval	Gina's Count	Melissa's Count
20 minutes	1536 cars	198 trucks
10 minutes	83 trucks	675 cars

4.3.3 PM 2.5 Sensor:

Data was collected on July 10, 2015 from 1:55pm till 2:45 pm. The three sensors were placed in different locations. Sensor 1 was taken to the student smoking area, placed behind the exhaust of a motorcycle and a utility van. Sensor 2's location was an opening in the wall near student shuttle service. Sensor 3 was placed behind the exhaust pipes of the shuttle buses and an opening in a wall very close to the shuttle services. The result were the sensors did work, a spike in voltage was recorded in sensor 1.The data collected was inconclusive due to possible mis-programming. The sensors were reprogrammed. At 3:10pm the sensors were taken to the intersection of Martin Luther King and Clifton Avenues. A fourth sensor was added to the study. The sensors were placed at four different points: island of the intersection, sidewalk, 8 feet off sidewalk in the grass area and 16 feet off the sidewalk in the grass area. The sensors were rotated between locations every 10 minutes. The results showed that sensor 1, 2 and 3 displayed no voltage spikes but sensor 4 exhibited a voltage spike when located in the middle of the intersection. Inconsistent results could be due to low battery in sensors 1, 2 and 3. The battery life for gathering data from the sensors is approximately 2 hours based on this trial.

4.4 Data Collection and Analysis

Data was collected on July 14, 2015 from 6:30 am until 8:30 am. The chosen site was the on-ramp to eastbound I-74 at North Bend Road. The traffic remained at a free flow status on both the ramp and the freeway mainline throughout the period of the study. (Figure 6 & 7) The traffic data did not warrant input into MOVES as the freeway did not reach a congested status. Cursory collection of the data did not warrant further analysis. The traffic was counted on the freeway and the ramp; separate counts were taken for trucks and cars and recorded in 5 minute intervals. (Figure 8 & 9) Traffic counts taken, verify a non-congested status as the number of vehicles did not reach a high density for a two lane freeway.

Figure 6: Free flowing traffic on Freeway

Figure 7: Free flowing traffic on Ramp

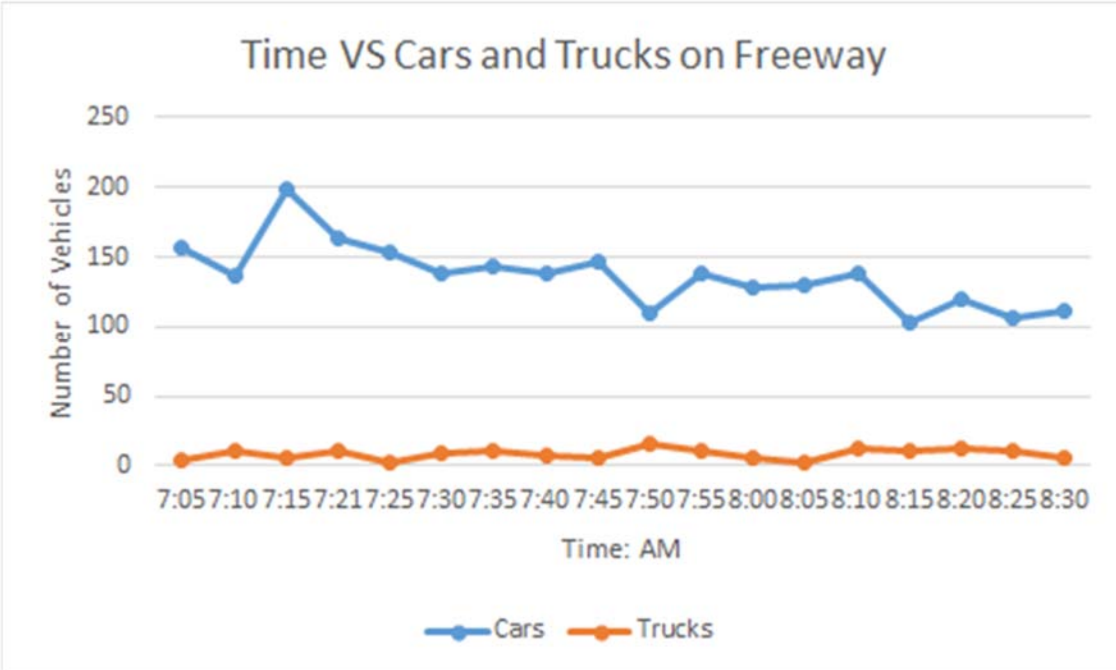

Figure 8: Vehicles on freeway

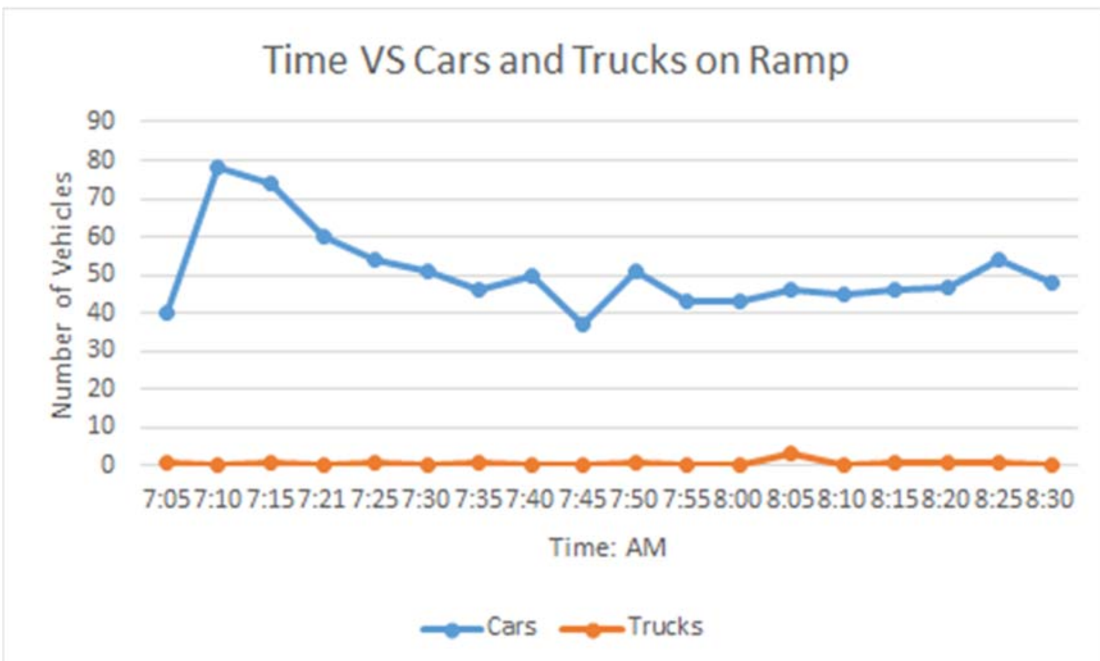

Figure 9: Vehicles on ramp

Emissions data was collected by the PM 2.5 sensors placed at two different locations: near the ramp and the freeway overpass (Figure 10). Figure 11 shows a graph of the freeway emissions data from freeway. Figure 12 shows a graph of the emissions data from the ramp. The horizontal axis is measuring time and the vertical axis displays the voltage recorded every second. The voltage spike increases with the increase in the PM 2.5 concentration. The data does not indicate a very noticeable change in emissions since the freeway remained at a constant free flow. The day before the day of the data collection i.e., June 13, 2015 had severe thunderstorms. This may have led to the improvement in the air quality on the day of the study thus reducing the ability of the sensors to capture a considerable change in the PM 2.5 concentration. Also a constant wind and the position of the sensors proximity to the traffic on the overpass may have obscured the results.

Figure 10: Location of study site and placement of sensors

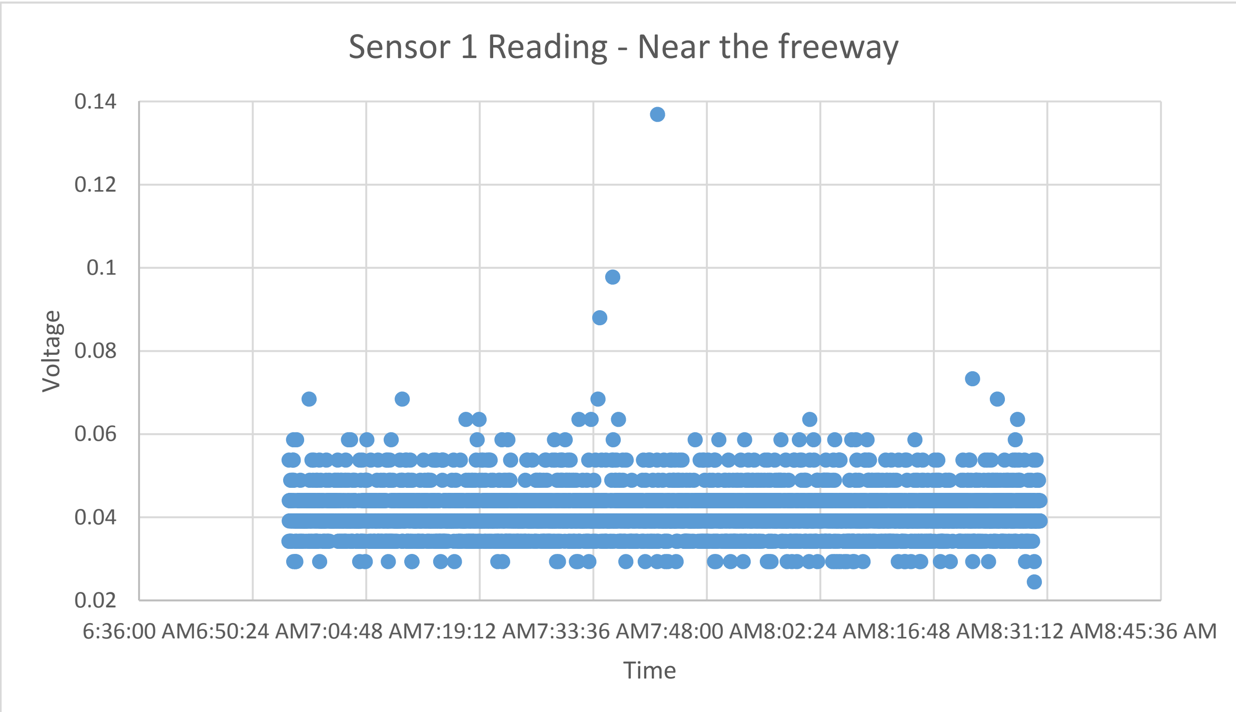

Figure 11: Sensor reading near the freeway

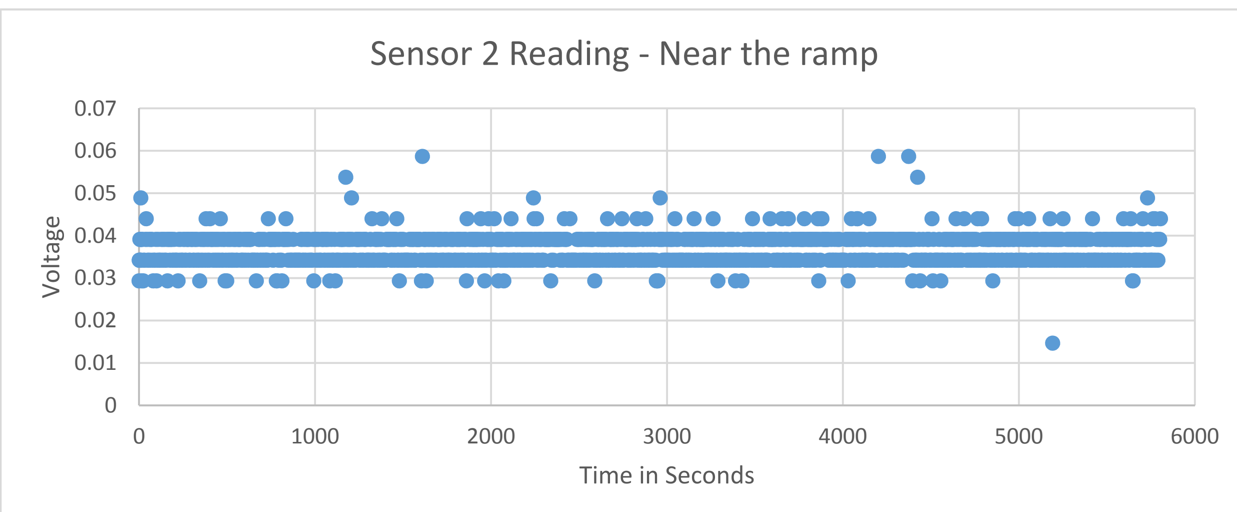

Figure 12: Sensor reading near the ramp

The graph from the second sensor (figure 12) displays a consolidated view of the scatter plot which displays the voltage across time in seconds. As concluded from both the traffic and sensor graphs, it can be seen that the emissions are really low since there is an absence of traffic congestion on both the freeway and the ramps.

5 Research Results

The data collected did not show a difference in the traffic flow from one time interval to the next. The study requires a certain level of congestion in traffic flow to collect data. A method for identifying areas of higher traffic congestion at peak hours, needs to be established to be able to collect the data required. A criteria rubric needs to be established for assessing the best possible site for data collection.

The PM 2.5 sensors while cost efficient and fairly easy to assemble were not sensitive enough to pick up on emissions when tested at a close proximity to traffic on the overpass. The sensors lack of ability to detect voltage changes at the end of their battery life (2h) needs to be considered so as to maintain accuracy. The study of the emissions on the freeway mainline requires collection at a distance for safety. A possibility of using other methods to collect emissions needs to be explored. Possible solutions could be more expensive equipment or to design a method for placing the PM 2.5 sensor closer to traffic without the requirement of being held by a person and noticeable enough to not be hit by traffic.

6 Research Conclusion

6.1 Criteria for Future Site Selection

The results of the research indicate that criteria needs to be established in the selection of a site for future studies. To develop criteria for the rubric, information from USDOT and the results from I-74 North Bend study on July 14, 2015, were considered. Criteria is categorized in relationship to traffic and to emissions.

The traffic related criteria includes the following:

- Mainline congestion needs to be evident. Congestion should be severe and recurring.
- Heavy ramp volume needs to be evident. Space is needed to implement ramp queue management techniques.
- Existing roadway statistical inventory (traffic counts, crash records, detector data) needs to be available.
- Existing ramp geometry needs to be such that it is feasible to test new technology.

(Ramp Metering: A Proven, Cost Effective Operational Strategy-A Primer, USDOT, FHA, October 2014)

The emissions related criteria includes the following:

- The area for study must be easily and safely accessible: Space is needed to count traffic and for placement of sensors.

6.2 Process for evaluating data from rubric

The rubric scale is assessed between 1-5; 1 being least favorable and 5 being most favorable. Each criteria will receive a weight depending on its importance in meeting the study objectives.

If safety categories receives a ranking of 1, least favorable, then consideration for not using the site needs to be highly considered. If ranking for recurring congestions is 3 or less consideration for not using the site needs to be highly considered. Refer to Appendix I for the criteria rubric.

6.3 Identification of Future Study Sites

Three sites were identified as potential sites for future research studies; therefore will be evaluated using the criteria rubric. Two of the chosen study sites: Montana Avenue and Colerain Avenue, currently have operational ramp meters. A ramp meter will soon be operational at the third study site i.e., Mitchell Avenue. Since the sites are equipped with the ramp metering systems and display high traffic volumes during peak hours, they were determined to be potential study sites.

6.4 Evaluation of Future Study Sites

The following sites have been identified as warranting evaluation to be scored using the criteria stated. The sites were observed scored with comments noted both positives and negatives. The site observations were completed on Monday July 20, 2015, beginning at 7.30 AM. See Appendix II for evaluators' rubrics for each site.

a. Colerain Avenue Eastbound Ramp to I-74

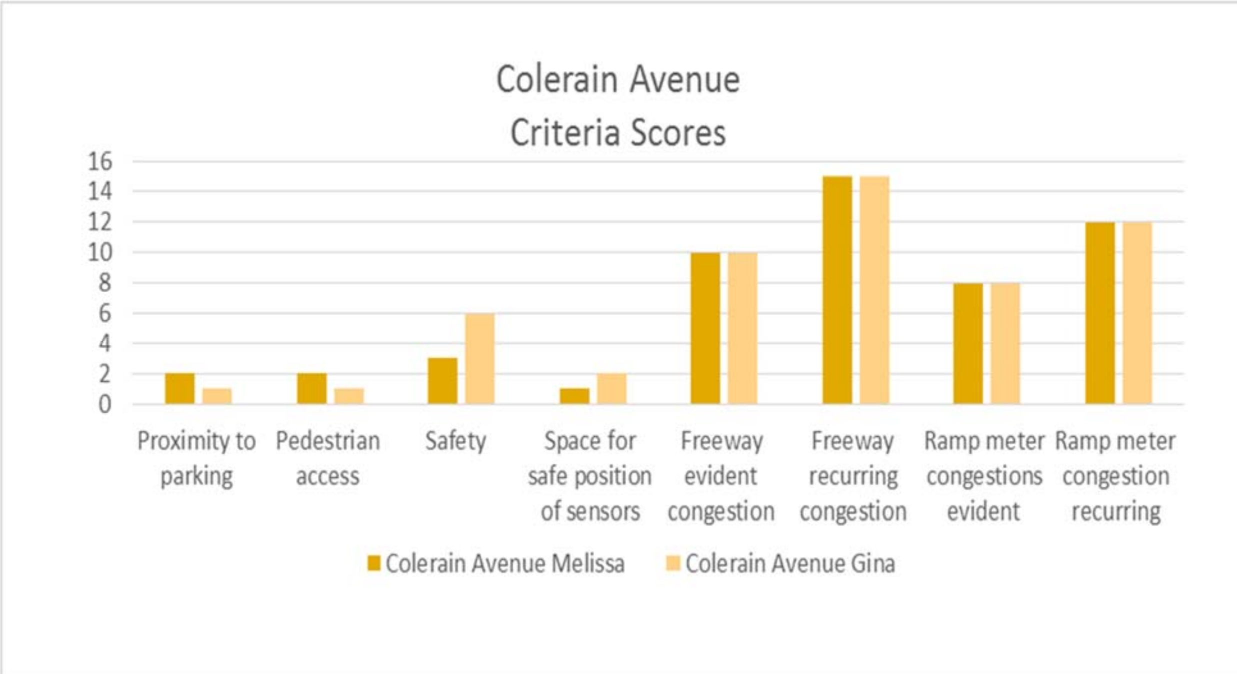

Figure 13: Criteria score for Colerain Avenue

Safety- Areas of concern on the Colerain Avenue Eastbound ramps were a safe place to park and evaluate traffic. The surrounding neighborhood that had a walkway over the freeway. The walkway would provide an area for the sensors and the evaluators. The side of the freeway also had a large enough greenspace for sensors to be set up. To park safely in the neighborhood and gain access to the walkway a police escort would be advised. ODOT approval would be needed to set up sensors along the freeway. The area for safety scored 8 out of 30 points and 18 out of 30 points by the evaluators.

Traffic Conditions- Colerain Avenue Eastbound Ramp showed the highest level of congestion both on the freeway and the ramp. Traffic conditions scored 45 out of 50 total points by both evaluators. In conclusion if proper safety could be arranged by local police this area would provide the best traffic data.

b. **Montana Avenue Eastbound Ramp To I-74**

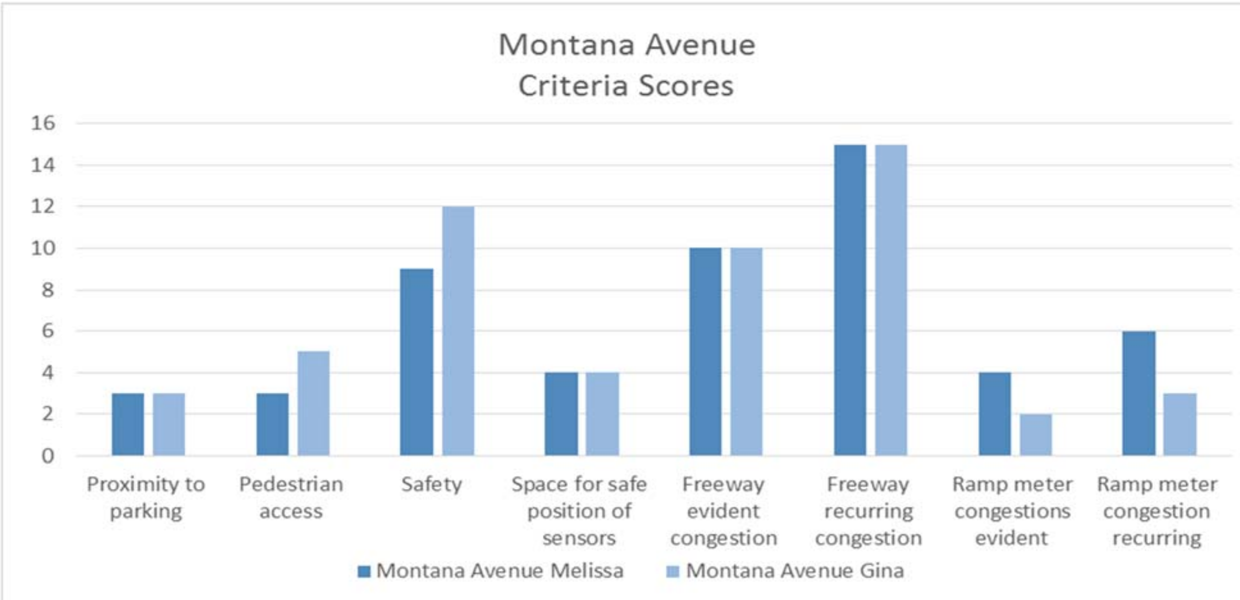

Figure 14: Criteria score for Montana Avenue

Safety- Located near Montana Avenue eastbound ramp is a convenient store that with permission evaluators' cars could be parked. The site is accessible by a sidewalk and has ample green space along the ramp and freeway to set up sensors and observe traffic. ODOT approval would be needed for the evaluators to be on the berm. The area received a safety score of 19 out of 30 points and 24 out of 30 points from the evaluators.

Traffic Conditions- The freeway at the Montana Avenue Eastbound ramp was congested on the freeway yet not on the ramp. The area scored 30 out of 50 points and 35 out of 50 points by the evaluators due to the lack of ramp congestion.

In conclusion the Montana Avenue Eastbound ramp safety was of minimal concern. The data that could be gathered from the volume of traffic would be moderate.

c. Mitchell Avenue Northbound Ramp to I-75

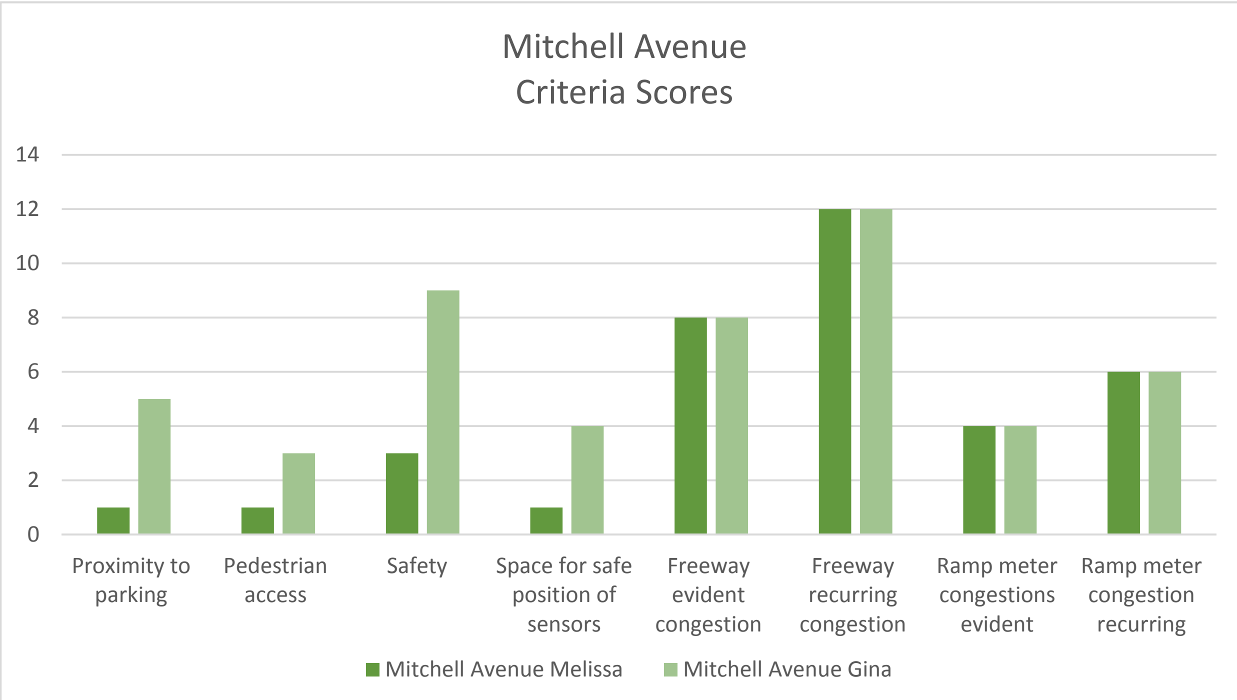

Figure 15: Criteria scores for Mitchell Avenue

Safety- The area is under construction therefore a clear picture of the finished site is not evident. A Holiday Inn Express is located nearby for parking and a walkway leads approximately to the entrance ramp. If evaluators can gain access to the top of the retaining wall that follows the entrance ramp, then the freeway and ramp observations can be made. ODOT approval would be needed to be at this location site and proper reflective attire is essential. The area scored 6 out of 30 points and 21 out of 30 points by the evaluators.

Traffic Conditions- The traffic on the freeway at the site was slowed down, bottle necked yet not stopped. The ramp area was free of congestion. The site scored a 30 out of 50 points by both evaluators.

In conclusion, the area needs to be further assessed once the construction is complete to evaluate safety.

7 Recommendations for Future Research

The overall conclusion based on the evaluation using the scoring rubrics is that the Colerain Avenue Eastbound Ramp is the best site for study. The site provides the essential traffic components needed to evaluate emissions. Montana Avenue ramp site is ranked high in regards to safety but due to the lack of congestion it scored second overall. These conclusions are based on July 2015 observations. Once construction is complete, further evaluation of the I-75 Mitchell Avenue Northbound ramp is recommended.

8 Classroom Implementation Plan

8.1 Melissa Doll's Unit

This research will be implemented into Melissa Doll's 5th grade class at Lakota Endeavour Elementary. The approximate class size is 25 students with the lesson be presented to three bells of student, 75 students. The unit will focus on the introduction to students on the concepts of force, motion and speed. The unit will meet OHIO 5 PS 4. The amount of change in movement of an object is based on the mass of the object and the amount of force related and NGSS 3-5 PS2 A Force and Motion. The unit will last 14 days of 55 minute classes and will be implemented in the first semester of the school year. The Big Idea is "Cars are moved by a force and the amount of force can be calculated (speed)." The Essential Question that will be guiding the unit is "How do forces move objects." The students will be engaged in mini lesson instructing on the content and labs to support instructions. The Challenge the student will solve is to use the engineering design model to construct a vehicle using a force and parts found around the house that can travel 5 meters. The students will then calculate the speed of their vehicles using stop watches and a meter sticks. The students will work in teams of 3.

The unit was selected as a way to introduce the concept of force, motion and speed to students. Students in the fifth grade are just beginning to apply basic physic concepts. The vocabulary of forces, speed, acceleration, deceleration, mass and gravity will be introduced for the first time. Students better understand these concepts when they can conceptualize them through hands on labs.

The unit will consist of two lessons broken down into four activities. In Lesson 1 students will be introduced to the hook for the unit. The hook is to engage the students in wanting to learn about motion and force. The Hook is a short video on NASCAR crashes. Before watching the video students will be asked to identify what they know about forces, their responses will be recorded on a poster to hang in the classroom. Student after watching the video will be asked to talk about what moves an object forward and generate questions that they have about movement. The questions the students generate will lead to the essential question that will be used to define the challenge. The students then will receive a lesson on forces, contact and non-contact. Following the lesson on forces the student will conduct a lab in which they will be given a force and will have to identify the force and label the force contact on non-contact. An example is a blow drier with a ping pong ball, the air from the blow drier will be able to support the ball in the air a contact force.

In lesson two the students will be given instructions on gravity, mass and speed in how it relates to forces. The student will gain an understanding for the concepts of more mass more force needed to move an object and that faster moving objects have more force. The students will conduct a lab in which they will use 3 different mass ball bearing to move a block at the end of a ramp. The largest ball bearing will move the block the farthest demonstrating more mass more force. The students will then increase the slope of the ramp for maximum speed which will move the block the farthest demonstrating more speed more force.

The students will end with the challenge that will be graded using a rubric. The challenge will be to use household items to make a car and use a force to move the car 5 meters. The students will use a worksheet that will guide them through the engineering design method and they will be working in teams of 3. The students will brainstorm items that can be used to build the car. They will design the car by sketching with labels first and then getting feedback from their group on how to improve the design. They will then build the design and test the design making any changes needed before they compete with the design. On the day of the competition the students will run their cars on the 5 meter track and calculate the speed of their car. The rubric used for grading the students will award points for 3 out of 5 trials moving 5 meters and completion of the written work, including labeled diagrams. The students will also take a post test on the concepts taught in the unit.

The unit's goals are to have the students grow in knowledge of force, motion and speed as required for physical education in the 5th grade and the engineering design method. The student knowledge will be gained through the lessons and the reinforcing labs. The engineering design method will be taught in the challenge where students will design a model car propelled by a force. The students will be creating their own solution to the challenge and implementing design changes as the work through the challenge as a group.

8.2 Gina Rider's Unit

This research will be implemented into Gina Rider's 9th grade Honors Algebra I classroom in a unit titled "What's your "Q" time?" This unit will take approximately 2 weeks or six 50 minute and two 88 minute class periods to implement. The unit will concentrate on the following math standards: creating equations in two variables to represent relationships between quantities, graphing equations of coordinate axes with labels and scales, and solving systems of linear equations exactly and approximately (with graphs). The projected start time for the unit is Monday, October 12th. The Big Idea proposed for this unit is how to minimize wait time. The Challenge for the students is to give an intersection a makeover so that efficient flow of traffic is maintained. Efficient flow will be defined as the minimum time it takes for a vehicle to get between two points.

The unit is comprised of 2 lessons and each lesson includes 2 activities. In the first lesson, students will be introduced to the big idea of wait time. A video produced by Corning titled "A Day Made of Glass" will be presented to the class. The purpose of this video is encourage students to think about how their lives could be made easier of a daily basis. Students will then work both individually and in groups identifying situations that involve excessive wait time. Students should consider the factors that impact wait time, whether there is a limit to the length of wait time and why waiting is so important. At the end of this lesson students will have generated the essential question, "How can wait time be minimized in relationship to traffic flow?" In the second activity a lesson on the introduction of queue theory. Students will use basic ideas of queue theory to evaluate the maximize wait time and queue length at the entrance to an amusement park. This activity involves students creating equations for arrival and departure rates. Students will graph their equations and interpret from their graphs the maximum wait time and queue length.

The second lesson involves students identifying ideal intersections. In the third activity the class will take a walking fieldtrip to a nearby 5 points intersection. At this intersection students will collect data in regards to vehicle arrival and departure rates. Students will also diagram the intersection to take back to the classroom so they can discuss with their groups the pros/cons of its design. After students have collected their data they will create equations that will also be graphed and interpreted. In the final activity student will be completing the Challenge. Students will be asked to makeover an intersection so that traffic flow is maintained efficiently. They will present graphical models of their intersections. Constraints involved include: vehicles must be able to make any necessary turn, bus and bicycle lanes, and pedestrian crosswalks. Throughout the Challenge students will be using the steps of the Engineering Design Process which include: identifying/defining problem, gathering information, identifying alternatives, selecting solution, implementing solution, evaluating solution, refining solution, and communication.

Formative assessments will be taken throughout these four activities. In each activity students are responsible for writing equations correctly and then properly graphing them on the coordinate plane. In the 2nd and 3rd activities students are required to complete worksheets. Data calculations and graphs will be assessed on precision and accuracy. The final project will be judged according to the use of constraints and the travel time calculated by different scenarios. The initial implementation of this unit is expected to impact 25 Honors Algebra I students. It is expected that students will increase their understanding of equations of lines, graphing of lines, and solving systems of equations which will improve their achievement test scores.

9 ACKNOWLEDGEMENTS:

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11 Appendix I

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Colerain Avenue Eastbound____
Evaluator Gina Rider
Date July 7, 2015_
Time 07:58 AM

1 is least favorable 5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	1	1	No available parking
Pedestrian access	1	1	1	Fence – No ped access/ Overpass?
Safety	3	2	6	Contact local PD/ODOT
Space for safe position of sensors	1	2	2	Small patch of grass area to stand and collect data

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	5	10	Very congested
Freeway recurring congestion	3	5	15	Congestion due to I-75 merge
Ramp meter congestion evident	2	4	8	Ramp meter placed too far back on ramp
Ramp meter congestion recurring	3	4	12	

TOTALS

Ease of Access possible 30	10
Traffic Conditions possible 50 points	45
Overall Total possible 80 points	55

Comments: Colerain would be the best site for future studies because of the amount of congestion both on the freeway mainline and the ramp.

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Colerain Avenue Eastbound____
Evaluator ________Melissa Doll___________
Date ________July 7, 2015_ __________
Time __________07:58 AM____________

1 is least favorable 5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	2	2	Park in neighborhood/Fence
Pedestrian access	1	2	2	Walkway from neighborhood to ped walkway over freeway
Safety	3	1	3	Little to none
Space for safe position of sensors	1	1	1	Green space

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	5	10	
Freeway recurring congestion	3	5	15	
Ramp meter congestion evident	2	4	8	
Ramp meter congestion recurring	3	4	12	

TOTALS

Ease of Access possible 30	8
Traffic Conditions possible 50 points	45
Overall Total possible 80 points	53

Comments: Ramp meter too far back on the ramp – ramp area to freeway long. Congestion is high and safety could be arranged through local police and ODOT.

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Montana Avenue Eastbound____
Evaluator Gina Rider____________
Date July 7, 2015_
Time 07:54 AM

1 is least favorable   5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	3	3	Convenience Store; BP permission to park on pvt property
Pedestrian access	1	5	5	Sidewalk available
Safety	3	4	12	Limited space – permit required from ODOT
Space for safe position of sensors	1	4	4	

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	5	10	Very congested. Stopped traffic
Freeway recurring congestion	3	5	15	Congestion due to I-75
Ramp meter congestion evident	2	1	2	No ramp congestion evident
Ramp meter congestion recurring	3	1	3	

TOTALS

Ease of Access possible 30	24
Traffic Conditions possible 50 points	30
Overall Total possible 80 points	54

Comments: This location is very safe though there is not enough congestion on the freeway entrance ramp.

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Montana Avenue Eastbound____
Evaluator Melissa Doll___________
Date July 7, 2015_
Time _07:54 AM_____________

1 is least favorable 5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	3	3	Convenience Store permission needed
Pedestrian access	1	3	3	Sidewalk available
Safety	3	3	9	Green space
Space for safe position of sensors	1	4	4	Large green space

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	5	10	
Freeway recurring congestion	3	5	15	
Ramp meter congestion evident	2	2	4	Flowed freely into traffic
Ramp meter congestion recurring	3	2	6	

TOTALS

Ease of Access possible 30	19
Traffic Conditions possible 50 points	35
Overall Total possible 80 points	54

Comments: Safety is high with congestion. ODOT approval may or may not be required.

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Mitchell Avenue Northbound____
Evaluator Gina Rider
Date July 7, 2015
Time 08:06 AM

1 is least favorable 5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	5	5	Holiday Inn Express parking
Pedestrian access	1	3	3	Sidewalk but ends at ramp
Safety	3	3	9	Cannot see freeway till you are to the top of ramp
Space for safe position of sensors	1	4	4	

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	4	8	Traffic was bottle-necked on the overpass
Freeway recurring congestion	3	4	12	
Ramp meter congestion evident	2	2	4	No traffic on ramp
Ramp meter congestion recurring	3	2	6	

TOTALS

Ease of Access possible 30	21
Traffic Conditions possible 50 points	30
Overall Total possible 80 points	51

Comments: Since this site is still under construction it is difficult to know how safe this site would be for future studies. Once the construction is finished, the score for safety could be adjusted.

Rubric to analyze a suitable ramp meter site for future studies

Site Location __Mitchell Avenue Northbound____
Evaluator ________Melissa Doll___________
Date ________July 7, 2015____________
Time _________8:06 AM____________

1 is least favorable   5 is most favorable

Criteria Ease of access	Weight	1-5	Points Awarded	Comments
Proximity to parking	1	1	1	Under Construction
Pedestrian access	1	1	1	
Safety	3	1	3	
Space for safe position of sensors	1	1	1	

Criteria Traffic Conditions	Weight	1-5	Points Awarded	Comments
Freeway evident congestion	2	4	8	Not stopped but slowed down
Freeway recurring congestion	3	4	12	
Ramp meter congestion evident	2	2	4	
Ramp meter congestion recurring	3	2	6	

TOTALS

Ease of Access possible 30	6
Traffic Conditions possible 50 points	30
Overall Total possible 80 points	36

Comments: ODOT approval required. Area still under construction so all areas could not be studied.

12 APPENDIX II : UNIT TEMPLATE OF TEACHER 1

Name:Melissa Doll	**Contact Info:dollmelissa17@gmail.com**	**Date:6/30/15**

Unit Number and Title: Force, Motion and Speed

Grade Level:	5
Subject Area:	Science

Total Estimated Duration of Entire Unit:	14 day

Part 1: Designing the Unit

1.Unit Academic Standards (Identify which standards: NGSS, ONLS and/or CCSS. Cut and paste from NGSS, ONLS and/or CCSS and be sure to include letter and/or number identifiers.**):** **OHIO 5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force related.** **NGSS 3-5 PS2 A Force and Motion**

Unit Summary

The Big Idea (including global relevance): In today's society, we are exploring alternative energies to fuel cars. Force fueled by wind, magnetism, solar powered batteries etc. can be used to move cars. Cars are moved by a force and the amount of force can be calculated. Objects remain at rest unless a force acts on the object. Forces can be contact such as a push/pull or wind or non-contact like gravity or magnetism. Cars use many forces to move. However, our 5th grade standard explores one force as it acts upon an object.

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge):

1. Can a car move as fast as a semi?
2. Are smart cars safe, how come they use less fuel?
3. What holds cars to the ground?
4. How do you measure speed? How does a Police officer's radar gun work?
5. How do forces move objects?

6. What is needed to make a car move?
7. What makes a car move fast?

Unit Context – Check all that apply.

Justification for Selection of Content:

- ☐ Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.
- ☐ Misconceptions regarding this content are prevalent.
- ☐ Content is suited well for teaching via CBL and EDP pedagogies.
- ☐ The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)
- X Other reason(s) ___Link to Research Education for Teachers Project on Ramp Meters

The Hook: The students will be presented with a 3 minute video on NASCAR races with pictures of traffic jams and demolition derby as the hook. The unit will start with a brainstorm on what they know about forces, the information will be gathered onto a large poster board to hang in classroom. Then the students will be presented with a slide and ask to identify what pictures they think represent forces, with a discussion on why they identified them as forces. The students will then be shown the videos. After the videos the students will be asked to identify questions that they now have about forces. Their questions will be written on poster board and hung up next to the brainstorm.

The Challenge and Constraints: The students will work in groups of three, assigned by teacher.

Task: Create a vehicle that can travel a distance of <u>at least 5m</u> using one of the forces from the unit.

Constraints are as follows:

- The vehicle cannot be pushed or pulled to begin movement.
- It must be an original design. No store purchased toys or kits may be used.
- It must travel a distance of at least 5m for three consecutive trials.
- No vinegar and water, mementos and coke, gas- propane or derby cars.
- Must use items found in your house.

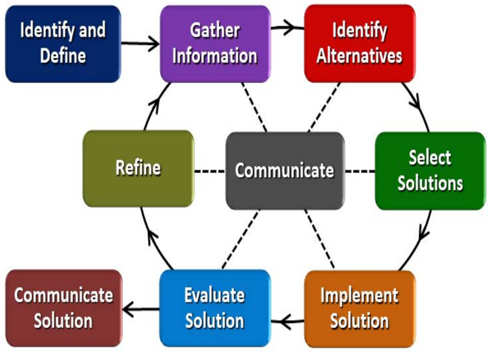
X Product **<u>or</u>** ☐ Process (Check one)

Description of Challenge (Either Product or Process is clearly explained below):	List the Constraints Applied
Create a vehicle that can travel a distance of at least 5 meters using one of the forces from the unit.	The vehicle cannot be pushed or pulled to begin movement. · It must be an original design. No store purchased toys or kits may be used. · It must travel a distance of at least 5m for three consecutive trials. · No vinegar and water, mementos and coke, gas- propane or derby cars. · Must use items found in your house that are brought into school Students must work in groups of 3.

Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

- How can different forces be used to move a car forward?
- What forces oppose the forward movement?
- Does size of the car impact how much force is needed to move it forward?
- How can you get the car to overcome the forces that oppose forward movement?

4. EDP: Use the diagram below to help you complete this section.



How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

The students will bring their cars to school and they will run their cars on the 5 meter track. They will then explain how they built their cars. Once everyone has introduced their car and run the track, students will receive one day to revise their car for a better design and then run the track to measure speed.

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

The students will fill out a worksheet that guides them through the process of building their car. The worksheet ask them to sketch and labeled their design and redesign. The worksheet will be turned in and a rubric will be used to grade the worksheet and the car design.

Rubric Score	Criteria
90-100	• Vehicle travels 5m at least once out of the five trials. • Vehicle travels 5m three out of five trials. • Vehicle meets all of the constraints/original design • Paper work completed in detail, with no missing information, well thought out. • Able to explain how force moved vehicle.
80-89	Meets 3 of 5 criteria
70-79	Meets 2 of 5 criteria
60-69	Meets 1 of 5 criteria

Comments

What academic content is being taught through this Challenge?

The students will be assessed on their content knowledge of forces and how to calculate speed. Their car will use a force and they will need to explain how the force they choose moves their car. They will be calculating the speed of their cars by determining the speed traveled in the 5 meter distance. All the cars are being tested on the forces used to travel the same distance – 5 meters.

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

What EDP Processes are ideal for conducting an Assessment? (List ones that apply.)	List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative.
_____Exit tickets that check for understanding of daily objectives at the end of class _____lesson quizzes_________ Challenge data table and worksheet ____challenge rubric______ __________Unit test___	________________________ X formative ☐ summative ________________________ ☐ formative X summative ________________________ X formative ☐ summative ________________________ ☐ formative X summative ________________________☐ formative X summative

Check below which characteristic(s) of this Challenge will be incorporated in its implantation using EDP. (Check all that apply.)

- X Has clear constraints that limit the solutions
- X Will produce than one possible solution that works
- ☐ Includes the ability to refine or optimize solutions
- X science or math content
- ☐ Includes Math applications
- ☐ Involves use of graphs
- ☐ Requires analysis of data
- X Includes student led communication of findings

5. ACS (Real world applications; career connections; societal impact):

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

Abstract or Loosely Applies to the Real World	**|-----------------------------------|-------------------X-------------------|**	**Strongly Applies to the Real World**

Provide a brief rationale for where you placed the X**: Forces move objects, objects remain at rest until a force acts upon them. Anything that moves is being moved by a force or combination of forces; cars, books falling of desk, trees blowing in wind.**

What activities in this Unit apply to real world context? The ramp lab, more mass and higher speeds more force is a real world example. This concept applies to all moving things made of mass. Newton laws apply to how everything moves according to the laws of physics in the natural world.

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

Shows Little or No Societal Impact	**|-----------------------------------|-----------x----------------------------|**	**Strongly Shows Societal Impact**

Provide a brief rationale for where you placed the X**: Students will be constructing cars made of alternative energy sources; wind, magnetisms, springs, gravity. The student will need to work in groups of three, learning to work as a team. Student will need to use items from their homes showing resourcefulness and creativity.**

What activities in this Unit apply to societal impact? The challenge of making the vehicle allows the students to engage in problem solving by being resourceful in using products found around their house. The students will, also, be working in groups, teamwork.

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.)

Civil, mechanical and environmental engineers. The students will each look up one type of engineer and work in a group to present a job description.

6. Misconceptions:

Students struggle with

Non contact forces being able to move objects. Students cannot conceptualize something that does not have direct contact affecting an object.

Force is required to keep an object in motion.

Gravity only acts on falling objects. Students struggle with the concept that gravity holds objects down. Gravity makes objects fall to Earth and keeps them on the surface.

7. Unit Lessons and Activities: (Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #'s and Activity #'s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.)

The Challenge Based Learning and Engineering Design Process Lesson is the Challenge Lesson 2 Activity 4.

Unit 1 Force, Motion and Speed

Students will explore how the different forces move objects. The students will be able to identify the difference between contact and non- contact forces. They will then learn the formula for speed and be able to calculate speed over a distance in a specific amount of time. The students will learn the variable that affect the amount of force of an object. The effects of mass and speed.

Lesson 1: Forces and How They Move Objects

Students will learn the forces that move objects that are at rest. All objects will remain at rest unless a force acts upon them. The forces are contact push, pull, wind, spring, buoyance and non-contact gravity, magnetism and electrostatic.

Lesson 1 will focus on giving the students an understanding of contact and noncontact forces. Students will have the opportunity to explore the different forces through a lab that ask them to identify forces. An example is a blow drier holding up a ping pong ball for wind force.

Activity 1 –introduction to the Big Idea, Generating the Essential Question and Guiding question to defining what the Challenge will be. The students will watch a video on NASCAR crashes as the hook. Day 1 and 2

Activity 2- Force lab with 8 stations of different forces to identify. Day 3 https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4Ojc2YmFmYzQ3MWI3ZjdmZjE

Lesson 2- Lessons and Labs on Gravity, Mass and Speed

Student will learn the basic concept of gravity as it affects motion. Student will learn that gravity hold things on earth along with bring things down to earth. They will then move on the more mass an object has the more gravitational pull therefore the more force needed to move the object. The students will then measure speed by calculating time over distance. They will learn that an object with more speed has more force.

Lesson 2 will give content through a PowerPoint and conduct labs on the effects of mass and speed on the amount of force as object has. Day three through seven will be providing information to the students on gravity, mass and speed through the PowerPoint.

Activity 3- Ramp Lap exploring mass and speed as it applies to force- Day 8

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjI1ZGNhYjQxOTVlNTE2Mjc

Activity 4- The Challenge- intro day 9, worksheet day 10, 11 and 12, present 13, redesign 14

This is the Engineering Design Process and Challenge Based Learning Lesson. The students will be using a worksheet to follow the steps to of the Engineering Design Process through Challenge Based Learning.

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjE0M2U0MGM0Njk2ZGIyZmI

The attached power point will be used as the teaching tool to communicate Activity 1 along with daily lessons and objective.

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjM4ODU2MzdjNmJiMmY5YTM

CBL: Lesson 1 Activity 1, Lesson 2 Activity 4.

EDP: Lesson 2 Activity 4.

8. Additional Resources:

The Physics Class Room http://www.physicsclassroom.com/Physics-Tutorial/Newton-s-Laws

Physcis4kids- http://www.physics4kids.com/

Physics for kids- http://scienceforkids.kidipede.com/physics/

9. Pre-Unit and Post-Unit Assessment Instruments: https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjMwNzg0NTU5ZjIxMDM1ZWY

10. Poster (Link here.)	**11. Video (Link here.)**

If you are a science teacher, check the boxes below that apply:

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
X Developing and using models	X Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

If you are a science teacher, check the boxes below that apply:

Ohio's New Learning Standards for Science (ONLS)

Expectations for Learning - Cognitive Demands (Check all that apply)
X Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

If you are a math teacher, check the boxes below that apply:

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☐ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Part 2: Post Implementation- Reflection on the Unit

Results: Evidence of Growth in Student Learning - After teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.

Please include:

- Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.)
- An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.)
- Other forms of assessment that demonstrate evidence of learning.
- Anecdotal information from student feedback.

Reflection: Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Instruction sheet. Describe how the actual Engineering Design Process was actually used in the implementation of the Unit.

Name:Melissa Doll	Contact Info:dollmelissa@gmail.com	Date:6/30/15

Lesson Title : Forces	Unit #:1	Lesson #:1	Activity #:1
Activity Title: The Hook			

Estimated Lesson Duration:	3 days
Estimated Activity Duration:	1 day

Setting:	Day one of lesson, classroom

Activity Objectives:

5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

- **Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t).**
- **Earth pulls on all objects with a gravitational force. Weight is a measure of the gravitational force between an object and the Earth.**
- **Any change in speed or direction of an requires a force and is affected by the mass of the object and the amount of force applied.**

I can determine the forces that can move an object that is at rest.

I can generate questions about movement of objects after watching a video of NASCAR crashes.

Activity Guiding Questions:

1. What makes some cars go faster than others?
2. Why are some of the cars more damaged than others?
3. What makes the cars move?
4. Do all the cars move the same way?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
X Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	X Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☐ Designing Technological/Engineering Solutions Using Science concepts **(T)**
X Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☐ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

OHIO 5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force related.

NGSS 3-5 PS2 A Force and Motion

Material:

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjM4ODU2MzdjNmJiMmY5YTM

Lesson PowerPoint

Link to NASCAR crashes

2 large posters for brainstorming and question generating

Pre/post test

Students notebooks

Teacher Advance Preparation:

Set up PowerPoint to run on smart board

Set up NASCAR video to run on smart board

Activity Procedures:

The Hook: The students will be presented with a 3 minute video on NASCAR races with pictures of traffic jams and demolition derby as the hook. The unit will start with a brainstorm on what they know about forces, the information will be gathered onto a large poster board to hang in classroom. Then the students will be presented with a slide and ask to identify what pictures they think represent forces, with a discussion on why they identified them as forces. The students will then be shown the video. After the video the students will be asked to identify the essential questions that they now have about forces. Their questions will be written on poster board and hung up next to the brainstorm. The questions will be looked at later in the unit to arrive at the essential question to determine the challenge. The essential question will be determined after the students have learned the different forces. The list of generated questions will be revisited added and subtracted from until we have the question- how do forces move objects? The essential question then will be used to guide the rest of the lessons and the challenge.

Students need to share at their table, group of 4.

The prepared PowerPoint will be the guide for the lesson.

Link to PowerPoint
https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjM4ODU2MzdjNmJiMmY5YTM

The Challenge-students will be working on lesson and labs in the next activities to lead up to the challenge. The challenge will be to create a car that moves 5 meters using a force. The car must be made of material that is at home. The students will follow the engineering design model using a worksheet and working in a group of three.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Exit question posted in PowerPoint – written in notebook by students-

What is a force? How do forces move objects?

Give an example of a force and how it moves the object.

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.

Refer to Activity Template for details.

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name:Melissa Doll	Contact Info:dollmelissa17@gmail.com	Date:6/30/15

Lesson Title : Forces	Unit #:1	Lesson #:1	Activity #:2
Activity Title:Identifying forces			

Estimated Lesson Duration:	3 days
Estimated Activity Duration:	2 days

Setting:	Last day of lesson on forces. Classroom

Activity Objectives: I can determine the forces that can move an object that is at rest.

Activity Guiding Questions:

What is the difference between a contact or non-contact force?

How do you explain what a force is?

How many kinds of forces are there?

Is this the same force as star wars?

Can/ do forces move all objects? What about heavy objects?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
X Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	X Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☐ Designing Technological/Engineering Solutions Using Science concepts **(T)**
X Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)

Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☐ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

OHIO 5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force related.

NGSS 3-5 PS2 A Force and Motion

Materials:

PowerPoint

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjM4ODU2MzdjNmJiMmY5YTM

Student worksheet

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4Ojc2YmFmYzQ3MWI3ZjdmZjE

Supplies:

Magnetic wands and magnetic balls

Toy car that is spring operated

Balloon

Match box car

Blow drier

Ping pong ball

Pinwheel

Toy marble track set

Plastic cup

Cork

Teacher Advance Preparation: set up stations for each force

Set up stations-

Station one-magnetic marble and magnetic wand

Station two- toy car that operates by pushing down on a spring

Station three- balloon that is blown up

Station four- toy car

Station five- blow drier and ping pong ball

Station six- pinwheel

Station seven- marble track toy

Station eight-cork in a cup of water

Activity Procedures:

Follow PowerPoint for today's lesson starting with review slide

Review – Bell work – name a contact and a non contact force from yesterday's lesson

After review introduce the station locations and explain that they will rotate clockwise filling out the worksheet.

Group students in groups of 4.

3- 5 min per station for rotations. Students will rotate when the timer rings using an online timer.

Student Directions on worksheet- fill out worksheet and turn in at end of lab

Direction on the worksheet-Directions: Your group will be conducting activities at eight different stations. For each station observe and identify the force that is at work. Explain whether the force you identified is contact or non-contact. Work as a table and be prepared to turn in your worksheet.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Students will turn in lab worksheet. (Attached to material)

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.

Refer to Activity Template for details.

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name: Melissa Doll	Contact Info:dollmelissa17@gmail.com	Date:6/30/15

Lesson Title : Gravity, Mass and Speed	Unit #:1	Lesson #:2	Activity #:3
Activity Title: Ramps			

Estimated Lesson Duration:	12 Days
Estimated Activity Duration:	1 day

Setting:	After lesson on gravity, mass and speed. Classroom

Activity Objectives:

I can explain gravity's effect on objects.

I can describe mass.

I can calculate the speed of an object.

I can describe a change in motion, speed up or slowing down

I can describe the force needed to move object.

I can predict the movement of an object based on the force applied and the object's mass.

Activity Guiding Questions:

1. **Why do all objects fall to the ground? Do heavier objects fall faster?**
2. **Does mass have to do with size? Do bigger objects have more mass? Do objects that take up more space have more mass? How do you measure mass?**
3. **How does a speedometer work? How does a radar gun work?**
4. **When a car slows down how do you calculate speed? When a car speeds up how do you calculate speed? What is a car slows down and speeds up when you are calculating speed?**
5. **How much more force is needed to move heavy objects? What if you used more the same force on a lighter object? Can force be applied to move all objects- like buildings?**
6. **How can you measure how speed and mass affect the force of an object?**

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
X Developing and using models	X Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation

☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☐ Designing Technological/Engineering Solutions Using Science concepts **(T)**
X Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☐ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

OHIO 5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force related.

NGSS 3-5 PS2 A Force and Motion

Materials:

Worksheet for lab

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjI1ZGNhYjQxOTVlNTE2Mjc

3 2 X 4 blocks for each group

1 ramp for each group (cut molding to 12 inch pieces)

1 small ball bearing each group

1 medium ball bearing each group

1 large ball bearing each group

1 ruler each group

1 block each group

Teacher Advance Preparation:

1. Place in bins for each team of students – 3 different mass ball bearings, 3 wood blocks, one ramp, ruler and worksheet
2. Students will work at their tables as a group
3. Demonstrate the set up after passing out the lab worksheet
4. To measure speed the students need to create the steepest incline- all three blocks under the ramp. Using a stop watch time as a class the difference between the different inclines to show the fastest set up.
5. To measure mass weight using a scale in grams each ball bearing.
6. Collect the lab worksheet

Activity Procedures:

Pass out the worksheet and demonstrate the set up for each scenario and complete class demonstration of speed and mass.

Directions for set up –

1. Stack two wood 2 by 4 blocks on top of each other
2. Lean the ramp- piece of wood modeling on the stacked two by fours
3. Place a ruler at the end of the ramp to measure distance
4. Place a wood toy block at end of ramp
5. Roll ball bearing down the ramp
6. Measure the distance the block moves
7. Record in the chart (worksheet for lesson)

Demonstrate incline needed for fastest speed as a class

Weigh the ball bearings as a class

Student will work in groups of 4 at their tables.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Collect the worksheet and take a grade on the follow up questions.

When you increased the speed of the marble how far did the block move compared to slower speeds?

•When you increased the mass of the marble how far did the block move compared to lower masses?

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.

Refer to Activity Template for details.

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name:Melissa Doll	**Contact Info:dollmelissa17@gmail.com**	**Date:6/30/15**

Lesson Title : The Challenge	**Unit #:1**	**Lesson #:2**	**Activity #:4**
Activity Title: The Challenge			

Estimated Lesson Duration:	**12 days**
Estimated Activity Duration:	**6 days**

Setting:	**After all content has been taught. Classroom and at home to build.**

Activity Objectives:

I can construct a vehicle using the engineering design method.

I can calculate the speed of the vehicle.

Activity Guiding Questions:

1. What is a vehicle?
2. What can I use to create the vehicle? Why can I only use the items set forth in the constraints?
3. How will I measure distance and time?
4. Can I use more than one force to move my vehicle?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
X Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	☐ Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	X Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
X Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☐ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

OHIO 5 PS 4 The amount of change in movement of an object is based on the mass of the object and the amount of force related.

NGSS 3-5 PS2 A Force and Motion

Materials:

Worksheet

5 meters sticks for track

2 Stopwatches

Teacher Advance Preparation: review worksheet with students

Pass out the worksheet for the project.

https://docs.google.com/viewer?a=v&pid=sites&srcid=c2FzZWFzLm9yZ3xtZWxpc3NhLWEtZG9sbC0yMDE1fGd4OjE0M2U0MGM0Njk2ZGIyZmI

Activity procedures:

Task: Create a vehicle that can travel a distance of at least 5m using one of the forces from the unit.

Constraints are as follows:

- The vehicle cannot be pushed or pulled to begin movement.
- It must be an original design. No store purchased toys or kits may be used.
- It must travel a distance of at least 5m for three consecutive trials.
- No vinegar and water, mementos and coke, gas- propane or derby cars.
- Must use items found in your house.

1. Review the rubric for grading with the students.
2. Day one work on brainstorming items to use for project and picking a force and sketching first design.
3. Day two brainstorm possible problems with design by sharing ideas at table. List possible problems and solutions from your group. Sketch second design based on changes. Homework bring in items to make your design.
4. Day three and four Design and test. Make any necessary changes.
5. Day five compete using the rubric for scoring.
6. Day six using stop watches and meter sticks measure the speed of the cars. Let students create super cars based on using each other designs and parts as a table.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Students will be filling out the worksheet and a data table of their initial trials.

Summative Assessments:

Scoring Rubric:

Rubric Score	Criteria
90-100	• Vehicle travels 5m at least once out of the five trials. • Vehicle travels 5m three out of five trials. • Vehicle meets all of the constraints/original design • Paper work completed in detail, with no missing information, well thought out. • Able to explain how force moved vehicle.
80-89	Meets 3 of 5 criteria
70-79	Meets 2 of 5 criteria
60-69	Meets 1 of 5 criteria

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.

Refer to Activity Template for details.

Reflection: Reflect upon the successes and shortcomings of the lesson.

13 APPENDIX III: UNIT TEMPLATE OF TEACHER 2

Name: Gina Rider	Contact Info: ginarider12@gmail.com	Date: 06/30/15

Unit Number and Title: Unit #1

Grade Level:	9th	Subject Area:	Honors Algebra I

Total Estimated Duration of Entire Unit:	?—minimum of 10 teaching days; max 15

Part 1: Designing the Unit

1. **Unit Academic Standards (**Identify which standards: NGSS, ONLS and/or CCSS. Cut and paste from NGSS, ONLS and/or CCSS and be sure to include letter and/or number identifiers.**):**

This unit will cover the following guided by NGSS:

- ETS1: Engineering Design
- ETS1A: Designing and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutions
- ETS1C: Optimizing the Design Solution

The unit will cover the following guided by CCSS-Mathematics:

- Quantities **N-Q**
  - **CCSS.Math.Content.HSN.Q.A.2**
    - Define appropriate quantities for the purpose of descriptive modeling.
  - **CCSS.Math.Content.HSN.Q.A.3**
    - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- Seeing Structures in Expressions **A-SSE**
  - **CCSS.Math.Content.HSA.SSE.A.1**
    - Interpret expressions that represent a quantity in terms of its context
- Creating Equations **A-CED**
  - **CCSS.Math.Content.HSA.CED.A.2**
    - Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales
- Reasoning with Equations and Inequalities **A-REI**
  - **CCSS.Math.Content.HSA.REI.C.6**
    - Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.
- Interpreting Functions **F-IF**
  - **CCSS.Math.Content.HSF.IF.A.1**
    - Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y = f(x).
- Building Functions **F-BF**
  - **CCSS.Math.Content.HSF.IF.A.2**

        - Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.
- Linear, Quadratic and Exponential Models **F-LE**
    - **CCSS.Math.Content.HSF.LE.A.2**
        - Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

- Modeling with Geometry **G-MG**
    - **CCSS.Math.Content.HSG.MG.A.**1
        - Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).*
    - **CCSS.Math.Content.HSG.MG.A.3**
        - Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

2. Unit Summary

The Big Idea (including global relevance): The Big Idea for this unit is how to minimize wait time; specifically in relationship to car travel. This idea is important because of the effects traffic congestion with air pollution, the psychological effects with stress, and the social effects that involve time and money.

The (anticipated) Essential Questions: List 3 or more questions your students are likely to generate on their own. (Highlight in yellow the one selected to define the Challenge): I anticipate that my students will first discuss their experiences in which they had considerable wait time. These are the questions I want my students to explore:

What is acceptable wait time?

How can we minimize the number of people waiting in a "service" line?

What are the benefits of improving traffic flow?

How can intersections be improved to move cars at a more constant rate?

3. Unit Context – Check all that apply.

Justification for Selection of Content:

☐ Students previously scored poorly on standardized tests, end-of term test or any other test given in the school or district on this content.

☐ Misconceptions regarding this content are prevalent.

☐ Content is suited well for teaching via CBL and EDP pedagogies.

☐ The selected content follows the pacing guide for when this content is scheduled to be taught during the school year. (Unit 1 covers atomic structure because it is taught in October when I should be conducting my first unit.)

☒ Other reason(s) I chose this topic for its relevancy to the RET research project I am working on this summer.

The Hook: I plan on using two videos to show to my class. The first is a video produced for Corning titled a Day Made of Glass. The second is a clip from the movie, Minority Report, starring Tom Cruise. The clip shows cars moving very fast on a freeway system with no congestion though high volume. The videos are being used to inspire students about what an ideal freeway system could look like and what cars of the future could look like. I also plan on taking my students on a “walking fieldtrip”. We will visit a nearby 5-point intersection and collect data (wait time, number of cars in queue, light time, design of intersection).

The Challenge and Constraints: My challenge will involve students giving an intersection a makeover. They will create a scale model of their intersection. Students will create what they feel is the most efficient traffic flow model for an intersection. Efficiency is determined the amount of congestion, the relative speed of the cars, and the time traveled between two points. The constraints involved with the challenge include:

Intersection design must fit into the designated area

Must have access for Metro busses, pedestrian crosswalks, and bicycle paths

Minimum of 15 cars per platoon

Cars cannot have more than 3 minutes of wait-time

Yellow light time (5 seconds)

Red/green light time (40 seconds)

☐ Product **or** ☒ Process (Check one)

Description of Challenge (Either Product or Process is clearly explained below):	List the Constraints Applied
For the challenge, students will construct a graphical model of an “efficient” intersection.	Must have accessibility for busses, pedestrians, and bicycles Each throughway has a minimum of 15 cars per platoon Cars cannot exceed speed limit of 35 mph Wait time per car cannot exceed 3 minutes

Anticipated Guiding Questions (that apply to the Challenge and may change with student input.):

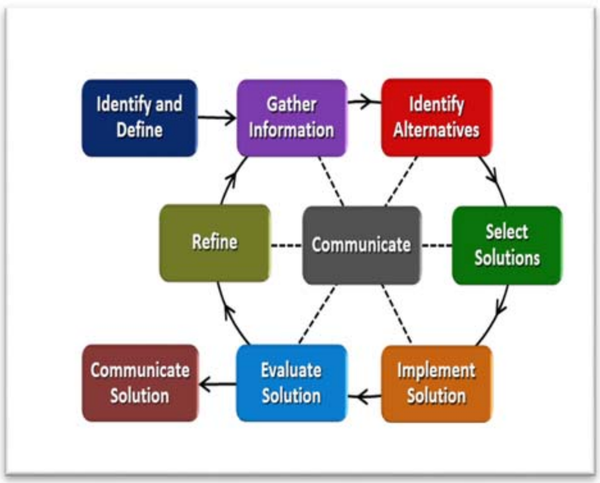
What are the different type of geometric models that could be used for the intersection?

How do we compute wait time?

What will minimize the wait time?

How do we determine the numbers of cars waiting?
How can we maintain traffic flow?

4. EDP: Use the diagram below to help you complete this section.



How will students test or implement the solution? What is the evidence that the solution worked? Describe how the iterative process from the EDP applies to your Challenge.

As students are designing their intersections, they will have to use the iterative process. They will have to make sure that they are able to fit all the necessary lanes for traffic (cars, busses, pedestrians, bicycles) in the designated area. Students will test their solutions by using their arrival rates and departure rates from our walking field trip. If they are able to keep cars from waiting no more than 4 minutes at the intersection then they know their designs are successful.

How will students present or defend the solution? Describe if any formal training or resource guides will be provided to the students for best practices (e.g., poster, flyer, video, advertisement, etc.) used to present work.

Students will present their graphical models to the class. They will explain how their intersection is laid out in terms of lanes, stop lights, etc. I will then chose a scenario (car in a certain lane, headed in a certain direction) and we will determine the amount of time it takes for that car to progress through the intersection. The evidence that the solution works will be determined by how much travel time it takes the car to get from one point to another. The iterative process from EDP applies to this Challenge since students will have to consider all different types of intersection designs. Students will have the opportunity to modify their initial designs after designs are tested within the classroom.

What academic content is being taught through this Challenge? The academic content being taught in this Challenge will include the following:

- How to write equations of lines
- How to solve a system of equations
- How to find the equation of a line perpendicular to a given line
- How to find the area of a triangle

Using the diagram above, identify any places in the EDP where assessments should take place, as it applies to your Challenge. Describe below what kinds of assessment are most appropriate.

What EDP Processes are ideal for conducting an Assessment? (List ones that apply.)	List the type of Assessment (Rubric, Diagram, Checklist, Model, Q/A etc.) Check box to indicate whether it is formative or summative.	
Select Solutions	Diagram of intersections	☒ formative ☐ summative
Implement Solution	Presentation Rubric of Solution	☐ formative ☒ summative
Evaluate Solution	Evaluation Checklist	☐ formative ☒ summative
____________________	______________________________	☐ formative ☐ summative

Check below which characteristic(s) of this Challenge will be incorporated in its implementation using EDP. (Check all that apply.)

☒ Has clear constraints that limit the solutions
☒ Will produce than one possible solution that works
☒ Includes the ability to refine or optimize solutions
☐ Assesses science or math content
☒ Includes Math applications
☒ Involves use of graphs
x Requires analysis of data
☒ Includes student led communication of findings

5. ACS (Real world applications; career connections; societal impact):

Place an X on the continuum to indicate where this Challenge belongs in the context of real world applications:

Abstract or Loosely Applies to the Real World	**|------------------------------------|------------------------------X--------**	**Strongly Applies to the Real World**

Provide a brief rationale for where you placed the X**:** I believe this Challenge strongly applies to the real world since most people encounter intersections every single day in their travels. I also believe it introduces to my students how engineering is used in the real world. Hopefully my students will understand that a common goal of engineers is to make the world better through problem solving.

What activities in this Unit apply to real world context? The real world activities involved with this Challenge include the gathering information assignment where students have to investigate different intersection models and the implementation piece where students have to create a graphical model of their intersection.

Place an X on the continuum to indicate where this Challenge belongs in the context of societal impact:

Shows Little or No Societal Impact	**|-----------------------------------|----------------------------X----------- |**	**Strongly Shows Societal Impact**

Provide a brief rationale for where you placed the X**:** Again, I feel this Challenge exhibits a strong impact on society because people want to quickly get between two points. People do not like to wait; whether it is in traffic or in stores. How time is spent is very important to people.

What activities in this Unit apply to societal impact? When the students have to communicate their ideas to the other members of their group and when the groups have to present their solutions to the class will be instances of how this Challenge impacts society. During these discussions, I anticipate a lot of sharing among the students on how traffic has disrupted their daily lives and the effects traffic has on pollution and safety.

Careers: What careers will you introduce (and how) to the students that are related to the Challenge? (Examples: career research assignment, guest speakers, fieldtrips, Skype with a professional, etc.) Ideally I would love to have a civil engineer come to my classroom and speak about the different aspects of his/her job. If this is not possible, I will have my students do a short poster presentation of the different civil engineering jobs. I would also like to incorporate a "kahoot" lesson where I ask the class different questions in regards to engineering.

6. Misconceptions:

Math students always want the quickest way to that one right answer. Students might assume that there are a very limited number of options when it comes to constructing an intersection. My hope is that when they do their research on the design possibilities they will develop a greater understanding of the engineering process and how there can be more than one "right" answer.

7. Unit Lessons and Activities: (Provide a tentative timeline with a breakdown for Lessons 1 and 2. Provide the Lesson #'s and Activity #'s for when the Challenge Based Learning (CBL) and Engineering Design Process (EDP) are embedded in the unit.)

Unit Timeline: The goal is to implement this unit the last week of the first quarter and the first week of the second quarter (October 12-27).

- Lesson 1 Activity 1—1 day—Big Idea, Hook, Essential Questions
    - EDP: identify and define problem, communication
- Lesson 1 Activity 2—2 days—Queue Theory Lesson

    - EDP: gather information, communication
- Lesson 2 Activity 3—2 days—Walking Field Trip Lesson
    - EDP: identify and define problem, gather information, communication
- Lesson 2 Activity 4—4days—Challenge: Makeover an Intersection
    - EDP: identify and define problem, gather information, identify alternatives, select solution, implement solution, evaluate solution, refine solution, communication

8. Additional Resources:

9. Pre-Unit and Post-Unit Assessment Instruments:

10. Poster (Link here.)	**11. Video (Link here.)**

If you are a science teacher, check the boxes below that apply:

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
x Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	☐ Cause and effect
x Planning and carrying out investigations	x Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
x Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
x Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

If you are a science teacher, check the boxes below that apply:

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☒ Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

If you are a math teacher, check the boxes below that apply:

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☒ Reason abstractly and quantitatively	☐ Attend to precision
☒ Construct viable arguments and critique the reasoning of others	☒ Look for and make use of structure
☒ Model with mathematics	☒ Look for and express regularity in repeated reasoning

Part 2: Post Implementation- Reflection on the Unit

Results: Evidence of Growth in Student Learning - After teaching the Unit, present the evidence below that growth in learning was measured through one the instruments identified above. Show results of assessment data that prove growth in learning occurred.

Please include:

- Any documents used to collect and organize post unit evaluation data. (charts, graphs and /or tables etc.)
- An analysis of data used to measure growth in student learning providing evidence that student learning occurred. (Sentence or paragraph form.)
- Other forms of assessment that demonstrate evidence of learning.
- Anecdotal information from student feedback.

Reflection: Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Instruction sheet. Describe how the actual Engineering Design Process was actually used in the implementation of the Unit.

Name: Gina Rider	Contact Info: ginarider12@gmail.com	Date: 7/16/15

Lesson Title : Traffic Flow	Unit #: 1	Lesson #: 1	Activity #: 1
Activity Title: Wait Time			

Estimated Lesson Duration:	3 days
Estimated Activity Duration:	**1 day**

Setting:	

Honors Algebra I class; activity will take place in my classroom

Activity Objectives:

Students will be able to:

1. Describe, define and provide examples of wait time
2. Identify the factors that impact wait time
3. Hypothesize how wait time might be explained mathematically
4. Generate essential questions about wait time

Activity Guiding Questions:

Students will be asked the following questions to guide them through this activity:

- When do you typically have to wait?
- What are the factors of you having to wait?
- Is there a limit to acceptable wait time?
- Why is waiting so important to you?
- Is there a mathematical formula for acceptable wait time?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☒ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☐ Developing and using models	☐ Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing and interpreting data	☐ Systems and system models
☐ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
X Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☐ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☐ Reason abstractly and quantitatively	☐ Attend to precision
☒ Construct viable arguments and critique the reasoning of others	☐ Look for and make use of structure
☒ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

CCSS.Math.Practice.MP4 Model with mathematics.

CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others.

Materials: (Link Handouts, Power Points, Resources, Websites, Supplies)

Powerpoint presentation of lesson

Video with link to A Day Made in Glass

Teacher Advance Preparation:

I need to have powerpoint ready and link for video ready to use. I am going to let students choose their own groups for discussion.

Activity Procedures:

The powerpoint presentation gives an outline of activity procedures. The procedures include:

1. Begin class with video—A Day Made of Glass produced by Corning
2. Group discussion on the video; students will be asked to reflect on the following questions
    a. What impressed you most in this video?
    b. How far away do you feel this technology is from making into our homes?
    c. What type of technology are anxiously waiting for? What have you waited for?
    d. What has impeded your wants/needs for the latest technological gadgets?
    e. When have had to wait the longest?
3. Students will then work in pairs and search the internet to find 3 images of wait time to share with the class.
4. Groups will share their images with the entire class.
5. Teacher will use Think-Pair-Share to get students to generate essential questions about wait time.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Students will be assessed as they answer questions to the video and when they share their images from the internet regarding wait time. Images should be directly related to wait time. Students will also be assessed when they present their essential questions; these questions should directly meet the objectives of the lesson.

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.
Refer to Activity Template for details.

Students who need extra time to reflect on wait time and to generate questions will be given the extra time and they will have the opportunity to email the teacher before the challenge is presented.

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name: Gina Rider	**Contact Info: ginarider12@gmail.com**	**Date: 7/15/15**

Lesson Title : Traffic Flow Patterns	**Unit #: 1**	**Lesson #: 1**	**Activity #: 2**
Activity Title: Queue Theory			

Estimated Lesson Duration:	**3 days**
Estimated Activity Duration:	**2 days**

Setting:	

Honors Algebra I class; activity will take place in my classroom.

Activity Objectives:

Students will:

1. Problem solve using their understanding of queue theory.
2. Find equations of lines and graph the information on a coordinate plane.

Activity Guiding Questions:

Guiding questions for this activity include:

1. What is acceptable wait time?
2. What are the psychological factors of waiting?
3. Why is wait time so important to you?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
x Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☒ Developing and using models	☐ Cause and effect
☐ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☒ Analyzing and interpreting data	☒ Systems and system models
☒ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.
☐ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☐ Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☒ Make sense of problems and persevere in solving them	☐ Use appropriate tools strategically
☒ Reason abstractly and quantitatively	☐ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☒ Look for and make use of structure
☒ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

CCSS.Math.Content.HSA.CED.A.4

Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

CCSS.Math.Content.HSA.CED.A.1

Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

CCSS.Math.Content.HSA.REI.C.6

Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

Materials: (Link Handouts, Power Points, Resources, Websites, Supplies)

Handouts: Article from website www.shmula.com/queueingtheory titled "The Psychology of Waiting Lines-An Introduction and my Power Point presentation.

Teacher Advance Preparation:

Lesson cannot be taught until students understand how to find equations of lines and how to graph the equation of a line. Handouts should also be made for those students who do not have their tablets.

Coordinate plane paper also needs to be available or students may choose to use their one-notebooks on their tablets.

Activity Procedures:

Procedures are outlined in the Powerpoint. They are as follows:

1. Introduce Queue Theory and Little's Law—do an example
2. Have students read the article on The Psychology of Waiting and have a class discussion
3. Present Kings Island Problem
4. Have students work in groups of 3 to answer questions related to the Kings Island Problem
5. Detailed work will be required from each group

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

When students turn in their work prepared within their groups, a formative assessment will be taken. Students will be assessed on whether they correctly wrote the equations and on how they graphed their equations. More importantly, students will be assessed on how they interpreted their graphs—did they identify the time that has the longest queue and at that time, how many cars are in the queue? Also can they identify when the queue will dissipate.

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners. Refer to Activity Template for details.

I will have handouts available for students who are not comfortable using their tablets. I have also found a youtube video presenting a similar exercise to the Kings Island Activity. I will have that link available for students who need further explanations.

https://www.youtube.com/watch?v=D14uLcnmfZI

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name: Gina Rider	**Contact Info: ginarider12@gmail.com**	**Date: 7/15/15**

Lesson Title : Traffic Flow	**Unit #:** 1	**Lesson #:** 2	**Activity #:** 3
Activity Title: Let's Take A Walk			

Estimated Lesson Duration:	**6 days**
Estimated Activity Duration:	**1—regular period and 1—88 minute period**

Setting:	

Honors Algebra I class will take a walking field trip to the intersection of Glenway, Warsaw, and Quebec Avenues. After data is collected we will proceed back to classroom.

Activity Objectives:

Students will:

1. Collect data on number of vehicles that populate an intersection; data will be precise and accurate.
2. Students will analyze data; they will calculate arrival rate, departure rate and wait time at each street location.
3. Students will graph data using equations of lines.

Activity Guiding Questions:

Students will be guided through this activity with the following questions:

1. What effects the travel time of vehicles?
2. What is the quickest distance between two points?
3. What improvements can be made to the intersections to increase the flow of traffic?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☐ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☒ Developing and using models	☐ Cause and effect
☒ Planning and carrying out investigations	☐ Scale, proportion, and quantity
☒ Analyzing and interpreting data	☒ Systems and system models
☒ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
☐ Constructing explanations (for science) and designing solutions (for engineering)	☐ Structure and function.
☐ Engaging in argument from evidence	☐ Stability and change.

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☒ Obtaining, evaluating, and communicating information	

Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
☒ Designing Technological/Engineering Solutions Using Science concepts **(T)**
☐ Demonstrating Science Knowledge **(D)**
☐ Interpreting and Communicating Science Concepts **(C)**
☐ Recalling Accurate Science **(R)**

Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☒ Make sense of problems and persevere in solving them	☒ Use appropriate tools strategically
☒ Reason abstractly and quantitatively	☒ Attend to precision
☐ Construct viable arguments and critique the reasoning of others	☒ Look for and make use of structure
☒ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

CCSS.Math.Content.HSA.REI.C.6

Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

CCSS.Math.Content.HSA.REI.D.10

Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

Materials: (Link Handouts, Power Points, Resources, Websites, Supplies)

For the Walking Field Trip the following materials are needed: counters, timers, cameras, data collection handout. Powerpoint is created for lesson.

Teacher Advance Preparation:

Field trip permission forms need to be completed prior to activity.

Also need to make copies of the data collection worksheet.

Activity Procedures:

Activity procedures are outlined on the activity's powerpoint. Here are the procedures to follow:

1. At the beginning of class I will have distribute materials to students. I will also separate students into their groups. I will also discussion the safety issues involved with this activity; must stay on sidewalks and do not solicit conversation with strangers.
2. Students will determine which their data collection location points.
3. We will then process outside to designated location points.
4. First day I hope to get through one location point and on second day I hope to get through other 2 location points.
5. Once all data is collected we will proceed back to the classroom to analyze our data.
6. Each student will be required to turn in activity worksheet.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Each student is expected to complete the activity handout. These will be collected and assessed according to whether they followed the directions of the activity, accuracy of measurements and their final graphical representation.

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.
Refer to Activity Template for details.

I can modify this activity for those students who want a greater challenge by asking them to choose a busier intersection to observe and data collect. If students are absent the day of the activity they could also implement the same activity using the school cafeteria as a model.

Reflection: Reflect upon the successes and shortcomings of the lesson.

Name: Gina Rider	**Contact Info: ginarider12@gmail.com**	**Date: 7/16/15**

Lesson Title : Traffic Flow	**Unit #:**	**Lesson #:**	**Activity #:**
Activity Title: Give An Intersection a Makeover	**1**	**2**	**4**

Estimated Lesson Duration:	**6 days**
Estimated Activity Duration:	**4 days**

Setting:	

Honors Algebra I class; activity will take place in my classroom

Activity Objectives:

Students will create a traffic flow graphical model for the intersection of Queen City and Harrison Avenues; model should allow for efficient flow of traffic.

Activity Guiding Questions:

Students will be guided by the following questions throughout this activity:

1. How can we minimize the number of people/vehicles waiting in a service line (intersection)?
2. What are the benefits of improving intersection?
3. What are the benefits of improving traffic flow?
4. What measures can be enforced that impact safety of traffic flow?
5. How can an intersection be improved to move cars at a more constant rate?

Next Generation Science Standards (NGSS)	
Science and Engineering Practices (Check all that apply)	**Crosscutting Concepts (Check all that apply)**
☒ Asking questions (for science) and defining problems (for engineering)	☐ Patterns
☒ Developing and using models	☒ Cause and effect
☒ Planning and carrying out investigations	☒ Scale, proportion, and quantity
☒ Analyzing and interpreting data	☒ Systems and system models
☒ Using mathematics and computational thinking	☐ Energy and matter: Flows, cycles, and conservation
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Ohio's New Learning Standards for Science (ONLS)
Expectations for Learning - Cognitive Demands (Check all that apply)
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Common Core State Standards -- Mathematics (CCSS)	
Standards for Mathematical Practice (Check all that apply)	
☒ Make sense of problems and persevere in solving them	☒ Use appropriate tools strategically
☒ Reason abstractly and quantitatively	☒ Attend to precision
☒ Construct viable arguments and critique the reasoning of others	☒ Look for and make use of structure
☒ Model with mathematics	☐ Look for and express regularity in repeated reasoning

Unit Academic Standards (NGSS, ONLS and/or CCSS):

CCSS.Math.Content.HSA.CED.A.1

Create equations and inequalities in one variable and use them to solve problems.

CCSS.Math.Content.HSG.MG.A.1

Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).*

CCSS.Math.Content.HSG.MG.A.3

Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

Materials: (Link Handouts, Power Points, Resources, Websites, Supplies)

Graph paper, rulers, compasses, protractors.

Teacher Advance Preparation:

Generate a list of possible websites for researching intersection design models.

http://www.fhwa.dot.gov/publications/research/safety/04091/03.cfm

http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-4365-S.pdf

http://nacto.org/publication/urban-street-design-guide/intersections/intersection-design-principles/

http://www.fhwa.dot.gov/environment/publications/flexibility/ch08.cfm

Activity Procedures:

First day procedures:

1. Students will be placed into their groups.
2. Each student will take about 20-30 minutes to research the internet on ideas for intersection designs. Students will take screen shots of their intersections and paste on their activity sheets.
3. Within their groups, each student will take 5 minutes to present their findings.
4. Group will decide at this point the approach they want to take for their design.
5. The assignment at the end of this first day will be for students to discuss their design approach with their parents (or preferably someone that drives that route each week) and write down any comments/suggestions.

Second day procedures:

1. Students will share their "homework" results with their groups. At this point, students may decide to change the design plan.
2. Students will be assigned jobs for the project:
   a. Lane construction for vehicles/ stop signals
   b. Metro lanes and stops
   c. Pedestrian walkways and signals/ bicycle path
   d. Intersection Aesthetics
3. For each job specific dimensions need to be calculated. Students will search the internet for ideas pertaining to their specific jobs.

Third (+) day procedures:

1. Students will begin to draw map out their designs. Students will use graph paper to plan out their intersections. These plans are required to be turned in at the end.
2. After students have their initial design, they will test different scenarios using the speed of cars and stop light times. Students will need to consider cars making right/left hand turns, bicycle/pedestrian traffic and Metro bus stops.
3. Students will refine their designs after they test 10 different scenarios (cars traveling in different directions, pedestrians using crosswalks, bicycle traffic, bus traffic).
4. Once groups have refined their intersection, they will create a graphical model of their intersection. Model should be drawn to scale and should be properly labeled (signs, lanes, lights). Intersection aesthetics will also be important to show on model.

Formative Assessments: Link the items in the Activities that will be used as formative assessments.

Individually, students will be assessed of their internet searches for possible intersection designs and for their job tasks. For the internet search students will complete a record sheet where they will illustrate their

3 ideas and they will state their justifications for their designs. This form will be due at the beginning of day 2 of the Challenge. Students will also need to complete a task form for their assigned jobs. Groups will be required to submit preliminary designs and drawings as they progress through the Challenge. These designs should note justifications for additions/deletions. The group will be assessed on their final model as to how it meet the specifications of the Challenge. Models should show well developed ideas using necessary geometric shapes with the proper areas. Students will also be assessed by how well their intersections enable vehicles to move through using the equations for arrival rate and departure rate from the previous activity.

Summative Assessments: These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

At the end of the Challenge, each group will present their project to the class. Each member of the group will need to explain their position within the group and explain what they contributed most to the final project.

Differentiation: Describe how you modified parts of the Lesson to support the needs of different learners.
Refer to Activity Template for details.

Reflection: Reflect upon the successes and shortcomings of the lesson.