**TEAM PROJECT REPORT**

**“Ramp Metering Control for Mitigating Freeway Congestion”**

**Submitted To**

**The RET Site**

**For**

**RET Site on "Challenge-Based Learning and Engineering Design Process Enhanced**

**Research Experiences for Middle and High School In-Service Teachers"**

**Sponsored By**

**The National Science Foundation**

**Grant ID No.: EEC-1404766**

**College of Engineering and Applied Science**

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**Reporting Period: June 16 – August 1, 2014**

**“Ramp Metering Control for Mitigating Freeway Congestion”**

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**ABSTRACT:**

Traffic congestion on highway entrance ramps is a safety, time, and environmental issue that might be easily rectified through the implementation of ramp meters at specific locations. Traffic simulation models are created using real-world data to determine whether freeway traffic performance and safety can be improved. This research project aims to result in the design of the most effective ramp metering system that addresses the issue of freeway congestion. Documentation of the methodology and results for the study site, contributing to the understanding of the application of ramp metering and its advantages and limitations of deployment will also be provided. VISSIM simulation software will be used to simulate pre and post ramp metering data to determine if the congestion would be reduced. The VISSIM simulation output will be compared with baseline results to identify the impacts of the ramp meter. Involvement in this research project will broaden the knowledge of the participant, allowing him or her tangible access to the university laboratories, equipment, and faculty, all providing incredible resources to aid the teacher in implementing an Engineering Design Process Unit during the academic year.

**KEY WORDS:** ramp metering, highway congestion, ramp queue, micro simulation, freeway management, traffic control

1. **INTRODUCTION**

Motorists driving down the highway occasionally encounter a sudden extreme decrease in highway speed, and assume that the disruption must be the result of a traffic accident. However, more often than not, this decrease in highway speed is a result of entering the entrance ramp merging area of the highway. These merging points tend to be high-congestion areas, resulting in traffic flow breakdown. One proposed method for preventing this breakdown is through the implementation of a ramp metering system. In order to justify this implementation, both freeway and arterial street traffic congestion must be able to be reduced as a whole and at least one of the following issues must be occurring: 1.) Severe, recurring congestion, either as a result of insufficient capacity or high vehicular accident rates, results in highway speeds below 30 mph for over 30 minutes straight. 2.) Local transportation system management goals relating to freeway flow management require signals for their execution. 3.) Special event or recreational traffic results in the need for a signal to control and mitigate brief, but intense congestion (Arnold 1998). When any of these three situations occur, development of a ramp metering system is favorable.

Traffic congestion on highway entrance ramps is a safety, time, and environmental issue that might be rectified through the implementation of ramp meters at specific locations. Ramp metering systems, which consist of a traffic signal with red and green intervals are used to control the timing of vehicles entering a freeway. There are two ramp metering methods, pre-timed and traffic-responsive. Traffic-responsive ramp meters allow entrance of vehicles, based on the traffic flow rate currently taking place on the targeted freeway, whereas pre-timed ramp meters allow entrance at predetermined time intervals, typically only during periods of peak highway utilization. Pre-timed ramp meters cycle between red and green signal lights, at a fixed interval of time and are often used in situations of traffic congestion that are predictable and consistent (Chaudhary and Messer 2000). This time interval is rigid, meaning that the signal interval is not automatically influenced by the current traffic situations on the highway.

The use of ramp meters has shown to be beneficial in a variety of ways, including but not limited to decreasing fuel consumption, emissions, accident rate, and travel time, and increasing freeway speed and capacity. According to a study conducted by the U.S. Department of Transportation (U.S. DOT), fuel consumption decreased about 41% in situations where ramp meters were implemented. A study conducted in Detroit, Michigan found that, on an annual basis, emissions (122,000 tons of CO; 1,400 tons of HC; and 1,200 tons of NOx) also drastically decreased. Vehicular accident rates across the nation also demonstrated a 25-50% reduction with the implementation of ramp metering systems (Jacobson et al. 2006). With this decrease in accident rates, freeway speeds tend to increase and less time is needed for travel as a result. Ramp metering systems also help to increase freeway capacity by encouraging local drivers to select alternative routes on local streets, rather than using the freeway, during peak traffic hours when the ramp metering system is in effect. Ramp meters also decrease congestion rates by increasing the use of high occupancy vehicle (HOV) lanes.

In this particular research study, inconsistent speeds and high levels of traffic congestion resulted in the selection of the study site to include both the eastbound and westbound entrance ramps at I-275 and 42 Lebanon road. Utilizing this site as a case study, simulation models will be created to determine both the benefits and limitations of implementing a fixed ramp metering system on one or both of these entrance ramps. This control scheme will be applied to both a single lane and a dual lane scenario, then compared to the baseline congestion levels to determine the most effective scenario for managing freeway and local street congestion levels.

1. **LITERATURE REVIEW**

Ramp metering was first used in the United States in the 1960’s as a means to more fully utilize the capacity on the existing highways. This is seen as an alternative to merely adding additional lanes to the mainline road as a solution to highway congestion. The idea is that keeping the majority of the traffic, that on the mainline, moving as close to the posted speed is better than having a relatively small number of vehicles disrupt the flow. Specifically, much of the congestion that occurs on the mainlines occurs at those points where platoons of vehicles enter the mainline causing a disruption to the smooth flow of traffic already present on the mainline. Kacharoo (2003) indicated that congestion on highway transportation systems results in 5.7 billion person-hours of delay annually in the United States, making it a significant issue to address.

Ramp metering as we know it began in the early 1960’s in Chicago and has expanded to Los Angeles, Minneapolis-St. Paul, Detroit, San Francisco, Cincinnati, Columbus, Cleveland, New York City, and many others. Various implementations and strategies of ramp metering have been used in different cities with varying levels of improvement (Jacobson et al. 2006).

In Portland Oregon, 16 ramps meters were installed using a fixed time strategy with nine operating on northbound ramps during the PM peak and seven controlled on the southbound ramps during the AM peak traffic. In Minnesota over 300 ramps were installed with traffic responsive meters, some of which had HOV bypass lanes. The Seattle implementation of ramp meters, including 17 southbound ramp meters and 5 northbound meters, operate under centralized computer control. In Denver Colorado, 28 metered ramps are used under a coordinated system plan with centralized computers. Detroit, Michigan a total of 28 ramp meters have been installed and in Austin, Texas three traffic responsive ramp meters were installed at the location of a lane drop and after the reconstruction of the highway that eliminated the lane drop, the ramp meters were removed. Long Island, New York highways include 70 ramp meters along some 39 miles of expressway servicing the area.

The overall results of these implementations show a significant improvement in the general driving experience for commuters who frequent the highways involved (Jacobson et al. 2006).

**Table 1. Freeway Performance Improvements with Ramp Meter Implementation (Cambridge, 2001)**

|  |  |  |
| --- | --- | --- |
| **City** | **Safety** | **Speed & Travel Time** |
| Minneapolis, MN | 26% reduction in peak period collisions | Average peak hour speeds improved from 40 to 43 mph. |
| Seattle, WA | 34% decrease in collision rate. | Decrease in average travel time  from 22 to 11.5 minutes. |
| Denver, CO | 50% reduction in rear-end and  side swipe collisions | Average vehicle speeds improved from 43 to 50 mph |
| Detroit, MI | 50% reduction in total collisions,  71% reduction in injury collisions |  |
| Portland, OR | 43% reduction in peak collisions | Average vehicle speeds improved 16 to 41 mph |
| Long Island, NY | 15% reduction in collision rate. | Average vehicle speed increased 9% |

In response to concerns about the effectiveness of ramp-metering, the Minnesota legislature authorized a study in which the meters were turned off and data collected to quantify the benefits of the meters. Cambridge Systematics (2001) found that with meters turned off, traffic volumes decreased by 14% and accidents increased by 26% during the period where meters were turned off. Denver inadvertently tested their ramp meter system when someone failed to adjust their system for daylight savings time causing the ramp meters to begin an hour later than usual. The result was traffic congestion that residents described as the worst in memory. Ramp metering has also been implemented in a number of countries throughout the world including Britain, The Netherlands, Japan, Australia, New Zealand, United Arab Emirates, Germany and many more.

Critics of ramp metering argue that sometimes the meters result in traffic backups in neighborhoods directly adjacent to the metered ramps. However, one study found that no more than 5-10% of traffic is diverted and in nearly all cases, found no detrimental effects on the adjacent roads (LEAP 1997). In some cases, arterial traffic is affected when the ramp is unable to hold the cars in queue. This has led some cities to turn the meters off for brief intervals to allow the ramp to clear, thus minimizing the impact on surface streets (Fang et al. 2012).

1. **GOALS AND OBJECTIVES**

The goal of this RET research project is to summarize the applications of ramp metering with respect to effectiveness and limitations. To achieve this goal, there are four objectives.

The first objective is to identify application conditions, benefits, and impacts of implementing a ramp metering system. From this, the team will seek to gain a high-level understanding of what ramp management strategy entails.

The second objective is to develop an approach to evaluate the effectiveness and operational problems of a ramp metering system. This information will provide us support in identifying the need of a ramp meter.

The third objective is to develop two ramp scenarios. This can be achieved after identifying where ramp metering strategies have been applied and the results the strategies produced.

Lastly, the fourth objective of the project is to identify the difference between two scenarios at the study site on I-275 and Exit 42 Lebanon Road. Specifically, the two scenarios include a fixed ramp-metering with one lane and a fixed ramp-metering with two lanes. These two scenarios will be compared with the current traffic operation of a single lane with no ramp meter. Identifying these differences allow the team to give a suggestion for the most effective method of implementation.

Ultimately the project will explore the mechanisms of typical ramp metering control and then provide a proof-of-concept study using simulation techniques to assess the effect of the control scheme in optimizing operation of the freeway and arterials. The research project will suggest the suitable strategy for the traffic congestion problem and eventually, in 2015, estimate ramp metering impacts on energy consumption and the environment.

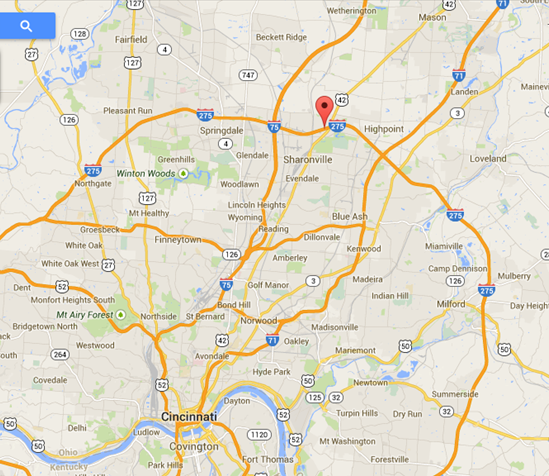
**4. RESEARCH STUDY DETAILS**

**4.1 Methodology and Study Scope**

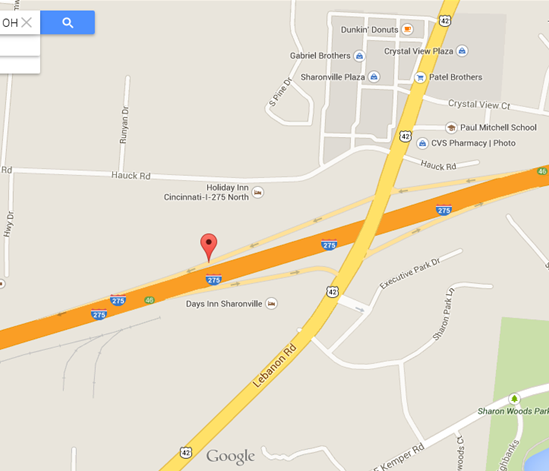
**4.1.1 Scope of Study**

The methodology for this project first began with exploring the mechanisms of typical ramp metering control for fixed-time ramp metering. The study site chosen for this investigation was at Interstate 275 and US 42 (Lebanon Road) in Sharonville, Ohio. This is located in between interstate I-71 and I-75. Both the westbound and eastbound mainline have three lanes. As depicted in the figure below, local streets Executive Park Drive and Sharon Park Lane are located near the eastbound on-ramp. The local streets Hauck Road and Crystal View Court are located near the westbound on-ramp.

Through site observation, it was noted that traffic fluctuates greatly as mainline vehicles approach merging areas. This inconsistency in speed, coupled with the heavy traffic volume at peak traffic times indicated a problem in this particular portion of I -275.

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**Fig. 1. Study site on Interstate 275 and US 42 (Lebanon Road)**

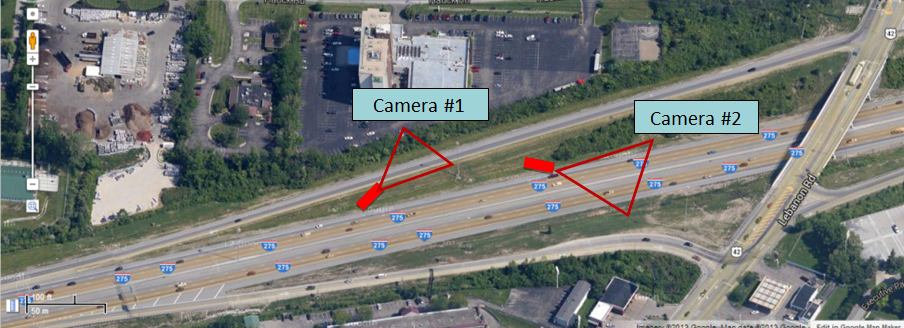


**Fig. 2. Map of Study Site in Sharonville, Ohio**

**4.1.2 Data Collection**

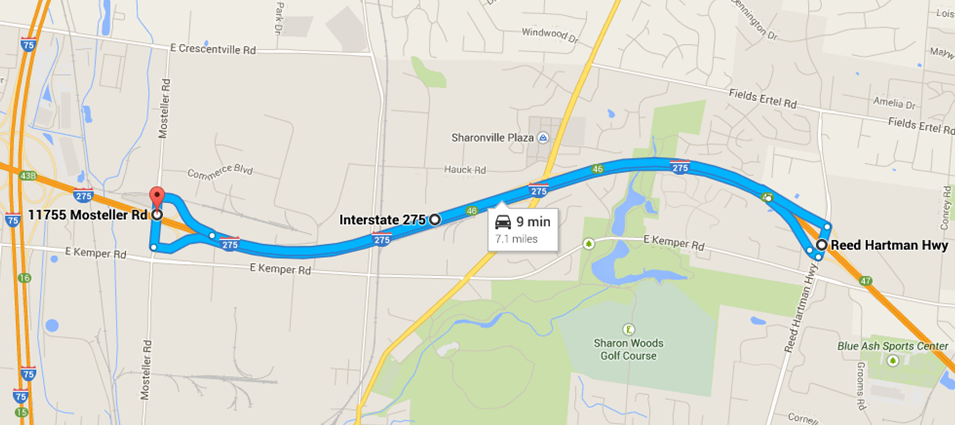
There were three pieces of data types which needed to be collected. These included traffic volume, GPS travel data, and site geometry. Traffic volume includes both on ramp and freeway mainline volume, combined with vehicle types (passenger car, heavy good vehicles (HGV), and bus). GPS travel data includes travel time, travel routes, elevation, longitude, and latitude. Site geometry includes both on ramp and freeway mainline lane width, ramp length, grade, and number of lanes.

The method of collection involved setting up four video cameras during peak weekday times, 7:00- 9:00 am and 4:00- 6:00 pm, over a period of seven days. One video camera was placed on the roadside near the middle point of the westbound on-ramp and in the middle to take the West-bound mainline volume. To record vehicle trajectory eastbound, a third video camera was in the middle to take the eastbound on-ramp and a fourth video camera recorded mainline traffic. The traffic count was collected manually with a traffic counter upon viewing the video recordings. Traffic count data was essential to apply later into the VISSIM software to calibrate and validate the ramp-metering simulation model.



**Fig. 3. Video camera location sites to collect traffic count**

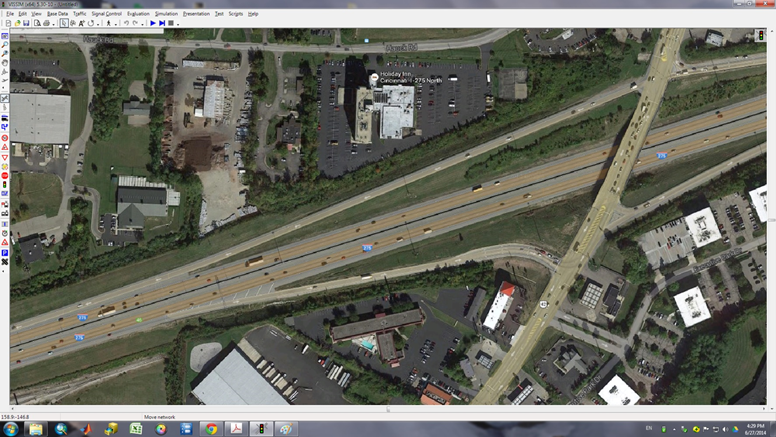
The second piece of data which needed to be collected was the GPS travel data. A GPS receiver was carried in vehicles that had been driven around. The probe vehicle runs were carried out every thirty minutes during the observation period. At least three trips were taken per observation period. The route taken started from Mosteller Rd (exit 44) which turned onto the eastbound on-ramp then onto I-275 which went to Exit 47, turning left onto Reed Hartman Hwy. From Reed Hartman Hwy (exit 47), the probe vehicle turned onto westbound on-ramp then onto I-275, which went back to Exit 44 to the starting point. GPS data was essential in order to determine acceleration and deceleration distributions, which would later be applied into the VISSIM software to calibrate and validate the ramp-metering simulation model.



**Fig. 4. GPS data collection floating car route**

The third piece of data needed was site geometry. Satellite imagery was extracted from google maps and aerial imagery from Bing maps. This imagery provided both on-ramp and freeway mainline lane width, ramp length, grade, and number of lanes. Information retrieved included the length of the ramps, WB- on ramp measures approximately 2800 ft, with a single lane width of 12 ft. The EB- on ramp length measures approximately 1600 ft, with a single lane width of 12 ft. Both the WB and EB- freeway have three lanes, each measuring 12 ft in lane width.

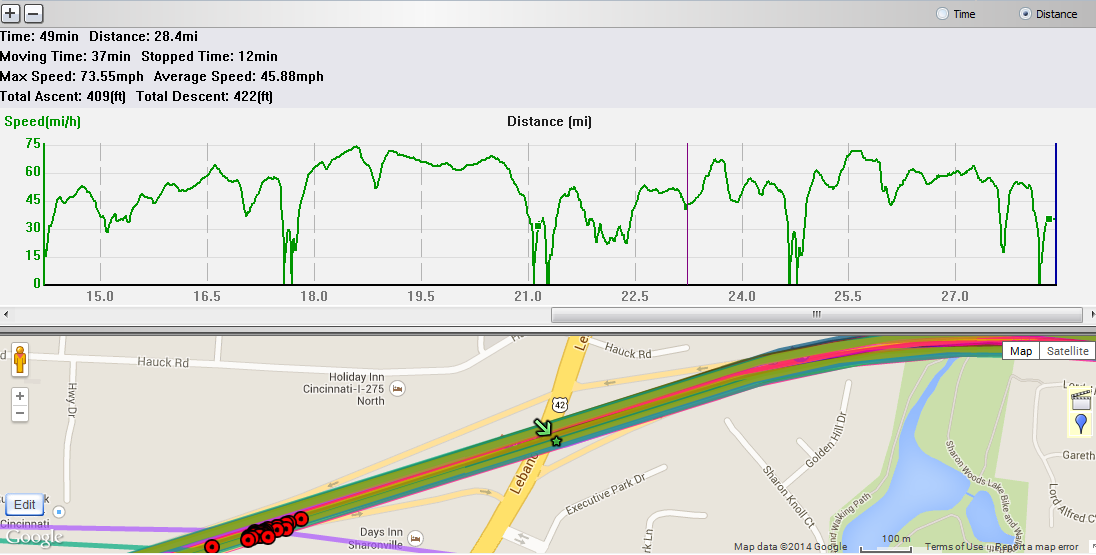
The imagery was used as a base onto which the VISSIM network was built upon. The other pieces of data will later be applied into the VISSIM model, but most importantly be useful for developing ramp meter scenarios.



**Fig. 5. Site geometry data collection using Google satellite map**

**4.1.3 Data Analysis**

After collecting the GPS recordings, the research team was able to view the data through QTravel Software. Using the GPS data speed, travel time, density, and queue length were analyzed. The GPS readings (captured below) show fluctuating speeds, for example reading 50 mph, then down to 45 mph, and back up to 66 mph. This inconsistent speed pattern occurs as the readings get closer to the merging point. With the reading below, the speed recorded is on the mainline eastbound heading towards the merging on-ramp traffic.



**Fig. 6. GPS recording data of speed fluctuations on Eastbound on the I-275 towards the**

**merging on-ramp traffic by US 42**

The traffic counts collected included westbound (WB) on-ramp, WB Freeway, eastbound (EB) on-ramp, and EB Freeway volumes for all vehicle types. The EB-on ramp volume count was 805 vehicles and the WB- on ramp volume was 541, showing a total on-ramp count of 1346 vehicles, where 95% of the vehicles were cars, 5% were trucks. The EB- freeway volume was 6295 vehicles and the WB- freeway volume was 5146 vehicles, showing a total freeway volume of 11,441 vehicles, where 95% of the vehicles were cars, 5% were trucks.

**4.2 Design of Fixed-time Ramp Metering System**

**4.2.1 Ramp Metering Strategy**

(1) Warrants

There are nine different warrants that are considered to determine whether or not ramp metering should be implemented in a given location:

Warrant 1: This warrant focuses on recurring congestion and states that if a freeway spends at least 30 minutes with traffic slowed to speeds under 50 mph for a minimum of 200 days in a year-period, then ramp metering is warranted.

Warrant 2: This warrant focuses on collision history pattern, claiming ramp metering necessary if an above-average rate of accidents occurs as a result of congestion.

Warrant 3: This warrant addresses the freeway level of service, specified in the local transportation documents.

Warrant 4: This warrant explains that ramp meters encourage drivers to utilize HOV methods by providing them with preferential treatments, such as a designated late that allows them to bypass ramp meters.

Warrant 5: This warrant explains that ramp meters help to redistribute access to freeways, rather than allowing for all vehicles to overcrowd one entrance ramp.

Warrant 6: This warrant addresses the purpose of ramp meters in relation to sporadic congestion as a result of one-time or irregularly scheduled events.

Warrant 7: This warrant states that the ramp and freeway combined exceed the maximum total traffic volume able to be handled by the freeway for that specific time period.

**Table 2. Total Volume Warrant Criteria (ITS Engineers and Constructors, Inc. 2003)**

|  |  |
| --- | --- |
| **Number of Mainline Lanes in One Direction (including Auxiliary Lanes Continue at least 1/3 Mile downstream from Ramp Gore)** | **Criteria Volume Ramp Plus Mainline Volume Downstream of Gore (total vph)** |
| 2 | 2,650 |
| 3 | 4,250 |
| 4 | 5,850 |
| 5 | 7,450 |
| 6 | 9,050 |

Warrant 8: This warrant states that the freeway’s right lane and the entrance ramp combine to a volume greater than 2,100 vph.

Warrant 9: This warrant states that ramp length, incline, and geometry provide an adequate queue length for ramp metering to be a safe and effective option.

Taking into account the aforementioned warrants, if none of the following warrants, 1, 2, 3, 4, 5, or 6, are satisfied, then there is no justification for implementing a ramp meter. If one or more of the following warrants, 1, 2, 3, 4, 5, or 6, are satisfied, as well as 7 or 8, then ramp metering is justified. If neither warrant 7 or 8 is satisfied, then ramp metering should not be implemented. If warrant 2 is satisfied and a high rate of vehicular accidents occur at that same entrance ramp, then ramp metering is justified. Warrant 9 must be satisfied, or ramp metering will not be implemented in any situation (ITS Engineers and Constructors, Inc. 2003).

Using this procedure, the study site selected for this project was justified through satisfying warrants 3, 7, and 9. Warrant 3 was satisfied, because the Level of Service at the study site severely decreased as a result of traffic congestion issues at the freeway entrance merge points. Warrant 7 was satisfied for the specific study site, because when the entrance ramp volume is combined with the freeway volume, the total exceeds the maximum capacity of the freeway. Both the eastbound and westbound freeways have three lanes, each with a width of 12 ft. The average total volume for the eastbound entrance ramp and freeway combined is 7100.05 vph. The average total volume for the westbound entrance ramp and freeway combined is 5687.61 vph. According to the table provided above relating to freeways with three lanes, if the freeway volume exceeds 4250 vph, then warrant 7 is satisfied. This study site was also justified using Warrant 9, because the site entrance ramps are both extremely long, allowing the appropriate distance for acceleration to the freeway merging speed. The length of the eastbound and westbound entrance ramps are about 1600 ft and 2800 ft, respectively. Both entrance ramps are single lane ramps and have a width of 12 ft.

(2) Geographic Extent

Geographic extent involves the entire expanse of area that is controlled or monitored through the use of ramp meters. When first implementing a ramp metering system, engineers must first consult traffic patterns and pinpoint areas of high congestion on a recurring basis. These areas can then be targeted as possible locations for ramp meters. In some situations, such as this research project, program objectives and goals must also be taken into account. To determine geographic extent and the appropriate metering approach, a variety of different factors are examined, including the extent of safety issues and repetitive congestion, limiting diversions, and political / institutional / jurisdictional boundaries (Arnold 1998). For isolated congestion or safety issues, issues only occurring at one location, only one ramp meter is installed to mitigate or eradicate the issue. In contrast, a congestion issue is considered linked if its occurrence involves multiple ramps (ITS Engineers and Constructors, Inc. 2003; Smith 2006). In this type of situation, multiple ramp meters are installed, often across an entire transportation system, to deal with the issue.

Local or System-wide Ramp Metering

Local or isolated ramp metering allows for metering rates to be selected in a more focused, specific way than in system-wide or coordinated ramp metering. Local ramp metering only takes into consideration the traffic conditions on the specific ramp in question, whereas system-wide ramp metering takes into consideration the traffic conditions on a much greater scope. Local ramp metering is ideal when the occurring traffic congestion is focused in one specific area and can be mitigated through the implementation of a single ramp meter. Local ramp metering is most appropriate for the study site that is the focus of this research project, because only local traffic conditions are being studied. In system-wide ramp metering, an entire transportation network or an entire length of freeway becomes the determining factor for the metering rate. System-wide ramp metering is a valuable system for alleviating congestion issues relating to multiple ramps and is often selected when vehicular accidents take place along a significant portion of a freeway and / or congestion is found at various locations along the freeway. The ability to coordinate ramp meter rates also provides a certain level of flexibility that allows compensation for changes in traffic patterns over time (Arnold 1998; Chaudhary and Messer 2000; Smith 2006).

For this specific research project, congestion issues mostly occur during the peak-traffic hours of the workday commute and are localized to the selected study site, so the installation of only one ramp meter on the eastbound and one ramp meter on the westbound entrance ramps are being considered.

Ramp-metering Approaches

Two distinctly different methods for controlling ramp meters are currently being used to alleviate issues of high traffic congestion. The first method, pre-timed metering, is the more cost effective and easy to install and operate of the two. In this method, metering rates are pre-determined and stagnant. They do not change or alter in response to the level of congestion on the freeway; however, their metering rates may be manually adjusted, based off of traffic condition data gathered over time. This method is most effective in short-term and predictable situations, where the general volume of traffic and congestion is consistent from day to day. The second method, traffic-responsive metering, uses collected real-time data on traffic conditions, either locally or system-wide, to determine the metering rate. As a result of using actual data to determine the metering rate, the metering rates of this second method tend to be about 5-10% more accurate (Arnold 1998; Chaudhary and Messer 2000; Smith 2006). In this particular study, pre-timed ramp metering will be considered as a first measure, for purposes of simplicity.

**Table 3. Summary of Ramp Metering Approaches (Arnold 1998)**

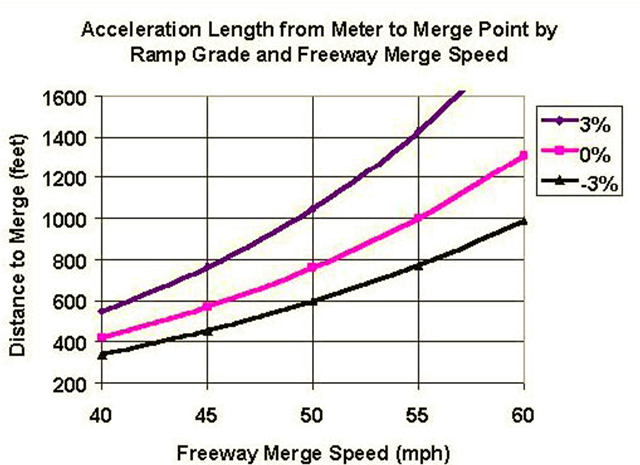
|  |  |  |
| --- | --- | --- |
|  | **Pre-timed** | **Traffic Responsive** |
| **Local** | Localized traffic problems,  Requires periodic manual updates,  Not effective for changing conditions  No need of current traffic detection,  Greater operational cost | Localized traffic problems,  More accurate congestion control,  Needs current traffic detection,  Greater maintenance cost |
| **System-wide** | No need of current traffic detection,  Effective for extensive issues,  Used less often than system-wide traffic responsive systems | Effective for extensive issues,  Needs current traffic detection,  Greatest cost, but also most accurate congestion control |

**4.2.2 On-ramp Acceleration Distance and Queue Storage**

(1) On-ramp Acceleration Length Distance

As a means of entry onto a freeway, entrance ramps require the merging vehicles to reach the freeway speed prior to merging. Therefore, the length of the entrance ramp, also known as the acceleration distance, must be great enough to account for this increase in speed. In a standard situation, when a ramp meter is not present, a vehicle may use the entire length of the entrance ramp to accelerate to the operating speed of the freeway; however, when a ramp meter is present, the vehicle can only use the distance between the stop bar and the merge point to accelerate. The merge point is defined as the location at which the entrance ramp completely combines with the right lane of the freeway, is no longer distinguishable as a separate entity, and measures a width of 12 feet. It is essential when implementing a ramp meter to make sure that this acceleration distance is adequate (Fang et al. 2012). The incline, or ramp grade, of an entrance ramp also influences the required length for acceleration. According to the table below, from the American Association of State Highway and Transportation Officials (AASHTO), as the ramp incline is altered, the speed and distance required for vehicles attempting to reach the freeway merging speed from a stopped position changes as well. The desired distance to merge, ramp grade, and freeway merge speed are all directly related. As one increases, the other two values increase as well (Chaudhary and Messer 2000).

The ramp grade for both the eastbound and the westbound entrance ramps are -3%, so the ramp grade decreases the required speed-distance profile to reach the freeway merge speed. The westbound entrance ramp has a merge speed of 60 mi/hr, so according to the graph, on a -3% grade ramp, a distance of about 1000 feet is needed for vehicle acceleration. The eastbound entrance ramp has a merge speed of 55 mi/hr, so on a -3% grade ramp, a distance of about 800 feet is needed for vehicle acceleration. As previously mentioned, the length of the eastbound and westbound entrance ramps are about 1600 ft and 2800 ft, respectively. Therefore, both ramps are of sufficient length for acceleration to reach the merging speed of the freeway.

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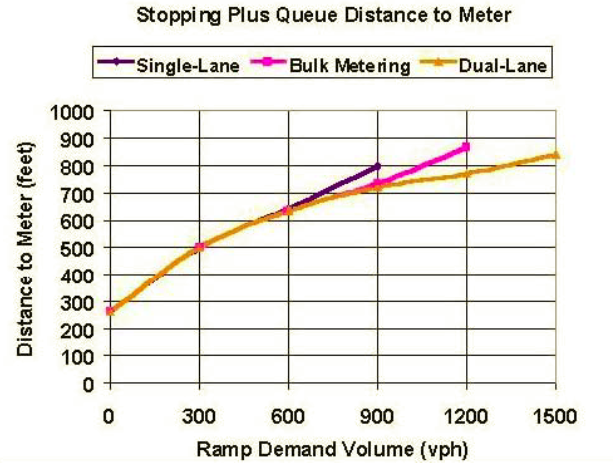
**Fig. 7. Graph on Required Length for Acceleration (Chaudhary and Messer 2000)**

(2) On-ramp Queue Storage

In the implementation of a ramp meter, careful attention must be paid to providing an adequate queue storage length, or adequate room for waiting vehicles. Without adequate queue storage room, spillback may occur onto local streets and simply relocate the freeway congestion issues to the arterial streets, rather than solving the issues (Arnold 1998; Yu et al. 2014). Four factors, including metering rate, vehicle length, release rate, and ramp volume, are taken into consideration when determining the required queue storage for a specific entrance ramp. For ramps with volumes between 500 and 900 vph during peak traffic, a second storage lane is also investigated. If the volume exceeds 900 vph for a particular ramp, then a second storage lane should be implemented. Providing adequate storage space on the ramp itself should be considered first, then if increasing the length or width is not a possibility, modifications to surrounding arterial streets can be considered (Fang et al. 2012; Jacobson et al. 2006).

If the rate at which vehicles arrive at the ramp greatly outweighs the rate at which vehicles merge onto the freeway, then a greater storage area is required for the queue. According to the Mn/DOT, ramps should allow for 10% of the traffic volume, prior to implementing the ramp meter, to be stored on the ramp. Using the average vehicle length of 25 feet, and multiplying it by this 10% value, the necessary storage requirement can then be calculated. At locations where extended vehicles tend to travel in greater quantities, this average vehicle length may need to be increased to closer to 30 feet (Arnold 1998; Jacobson et al. 2006).

The graph below displays the ramp requirements for storage and stopping distance during periods of major traffic congestion. The recorded ramp demand for each configuration includes both the maximum storage distance and 250 feet for a minimum stopping distance (Chaudhary and Messer 2000). For this research study, the entrance ramps in question exhibited a ramp demand volume of approximately 805 vph for the eastbound and 542 vph for the westbound. Applying these values to the graph below produces very similar results for both single-lane and dual-lane metering scenarios. As a result, both metering scenarios are being investigated in this study.



**Fig. 8. Graph on Stopping Plus Queue Distance to Meter (Chaudhary and Messer 2000)**

**4.2.3 Metering Rate and Flow Control**

When a meter is implemented on an entrance ramp, the flow of traffic onto the freeway is suddenly controlled, rather than allowed to flow freely, and resultantly a metering rate can be calculated. It is essential that the metering rate and the upstream volume, when combined, do not exceed the downstream capacity of the freeway [metering rate *r(i)* + upstream volume *Qt(i)* ≤ downstream capacity *Qout(i)*]. The downstream capacity is the maximum volume of cars that the downstream portion of the freeway can support without producing congestion that obstructs the flow of traffic. The metering rate for a particular entrance ramp tells engineers the number of vehicles that pass from that ramp onto the freeway each hour, reported in the ratio of veh/h. The minimum metering rate reported is 240 veh/h (Chaudhary and Messer 2000; Yang and Wu 2012). Ramp meters only have two lights; red and green. Unlike traffic signal lights, which also have a yellow warning light, ramp meters simply cycle between red and green. The green light interval and the red light interval add up to the cycle length for the ramp meter. For a pre-timed, single lane ramp meter, the time interval for a green light is roughly 1.5 - 2.0 seconds. This time interval is just long enough to allow entry of one vehicle from the entrance ramp onto the freeway. To calculate the cycle length, 3600 seconds (the number of seconds in one hour) is divided by the metering rate (Yang and Wu 2012).

**Table 4. Flow Control Options for Ramp Demand Levels (Jacobson et al. 2006)**

|  |  |  |
| --- | --- | --- |
| **Pre-metering Ramp Demand (veh/h)** | **Flow Control Scheme** | **Number of Lanes** |
| <1,000 | Single Entry | 1 |
| 900 - 1,200 | Platoon | 1 |
| 1,200 -1,800 | Tandem/Two-Abreast | 2 |

**Table 5. Ramp Volume and Suggested Treatment (ITS Engineers and Constructors, Inc. 2003)**

|  |  |
| --- | --- |
| **Ramp Volume (RV, vph)** | **Ramp Treatment** |
| 180 < RV < 500 | Single Lane Ramp Meter |
| 500 < RV < 900 | Consider Two Lane Ramp Meter for Queue Storage |
| 900 < RV | Two Lane Meter |

To maintain the appropriate freeway speed, ramp meters must be installed and programed to allow the vehicles to enter the freeway at an appropriate rate and in an appropriate manner. To determine the desired flow rate from the ramp, engineers take into account the number of lanes, the volume of the traffic, and the length of the ramp. Civil engineers use one of three main strategies to control the traffic and prevent congestion as vehicles transition from the entrance ramp onto the freeway. These three different strategies consist of the following: Single Lane (one vehicle per green metering), Single Lane Platoon (multiple vehicles per green metering), and Dual Lane (tandem or two-abreast metering. The first strategy, Single Lane, allows one vehicle to enter the freeway at a time, resulting in a 900 veh/h entrance capacity. Each cycle length must be at least 4 seconds long so that there is enough time for a vehicle to pass safely onto the freeway from the entrance ramp. If the expected vehicle capacity will exceed 900 veh/h, then the second strategy, Single Lane Platoon, is used instead. In Single Lane Platoon, for every green light, two or more vehicles are permitted to travel from the ramp onto the freeway. The green signal light time interval is significantly longer in this strategy, with a minimum of 6 seconds, to allow for more than one vehicle to pass at a time. Comparatively speaking to strategy one, strategy two allows for an additional 200-400 veh/h, or about 1200 veh/h total, to enter the freeway from the metered entrance ramp. The third and final strategy is the Dual Lane strategy, which consists of a dual lane metered entrance ramp. Each cycle of the traffic signals, one vehicle is allowed to enter the freeway from each lane, resulting in the entrance of two vehicles onto the freeway per cycle. In this strategy, the minimum cycle length is once again 4 seconds long, and vehicle entrance from each of the two lanes is staggered. In one hour, the maximum number of vehicles permitted to enter the freeway in this strategy is 1800 vehicles. To compensate for immensely heavy periods of traffic, multiple vehicles may be permitted entrance at a time for each cycle of the traffic signal.

**Table 6. Metering Rate and Cycle Time Criteria of FHWA (Arnold 1998)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Flow Control Scheme** | **No. of Lanes** | **Cycle Length (sec.)** | **Approximate Range of Metering Rates (veh/h)** |
| One Vehicle per Green | 1 | 4 – 4.5 | 240 – 900 |
| Two/Three Vehicles per Green (Bulk) | 1 | 6 – 6.5 | 240 – 1200 |
| Dual-lane | 2 | 6 – 6.5 | 400 - 1700 |

**4.2.4 Designed Scenarios**

For this research project, there are two different designated scenarios that will be analyzed and compared to the current situation to draw conclusions regarding the need for a ramp meter on the specified entrance ramp. The current freeway condition, referred to as baseline, consists of an entrance ramp with only one lane for vehicles and no ramp meter present. Vehicles are allowed to enter the freeway without regulation or control. Each vehicle driver is responsible for navigating the flow of traffic and finding his or her own entrance onto the freeway. This freeway entrance ramp without a meter will be referred to as the control.

The first scenario that will be assessed is an entrance ramp onto the same freeway with only one lane for vehicles and with a ramp meter present. In this scenario, the entrance of vehicles onto the freeway is regulated at set intervals of time that are predetermined. In this scenario, the cycle length for the ramp signal is 4-4.5 seconds, and one vehicle is allowed to enter onto the freeway each time the signal changes from red to green. In this scenario, approximately 240 - 900 vehicles should gain entry to the freeway per hour. This scenario will be referred to as the Meter with Single Entry Scenario.

The second and final scenario that will be assessed in this project is an entrance ramp onto the same freeway with two lanes for traffic and with a ramp meter present. In this scenario, the entrance of vehicles onto the freeway is regulated at set intervals of time that are predetermined. The cycle length for the ramp signal is 6-6.5 seconds, and one vehicle is allowed to enter onto the freeway per lane each time the signal changes from red to green. In other words, for every green light, two vehicles gain access to the freeway. In this scenario, approximately 400-1700 vehicles should gain entry to the freeway per hour. This scenario will be referred to as the Meter with Dual Lane Scenario.

**Table 7. Comparison of Scenario Results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **No. of Lanes** | **Flow Control Scheme** | **Cycle Time, s** | **Green Interval, s** | **No. of Vehicles/ Green Interval** |
| **Baseline** | 1 | N/A | N/A | N/A | N/A |
| **Scenario 1** | 1 | Single Entry | 4 | 2 | 1 |
| **Scenario 2** | 2 | Dual Lane | 6 | 2 | 2 |

In the baseline and two scenarios described above, there are three major assumptions taking place. The first assumption is that the parameters relating to driving behavior are consistent across both scenarios. Secondly, for both scenarios, the traffic volume is consistent. The third and final assumption is that the type of vehicle and desired speed match the definitions specified in VISSIM for both scenarios.

**4.3 Simulation-based Evaluation of Designed Scenarios**

**4.3.1 Modeling in VISSIM**

(1) Road network build up in VISSIM

The physical layout of the mainline, surface streets and ramps must be created within VISSIM. This process is made ever so much easier by importing a satellite map into VISSIM first and establishing the scale of the map. This allows for the reproduction of the perfectly scaled geometry of the roadways. What must be created afterward are the various links or road segments which make up the overall roadway. Because not all drivers on the highway or even in a single lane travel at the same speed, a speed range is entered for each link followed by a distribution curve for the drivers. This process is repeated for each link on the model. Some traffic signals, and traffic signage is also inserted into the VISSIM model to reflect the actual physical layout of the study site.

(2) Calibration and validation in VISSIM

Once the physical model of the roadway system, the GPS and video data could be entered into VISSIM. The traffic counts of cars and trucks on each of four sections of roadway was transcribed from the video footage at the site taken in the fall of 2013. The four include the westbound entrance ramp traffic, westbound mainline traffic, eastbound entrance ramp traffic and eastbound mainline traffic that was used to collect traffic volumes. On each of these links, car volume (number of cars per hour) was distinguished from truck volume. This is necessary to create a more accurate model since trucks do not accelerate as quickly as cars or maintain speeds where the mainline has an incline. These vehicle volumes were used as inputs into the VISSIM model.

The GPS data was also gathered to establish the vehicle trajectory or speed of traffic at various points along the stretch of highway one exit before and one exit after the study site – in both eastbound and westbound directions.

Validation is a process of checking the model results against observed data and adjusting parameter values until the simulation results fall within an acceptable range. For instance, the aggressiveness of the drivers, the safety distance between cars are but two of factors that can be altered to better model observed behaviors. In order for the model to be considered acceptable, the modeled traffic pattern must match actual traffic patterns. We compare the speed and travel time and traffic counts collected by the GPS and video to the data output from the VISSIM simulation. The traffic volume output from VISSIM must also result in a GEH calculated value less than 5 for the entire model to be valid. The VISSIM model created did indeed meet all three criteria for each data collection point. Therefore, the simulation model is considered valid and can be used with confidence to simulate traffic patterns when adding a single entry ramp metering system (Scenario 1) and a dual entry ramp meter (Scenario 2).

**Table 8. VISSIM Validation of Travel Time Data for Westbound & Eastbound Traffic**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Westbound |  | Accepted range | |  |  |
| GPS data | -10% | 10% | VISSIM data | Validation |
| Travel time segment 2 | 43.72 | 39.35 | 48.09 | 46.40 | Pass |
| Travel time segment 3 | 101.72 | 91.55 | 111.89 | 102.70 | Pass |
|  |  |  |  |  |  |
| Eastbound |  | Accepted range | |  |  |
| GPS data | -10% | 10% | VISSIM data | Validation |
| Travel time segment 5 | 35.37 | 31.83 | 38.91 | 38.80 | Pass |
| Travel time segment 6 | 83.42 | 75.08 | 91.76 | 88.60 | Pass |

**Table 9. VISSIM Validation of Speed Data for Westbound & Eastbound Traffic**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Westbound |  | Accepted range | |  |  |
| GPS data | -10% | 10% | VISSIM output | Validation |
| Data collection point 4 | 59.66 | 53.69 | 65.62 | 61.90 | pass |
| Data collection point 5 | 60.39 | 54.36 | 66.43 | 61.92 | pass |
| Data collection point 6 | 59.54 | 53.59 | 65.50 | 61.22 | pass |
| Data collection point 7 | 60.73 | 54.66 | 66.81 | 61.03 | pass |
| Data collection point 8 | 60.17 | 54.15 | 66.18 | 61.68 | Pass |
| Data collection point 9 | 60.51 | 54.46 | 66.56 | 62.07 | Pass |
|  |  |  |  |  |  |
| Eastbound |  | Accepted range | |  |  |
| GPS data | -10% | 10% | VISSIM output | Validation |
| Data collection point 13 | 56.18 | 50.56 | 61.80 | 57.13 | Pass |
| Data collection point 14 | 57.46 | 51.71 | 63.20 | 58.67 | Pass |
| Data collection point 15 | 57.53 | 51.77 | 63.28 | 60.49 | Pass |
| Data collection point 16 | 57.06 | 51.35 | 62.76 | 59.03 | Pass |
| Data collection point 17 | 58.14 | 52.33 | 63.96 | 58.14 | Pass |
| Data collection point 18 | 58.83 | 52.94 | 64.71 | 59.18 | Pass |
| Data collection point 19 | 59.84 | 53.86 | 65.83 | 61.07 | Pass |

**Table 10. VISSIM Validation of Volume Data for Westbound & Eastbound Traffic**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Westbound |  |  |  |  |
| Traffic count volume | VISSIM output | GEH (< 5) | Validation |
| Data collection point 1 | 542 | 530 | 0.52 | pass |
| Data collection point 2 | 542 | 525 | 0.74 | pass |
| Data collection point 3 | 542 | 523 | 0.82 | pass |
| Data collection point 4 | 5146 | 5105 | 0.57 | pass |
| Data collection point 5 | 5146 | 5092 | 0.75 | pass |
| Data collection point 6 | 5146 | 5063 | 1.16 | pass |
| Data collection point 7 | 5146 | 5052 | 1.32 | pass |
| Data collection point 8 | 5688 | 5550 | 1.84 | pass |
| Data collection point 9 | 5688 | 5532 | 2.08 | pass |
| Eastbound |  |  |  |  |
| Traffic count volume | VISSIM output | GEH (< 5) | Validation |
| Data collection point 10 | 805 | 742 | 2.27 | pass |
| Data collection point 11 | 805 | 738 | 2.41 | pass |
| Data collection point 12 | 805 | 738 | 2.41 | pass |
| Data collection point 13 | 6295 | 6235 | 0.76 | pass |
| Data collection point 14 | 6295 | 6229 | 0.83 | pass |
| Data collection point 15 | 6295 | 6203 | 1.16 | pass |

(3) Evaluation elements/measures (queue length, density/LOS, travel time, speed, volume, etc.)

The validated model provides a baseline for traffic performance data on which subsequent simulations will be compared. The customary metrics on which to compare whether one scenario is an improvement over the current situation or an alternative scenario are traffic density, travel time and speed. In comparing scenarios 1 & 2 from this study, it is important to also look at the queue length on the ramp since spillback is an undesirable consequence of putting in any ramp meter.

The current westbound mainline traffic volume is 5146 veh/hr, the average speed is 61.6 mph, and the density is 25 veh/mi/ln. Because there is no ramp meter, there is no associated queue length. The westbound ramp volume is 542 vehicles per hour. The westbound ramp is a single lane ramp 2800 feet in length.

The current east bound mainline traffic volume is 6295 veh/hr, the average speed is 59.4 mph, and the density is 32.0 veh/mi/ln. Because there is no ramp meter, there is no associated queue length. The eastbound ramp volume is 805 vehicles per hour. The eastbound ramp is a single lane ramp 1600 feet in length.

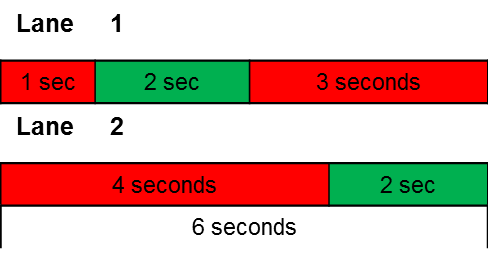
**4.3.2 Simulation-based Evaluation of Scenario 1**

In Scenario 1, a ramp signal was placed within the VISSIM model on the westbound ramp 1600 feet from the local traffic leaving 1200 feet for vehicles to accelerate from a stop at the signal and merge into the highway traffic. The signal plan was a fixed time signal with a cycle time of 4 seconds and a green time of 2 seconds. With these changes the VISSIM simulation showed the average speed of the mainline traffic increased by 2.4 mph, the travel time decreased from 102.7 seconds to 99.2 seconds and the traffic density decreased from 25 veh/mi/ln to 23.7 veh/mi/ln. The maximum length of the queue was 249 feet.

In this same scenario 1, a ramp signal was placed within the VISSIM model on the eastbound ramp 800 feet from the local traffic leaving 800 feet for vehicles to accelerate and merge onto the highway. The signal plan was a fixed time signal with a cycle time of 4 seconds and a green time of 2 seconds. With these changes the VISSIM simulation showed the average speed of the mainline traffic increased by 3.3 mph, the travel time decreased from 88.6 seconds to 84.2 seconds and the traffic density decreased from 32 veh/mi/ln to 29.6 veh/mi/ln. The maximum length of the queue was 616 feet.

**4.3.3 Simulation-based Evaluation of Scenario 2**

In Scenario 2, the westbound on ramp was widened to two lanes, each 12 feet in width and two signals placed within the VISSIM model on the ramp 1600 feet from the local traffic leaving 1200 feet for vehicles to accelerate from a stop at the signals and merge into the highway traffic. The signal plans were a fixed time signal with a cycle time of 6 seconds and a green time of 2 seconds. The two signals were staggered so that when one lane was green the other was red to avoid having two cars being side by side as they approached the merge point. With these changes the VISSIM simulation showed the average speed of the mainline traffic increased by 2.4 mph, the travel time decreased from 102.7 seconds to 98.5 seconds and the traffic density decreased from 25 veh/mi/ln to 23.8 veh/mi/ln. The maximum length of the queue was 169 feet.



**Fig. 10. Dual Lane Ramp Signal Timing Plan**

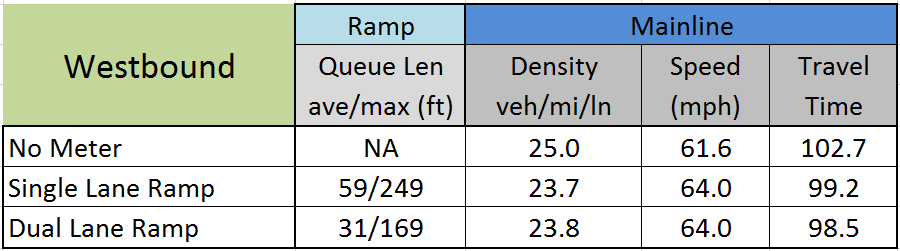
In the same Scenario 2, the eastbound on ramp was widened to two lanes, each 12 feet in width and two signals placed within the VISSIM model on the ramp 800 feet from the local traffic leaving 800 feet for vehicles to accelerate from a stop at the signals and merge into the highway traffic. The signal plans were a fixed time signal with a cycle time of 6 seconds and a green time of 2 seconds. The two signals were staggered with one vehicle per green per lane. With these changes the VISSIM simulation showed the average speed of the mainline traffic increased by 3.2 mph, the travel time decreased from 88.6 seconds to 83.9 seconds and the traffic density decreased from 32 veh/mi/ln to 29.7 veh/mi/ln. The maximum length of the queue was 211 feet.

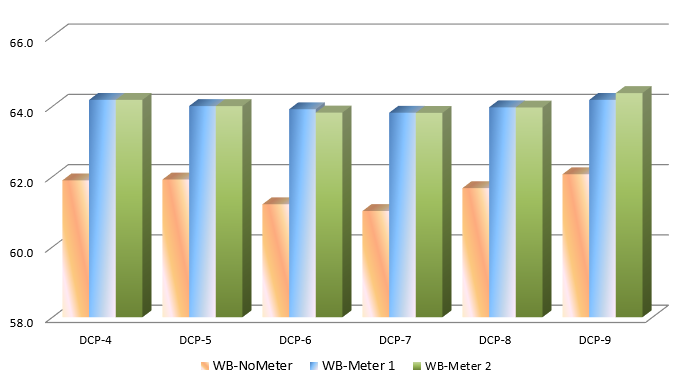
**4.3.4 Comparison of Scenarios Results**

The VISSIM simulations of both Scenario 1 and Scenario 2 show improvements both eastbound and westbound, over the current traffic conditions. The westbound traffic volume is lower than that in the eastbound direction. The speed increases, travel time reductions and density improvements are modest improvements over the current conditions.

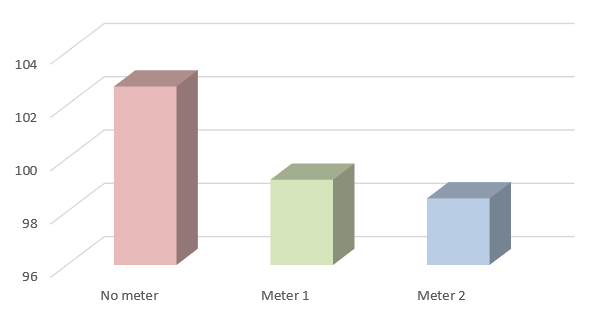
It’s important to note that the maximum queue lengths are very reasonable given the queue storage except in one case. On the eastbound on ramp, the maximum queue length reaches more than three-quarters the capacity of the ramp. Spillback onto the local roads is undesirable and may result in congestion on the local roads where congestion may not have existed under the current traffic conditions. The tables below summarize the improvements for each scenario.

**Table 11. VISSIM WB Output**

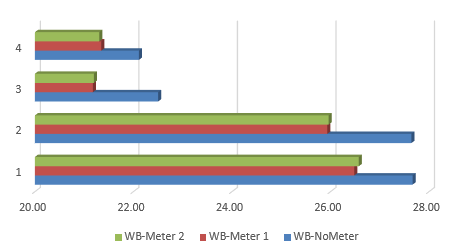




**Figure 11: WB VISSIM Speed Output (mph)**

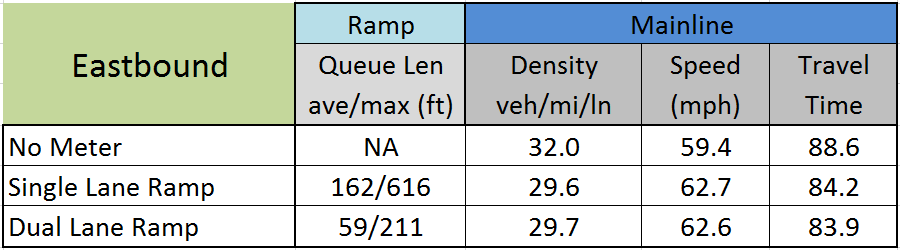


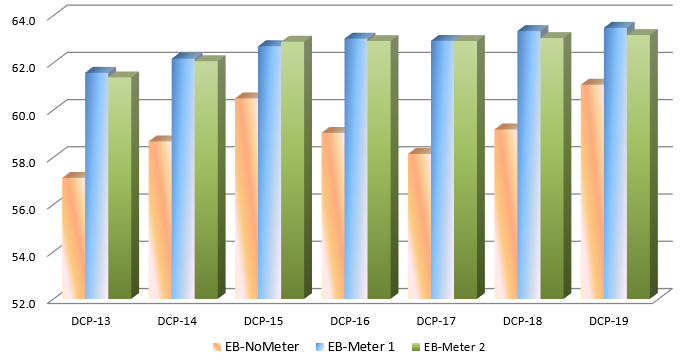
**Figure 12: WB Travel Time Output (sec)**



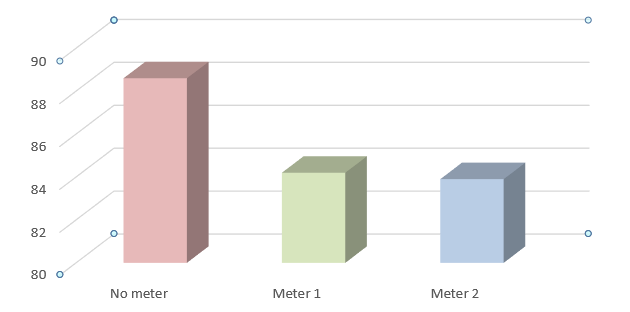
**Figure 13: WB Densiy Output (veh/mi/ln)**

**Table 12. VISSIM EB Output**

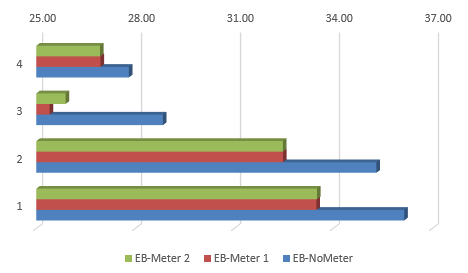




**Figure 14: EB VISSIM Speed Output (mph)**



**Figure 15: EB Travel Time Output (sec)**



**Figure 16: EB Density Output (veh/mi/ln)**

The simulation data clearly shows an improvement in vehicle speeds and reductions in travel times. The figures point out a major advantage in implementing ramp meters on both eastbound and westbound on ramps. It’s apparent that the current traffic speeds along the East and West bound mainlines is rather variable, especially in the eastbound lanes. This variation in vehicle speeds is a major cause of accidents and injuries on the highway.

To improve overall vehicle speeds, reduce the probability of accidents and plan for future growth at these key on ramps, it is recommended that the westbound ramp remain a single lane and that a ramp meter is installed with a fixed time signal plan and operational during peak traffic periods only. Furthermore, it is recommended that the eastbound ramp be widened to two lanes and two ramp meters be installed with a staggered fixed time signal plan operational only during peak periods.

The current traffic, while not in the E or F level of service category, could benefit from ramp meters being installed and serve as a tool to manage traffic congestion should further growth at this site lead to additional mainline and/or on ramp traffic volumes.

1. **RESEARCH RESULTS**

The following is a table that summarizes the improvements that take effect under scenarios 1 and 2. The increase is small but, an important improvement that could be integrated into a system of ramp meters both upstream and downstream from the current study site to enhance the overall travel times across large portions of I-275.

**Table 13: Improvements in Traffic Performance Based on VISSIM Output**

|  |  |  |  |
| --- | --- | --- | --- |
| **Westbound** | **Density** (veh/mi/ln) | **Speed** (mph) | **Travel Time** (seconds) |
| **Scenario 1** | 5.2% decrease | 3.9% increase | 3.4% decrease |
| **Scenario 2** | 5.2% decrease | 3.9% increase | 4.1% decrease |
| **Eastbound** | **Density** (veh/mi/ln) | **Speed** (mph) | **Travel Time** (seconds) |
| **Scenario 1** | 7.5% decrease | 5.6% increase | 5.0% decrease |
| **Scenario 2** | 7.2% decrease | 5.4% increase | 5.3% decrease |

1. **RESEARCH CONCLUSIONS**

To improve overall vehicle speeds, reduce the probability of accidents and plan for future growth at these key on ramps, it is recommended that the westbound ramp remain a single lane and that a ramp meter be installed with a fixed time signal plan and operational during peak traffic periods only. The signal plan would have a 4 second cycle time and 2 second green light. Furthermore, it is recommended that the eastbound ramp be widened to two lanes a ramp meter with two signal heads be installed with a staggered fixed time signal plan operational only during peak periods. The signal plan would have a 6 second cycle time with a 2 second green light.

The current traffic, would improve if ramp meters were installed and they would serve as a tool to manage traffic congestion now and should further growth at this site lead to additional mainline and on ramp traffic volumes.

1. **RECOMMENDATIONS FOR FUTURE RESEARCH**

Thoughtful consideration should be given to implementing a two lane ramp on the eastbound on ramp at S.R. 42 with one of the lanes being designated as an HOV bypass lane. This could serve as an alternative to the recommended dual lane, dual signal strategy. It would also add to an ongoing push to have commuters rideshare, thus reducing the overall number of vehicles on the road.

Another strategy that may lead to larger gains in vehicle speeds and reduced congestion would be to look at the East and Westbound ramps on either side of the current site. Having those metered in addition to the ramps at S.R. 42 may lead to bigger overall improvements.

The research carried out in this research project can be further expanded to address the relationship between ramp meter implementation, traffic congestion reduction, and reduction in emissions. Can ramp meters be used to reduce both traffic congestion as well as vehicle emissions, lessening the impact of humans on the environment? Furthermore, researchers could design a study comparing the impact of traffic-responsive ramp metering strategies with the impact of pre-timed ramp metering strategies to determine the most effective strategy. Traffic-responsive ramp metering strategies were not explored in this research project; however, further research should be conducted to determine if their implementation will result in more accurate control of freeway traffic flow on the proposed site of I-275 and US 42.

1. **CLASSROOM IMPLEMENTATION PLAN**

**8.1 Amy Gunderman’s Unit**

This research will be implemented in Amy Gunderman’s high school physics classroom, in the unit entitled “Ramping Up the Understanding of Acceleration and Velocity,” highlighting the standards relating to the construction and analysis of motion graphs. This unit should last approximately two weeks, or 10, 50 minute class periods, and will be implemented in the first semester of the academic school year. The Big Idea proposed is “Various Uses of Ramps,” and the Essential Question is: “How can we use physics to design an ideal ramp for a specific location or to fit a specific need?” From this Big Idea and Essential Question, the students will be guided to generating the following Challenge and constraints: “Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time).” This unit was selected because the ability to read, construct, and analyze different types of graphs relating to motion is a skill that is required in math classes, science classes, and college entrance exams (such as the ACT or SAT). Without a strong foundational understanding of these topics, a student will oftentimes struggle with more complex ideas in physics. All high school students are required to pass a standardized assessment prior to graduating high school. This assessment is currently transitioning from the Ohio Graduation Test (OGT) to an end of course exam for Physical Science. According to the school report card for this specific high school for the academic year of 2012-13, posted on the Ohio Department of Education’s website, this high school did not meet the Indicator for percentage of 10th graders passing the science OGT (70.6%) and they barely met it for math (76.1%). Clearly the core math and science skills necessary for reading and interpreting graphs need additional support and practice. The goal is to meet and exceed the Indicator for the Science OGT in 2014-15.

This unit will consist of two lessons broken down into four distinct activities. In Lesson 1, students begin to explore the different purposes (types), locations, and factors affecting the efficiency of different ramps. They will have the opportunity to manipulate the different variables on a computer-based traffic simulation, and observe the results in regards to traffic congestion. Activity 1 will lead to the generation of the essential questions, guiding questions, and ultimately the creation of the Challenge. Students will then analyze a variety of different data forms to gather more information relating to these different factors. In Activity 2, students will explore the relationship between force, mass, and acceleration through the completion of an activity involving ticker tape. Students will use this knowledge to create their own graphs and explain their graphs to the rest of the class. In Lesson 2, students will begin to experimentally investigate the effect that different inclines, ramp lengths, and masses have on the resultant velocity (and hence the safety), of a ramp. Students will gather their data and produce the three different graphs. In Activity 4, students will design and create a proposal for a ramp they would like to see implemented, complete with justification for its dimensions. The iterative portion of the EDP occurs halfway through the challenge completion, because students will share their progress with another group for feedback, use the feedback, and make improvements. The students will take a pre-assessment and a post-assessment exam that requires them to identify the motion occurring in various types of motion graphs. Throughout the unit’s implementation, the students will also undergo various formative assessments, such as probing questions, activity sheets, and progress checkpoints on their completion of the challenge. For the first implementation of this unit, two physics classes (roughly 50 students) are expected to be impacted. The expected impact on student learning growth is that the students will meet the Indicator for the percentage of 10th graders passing the science OGT in 2014-15 (about a 5% increase).

**8.2 Bob Leugers’ Unit**

This research will be implemented in Bob Leugers’ 9th grade Geometry class at the School for the Creative and Performing Arts in the unit entitled “Life in the Fast Lane”. This unit will focus on modelling situations, reasoning with inequalities and understanding relationships. This unit should last approximately two weeks, or ten, 42 minute class periods, and will be implemented in the first quarter of the academic school year. The Big Idea proposed is “Wait Time” and the Essential Question is: “What variables impact wait time and how can they be manipulated to reduce customer wait time”? The students will be led through this lesson in a Socratic fashion where students will be faced with the challenge of having to determine the fewest number of employees necessary to serve 60 customers in a fast food restaurant in a 15 minute period with no one having to wait longer than 5 minutes.

This challenge was chosen because high school students require a great deal of guidance to look at a real world situation and think that it can be modeled using mathematical equations or inequalities. Through teacher experience, word problems on the ACT and other tests prove nettlesome for the high school math student. Furthermore, they struggle to understand the impact that changing one variable has on the value of another variable. This unit, through the use of Challenge Based Learning and the Engineering Design Process, will help students work cooperatively to solve a problem each of them can identify with personally. The students will be given a pre and post assessment to see if they can identify key variables within a series of word problems. Having done this, they will be required to communicate in writing, how changes to each variable would affect the outcome.

This unit is broken down into 2 lessons, each having 2 activities. The engineering design process is introduced in the first lesson where students are expected to analyze the problem of wait time and do research to identify the causes of having to wait. They will be asked to work on a problem related to traffic congestion in which each group will adjust two variables related to traffic flow using a traffic simulation application. The groups will communicate to the class by way of a one minute speech followed by showing the class graphs and tables that reinforce and clarify the relationships they described in words. That is the first activity.

In the second activity of Lesson 1, the groups will take the information they gathered from the other groups about how other variables influence congestion and redesign the traffic simulation and they will manipulate 8 of the ten variables so that after 2 minutes of simulation, there are fewer than 4 cars on the ramp waiting to get on the freeway. The students will again communicate to the class how they achieved the goal. There will be multiple solutions expected.

In the first activity of Lesson 2, the students will focus on the wait times involved with fast food restaurants. They will research the components of wait time in this environment and research information they will need to solve the problems, such as how long it takes to cook a hamburger, dispense a drink, and how long the average customer uses a table in the restaurant. Students will be assessed on their understanding of how changes to these variables affect customer wait times. Groups of students will use information to simulate by their own hand (no software simulation is provided) the ordering of only hamburgers and fulfilling the orders. They will need to simulate the orders of 60 customers (hamburgers) over a 15 minute period and delivering them with no customer waiting more than 5 minutes. Students will communicate to the class how they achieved the goal so all groups can improve their simulations.

The final challenge in the second activity of Lesson 2 is to have the groups simulate a restaurant that serves cheeseburgers, fries and Pepsi. They will serve 60 customers in a 15 minute period with no one having to wait more than 5 minutes. Each group will present their solution to the class.

It is anticipated that the 120 students involved in these lessons will perform better than earlier classes on the word problems on the OGT test given in the spring of 2015.

**8.3 Joanne Vakil’s Unit**

This research will be implemented in Joanne Vakil’s Middle School Math and Science classroom, in the unit entitled “Stop and Go: Designing an Efficient Route to Help Reduce Gas Consumption,” highlighting the math standards relating to statistics and the science standard on Force and Motion. This unit should last approximately two weeks, or 20, 40 minute class periods, and will be implemented in the first semester of the academic school year. The Big Idea proposed is “Force, Motion, and Math’s Impact on Traffic Management,” and the Essential Question is: “What is the most efficient and optimal route for cars to travel in a congested area?” From this Big Idea and Essential Question, the students will be guided to generating the following Challenge and constraints: “Design a model that will show the most efficient traffic management system (an intersection with a stop sign or stop light, or a roundabout) given a set of constraints (a maximum of testing 30 vehicles, a range of speed (to be determined once human pace and/or battery operated vehicle speeds are calculated), and a maximum of six entrance ways into the congested area).”

This unit was selected because Physical Science, specifically forces and motion, is a major portion of the science standards for this grade level. The target of the lessons, however, are towards the math standards. Upon analyzing students’ sample work and chapter assessments over the past two years of teaching Common Core State Standards, there exists a pattern of student difficulty in grasping Domain 5 of Statistics and Probability. Specifically, for Grade 7, rigorous topics of sampling, mean and mean absolute deviation, making comparative inferences about two populations, and simulations are addressed. Emphasis on the mathematics of traffic management will allow eighth grade students an opportunity to review these concepts they may have not retained from last year.

This unit will consist of two lessons broken down into four activities. In Lesson 1, students begin to explore the different traffic management systems. They will analyze data from a variety of online sources and compare accident counts and other measures of impact of traffic lights or roundabouts before and after installation. Students can find measures of central tendency, as well as percent increase and decrease statistics. Activity 1 will lead to the generation of the essential question, guiding questions, and ultimately the creation of the Challenge. In Activity 2, Students will investigate essential questions about gas and how its consumption impacts society. Students will develop a survey to distribute to parents and teachers at the school. The survey will ask questions about their knowledge of gas consumption, as well as specific questions such as which vehicles they drive and how many hours they commute. Once all of the surveys are collected, students will again calculate measures of central tendency and design a way promote awareness for families in the school to reduce gas consumption. Activity 3 will allow students to investigate reaction time. By completing a lab, they will be able to measure, record data, graph, and analyze their results, as well as consider reaction time one of the many variables for drivers on the road.

Finally, in Activity 4, students will design a simulated model of a busy intersection and test out a solution for the safest, most efficient traffic management system given a set of constraints. Terms such as speed, velocity, and acceleration will be introduced, in addition to Newton’s laws. The iterative portion of the EDP occurs halfway through the challenge completion. Students will demonstrate their simulation to another group and teacher for feedback, use the feedback to redesign and make improvements. The students will take a pre-assessment and a post-assessment test that requires them to identify the basic speed, velocity, acceleration vocabulary, Newton’s laws, and calculating measures of central tendency, mean absolute deviation, percent increase and decrease, and concepts such as bias, populations, simulations. Throughout the unit’s implementation, the students will also undergo various formative assessments, such as probing questions, a lab sheet, research notecard check, written reflections and progress checkpoints on their statistics calculations. The expected impact on student learning growth is that the students will be more prepared and successful for Domain 5 Statistics standards and Grade 8 Physical Science Forces and Motions standards on the OAA.

1. **ACKNOWLEDGEMENTS:**

The authors of this paper would like to acknowledge the financial support of the National Science Foundation. Also, they would like to acknowledge the support and assistance of their project faculty mentor, Dr. Heng Wei, and their graduate research assistant, Ms. Bei Zhao. Additional support and guidance was provided by RET Project Director and Principal Investigator, Dr. Anant R. Kukreti, and RET Resource Person & Grant Coordinator, Debbie Liberi. RET is funded by the National Science Foundation, Grant ID# EEC-1404766. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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1. **APPENDIX I: UNIT TEMPLATE OF TEACHER : AMY GUNDERMAN**

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| **Name: Amy Gunderman** | **Contact Info: agunderman11@gmail.com** | **Date: 07/28/14** |

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| **Unit Number and Title:** 1.0.0 Ramping up the Understanding of Acceleration and Velocity |

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| **Grade Level:** | 11-12 |

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| **Subject Area:** | Physics |

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| **Total Estimated Duration of Entire Unit:** | 2 weeks (10 days, 50 minute bells) |

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| **Unit Summary** |

The Big Idea (including global relevance): Various uses of Ramps

(Take a look around you. Ramps are everywhere and they are used for a variety of different purposes. Ramps are just one form of a simple machine, simple devices or tools that use mechanical advantage to multiply the force applied. What are some of the different functions of ramps and what different variables make them more suitable for one purpose versus a different purpose?)

The Essential Question:

What variables impact the safety and specific function for different types of ramps?

How can we use physics to design an ideal ramp for a specific location or to fit a specific need?

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| **Unit Context** |

Justification for Selection of Content:

Velocity and acceleration are core fundamental principles in physics, from which many other topics stem. The ability to read, construct, and analyze different types of graphs relating to motion is a skill that is required in both math and a variety of different science classes. These skills are also required to do well on college entrance exams (such as the ACT or SAT) and be successful in college science / math classes. Without a strong foundational understanding of these topics, a student will oftentimes struggle with more complex ideas in physics. All high school students are required to pass a standardized assessment prior to graduating high school. This assessment is currently transitioning from the Ohio Graduation Test (OGT) to an end of course exam for Physical Science. According to the school report card for my specific high school for the academic year of 2012-13, posted on the Ohio Department of Education’s website, my high school did not meet the Indicator for percentage of 10th graders passing the science OGT (70.6%) and they barely met it for math (76.1%). Clearly the core math and science skills necessary for reading and interpreting graphs need additional support and practice. The goal is to meet and exceed the Indicator for the Science OGT in 2014-15.

The Challenge:

Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time).

The Hook:

Show clips / short videos from youtube, such as, <http://www.youtube.com/watch?v=aggptP6zw7Y>, <http://www.youtube.com/watch?v=1yzdXZzIEik>, and http://www.youtube.com/watch?v=z2EfBPgwi8E, then Have the students discuss different factors in the crashes / videos… How could these situations have been made safer or easier? (Play the videos on silent, due to some inappropriate language).

Teacher’s Guiding Questions:

1. How can fluctuations in acceleration and velocity be represented in the form of a graph?
2. What design problems exist in the entrance ramp you are analyzing and how can they be fixed?
3. What can cause the velocity to change given that the ramp length remains the same?
4. How can we predict the velocity of a vehicle traveling down an incline?
5. How is velocity different than speed and what do we need to know to calculate velocity?
6. Does the mass of the object affect its velocity?
7. What is acceleration and what do we need to know to calculate it?
8. What factors affect the safety of a ramp?
9. How does the angle / incline of a ramp affect its rate of acceleration?
10. What design problems are common in ramps and how can they be fixed?
11. What restrictions exist for different types of ramps?
12. What can cause the velocity to change given that the ramp length stays the same?

To generate the Challenge and the guiding questions, students will watch 3 different youtube videos, (<http://www.youtube.com/watch?v=aggptP6zw7Y>, <http://www.youtube.com/watch?v=1yzdXZzIEik>, and <http://www.youtube.com/watch?v=z2EfBPgwi8E>), silently jotting down their observations, without sharing their thoughts with any of their classmates. Have the students think about different factors in the crashes / videos… How could these situations have been made safer or easier? From their observations and notes they took during the videos and using Think – Pair – Share, the students will come up with the Big Idea.

If needed, the teacher may bring up the topics of velocity and acceleration and have the students compare the general rates of each in relation to the different ramps that they observe in the videos. In small groups, students will then brainstorm the “Essential Questions.” Through class discussion, the class will come up with a class list of essential questions (and display this list on the board). The teacher will use guiding mechanisms to help the students come up with the essential questions that will serve as the backbone for their challenge: What variables impact the safety and specific function for different types of ramps? How can we use physics to design an ideal ramp for a specific location or to fit a specific need? The students will record these two Essential Questions. Next, the students will discuss possible real-world challenges that they could solve relating to these essential questions. The teacher will guide the students to the following design challenge: “Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time).” The goal is to have the students come up with the challenge of proposing a ramp for a specific location. Realistically, the additional constraints of the challenge will likely need to be expressed by the teacher.

Still within their groups, the students will generate 3-5 guiding questions for the challenge. What do they need to know in order to complete this challenge? (If time is running short, this step can be converted into an individual homework activity instead). The students will share the questions as a class to produce a final class list of guiding questions for the challenge.

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

* Application: Ramps are utilized in numerous ways to reduce the force required to do the same amount of work to complete a specific job or task. Students will explore a broad array of different ramp types and analyze their efficiency. One specific type of ramp students will analyze in detail is a traffic entrance ramp. Many, if not all, of the students are new drivers and it is very important for them to become aware of different safety issues that will affect them. Students will explore the dangers that freeway entrance ramps can present. Beyond simply gaining an awareness of different safety issues relating to ramps, students will also have the opportunity to become a part of the solution, through the application of the Engineering Design Process to complete the challenge.
* Careers: Furthermore, public ramp design and construction is often completed by civil engineers, which is a growing field with a wide array of career opportunities. Providing students with an experience to analyze, critique, design, and redesign various ramps will serve as a great introduction to the field of civil engineering and hopefully allow students to see the possibilities presented by this career track.
* Societal Impact: This unit relates to the societal issues of safety pertaining to various forms of ramps. From safety regulations for handicap ramps to safety regulations for traffic ramps, ramp safety affects everyone! In a single day alone, students may drive up the entrance ramp to the school, walk up the ramp to the cafeteria, and soar from ramp to ramp at the skate park after school. Students will also have the opportunity to manipulate different variables to see how each affects ramp safety.

Engineering Design Process (EDP):

All of the following portions of the EDP are evident in Lesson 2 / Activity 2, also known as the “Challenge” of the Unit Plan.

* **Identify and Define:** Students will identify and define the details of an existing ramp that they believe needs modified, or a location that they believe needs to have a ramp implemented. Students will define the type of ramp that they want to implement or redesign.
* **Gather Information:** Students will research both the specific location (dimensions and regulations of the area) and the type of ramp that they plan to propose. Important components that they will need to focus on include safety regulations, desired function of the ramp (and the necessary design to allow this function), and pros and cons of existing designs.
* **Identify Alternatives:** Each student will sketch out one design for their group’s ramp, complete with dimensions and instructions. Students may use a digital program (such as SketchUp) or pencil and paper.
* **Select Best Solution to Try:** Within each group, students will share their ramp ideas and for each design, as a group, the students will list two pros and two cons. The group will discuss the designs and incorporate the best components of each to work as a group and design the most efficient ramp for their selected location and function.
* **Implement Solution:** The group will build their prototype and run the appropriate tests to collect the data needed to build the following three graphs and justify the efficiency of their ramp (position vs time, velocity vs. time, and acceleration vs time).
* **Evaluate or Test:** There will be a halfway checkpoint in the middle of the challenge completion. Students will share their progress thus far with another group (they will use this as a “dress rehearsal” for their final presentation) for feedback. Essentially, each group will evaluate another group’s proposal, and then reflect upon and evaluate their own proposal as well. I will also observe these presentations and use it as a formative assessment.
* **Refine:** Utilizing the feedback received from their peers as well as their own self-reflections on their product / proposal thus far, each group will refine their proposal and make necessary adjustments to maximize the efficiency of their ramp.
* **Do Again:** From these adjustments and redesign, the groups will each rebuild / alter their ramp prototype and add their new data to their existing three graphs.
* **Communicate:** Students will present their final proposals to their peers and to the teacher. If possible, depending on the location of the ramp design, students will present their ramp proposal to the appropriate audience responsible for making judgment calls for the specific location.

| **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. |
| ☒ 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 | ☒ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto 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 |

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

(ONLS)

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Design and conduct scientific investigations
  + Use technology and mathematics to improve investigations and communications;
  + Formulate and revise explanations and models using logic and evidence (critical thinking);
  + Recognize and analyze explanations and models; and
  + Communicate and support a scientific argument.
* Motion Graphs:
  + Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph.
  + Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects.
* Position vs. time graph:
  + increasing in speed, slope becomes steeper; Decreasing in speed become less steep.
* Velocity vs. time graph:
  + The slope indicates the acceleration:
    - Increasing in speed, slope away from the x-axis; decreasing in speed, slope toward the x-axis.
    - Straight line (not necessarily horizontal): acceleration is constant.
    - Acceleration is positive for objects speeding up in a positive direction or objects slowing down in a negative direction.
    - Acceleration is negative for objects slowing down in a positive direction or speeding up in a negative direction.
* Acceleration vs. time graph:
  + Objects moving with uniform acceleration will have a horizontal line on this graph.
    - This line will be at the x-axis for objects that are either standing still or moving with constant velocity.
  + The area under the curve gives the change in velocity for the object.

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| **Unit Lessons and Activities:** (Link here.) |

* **Lesson 1: Different Function, Different Design, Different Velocity:** 
  + In Lesson 1, students begin to explore the different purposes (types), locations, and factors affecting the efficiency of different ramps. They will have the opportunity to manipulate the different variables on a computer-based traffic simulation, and observe the results in regards to traffic congestion. Activity 1 will lead to the generation of the essential questions, guiding questions, and ultimately the creation of the Challenge. Students will then analyze a variety of different data forms to gather more information relating to these different factors. In Activity 2, students will explore the relationship between force, mass, and acceleration through the completion of an activity involving ticker tape. Students will use this knowledge to create their own graphs and explain their graphs to the rest of the class.
    - **Activity 1: Ramp Variables: Mini-Hooks and Traffic Simulation**
    - **Activity 2: Ticking the Tape of Motion**
* **Lesson 2: Different Factors Affecting Ramp Safety and Efficiency:**
  + In Lesson 2, students will begin to experimentally investigate the affect that different inclines, ramp lengths, and masses have on the resultant velocity (and hence the safety), of a ramp. Students will gather their data and produce three different graphs (position vs time, velocity vs time, acceleration vs time). In Activity 4, from their understanding of acceleration, velocity, and the different factors affecting ramp safety and efficiency, students will design and create a proposal for a ramp they would like to see implemented, complete with justification for its dimensions.
    - **Activity 3: Foam Trials**
    - **Activity 4: Ramp Design and Proposal**

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| **Where the CBL and EDP appear in the Unit: (Please provide the Lesson #’s and Activity #’s)** |

* CBL begins in the unit in Lesson 1, Activity 1, because the students begin to flesh out the challenge through the mini-hooks, discussions (think – pair – and shares), and use of the traffic simulation. The actual challenge is carried out in Lesson 2, Activity 4, through the design, creation, and proposal of the ramps.
* The EDP appears in the unit in Lesson 2, Activity 4. There will be a halfway checkpoint in the middle of the challenge completion. Students will share their progress thus far with another group (they will use this as a “dress rehearsal” for their final presentation) for feedback. I will also observe these presentations and use it as a formative assessment. The groups will then use the feedback they receive to make modifications to improve their ramps and / or the clarity of their presentation. This is the iterative portion of the EDP.

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| **Background Knowledge:** |

* Students will need to understand how to use the SI system of measurement.
* Dimensional analysis from English units to SI units.
* Basic Algebra skills (Including how to find the slope of a line).
* Basic understanding of line graphs and the ability to create them.

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| **Misconceptions:** |

* Two objects side by side must have the same speed.
* Acceleration and velocity are always in the same direction.
* Velocity is a force.
* If velocity is zero, then acceleration must be zero, too.
* Acceleration is the same as velocity.
* When the velocity is constant, so is the acceleration.
* Students do not realize that the acceleration is zero. If the speed is constant, there is no acceleration.
* A positive acceleration is always associated with speeding up and a negative acceleration is always associated with slowing down.
  + All the misconceptions above are from page 74 of the following resource: <http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>

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| **Additional Resources:** |

Hyperlink any other resources or documents web site links, books, podcasts, videos, presentations, databases, experts, forms to fill out, handouts used by the teacher or students.

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| **Pre-Unit Assessment Instrument: (Link it here.)** |

This will be a 10 or less set of questions that assess the learning objectives for this unit of study.

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| **Post-Unit Assessment Instrument: (Link it here.)** |

This will be a 10 or less set of questions that assess the learning objectives for this unit of study.

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

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| **How to Make This a Hierarchical Unit: (Check one of the following.)**  ☐ Middle School Unit ☒ High School Unit  **Refer to the Unit Template Description. Complete A or B below, whichever is applicable.** |

* Middle School Unit Standards (8th Grade ONLS):
  + A force is described by its strength (magnitude) and in what direction it is acting. Many forces can act on a single object simultaneously.
  + The forces acting on an object can be represented by arrows drawn on an isolated picture of the object (a force diagram).
  + The direction of each arrow shows the direction of push or pull. When many forces act on an object, their combined effect is what influences the motion of that object.
  + The sum of all the forces acting on an object depends not only on how strong the forces are, but also in what directions they act.
  + Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions.
  + Such forces are said to be balanced. If all forces are balanced by equal forces in the opposite direction, the object will maintain its current motion (both speed and direction).
  + Kinetic friction is a force that occurs when two objects in contact interact by sliding past one another.
  + Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction of motion.
    - This phenomenon leads to the misconception that objects require a sustained force to continue moving. Experimentation with objects that have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address the misconception that objects with a net force of zero naturally slow down.
* Activities / Challenge to accompany these standards: If taught at the middle school level, this unit could involve a different challenge. Students could be asked to design and present an entrance ramp that allows a provided vehicle to travel the entire queue length in exactly 4 seconds. Students will be required to take into account the surface material of the ramp, the angle of the ramp, and the force behind the initial movement of the vehicle (will the car roll freely down the ramp, or will it start with the aid of a specific, controlled, applied force?). As an iterative portion to this challenge, students will present their ramps (and test them) to the rest of the class, take notes, and then use what they have learned from each other’s presentations to redesign their ramp to allow the vehicle to travel the entire queue length in exactly half the time. Some of the activities leading up to this challenge will involve a mini-lab on the friction of different surfaces, air resistance simulations from phet, and a demo / mini-lab on force diagram drawings.

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| **Poster:** Link document. |

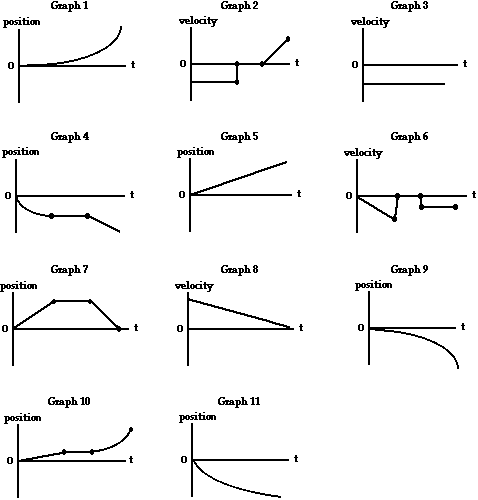
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| **Video:** Link Video. |

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| **Reflection:** Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Description sheet. |

Ramping up the Understanding of

Acceleration and Velocity Pre-Test

Directions:



Directions: For each of the statements below, write the graph that corresponds to the description.

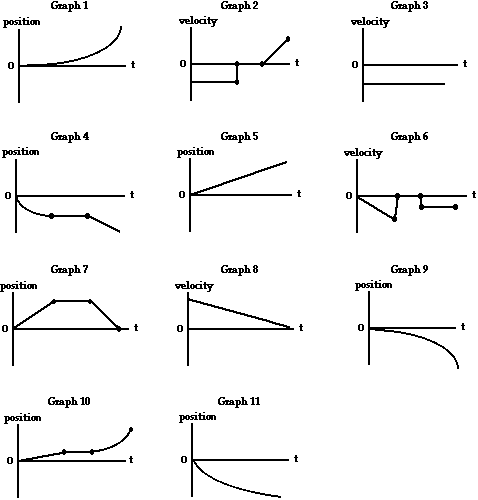
1. \_\_\_\_\_\_\_The object moves with a positive velocity and a positive acceleration.
2. \_\_\_\_\_\_\_The object moves with a constant negative velocity. Then, the object remains at rest for several seconds. Finally, the object moves with positive acceleration.
3. \_\_\_\_\_\_\_The object moves with a constant negative velocity.
4. \_\_\_\_\_\_\_The object moves with a negative velocity. Then, the object remains at rest for several seconds. Finally, the object moves with a low, constant speed.
5. \_\_\_\_\_\_\_The object moves with constant speed in the positive direction.
6. \_\_\_\_\_\_\_The object slowly accelerates from rest. Then, the object remains at rest for several seconds. Finally, the object moves with a constant negative velocity.
7. \_\_\_\_\_\_\_The object moves at constant speed. Then, the object remains at rest for several seconds. Finally, the object moves with a constant negative velocity.
8. \_\_\_\_\_\_\_The object moves in the positive direction with a negative acceleration.
9. \_\_\_\_\_\_\_The object moves in the negative direction with a negative acceleration.
10. \_\_\_\_\_\_\_The object moves with a low speed for a short time interval. Then the object remains at rest for several seconds. Finally, the object rapidly accelerates with a positive acceleration.
11. \_\_\_\_\_\_\_The object moves with a negative velocity and a positive acceleration

(Adapted from http://www.physicsclassroom.com/shwave/ntmintro.cfm)

Ramping up the Understanding of

Acceleration and Velocity Post-Test

Directions:



Directions: For each of the statements below, write the graph that corresponds to the description.

1. \_\_\_\_\_\_\_The object moves with a constant negative velocity. Then, the object remains at rest for several seconds. Finally, the object moves with positive acceleration.
2. \_\_\_\_\_\_\_The object moves with a positive velocity and a positive acceleration.

1. \_\_\_\_\_\_\_The object moves with a negative velocity. Then, the object remains at rest for several seconds. Finally, the object moves with a low, constant speed.
2. \_\_\_\_\_\_\_The object moves in the negative direction with a negative acceleration.
3. \_\_\_\_\_\_\_The object moves with a constant negative velocity
4. \_\_\_\_\_\_\_The object slowly accelerates from rest. Then, the object remains at rest for several seconds. Finally, the object moves with a constant negative velocity.
5. \_\_\_\_\_\_\_The object moves with a low speed for a short time interval. Then the object remains at rest for several seconds. Finally, the object rapidly accelerates with a positive acceleration.
6. \_\_\_\_\_\_\_The object moves at constant speed. Then, the object remains at rest for several seconds. Finally, the object moves with a constant negative velocity.
7. \_\_\_\_\_\_\_The object moves in the positive direction with a negative acceleration.
8. \_\_\_\_\_\_\_The object moves with constant speed in the positive direction.
9. \_\_\_\_\_\_\_The object moves with a negative velocity and a positive acceleration.

(Adapted from http://www.physicsclassroom.com/shwave/ntmintro.cfm)

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/25/14 |

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| **Lesson Title :** Different Function, Different Design, Different Velocity | **Unit #:** 1 | **Lesson #:** 1 | **Activity #:** 1 |
| **Activity Title:** Ramp Variables: Mini-Hooks and Traffic Simulation |

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| **Estimated Lesson Duration:** | 4 days, 50 minute classes |
| **Estimated Activity Duration:** | 2 days, 50 minute classes |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

1. I can identify design problems that exist in different types of ramps and propose modifications.
2. I can identify different factors that affect the safety of a ramp.
3. I can explain the different restrictions that exist for different types of ramps.
4. I can identify different functions or jobs that ramps help accomplish.

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| **Activity Guiding Questions:** |

1. What design problems exist in the entrance ramp you are analyzing and how can they be fixed?
2. What factors affect the safety of a ramp?
3. What design problems are common in ramps and how can they be fixed?
4. What restrictions exist for different types of ramps?
5. What different functions or jobs are ramps used to complete?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

**(ONLS)**

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Use technology and mathematics to improve investigations and communications;
  + Recognize and analyze explanations and models; and

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

* Youtube videos for the hook: <http://www.youtube.com/watch?v=aggptP6zw7Y>, <http://www.youtube.com/watch?v=1yzdXZzIEik>, and <http://www.youtube.com/watch?v=z2EfBPgwi8E>
* Worksheets (1. 1. 1a RampVariables\_Acc&Veloc\_AGunderman\_072214)
* Traffic Simulation Applet: <http://www.traffic-simulation.de/>
* Traffic Statistics and ramp regulations: (<http://www.dot.state.oh.us/Divisions/Engineering/Roadway/Pages/default.aspx>), (<http://safety.fhwa.dot.gov/intersection/>), (<http://www.flysanjose.com/fl/business/training/Ramp_Rules.pdf>)
* Computers (preferably enough for one computer to every two students)

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| **Teacher Advance Preparation:** |

* Be sure to administer the pre-test to the students the day prior to starting the unit.
* Locate the three different youtube videos on the internet and have them loaded and ready to show to the students.
* Copy necessary worksheets (1. 1. 1a RampVariables\_Acc&Veloc\_AGunderman\_072214)
* Have a Google Doc ready on day 2 for recording the student data

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| **Activity Procedures:** |

(If possible, give the students the pre-test for this unit on the day before starting this unit.)

**Day 1** (50 mins) - Introduce the Big Idea, produce the essential questions, identify the Challenge, and brainstorm the guiding questions.

1. At the start of the class, pass out to each student a copy of the “Big Idea to Guiding Questions” worksheet.
2. Show the three different youtube video clips (<http://www.youtube.com/watch?v=aggptP6zw7Y>, <http://www.youtube.com/watch?v=1yzdXZzIEik>, and <http://www.youtube.com/watch?v=z2EfBPgwi8E>), asking students to silently jot down their observations, without sharing their thoughts with any of their classmates. Have the students think about different factors in the crashes / videos… How could these situations have been made safer or easier? (Play the videos on silent, due to some inappropriate language).
3. From their observations and notes they took during the videos, have each student silently write on their paper what they think the Big Idea is for this unit.
4. Think – Pair – Share: Give the students 2 minutes to write down everything that they know about the Big Idea, then give them 3 minutes to share with a partner (and record on their worksheets).
5. Have one student from each group share with the entire class what they and their partner came up with relating to the Big Idea. It may be helpful to bring up the topics of velocity and acceleration and have the students compare the general rates of each in relation to the different ramps that they observe in the videos.
6. Combine groups together (there should now be 4 students per group) and give them 3 minutes to brainstorm “Essential Questions” as a group.
7. Circulate the room and listen to the groups working. If necessary, help plant some ideas for the groups, if they seem completely lost. Some possible “Essential Questions” that they may come up with include:
   1. What is the purpose of a ramp?
   2. What makes a ramp safe / not safe?
   3. How does the design of a ramp change, based off of its function?
   4. How does physics relate to ramps?
   5. Do all ramps produce the same velocity for any object that is rolled down them?
8. Through class discussion, come up with a class list of essential questions (and display this list on the board). Use the Big Idea worksheet to record and organize any important background information on the unit Big Idea.
9. Use guiding mechanisms to help the students come up with the essential questions that will serve as the backbone for their challenge: What variables impact the safety and specific function for different types of ramps? How can we use physics to design an ideal ramp for a specific location or to fit a specific need? Be sure to have the students record these two Essential Questions on their worksheets.
10. Have the students discuss possible real-world challenges that they could solve relating to these essential questions. Guide the students to the following design Challenge: Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time). The goal is to have the students come up with the challenge of proposing a ramp for a specific location. Realistically, the additional constraints of the Challenge will likely need to be expressed by the teacher.
11. Still within their groups, have the students generate 3-5 guiding questions for the Challenge. What do they need to know in order to complete this Challenge? (If time is running short, this step can be converted into an individual homework activity instead). Share the questions as a class to produce a final class list of guiding questions for the Challenge.

**Day 2** (50 mins) –

1. One major goal of this exercise is to have the students research to gather their own data relating to ramp safety, ramp regulations, ramp types, and ramp functions. At the very beginning of the class, remind the students of the Big Idea and Challenge, then have them record both on the top of their papers.
2. Write a few guiding questions on the board that relate to the specific goal of this exercise. See below for some examples:
   1. What design problems exist in the entrance ramp you are analyzing and how can they be fixed?
   2. What factors affect the safety of a ramp?
   3. What design problems are common in ramps and how can they be fixed?
   4. What restrictions exist for different types of ramps?
3. This portion of Activity 1 will be split into two different portions. The students will have the chance to be investigators, both through the analysis of the gathered data of others and through their own manipulation of variables. Pair the students up into groups of 2, and have half of the groups go over to the computers (1 computer per group) and the other half can remain at their desks.
4. Instruct the group of students at the computers to log-in and go to the following website: <http://www.traffic-simulation.de/>. These students will be exploring freeway entrance ramps. The Students will have 10 minutes to explore the simulation with their partner, adjusting the different variables and recording their observations on a sheet of notebook paper.
5. The second half of the class, in groups of two, will be analyzing various forms of traffic data relating to entrance and exit ramps. They will be provided with data from the summer RET research project, “Ramp Metering Control for Mitigating Freeway Congestion,” from the Ohio Department of Transportation, and from the San Jose Airport Ramp Safety and Traffic Regulations Handbook. Students will need to analyze tables, charts, graphs, technical documents, and Journal Articles. Additional resources may be provided, based off of the teacher’s recommendation. Students will need to record their findings on a sheet of notebook paper. One piece of paper per group is fine. Be sure to circulate around the room as the students work in pairs to ensure that all are actively contributing. Ask open-ended, broad questions to help guide the students or to help get them back on track if they seem to have hit a wall.
6. After 10 minutes have elapsed, have the groups switch, and give them each 10 more minutes to conduct their research and record their observations.
7. At the end of this 10 minute increment, have each group working on the computers go pair up with a group working at the desks / tables. Instruct the new groups of 4 students to compile all of their group’s data onto one sheet of paper, in an organized fashion. (Some suggestions may include creating a chart, a table, a list, etc.). Give the students about 5 minutes.
8. While the students are working in their groups, the teacher needs to pull up a pre-created google doc page that is entitled: Activity 1: Research Findings. As groups begin to finish compiling their results, have them send a representative to come up, one group at a time, and type 2-3 of their major findings onto the google doc. (Be sure to do this with all of the different classes that are going through this unit to produce a greater expanse of findings / conclusions).
9. At the end of the 5 minutes (or after all of the groups have recorded a few items in the google doc, have a brief class discussion about the findings of different groups from the two research activities. Be sure to discuss how altering the form or structure of the ramps affected the acceleration and / or velocity of the objects traveling up / down them. How do some of the regulations on ramp design and use limit or restrict the velocity that can be achieved on a specific ramp?

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

* “Big Idea to Guiding Questions” Worksheet
* Observations of groups brainstorming “Essential Questions.”
* Group data from day 2 (includes traffic simulation findings as well as analysis of research data)
* Google Doc with class findings and the class discussion that follows

**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.

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

* Student ability levels will be taken into account when grouping students.
* A graphic organizer will be provided to the students to assist with organizing their thoughts and ideas as they work from the Big Idea to the Challenge.
* Auditory / visual learners’ needs will be met through the use of youtube videos, the traffic simulation, and writing questions / notes on the board. Also, multiple class discussions will take place as additional support for auditory learners.
* Additional modifications will be made as I get to know my students, prior to teaching the lesson.

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

**From the Big Idea 🡪 to Essential Questions**

**Big Idea \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Think-Pair-Share**

First, for 2 minutes, write down what you know about the topic and then for 3 minutes share your thoughts with a partner and add to the list.

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| **What you know / Video Observations:** | **What your partner added:** |
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**What the Class Knows:**

Based on the **Big Idea** identified above, brainstorm some **Essential Questions** that interest you. List below at least five Essential Questions that clarify the **Big Idea** to you:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Challenge: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Guiding Questions:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/25/14 |

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| **Lesson Title :** Different Function, Different Design, Different Velocity | **Unit #:** 1 | **Lesson #:** 1 | **Activity #:** 2 |
| **Activity Title:** Ticking the Tape of Motion |

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| **Estimated Lesson Duration:** | 4 days, 50 minute classes |
| **Estimated Activity Duration:** | 2 days, 50 minute classes |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

1. I can graphically represent acceleration and velocity of an object.
2. I can differentiate between examples of velocity and speed.
3. When provided with the necessary data, I can mathematically calculate the velocity of an object.
4. When provided with the necessary data, I can mathematically calculate the acceleration of an object.
5. When provided with a motion graph, I can describe the motion occurring, including the acceleration, in words.

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| **Activity Guiding Questions:** |

1. How can fluctuations in acceleration and velocity be represented in the form of a graph?
2. How is velocity different than speed and what do we need to know to calculate velocity?
3. What is acceleration and what do we need to know to calculate it?
4. How can we use a graph to tell if an object is moving at a uniform acceleration or not?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

(ONLS)

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Use technology and mathematics to improve investigations and communications;
  + Recognize and analyze explanations and models; and
* Motion Graphs:
  + Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph.
  + Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects.
* Position vs. time graph:
  + Increasing in speed, slope becomes steeper; Decreasing in speed become less steep.
* Velocity vs. time graph:
  + The slope indicates the acceleration:
    - Increasing in speed, slope away from the x-axis; decreasing in speed, slope toward the x-axis.
    - Straight line (not necessarily horizontal): acceleration is constant.
* Acceleration vs. time graph:
  + Objects moving with uniform acceleration will have a horizontal line on this graph.
    - This line will be at the x-axis for objects that are either standing still or moving with constant velocity.

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

* Worksheet Copies: “Ticking the Tape of Motion Worksheet”
* Ticker tape
* Timers
* Masking tape
* Books with the same mass (4 per group, text books work well for this step)
* Rubber bands
* Metric measuring devices
* Carts (1 per group of 4)
* This activity was adapted from a similar activity in *Active Physics*, by AAPT / AIP

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| **Teacher Advance Preparation:** |

* Acquire the necessary supplies (ticker tape, timers, masking tape, rubber bands, metric measuring devices, carts)
* Make copies of the worksheet: “Ticking the Tape of Motion Worksheet”

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| **Activity Procedures:** |

**Day 1:** (50 minutes):

1. In this activity, students will be using ticker tape to learn about motion and graphing motion. Pair students up into groups of 2, and have each group get a timer with ticker tape. The timer will make a dot on a paper tape every 1/60 of a second. As the tape is pulled through the timer, the speed that the tape passes through the timer can be calculated by dividing the distance between two dots on the tape by 1/60 s. This ticker tape can be used to measure the speed of an object by attaching the tape to it, and then measuring the speed that the tape is pulled through the timer.
2. Pass out copies of the Ticking the Tape of Motion Worksheet #1 to each student and have each group record their answers to the following questions (already written on the worksheets) prior to starting the activity.
   1. What will the tape look like if you hold the end of it and pull it through the timer as you move?
   2. As you increase or decrease your movement, will the distance between the dots change? How will it change for each?
   3. If you begin walking at a constant speed, then increase your pace, how will the space between the dots change?
3. Have 1 student in the group, holding the end of the tape, walk forward at am much of a constant speed as he or she can manage, starting the timer at the same instant that the student begins walking.
4. The dots made on the tape are separated by equal amounts of time, and this time interval is referred to as a “tick,” and represents 1/60 of a second.
5. Remove the tape from the timer and use scissors to separate it into 6-tick sections (each section should be 6 spaces long).
6. Glue or tape the segments side-by-side on a plain sheet of paper to create a bar graph. Each of these bars represents the distance the student traveled in 1/10 of a second. (6 x 1/60 s). If the student actually managed to travel at a constant speed then the bars should all be exactly the same height. (Any groups that have vastly different heights of bars on their graphs may need to repeat steps 3-6). Have students answer question 1 on their worksheets.
7. Have groups repeat steps 3-6, except this time, have the student who is holding the tape and walking gradually and steadily increase his or her speed. (Obviously, the height of these bars should not all be the same).
8. Instruct the students to answer questions 2-6 on their worksheets. Student may need a brief review on calculating average speed and acceleration (see equations below).

Average speed (v) = Distance traveled (d) / Time elapsed (t)

Acceleration = Change in Speed / Time Interval

1. Have groups repeat steps 3-6 again, except this time, have the student holding the tape start moving at a high speed and gradually and steadily slow down. Have students answer questions 7-10 on their worksheets.
2. Have groups share their findings and facilitate a class discussion on acceleration.

**Day 2:** (50 minutes):

1. Have students get back into their same groups that they used the previous day. Have the guiding questions for this Activity clearly posted on the board as a reminder for the students the focus of this Activity. Take a few minutes to review these with the class.
2. Each group needs a large table top, a cart, a timer, ticker tape, a metric measuring device, 2 rubber bands, 4 books (all the same mass), and graph paper. Each student needs a copy of the Ticking Tape Motion worksheet #2 as well. Each group needs to delegate one student for each of the following jobs:
   1. Puller of the cart
   2. Catcher of the cart
   3. Keeper of the timer
   4. Keeper of the tape
3. Instruct the students to, side-by-side, attach two rubber bands to the front of the cart. Stretch each to a length of 60 cm, and practice pulling the cart carrying two books. Even while the cart is moving, keep the rubber bands stretched to 60 cm. After groups have mastered this task, they can proceed to step 4.
4. Next, have the students use masking tape to attach a 2-m long piece of paper tape to the back end of the cart. Thread the tape through the timer, turn it on, and pull the cart, keeping the rubber bands stretched to 60 cm.
5. As a group, have students perform the following experiments and label each tape:
   1. Experiment 1:
      1. 2 rubber bands, 1 book
      2. 2 rubber bands, 2 books
      3. 2 rubber bands, 3 books
      4. 2 rubber bands, 4 books
   2. Experiment 2:
      1. 2 books, 1 rubber band
      2. 2 books, 2 rubber bands
      3. 2 books, 3 rubber bands
      4. 2 books, 4 rubber bands
6. Students should make a graph of velocity vs time for each of the pieces of tape, following the same methods that they used on the previous day in the first half of this activity.
7. Students can complete this activity in groups, following the directions on their worksheets. They should complete all of the questions on their worksheets as well. Be sure to circulate the room and be ready to offer assistance. Ask probing questions while circulating to determine student understanding.
8. Collect student worksheets at the end of the class as a form of formative assessment. Determine from the worksheets whether or not the topic needs to be retaught prior to progressing on to Activity 3.

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

* (Day 1) Creation of the three different graphs from the ticker-tape segments.
* (Day 1) Ticking Tape Motion worksheet #1 turned in with graphs at the end of day 1.
* (Day 1) Class discussion on acceleration.
* (Day 2) Ticking Tape Motion worksheet #2 turned in with graphs at the end of day 2.
* (Day 2) Probing questions as the students create graphs / answer questions on worksheet #2.

**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.

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

* Student ability levels will be taken into account when grouping students.
* Visual learners’ needs will be met through writing questions / notes on the board. Also, multiple class discussions will take place as additional support for auditory learners. Kinesthetic learners needs will be addressed through the hand-on activities with ticker-tape.
* Additional modifications will be made as I get to know my students, prior to teaching the lesson.

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

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/25/14 |

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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 1 | **Activity #:** 2 | **Worksheet:** 1 |
| **Activity Title:** Ticking the Tape of Motion |
| **Worksheet Title:** Ticking the Tape of Motion, Part 1 |

Directions: Complete the following questions **prior to** starting the activity:

1. What will the tape look like if you hold the end of it and pull it through the timer as you move?
2. As you increase or decrease your movement, will the distance between the dots change? How will it change for each?
3. If you begin walking at a constant speed, then increase your pace, how will the space between the dots change?

Complete the following questions **during** the activity:

1. (Graph 1) Was the speed constant? Explain.
2. (Graph 2) After the second trial, what do the bars on the graph tell you about the student’s speed during each time interval?
3. (Graph 2) What is the pattern formed on the graph?
4. (Graph 2) On this second graph, are the bars all the same length or different? How would you describe this difference in bar length on your second graph? Can you think of a motion term to describe this?
5. (Graph 2) Calculate the acceleration for each time interval on your graph. Show your work!
6. (Graph 2) Did the student move with a constant acceleration?
7. (Graph 3) How do you expect the pattern on this new graph to compare to the pattern made in the previous graph (graph 2)?
8. (Graph 3) Calculate the acceleration for each 1/10 s, using the difference in the length of the tape strips to represent the change in speed. Was the student’s acceleration constant?
9. Comparing graphs 2 and 3, how did the acceleration rates differ?
10. Comparing graphs 2 and 3, how did the direction of the accelerations differ?

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/22/14 |

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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 1 | **Activity #:** 2 | **Worksheet:** 2 |
| **Activity Title:** Ticking the Tape of Motion |
| **Worksheet Title:** Ticking the Tape of Motion, Part 2 |

Directions: As a group, perform the following experiments and label each tape:

* Experiment 1:
  + 2 rubber bands, 1 book
  + 2 rubber bands, 2 books
  + 2 rubber bands, 3 books
  + 2 rubber bands, 4 books
* Experiment 2:
  + 2 books, 1 rubber band
  + 2 books, 2 rubber bands
  + 2 books, 3 rubber bands
  + 2 books, 4 rubber bands
* Make a graph of Velocity vs Time for each combination (8 graphs total). These graphs should be made using the same method as the previous day’s graphs.

1. What does the slope of each of these graphs represent?
2. What unit of time does each 6-tick interval represent?
3. When you keep the force constant and increase the mass of the cart, what happens to the cart’s acceleration?
4. When you keep the mass constant and increase the force acting on the cart, what happens to the cart’s acceleration?
5. What would the velocity vs time graph look like for a cart moving at a constant speed?
6. What forces are acting on the cart if its acceleration is zero?
7. On a separate sheet of paper, make a force diagram for each of the 8 experiments by sketching the setup used in each. Draw arrows to represent all of the forces acting on the cart while it is accelerating. The length of each arrow should be proportional to its magnitude.
8. Based off of your experiments (and any prior knowledge), write an equation showing the relationship between acceleration, force, and mass.

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/25/14 |

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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 2 | **Activity #:** 3 |
| **Activity Title:** Foam Trials |

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| **Estimated Lesson Duration:** | 6 days, 50 minute classes |
| **Estimated Activity Duration:** | 2 days, 50 minute classes |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

1. Keeping the ramp length the same, I can manipulate the velocity of an object through the adjustment of other ramp characteristics.
2. Based off of my own experimental data, I can predict the velocity of an object traveling down an incline.
3. I can make a claim about the relationship between mass and velocity, then support my claim through experimental evidence.
4. I can demonstrate my understanding of the relationship between ramp incline and acceleration rate through experimentation and construction of a graph.
5. I can demonstrate my understanding of the relationship between ramp length and acceleration rate through experimentation and construction of a graph.

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| **Activity Guiding Questions:** |

1. What can cause the velocity to change given that the ramp length remains the same?
2. How can we predict the velocity of an object traveling down an incline?
3. Does the mass of the object affect its velocity?
4. How does the angle / incline of a ramp affect its rate of acceleration?
5. How does the length of a ramp affect its rate of acceleration?

| **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. |
| Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

(ONLS)

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Design and conduct scientific investigations
  + Recognize and analyze explanations and models; and
  + Communicate and support a scientific argument.
* Motion Graphs:
  + Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph.
  + Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects.
* Position vs. time graph:
  + Increasing in speed, slope becomes steeper; Decreasing in speed become less steep.
* Velocity vs. time graph:
  + The slope indicates the acceleration:
    - Increasing in speed, slope away from the x-axis; decreasing in speed, slope toward the x-axis.
    - Straight line (not necessarily horizontal): acceleration is constant.
    - Acceleration is positive for objects speeding up in a positive direction or objects slowing down in a negative direction.
    - Acceleration is negative for objects slowing down in a positive direction or speeding up in a negative direction.

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

* Lab materials (3 different lengths of ramp, [foam piping cut in half lengthwise], 3 different masses of ball bearings, a stop watch, a metric ruler or tape measure, graph paper, and notebook paper)
* Exit Ticket
* Google Doc

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| **Teacher Advance Preparation:** |

* Create a Google Doc for recording data
* Gather lab materials listed above

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| **Activity Procedures:** |

**Day 1 –** (50 minutes)

1. In their small groups, students will conduct an experiment to determine the relationship between ramp length, mass, and degree of incline.
2. Provide the class with the following instructions: “Provided with the following materials, design and conduct an experiment to determine the relationship between ramp length, mass, and degree of incline. Before starting your experiment, be sure to make a hypothesis about the relationship. You must display all of your results in a table / tables, and eventually convert your table(s) into a graph(s).”
   1. Note: (This activity is inquiry-based and will require the students to design their own procedure for gathering the necessary data. In a way, this will help scaffold their learning and work them slightly closer to the level of independence that the Challenge will demand of them).
   2. The groups must write a procedure and make a hypothesis before they can retrieve the supplies and begin their experiment.
3. After the teacher has checked for a procedure and hypothesis, each group will need to get the following supplies:
   1. 3 different lengths of ramp (foam piping cut in half lengthwise)
   2. 3 different masses of ball bearings
   3. A stop watch
   4. A metric ruler or tape measure
   5. Graph paper
   6. Notebook paper
4. As the students work, circulate around the room and monitor their progress. If needed, ask guiding questions that will help the students get on the right track if they are completely lost.

**Day 2 -** (50 minutes)

1. Judging from the previous day’s progress and the students’ level of understanding, begin the class with a brief introduction of the type of graphs that should be created from this experiment. If possible, select a group of students who are on the right track to give a brief presentation of their graphs. This should only last about 5 minutes total. This is just a check point to help any groups that are slightly lost get back on track.
2. Have the students get back into their groups and continue their experiments where they left off the previous day.
3. When about 20 minutes remain in the class (or when all of the groups are done with their graphs / getting close), bring the class back together.
4. Pair two groups together, and have them compare their results (both the tables and graphs). Give them about 5 minutes to do this.
5. Then have the large double groups come up to the front of the class, one large group at a time, and share their data (possibly use a Google Doc again to record, share, and compare the data across the different physics classes).
6. If there are any major inconsistencies, discuss them as a class and have the students “trouble shoot” the problems.
7. If needed, repeat trials to get a conclusive answer to the relationship between the different ramp variables.
8. As a formative assessment and exit ticket, have the students answer the following questions on a sheet of notebook paper (individually) and turn them in before leaving the class. These questions can be written on the board.
   1. What was your hypothesis?
   2. Did your results support or refute your hypothesis?
   3. Support your answer with experimental data (this should include numerical values!).

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

* Group procedure and hypothesis prior to starting the experiment
* Monitoring student progress during student-created lab
* Class discussion on findings (including discussion on graphs)
* Exit ticket

**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.

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

* Student ability levels will be taken into account when grouping students.
* Visual learners’ needs will be met through writing questions / notes on the board. Also, multiple class discussions will take place as additional support for auditory learners. Kinesthetic learners needs will be addressed through the hand-on activities with the lab.
* Additional modifications will be made as I get to know my students, prior to teaching the lesson.

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

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| **Name:** Amy Gunderman | **Contact Info:** agunderman11@gmail.com | **Date:** 07/25/14 |

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| **Lesson Title :** Different Factors Affecting Ramp Safety and Efficiency | **Unit #:** 1 | **Lesson #:** 2 | **Activity #:** 4 |
| **Activity Title:** Ramp Design and Proposal |

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| **Estimated Lesson Duration:** | 6 days, 50 minute classes |
| **Estimated Activity Duration:** | 4 days, 50 minute classes |

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| **Setting:** | Classroom and possibly external ramp locations |

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| **Activity Objectives:** |

1. Keeping the ramp length the same, I can manipulate the velocity of an object through the adjustment of other ramp characteristics.
2. I can make a claim about the relationship between mass and velocity, then support my claim through experimental evidence.
3. I can synthesize my understanding of the relationship between ramp incline, ramp length, and acceleration rate through experimentation and construction of a ramp that meets my desired function and location.
4. I can further demonstrate my understanding of the relationship between ramp incline, ramp length, and acceleration rate through the construction of three different graphs (position vs time, velocity vs. time, and acceleration vs time) from data gathered through experimentation on my ramp.
5. I can apply my knowledge relating to the safety regulations and general restrictions in the construction of my ramp.

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| **Activity Guiding Questions:** |

1. What can cause the velocity to change given that the ramp length remains the same?
2. Does the mass of the object affect its velocity?
3. How does the angle / incline of a ramp affect its rate of acceleration?
4. How does the length of a ramp affect its rate of acceleration?
5. What restrictions exist for different types of ramps?
6. In relation to ramps, how is form related to function?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

(ONLS)

* Science Inquiry and Application:
  + Identify questions and concepts that guide scientific investigations;
  + Design and conduct scientific investigations
  + Use technology and mathematics to improve investigations and communications;
  + Formulate and revise explanations and models using logic and evidence (critical thinking);
  + Recognize and analyze explanations and models; and
  + Communicate and support a scientific argument.
* Motion Graphs:
  + Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph.
  + Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects.
* Position vs. time graph:
  + Increasing in speed, slope becomes steeper; Decreasing in speed become less steep.
* Velocity vs. time graph:
  + The slope indicates the acceleration:
    - Increasing in speed, slope away from the x-axis; decreasing in speed, slope toward the x-axis.
    - Straight line (not necessarily horizontal): acceleration is constant.
    - Acceleration is positive for objects speeding up in a positive direction or objects slowing down in a negative direction.
    - Acceleration is negative for objects slowing down in a positive direction or speeding up in a negative direction.
* Acceleration vs. time graph:
  + Objects moving with uniform acceleration will have a horizontal line on this graph.
    - This line will be at the x-axis for objects that are either standing still or moving with constant velocity.
  + The area under the curve gives the change in velocity for the object.

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

* Various supplies for ramp model construction
* Graph paper
* Metric measuring devices
* Stop watches

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| **Teacher Advance Preparation:** |

* Gathering supplies and tools needed for ramp construction
* Research school policies on safety that may affect the challenge

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| **Activity Procedures:** |

**Day 1 –** (50 minutes):

1. Put the students into groups of 3-4 students (or allow them to select their own groups…use your discretion based off of the range of abilities in your class). Remind them of the challenge (it is a good idea to have the challenge posted clearly on the board).

**Challenge:** Select a real life location for a needed ramp. Make a proposal for your ramp that you will present to the rest of the class. Your proposal needs to include a sketch or labeled diagram with measurements, a detailed description, justification for your ramp length and incline (using experimental data), and 3 graphs (position vs time, velocity vs. time, and acceleration vs time).

1. Students will identify and define the details of an existing ramp that they believe needs modified, or a location that they believe needs to have a ramp implemented. Students will define the type of ramp that they want to implement or redesign.
2. Students will research both the specific location (dimensions and regulations of the area) and the type of ramp that they plan to propose. Important components that they will need to focus on include safety regulations, desired function of the ramp (and the necessary design to allow this function), and pros and cons of existing designs.
3. Each student will sketch out one design for their group’s ramp, complete with dimensions and instructions. Students may use a digital program (such as SketchUp) or pencil and paper.
4. Various supplies will be made available already, however students may bring in additional supplies and / or submit a list of requested supplies to build their prototype / model to the teacher. The teacher maintains the right to deny any requests due to safety or cost reasons. (Based on teacher discretion).

**Day 2 –** (50 minutes):

1. Students will continue to work on their challenges.
2. The group will build their prototype and run the appropriate tests to collect the data needed to build the following three graphs and justify the efficiency of their ramp (position vs time, velocity vs. time, and acceleration vs time).
3. Within each group, students will share their ramp ideas and for each design, as a group, the students will list two pros and two cons.
4. The group will discuss the designs and incorporate the best components of each to work as a group and design the most efficient ramp for their selected location and function.

**Day 3 –** (50 minutes):

1. Students will continue to work on their challenges.
2. About 15 minutes into the class, pause all of the groups and have them pair up with another group for their half-way checkpoint.
   1. Students will share their progress thus far with another group (they will use this as a “dress rehearsal” for their final presentation) for feedback.
   2. The teacher should also observe these presentations and use it as a formative assessment.
   3. The groups will then use the feedback they receive to make modifications to improve their ramps and / or the clarity of their presentation. (This is the iterative portion of the EDP).
3. Utilizing the feedback received from their peers as well as their own self-reflections on their product / proposal thus far, each group will refine their proposal and make necessary adjustments to maximize the efficiency of their ramp.
4. From these adjustments and redesign, the groups will each rebuild / alter their ramp prototype and add their new data to their existing three graphs.

**Day 4 –** (50 minutes):

1. Give students about 5 - 10 minutes to review their proposals and make any last minute plans for their presentations.
2. Students will present their final proposals to their peers and to the teacher.
3. When students are not presenting, they will observe closely and record the title of each other group’s proposal, one suggestion for improvement, one positive comment, and one question. (It may be helpful to write these requirements on the board).
4. End the class with a class discussion about acceleration, velocity, different ramps, and the three different types of graphs constructed in this challenge. Revisit any of the graphs that students appeared to struggle with in their proposals. Be sure to collect these comment / question sheets from the students as well.
5. Administer the post-test and collect it for assessment.
6. If possible, depending on the location of the ramp design, students can make refinements to their ramp designs and arrange to present their proposals to the appropriate audience responsible for making judgment calls for the specific location.

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

* Identification of ramp need / remodel and accompanying sketches
* Prototype
* Half-way checkpoint of peer practice presentations (teacher observations)
* Prototype refinements after checkpoint

**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.

* Evaluation of the Ramp Proposal with accompanying graphs

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

* Student ability levels will be taken into account when grouping students.
* Visual learners’ needs will be met through writing questions / notes on the board. Also, multiple class discussions will take place as additional support for auditory learners. Kinesthetic learners needs will be addressed through the hand-on activities with the challenge.
* Additional modifications will be made as I get to know my students, prior to teaching the lesson.

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

1. **APPENDIX II: UNIT TEMPLATE OF TEACHER : BOB LEUGERS**

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| **Name: Bob Leugers** | **Contact Info: SCPA** | **Date:7/29/2014** |

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| **Unit Number and Title: Systems That Serve People** |

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| **Grade Level:** | 9 |

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| **Subject Area:** | Geometry |

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| **Total Estimated Duration of Entire Unit:** | 10 – 42 minute bells |

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| **Unit Summary** |

The Big Idea (including global relevance): Wait Time

We spend a lot of time in efforts that are unproductive because we are waiting to be served. The overall amount of time spent waiting by all humans is enormous. According to a Texas A&M report in 2011 "congestion caused urban Americans to travel 5.5 billion hours more and to purchase an extra 2.9 billion gallons of fuel." If each person in the world could reduce the amount of time spent waiting it might be comparable to adding extra days to each year or increasing the productivity of nearly every human being.

The Essential Question:

Productivity - What variables impact wait time and how can they be manipulated to reduce customer wait time? The students, through watching the videos should clearly see that wait time is an enormous issue that all of us endure. If they don’t immediately see it, there will be questions that will guide them to the big idea.

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| **Unit Context** |

Justification for Selection of Content:

The high school students require a great deal of guidance to look at a real world situation and think that it can be modeled using mathematical equations or inequalities. Through teacher experience, word problems have been identified as particularly nettlesome for the high school math student. Furthermore, they struggle to understand the impact that changing one variable has on the value of another variable. Finally, when faced with a written scenario, students struggle to identify the question, the variables associated with the problem and how to formulate a mathematical expression that reflects the description. This unit will help students recognize key variables and contemplate the impact changes to that variable has on wait time.

For this challenge, students are expected to identify a host of variables from a short verbal phrase, like “traffic jam”. Following this, they are expected to rank the importance of the variables and then define those most important. The individual components within the challenge can be modelled mathematically. All of these activities can be accomplished in a Socratic and non-judgmental manner. Since these steps are open ended and virtually any answer acceptable, students will be more willing to participate.

The Challenge:

Have students staff a fast food kitchen that will serve 60 customers in a 15 minute period with no one having to wait more than 5 minutes.  We want to minimize the amount of staff required to provide this level of service.  For simplicity, we assume that the arrival time of the customers is evenly distributed.

Additional information regarding how long it takes to cook a hamburger or to take a customer order will be found by the students via web searches.

Each customer is going to order 2 hamburgers, fries and a drink and every other customer sits in the restaurant at a separate table for 10 minutes while they eat. The other customers will carry their meal outside. Assume there are an unlimited number of tables to seat customers in the restaurant.

Each students will act as a single employee as they mimic the job roles and therefore, the number of “employees” is limited to the number of students in each group and the limit of 15 minutes for customer orders is to enable students to simulate the activity multiple times in a single class session.

Below is information that the students will need to identify and calculate on their own with as little help from the teacher as possible.

H- # of hamburgers = 2 hamburgers \* 4 customers/min = 12 hamburgers per minute.

F - # of fries = 6 customers/min = 4 fries/min

D - # of drinks = 6 customers/min = 4 drinks/min

C- # of cooks each of which can cook 6 hamburgers every 2.5 minutes and 10 fries every 4 minutes

S- # of customer service (cash register) personnel, each can take 1 order every 2 minutes and get 1 drink in 15 seconds or can clean 3 tables in 5 minutes.

This is information that the students should glean from websites in their research of the problem. Once these numbers are found by students, the rates above will be used by all to ensure consistent results.

The Hook:

Make students wait for me in the hall as I perform some task. Show video of people waiting for iPhone 5s release. Show students video of Disneyland-Paris waiting line. Show students video of 100km traffic jam in Beijing. This will get them in the frame of mind of all the places that people waste time waiting.

Do I get this out of this section??? Show students a video of customers in a restaurant waiting to get their food and Chef Ramsay getting mad.

A simple traffic simulation applet will be used to allow students to set specific parameters for highway entrance ramps to see how those parameters affect traffic congestion. Students will fix 6 variables at established values and alter two variables to collect data regarding the impact on congestion. Each group will have different parameters to adjust. Each will present their findings.

<http://www.traffic-simulation.de/>

The same simple simulation applet will be used by the groups but in this iteration, all groups will have the same two parameters fixed and the remaining six will be adjusted to achieve a queue on the ramp of 4 or less cars after 2 minutes.

Teacher’s Guiding Questions:

Can you give examples of places or times when you have to wait?

What is your definition of wait time?

What does it mean to be productive?

Can productivity be measured?

What factors affect wait time?

How can we categorize the factors?

What factors are most important?

What is the impact of each factor on wait time?

Can some of these factors be eliminated or their impact reduced? How?

How can the “suffering” of waiting be reduced?

If workers are less productive, what impact does this have on sales? On profits?

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

Application - Customer Service Models are based on probabilities of customer’s arrival and departure. Employers are using data collected from the previous few hours, prior days… to try to match customer demand with customer service personnel. Employees in customer service jobs are having to call in to find out whether they should report to work – many employees don’t have set schedules or work fewer hours than a schedule might indicate. Valvoline Oil Change stations are an example where this strategy is used to keep down labor costs at the expense of their employees. The application of queuing theory is applied to almost every large company involved in customer service operations. Think about all of the call centers handling customer service issues.

Career – Industrial engineering is the scientific field that specializes in applied queueing theory along with reducing wait-times in a manufacturing or service environment. Industrial engineers are well paid with a median annual income of $78,860.

Societal - The “cost” of people waiting is not typically measured in dollars but value can be assigned to each minute of a person’s life and this would lead to the cost of waiting. The dollar amount could be staggering for the entire human population and would likely add days to each year. If this time could be transformed into productive efforts, it could grow economies greatly.

Engineering Design Process (EDP):

**Identify Problem:** Students identify wait time and specifically traffic congestion as a major social issue.

**Gather Information:** Students use the web to research the factors associated with customer service.

**Identify Alternatives:** Students identify factors that are fixed (items on the menu, how long it takes to cook a burger…) and those that are variable (number of cooks, number of cashiers…) and learn that the alternatives can only be found by manipulating the variables.

**Select Best Solution:** Students attempt to model the fast-food restaurant by beginning with a certain number of cooks and cashiers.

**Implement Solution & Evaluate/Test:** They begin the simulation with those number of cashiers and cooks and attempt to simulate the restaurant model keeping track of customer wait times.

**Refine:** Should the simulation fail to give the desired results, students will alter the number of cashiers and cooks.

**Do it again:** The simulation will be run using the new number of cooks and number of cashiers.

**Communicate:** The students will report to the teacher and the class how they achieved their goal.

| **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. |
| ☒ 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 **®** |
| ☐ Recalling Accurate Science **®** |

| **Common Core State Standards – Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| ☒ Make sense of problems and persevere in solving them | ☒ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☒ Attendto 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 |

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

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| **Unit Lessons and Activities:** (Link here.) |

Lesson 1:

Activity 1: Show videos of various situations where people wait as a hook. The students will be asked a series of questions to identify the big idea as wait time. We’ll follow this with questions that get at the factors that influence wait time without regard for a specific situation. Essential question formulation: Ask students what specifically about each situation caused them to wait. I expect students to respond with “there were too many people”, “the rides at Disney can only handle…”, “the supply of iPhones was too few”, “people wanted to be the first”.

Activity 2: The students will then be directed to focus on traffic wait time & identify specific variables associated with traffic congestion. Students then will use a highway traffic simulator program to alter factors associated with congestion and identify the impact those factors have.

Lesson 2:

Activity 3: Show video specifically related to restaurants to focus students on a new problem related to wait time. Students will work to identify factors related with customer wait times in restaurants.

Activity 4: Groups of students will be given the final challenge of having to serve 60 customers in a 15 minute period with no more than 5 minute wait time but with a menu of cheeseburgers, fries and a drink.

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| **Where the CBL and EDP appear in the Unit: (Please provide the Lesson #’s and Activity #’s)** |

**Lesson 2, Activities 1 & 2:**

Each of the steps involved in CBL and EDP are incorporated into the final lesson of the unit.

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| **Background Knowledge:** |

Simple understanding of traffic and restaurants

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| **Misconceptions:** |

Students enter the classroom thinking that customer service models are very simple until they begin identifying all of the factors that affect wait time. Some of these factors can be changed but many would be very difficult.

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| **Additional Resources:** |

Timers and manipulatives to model the orders being taken and orders being filled.

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| **Pre-Unit Assessment Instrument: (Link it here.)** |

**Unit Assessment – Fast Food.docx**

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| **Post-Unit Assessment Instrument: (Link it here.)** |

**Unit Assessment – Fast Food.docx**

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

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| **How to Make This a Hierarchical Unit: (Check one of the following.)**   Middle School Unit ☐x High School Unit  **Refer to the Unit Template Description. Complete A or B below, whichever is applicable.** |

This unit could easily be adapted to an 11th grade math class where they would be expected to come up with a set of inequality statements to show the set of constraints related to how long it takes to take an order, cook a hamburger or clean a table. Using Excel, they could use the optimizer to find the least number of employees needed.

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| **Poster:** Link document. |

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| **Video:** Link Video. |

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| **Reflection:** Reflect upon the successes and shortcomings of the unit. Refer to the questions posed on the Unit Template Description sheet. |

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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/29/14** |

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| **Lesson Title : Life in the Fast Lane** | **Unit #: 1** | **Lesson #: 1** | **Activity #: 1** |
| **Activity Title: What causes traffic congestion** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Geometry class made up of mostly freshman students after using CBL and a shortened version Of EDP to look at a problem and try to arrive at a reasonable solution.** |

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| **Activity Objectives: Use CBL & EDP to identify variables associated with highway traffic congestion and rank their importance.** |

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| **Activity Guiding Questions: What causes highway congestion? Can these causes be put into a set of categories? Which are most influential in causing traffic congestion?** |

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

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

Pretest

Waiting for the iPhone 5s: <https://www.youtube.com/watch?v=rRwcIumf-mI>

Waiting in line at Paris Disneyland: <https://www.youtube.com/watch?v=2y4fvzJC_Mw>

100km Traffic Jam: <https://www.youtube.com/watch?v=iKhsPO6yYko>

PowerPoint with links to the above sites and other guiding material.

5 copies per class of the *Handout Factors 3 Column Worksheet*

Raffle tickets

Candy or other rewards

Popsicle Sticks with Colored Ends

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| **Teacher Advance Preparation:** |

Have strategies for grouping planned. For instance, to group by threes, I will have students select from a can of Popsicle sticks where there are three orange, three blue… There will then be an orange team, a blue team…The students can’t see the color when they choose so the groupings will be random. I will use a deck of card for groups of 4.

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| **Activity Procedures:** |

Give Pretest the day before Lesson 1 begins.

First, make students wait in the hall as I record the color of their eyes, hair and shirt. Then, open “Lesson 1.1.1 – Life in the Fast Lane PowerPoint. Show iPhone 5s video, followed by Disney – Paris video, followed by 100km traffic jam video. These are all linked in the PowerPoint. Now ask the students what is the theme of the three videos. They should be able to guess wait time. Ask students to take a minute to define wait time without using the word. Call on students for sharing their definition. Give a raffle ticket to those students that volunteer answers.

Use Popsicle sticks with colored ends to group students by threes. Have students take turns writing on a paper places where they have had to stand in line waiting. Call on students for sharing one item on their list. Give a raffle ticket to those students that volunteer answers.

Essential question formulation: Ask students what specifically about each situation caused them to wait. I expect students to respond with “there were too many people”, “the rides at Disney can only handle…”, “the supply of iPhones was too few”, “people wanted to be the first”.

Tell the students that their resume was received by a job recruiter that represents a fantastic company that wants to remain anonymous for now. They plan to open a new location in Cincinnati and need to hire someone to be responsible for customer service. The job salary is very high so you are definitely interested. They loved your resume and your personality really came through in the resume and cover letter you sent. They have a little bit of concern about your lack of experience with customer service but feel that you a quick learner. They are going to interview you in one hour. Your job is to come up with a list of questions you can ask the interviewer to show that you understand the issues involved in customer wait times. Your first question will be “how big is the new location going to be when it opens?” List as many additional questions as you can in the next ten minutes. Note: this is not a research based exercise. These questions will be shared with the class and reduced to some essential questions for the broad category of wait time. Lesson 2 will have students repeat this process

Narrow the discussion to talk about highway traffic jams by projecting slide that lists the amount of time and gas wasted in the U.S. on traffic congestion. Ask students if they have ever read the poem The Highwayman by Noyes. Discuss a little of the history of highways. Have each person make a list of factors that would influence drive times on the highway. Have students make a combined list on the 3 Column Factors Sheet in their group. See if the groups might come up with others. Call on students to share a single factor – give raffle ticket to those that share.

Have students work in their groups to rank their factors in order of biggest influence to least influential. Allow them to do research at this point to find other factors that should be included. Call on students to share their top factors. Have a student act as class recorder and keep a list of factors on the projection screen. Divide the projected list into three and assign one member from each group to a part of the list. Have each person write the factor, how it can be changed and what the effect of that change would be on highway traffic. Have each student share within their group, the factor and how they think it might change highway traffic flow.

Have a drawing of 5 raffle tickets. Each person whose ticket was drawn gets to choose from the candy jar.

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

The Factors 3 Column Sheet will be collected.

**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.

NA

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

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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/21/2014** |

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| **Lesson Title : Life in the Fast Lane** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **1** | **Worksheet:**  **a** |
| **Activity Title: Slow Down You Move Too Fast** |
| **Worksheet Title:** |

Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| Factors | Rank the Factors | Describe how changes to one factor 🡺 changes |
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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/29/14** |

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| **Lesson Title : Life in the Fast Lane** | **Unit #: 1** | **Lesson #: 1** | **Activity #: 2** |
| **Activity Title: Traffic Simulation** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Geometry class made up of mostly freshman students after using CBL and a shortened version Of EDP to look at a problem and try to arrive at a reasonable solution.** |

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| **Activity Objectives:** |

Use CBL & EDP to adjust previously identified variables associated with highway traffic congestion and determine the effect that each variable has on highway congestion. Furthermore, they will communicate the effects to the entire class.

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| **Activity Guiding Questions:** |

Is there a way that we investigate individual variables to understand how they influence congestion? How can we use that information to formulate a solution to how to reduce congestion? What is the best way to present the information gathered?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

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

Traffic Simulation website: [www.traffic\_simulation.de](http://www.traffic_simulation.de)

Powerpoint with links to the above sites and other guiding material.

An Activity 2 Data Collection Worksheet for each student.

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| **Teacher Advance Preparation:** |

Schedule time in the computer lab for students.

Make sure traffic simulation software will run since it is an unsigned Java app and therefore requires that the security settings of the browser must be set low and Java must be able to run.

Have strategies for grouping planned.

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| **Activity Procedures:** |

Project the website [www.traffic-simulation.de](http://www.traffic-simulation.de) onto the projection screen.

Assign students to new groups of two (or 3: need 10 groups). Have each group draw one variable from a hat with no replacement. Have students put the variables back into the hat and draw a second variable without replacement (make sure no one gets the same variable as their first draw.

Give the students the values to set for the initial factor settings. Tell them they can change the initial value of only the variable they are investigating at that moment. Give the students the rest of the bell to complete the Activity 2 Data Collection Worksheet. On it, they will record the two factors they will investigate by manipulating the value of one factor at a time and recording the number of vehicles on the ramp after one minute.

They will graph the data they collected and then they will write a short paragraph describing the meaning of the factor (this may require them to search the web for its meaning) and how changing the value of that variable affects traffic. Students will present their findings to the class as a whole.

In these same groups, students will be required to manipulate all variables except, highway inflow and ramp inflow to achieve a maximum ramp queue length of 4 cars after 2 minutes of simulation. They will record their results on a new copy of the data collection worksheet. The first team to achieve the goal will get two raffle tickets each and subsequent teams will get one ticket each. A raffle will be held with the 5 tickets chosen at random will be given prizes.

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

The Activity 2 Data Collection Worksheet will be collected.

**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.

NA

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

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

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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/21/2014** |

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| --- | --- | --- | --- | --- |
| **Lesson Title : Life in the Fast Lane** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** | **Worksheet:**  **a** |
| **Activity Title: Traffic Simulation** |
| **Worksheet Title:** |

Names \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Lesson 1 Activity 2b

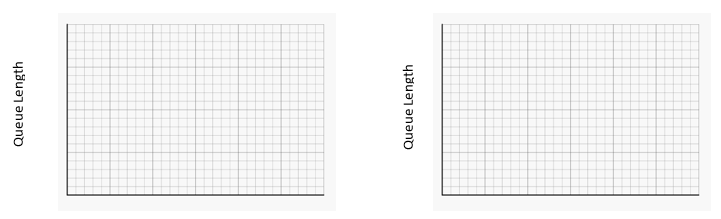
Fixed Variables:

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| Factor 1 Value | Queue Length @ 1 minute |  | Factor 2 Value | Queue Length @ 1 minute |
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Graph the 10 data points – one graph for each factor. Make sure you label the graph.



Describe in complete sentences how each variable was altered and what effect that change had on the overall queue length on the highway ramp.



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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/29/14** |

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| **Lesson Title : Reading Between the Lines** | **Unit #: 1** | **Lesson #: 2** | **Activity #: 3** |
| **Activity Title: The Wait Game** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **2 days** |

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| --- | --- |
| **Setting:** | **Geometry class made up of mostly freshman students after using CBL and a shortened version of EDP to look at a problem and try to arrive at a reasonable solution.** |

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| **Activity Objectives:** |

Use CBL & EDP to identify variables associated with serving food quickly at a fast food restaurant. Students should rank the most important factors and then predict how changes to these factors might impact customer service. Students will also attempt to simulate the operation of a fast food restaurant using timers and fake hamburgers.

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| **Activity Guiding Questions:** |

Describe the last time you went to a fast-food restaurant. How was the service? What made the service good or bad? What factors affect wait time? Are there some common themes or categories we could use for these factors? What happens if Dierdre stops to text her friend while she’s taking orders? Does this have a parallel to traffic on the highway? Is there a way that we can investigate individual variables to understand how they influence congestion? How can we use that information to formulate a solution to how to reduce congestion? What is the best way to present the information gathered?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

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

Chef Ramsey ranting about poor customer service. <https://www.youtube.com/watch?v=Vi3OnMJ-yO0>

John Belushi movie at Olympia restaurant. <https://screen.yahoo.com/olympia-restaurant-000000640.html>

PowerPoint with links to the above sites and other guiding material.

Manipulatives to mimic a hamburger, fries, drink

2 Data Collections Worksheet for each student.

4 timers per group

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| **Teacher Advance Preparation:** |

Have strategies for grouping planned.

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| **Activity Procedures:** |

Show Chef Ramsey video followed by John Belushi video. Ask class how these videos are similar and different from the Disneyland, iPhone and 100km traffic jam. Ask who works in a fast-food restaurant? Have a student describe their experience with relation to the videos just shown.

To brainstorm for the challenge, create new groups of 2 students by having students pick cards from a deck with the 2 of hearts and 2 of diamonds being a pair, etc. Have students come up with 3 factors related to good service at a fast-food restaurant. Have pairs of students, come up with a list of 10 factors associated with good service. The teacher will ask for volunteers to offer one factor. The volunteer will get a raffle ticket and the factor written on the board. Students will work in these pairs to define each factor and how changing that factor influences customer wait time.

Ask students if they’ve used their phone at work or been waiting while an employee is busy with their phone. Ask how many have called in sick to work?

To identify essential questions, ask the students what information they would need to know to ensure customers at their restaurant received good service. Likely, a student will say they need adequate staffing, but force them to dig deeper by asking whether they can quantify the number – lead them to recognize the need to know how long it takes to make a hamburger, take an order, dispense a drink or make fries. Ask students how they might simulate a fast food restaurant. Could they use manipulatives?

Have students form groups of 4 by combining all 2’s, all 3’s… Give the groups a simplified challenge. Staff a fast-food restaurant with the fewest people possible to handle 60 customers in 15 minutes where everyone orders a single cheeseburger. The constraint is that no one can wait longer than 5 minutes for their food. They will use the Lesson 1 Activity 1 data collection worksheet to record their results.

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

The Lesson 2 Activity 1 Data Collection Worksheet will be collected.

**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.

NA

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

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

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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/21/2014** |

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| **Lesson Title : Reading Between the Lines** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **3** | **Worksheet:**  **a** |
| **Activity Title: The Wait Game** |
| **Worksheet Title:** |

Names \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Lesson 2 Activity 2a

Number of Cashiers \_\_\_\_\_\_\_ Number of Cooks \_\_\_\_\_\_\_ Number of Runners \_\_\_\_\_\_\_

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| Time | # of Customers Waiting | Longest Wait Time |
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Number of Cashiers \_\_\_\_\_\_\_ Number of Cooks \_\_\_\_\_\_\_ Number of Runners \_\_\_\_\_\_\_

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| Time | # of Customers Waiting | Longest Wait Time |
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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/29/14** |

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| **Lesson Title : Reading Between the Lines** | **Unit #: 1** | **Lesson #: 2** | **Activity #: 4** |
| **Activity Title: Serve Em Up** |

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| **Estimated Lesson Duration:** | **4 days** |
| **Estimated Activity Duration:** | **2 days** |

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| **Setting:** | **Geometry class made up of mostly freshman students after using CBL and a shortened version of EDP to look at a problem and try to arrive at a reasonable solution.** |

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| **Activity Objectives:** |

Use CBL & EDP to identify variables associated with serving food quickly at a fast food restaurant. Students should rank the most important factors and then predict how changes to these factors might impact customer service. Students will also attempt to simulate the operation of a fast food restaurant using timers and fake hamburgers.

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| **Activity Guiding Questions:** |

This activity is identical to Activity 3 but where customers are ordering a variety of menu items. Instead of just serving cheeseburgers, they have to serve French fries and Pepsi as well. The guiding questions for this came primarily in activity 3. Additional questions will come when they present their results to the class from Activity 3. What were the bottlenecks in activity 3? How could you overcome those bottlenecks in a perfect world where anything could be done (lead students to: incr. productivity, more grills & cooks, more cash registers, more tables in the restaurant…)?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

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

Manipulatives to mimic a hamburger, fries, drink

2 Data Collections Worksheet for each student.

4 timers per group

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| **Teacher Advance Preparation:** |

Have strategies for grouping planned.

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| **Activity Procedures:** |

Remind students of the challenge yesterday where only cheeseburgers were served. Ask what the bottlenecks were? What other challenges did you face? Can you alter the way you simulate taking orders, cooking, packing the orders…?

Have students work in the same groups of 4 students to work on the following challenge: Staff a fast-food restaurant with the fewest people possible to handle 60 customers in 15 minutes where everyone orders a single cheeseburger, fries and a Pepsi. The constraint is that no one can wait longer than 5 minutes for their food. They will use the Lesson 1 Activity 1 data collection worksheet to record their results.

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

The Lesson 2 Activity 1 Data Collection Worksheet will be collected.

**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.

NA

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

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

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| **Name: Bob Leugers** | **Contact Info: SCPA, Cincinnati Public** | **Date: 7/21/2014** |

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| **Lesson Title : Reading Between the Lines** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** | **Worksheet:**  **a** |
| **Activity Title: Serve Em Up** |
| **Worksheet Title:** |

Names \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Lesson 2 Activity 2a

Number of Cashiers \_\_\_\_\_\_\_ Number of Cooks \_\_\_\_\_\_\_ Number of Runners \_\_\_\_\_\_\_

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| Time | # of Customers Waiting | Longest Wait Time |
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Number of Cashiers \_\_\_\_\_\_\_ Number of Cooks \_\_\_\_\_\_\_ Number of Runners \_\_\_\_\_\_\_

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| Time | # of Customers Waiting | Longest Wait Time |
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1. **APPENDIX III: UNIT TEMPLATE OF TEACHER : JOANNE VAKIL**

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| **Name: Joanne Baltazar Vakil** | **Contact Info: jvakil@dis4u.org** | **Date: 7/28/14** |

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| **Unit Number and Title:**  **Stop and Go: Designing an Efficient Route to Help Reduce Gas Consumption** |

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| **Grade Level:** | 8 |

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| **Subject Area:** | Math and Science |

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| **Total Estimated Duration of Entire Unit:** | 13- 14 hours, approximately 2 weeks of 80 minute periods |

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| **Unit Summary** |

The Big Idea: Force, Motion, and Math’s Impact on Traffic Management

With the United States using approximately half of the world’s gasoline, it is imperative that we address how we can start changing our habits of gas consumption. According to the U.S. Energy Information Administration, about 134.51 billion gallons of gasoline were consumed in the United States. Idling in traffic alone utilizes over 8 million gallons of gasoline per day, which is equivalent to a 25 acre lake of gas. In this unit, students will review Common Core math statistics standards and learn concepts of forces and motion, specifically, that forces between objects act when the objects are in direct contact or when they are not touching, while exploring the impact of traffic management on their local and global community.

The Essential Question:

What is the most efficient and optimal route for cars to travel in a congested area?

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| **Unit Context** |

Justification for Selection of Content:

Physical Science, specifically forces and motion, is a major portion of the science standards for this grade level. The target of the lessons, however, are towards the math standards. Upon analyzing students’ sample work and chapter assessments over the past two years of teaching Common Core State Standards, there exists a pattern of student difficulty in grasping Domain 5 of Statistics and Probability. Specifically, for Grade 7, rigorous topics of sampling, mean and mean absolute deviation, making comparative inferences about two populations, and simulations are addressed. Emphasis on the mathematics of traffic management will allow eighth grade students an opportunity to review these concepts they may have not retained from last year.

The Challenge:

The students will design a model for a safe and efficient route for drivers to take when entering a specific, congested area in town. Students will take into account the variables of speed, number of entrance ways, placement of lights or signs, wait time, accident counts, reaction time, and driver behavior. The constraints will include the following: a designated intersection (agreed upon by the teacher and students), a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), a maximum of six entrance ways into the congested area, and the amount of allowable gas emission (if applicable, to be determined).

The Hook: Have any of you driven on Ohio 235 and 41 over the summer? Clark County is currently constructing a first-of-its kind roundabout. The project will cost $1.1 million. What dangerous intersection problems and driving habits led to the approval of this particular type of traffic management plan? How does it compare to the 17 traffic circles located in Dublin, Ohio? Does our city of Beavercreek need a roundabout? What impact would roundabouts have on our traffic and what positive or negative effects would it have on our nation’s gas consumption? These are the questions students will be discussing on the first day. Visuals such as photos and new articles will be presented to the class. Students will have a chance to walk around four posters laid out on tables and briefly write about some of their pre-knowledge on traffic and gas consumption, as well as their own experiences with time, speed, and traffic. A guest speaker, either a civil engineer or a police officer, will be scheduled to talk to the class about traffic issues. As a back-up, students will view online clips of police officers directing traffic manually on busy intersections and a clip of how a roundabout operates.

Teacher’s Guiding Questions:

How do cars move around in traffic?

What is the difference between a roundabout, an intersection with a stop sign or a traffic light?

What are the pros and cons to using these? When is each system best used?

How fast can vehicles travel on each type of system?

How exactly does a stop sign and traffic signal work?

What is the definition of a safe intersection?

How can we find out information about crash rates?

How do crash rates compare before and after a traffic management system is constructed?

Who collects this type of information?

Who oversees traffic management?

How can we compare this data?

How can we graph this data?

How can we compare crash rates before a traffic system is constructed with crash rates after a

system is constructed?

What is reaction time?

What is a stimulus? What parts of the body are involved with reaction time?

What are some naturally occurring reaction times?

What are some reaction times that can be improved with practice?

How can reaction time affect drivers?

Where does gasoline come from? What is gas consumption?  
 Why is the topic of gas consumption important?

What are ways drivers can reduce gas consumption?

How will reducing gas consumption help our community? How will it help our world?

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

**A**= Students will deliver an awareness campaign on the current global gas consumption problems

and convey the steps families can take to help contribute to reducing gas consumption.

**C**= Career connections to civil, environmental, petroleum, transportation and mechanical design

engineering; Students may also consider a future as an inventor or industrial or governmental

mathematician.

**S**= Students will learn about the environmental impact of gas consumption. Upon research students

will realize the geographical and political aspects of gasoline production and consumption, as well

as its scientific effects on the planet.

Engineering Design Process (EDP):

The problem students will need to define is how to construct the most efficient and safe type of traffic management system for a particular area of heavy traffic (to be determined in class). Students will do background research on the various types of management (roundabout, intersections with a stop sign or traffic light), understand how these best operate, and also investigate the importance of simulations. The teacher and class will specify the requirements of the traffic area (the constraints mentioned above Challenge section) and brainstorm which method might operate most efficiently and safely. They will then design a human model (using students as cars) method to simulate a busy traffic intersection. Within this model, the students will test out the three different systems. After analyzing data, the students will choose which might be the best solution to the problem. They will develop a better solution using this type of system and establish a traffic management prototype. Students will test this on a human scale and if time permits, a small-scale (battery-operated vehicle) model to see if it works efficiently and safely. They will then redesign the prototype system to maximize efficiency and safety.

| **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. |
| ☒ 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 | ☐ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☒ Attendto 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 |

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

Forces have magnitude and direction. (PS8. 2 ONLS)

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

Simulations 7.SP.8.c

Investigate patterns of association in bivariate data 8.SP.A.1, 8.SP.A.2, 8.SP.A.3, 8.SP.A.4

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| **Unit Lessons and Activities:** |

Hook

1. Presentation of news article clips and photos of local and in-state construction of roundabouts.
2. Four poster papers will be set up on the tables. Using markers, students will take turns writing down their pre-knowledge and brainstorming ideas to the following questions:
3. Name places where you and your family have been stuck in traffic. How long did you wait? What other problems were associated with it?
4. What are some ways traffic is controlled?
5. How is Math related to traffic?
6. Why is it important to use our gas resources wisely? How can this be done?
7. If possible, a guest speaker will come in to talk about traffic management, specifically about using hand signaling during emergencies or other times when traffic lights are not operating. (As an extension, or challenge, students will be encouraged to research proper hand signaling for bicyclists and a general review of rules for bicyclists.)
8. A pre-test assessment will be given.

Lesson One-

Activity 1- **Data Day**:

Hook activity to be done first. Then, students will begin group and individual research on

different traffic management systems. Students will analyze data from different sources and

compare accident counts and other measures of impact of traffic lights or roundabouts

before and after installation. Students can find measures of central tendency, as well as

percent increase and decrease statistics.

Activity 2- **Guzzling Gas**: Students will investigate essential questions about gas and how its

consumption impacts society. Students will develop a survey to distribute to parents and

teachers at the school. The survey will ask questions about their knowledge of gas

consumption, as well as specific questions such as which vehicles they drive and how

many hours they commute. Once all of the surveys are collected, students will again

calculate measures of central tendency and design a way promote awareness for

families in the school to reduce gas consumption.

Lesson Two

Activity 3- **Don’t Overreact: Reaction Time and Other Driver Behavior Issues on the Road**:

Students will have a partner and work on the Ruler Drop Test

<http://www.education.com/science-fair/article/reaction-time/>. They will investigate if

reaction time can be measured and if it can be improved. Students will graph and

discuss their results in front of the class. As a whole group, students will discuss what

other issues might act as variables for drivers on the road. Students will consider these

when designing their challenge.

Activity 4- **Stop and Go! Design a Traffic Management System and Model**:

Students will design a simulated model of a busy intersection and test out a solution for the safest, most efficient traffic management system given a set of constraints. Prior to the car movement activity, the teacher, using model cars, will introduce concepts of force and motion and how they are applied in the context of traffic. Specifically, the teacher will address how each car’s movement has magnitude and direction and use vocabulary such as speed and velocity. The teacher will also introduce students to Newton’s laws.

Students will design the best construction for a busy intersection and model it with

“human cars” (students motioning along the intersection to represent cars). (The constraints will include the following: a designated intersection (agreed upon by the teacher and students), a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), a maximum of six entrance ways into the congested area, and the amount of allowable gas emission (if applicable, to be determined)). If time permits, students will also test out their design using a smaller scale model, battery operated vehicles (Constraints will include time, speed of cars, number of cars, and number of streets crossing intersection).

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| **Where the CBL and EDP appear in the Unit:** |

CBL and EDP will appear in Lesson 2, Activity 4 where students will determine which traffic management system method works efficiently and safely and then proceed to design a simulation which will test that system’s effectiveness. Students may need to redesign the layout of the actual roundabout or intersection or change rules of the road in order to maximize efficiency and safety.

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| **Background Knowledge:** |

Students should have basic knowledge of arithmetic, multiplying, and dividing to calculate speed. It will also be helpful to distinguish between English units and SI units.

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| **Misconceptions:** |

* Students are not aware of the precision and accuracy involved with traffic signaling and traffic management.
* Students use the terms speed and velocity as synonyms.
* Only animate objects can exert a force.
* Force is a property of an object.
* An object has force and when it runs out of force, it stops moving.
* Large objects exert a greater force than small objects.
* Mass and weight are synonyms.

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| **Additional Resources:** |

Article: “Why is U.S. Oil Consumption Lower? Better Gasoline Mileage?”

<http://ourfiniteworld.com/2013/01/31/why-is-us-oil-consumption-lower-better-gasoline-mileage/>

Article: “Anti-Idling Primer”

<http://www.thehcf.org/antiidlingprimer.html>

Article: “Car Pollution Facts”

<http://www.evsroll.com/Car_pollution_facts.html>

Article: “Construction starts on first-of-its kind roundabout” Tiffany Latta, Dayton Daily News, June 30, 2014

<http://www.daytondailynews.com/news/news/transportation/construction-starts-on-first-of-its-kind-roundabou/ngTjR/>

<http://www.epa.gov/otaq/ld-hwy.htm>

<http://ci.beavercreek.oh.us/public-works-infrastructure-improvements/>

http://www.eia.gov/tools/faqs/faq.cfm?id=23&t=10

<http://safety.fhwa.dot.gov/intersection/roundabouts/>

<http://www.learners-guide.co.uk/lessons/roundabouts/>

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| **Pre-Unit Assessment Instrument:** |

Pre-Unit Assessment Instrument:

Students will individually complete a 10 question quiz (see attachment) on questions about Newton’s Laws, forces and motion, and using equations to calculate velocity, time, and distance. The math portion of the quiz will include questions on statistics, finding mean and MAD, sampling, and associations within scatterplots.

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| **Post-Unit Assessment Instrument:** |

Formative Assessment:

Using a ruler, pencil, and scissors, students will each construct red, yellow, and green circles and attach them to Popsicle sticks. These “traffic lights” will represent the student’s comfort level during the unit activities. Green would indicate that the student is on track and needs no assistance. Yellow would indicate that the student’s team is operating but has a question or needs help. A red light would indicate that the team needs assistance immediately.

Summative Assessment:

Students will individually complete a 10 question quiz (see attachment) on questions about Newton’s Laws, forces and motion, and using equations to calculate velocity, time, and distance. The math portion of the quiz will include questions on statistics, finding mean and MAD, sampling, and associations within scatterplots.

Students will also be graded as a team for both challenged based learning activities. The rubric will emphasize individual work ethic, participation in the challenge activity, and adherence to timelines (as well as adherence to the engineering design process for the final activity).

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| **Results: Evidence of Growth in Student Learning** |

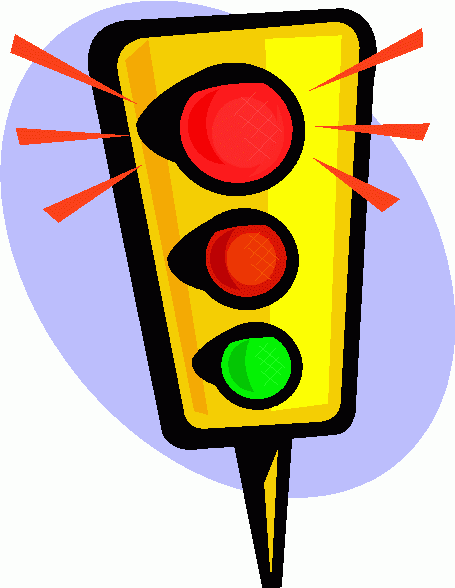
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| **How to Make This a Hierarchical Unit: (Check one of the following.)**  ☒ Middle School Unit ☐ High School Unit |

This unit can be modified for a high school level physics course by having students investigate and calculate acceleration in the model. High School content on Forces, Momentum and Motion and Newton’s Laws can be explored in depth. Graphing data can feature more statistical analysis, such as data distribution and spread (interquartile range, standard deviation) (HSS.ID.A.2), interpreting differences in shape, center, and data spread (HSS.ID.A.3), and using the mean and standard deviation of a data set to fit it in to a normal distribution and to estimate population percentages (HSS.ID.A.4).

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| **Poster:** |

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| **Video:** <http://www.youtube.com/watch?v=YLQnMYKEPCI> Dancing Traffic Cop |

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| **Reflection:** |

**UNIT Pre- and Post- TEST** Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 

1. What is the difference between **speed** and **velocity**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is **acceleration**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Give an example of **Newton’s second law:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. What is **inertia**? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. When a moving car collides into a car that is not moving and pushes it in the opposite direction, what law is demonstrated? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. Given a set of data for the number of daily crashes at an intersection over a period of one week, find the **mean, median, mode, outlier, and range**: 2, 0, 0, 3, 1, 0, 4
7. Given two sets of data concerning the amount of time it takes 15 cars to move through a busy intersection, draw a graph to best represent both sets of data:

Data 1: Mid-morning 1, 3, 5, 7, 9

Data 2: Early- morning 4, 5, 5, 5, 6

1. Given the same set of data above, calculate the **mean and MAD** (mean average deviation) for each set.
2. Using the information from #7 and 8, make a **comparative** **inference** about the two **populations**.
3. Give an example of **bias**.

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| **Name: Joanne Baltazar Vakil** | **Contact Info:** [**jvakil@dis4u.org**](mailto:jvakil@dis4u.org) | **Date: 07/28/14** |

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| **Lesson Title :** Lesson 1: Data Day | **Unit #: 1** | **Lesson #:**  **1** | **Activity #:**  **1** |
| **Activity Title:** Activity 1: Determining Data Dominance |

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| **Estimated Lesson Duration:** | **240 minutes** |
| **Estimated Activity Duration:** | **120** |

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| **Setting:** | Classroom and computer lab. |

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| **Activity Objectives:**  Students will be able to:   1. Understand a car’s movement to have magnitude and direction and use vocabulary such as speed and velocity. 2. Collect data and practice organizing data into data tables 3. Find measures of central tendency (mean, median, mode, min, max, outliers, mean average deviation) within the data. 4. Graph and analyze classroom data. 5. Practice finding percent increase and decrease within the data. 6. Take into account sampling size, comparing populations, and investigating patterns of association in bivariate data. |

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| **Activity Guiding Questions:**   1. How do cars move around in traffic?   What is the difference between a roundabout, an intersection with a stop sign or a traffic light?  What are the pros and cons to using these?  When is each best used?  How fast can vehicles travel on each type of system?  How exactly does a stop sign and traffic signal work?  What is the definition of a safe intersection?   1. How can we find out information about crash rates?   Who collects this type of information?  Who oversees traffic management?  3 – 6) How do crash rates compare before and after a traffic management system is constructed? |

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

Forces have magnitude and direction.

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

Investigate Patterns of Association in Bivariate Data 8.SP.A.1

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| **Materials**: |

Laptops or computers

Pink, blue, yellow, green, white index cards

Calculators

Scrap paper/pencils

Red, green, and yellow pre-cut circles

Black pre-cut rectangle

Glue sticks

Popsicle sticks

Colored markers/pencils for entire class (red, yellow, green)

Graph paper

Rulers

Baskets or containers for each team to hold materials

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| **Teacher Advance Preparation:** |

For the hook, the teacher will need to prepare news article clips and photos of local and in-state construction of roundabouts, intersections, and installation of traffic lights (or stories on traffic lights not operating properly).

The teacher will need to reserve the computer lab and gather all materials into a basket.

If necessary, the teacher will decide ahead of time which students will work best together as a group and then designate a particular color to those particular students.

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| **Activity Procedures:** |

Hook for Day 1

1. Present news article clips and photos of local and in-state construction of roundabouts, intersections, and installation of traffic lights (or stories on traffic lights not operating properly). (10 minutes)
2. Four poster papers will be set up on the tables. Using markers, students will take turns writing down their pre-knowledge and brainstorming ideas to the following questions:
3. Name places where you and your family have been stuck in traffic. How long did you wait? What other problems were associated with it?
4. What are some ways traffic is controlled?
5. How is Math related to traffic?
6. Why is it important to use our gas resources wisely? How can this be done? (7 minutes)
7. If possible, a guest speaker will come in to talk about traffic management, specifically about using hand signaling during emergencies or other times when traffic lights are not operating. (As an extension, or challenge, students will be encouraged to research proper hand signaling for bicyclists and a general review of rules for bicyclists.) (13 minutes)
8. A pre-test assessment will be given. (10 minutes)

Day 2

1. As students enter the class, they will be directed to glue together a stop light with red, green, and yellow pre-cut circles, a black rectangular paper, Popsicle stick, and glue stick. They will be advised to use it for quiet communication to the teacher (red = needs help immediately, yellow = having trouble, needs advice, green = no problem). (3 minutes)
2. The teacher will reintroduce the Big Idea which was presented during yesterday’s Hook: Forces, Motion, and Math all have an impact on traffic management. Students will respond to this idea. The teacher will hear the responses and help construct the essential question -- What is the most efficient, and optimal route for cars to travel in a congested area? (10 minutes)
3. The teacher will then pass out a marker to each student. The marker colors will be arranged so that there will be groups of 3. To distinguish one red group from another, a circular sticker on the side of a red marker might read 1 or 2. The teacher will instruct the students to get in their groups. (3 minutes)
4. The teacher will ask students to share within their group what they feel are essential questions to the guiding question. The teacher will walk around to each group to review these essential questions and help them form more, if necessary. The teacher will explain that their task will be two-fold: First they need to find websites that will help them collect data (refer to essential questions) and second the group will need to compile written research on the notecards. Pink notecards will be designated for data on roundabouts, yellow notecards for traffic signals, green for stop signs, blue on general traffic management information, and white for extra information. (2 minutes)
5. The class will then head over to the computer lab to do their research. Students will save their calculations and notecards in a designated team basket. (22 minutes) If necessary, students will continue doing more research at home for homework.

Day 3

1. On the second day of this activity, the teacher will pass out graph paper and rulers and demonstrate on the board how to find measures of central tendency within a set of data (mean, median, mode, min, max, outliers, mean average deviation) using examples. The teacher will demonstrate how best to graph the data (scatterplot, line plot, bar graph, etc.) Students will also practice finding percent increase and decrease within the data. They will take in account sampling size, comparing populations, and investigating patterns of association in bivariate data. (15 minutes)
2. Students will then gather back into yesterday’s groups and work together in analyzing the data, determining mean, median, mode, min, max, outliers, mean average deviation and graphing the data. Each student will be responsible for completing 1/3 of the work in his/her handwriting. (25 minutes)
3. Students will save their calculations and notecards in a designated team basket.

* **Key Vocabulary** to be learned:
  + Measures of central tendency, mean, median, mode, min, max, outliers, mean average deviation, scatterplot, line plot, bar graph, percent increase, percent decrease, sampling size, populations, associations in bivariate data

**Student Instructions**

All student instructions will be oral and the following key reminders can be written on the

Blackboard: Red = I need help immediately, Yellow = I am having trouble and need advice, Green = I have no problem

Pink = data on roundabouts, Yellow = traffic signals, Green = stop signs, Blue = general

traffic management information, White = extra information.

**Formative Assessments:**

The utilization of the traffic lights will allow the teacher to assess which students need assistance with the content or tasks required.

Group classwork assignment analyzing the data, determining mean, median, mode, min, max, outliers, mean average deviation and graphing the data.

**Summative Assessments:**

Half of the questions on the post-test will assess the above math objectives.

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| **Differentiation:** |

Students with ADHD will be allowed to stand up, take water breaks, and squeeze a stress ball throughout the activity. The teacher will repeat the directions slowly to ESL students and ask if there are any questions they might have. The teacher will write key vocabulary words and their definitions on large colored cards and hang them on the wall for the students to refer to. Students with physical disabilities will be assisted with typing, writing, or calculating. Advanced students will be asked to search for additional related online websites and statistics extending the activity, in addition to making additional data analysis and calculations.

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| **Reflection:** |

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| **Name: Joanne Baltazar Vakil** | **Contact Info:** [**jvakil@dis4u.org**](mailto:jvakil@dis4u.org) | **Date: 7/24/14** |

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| **Lesson Title : Data Day** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Guzzling Gas** |

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| **Estimated Lesson Duration:** | **240 minutes** |
| **Estimated Activity Duration:** | **80 minutes** |

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| **Setting:** | **Science Lab or classroom** |

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| **Activity Objectives:** |

Students will be able to:

1. Examine the data and data analysis from the previous lesson.
2. With this and additional research, discuss and decide what will be the best questions to ask in a parent survey about gas consumption.
3. Practice organizing data into data tables
4. Design a survey, distribute it, and collect the data.
5. Tabulating measures of central tendency.
6. Analyze the data.
7. Present an awareness campaign of their findings.

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| **Activity Guiding Questions:** |

1. How can we compare this data?
2. Where does gasoline come from? What is gas consumption?  
    Why is the topic of gas consumption important?
3. – 6) How can we compare this data? How can we graph this data?
4. What are ways drivers can reduce gas consumption?

How will reducing gas consumption help our community? How will it help our world?

| **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. |
| 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 | Useappropriate tools strategically |
| Reason abstractly and quantitatively | Attendto 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 |

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

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

Simulations 7.SP.8.c

Investigate patterns of association in bivariate data 8.SP.A.1, 8.SP.A.2, 8.SP.A.3, 8.SP.A.4

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| **Materials**: |

Previous lesson’s basket of index cards and materials

ipads

rulers

posters

markers

neon yellow, pink, and blue notecards

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| **Teacher Advance Preparation:** |

Teacher will reserve ipads for classroom use.

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| **Activity Procedures:** |

**Teacher Instructions: Guiding Activity**

1. The teacher will remind the students how to use the stop signs they constructed the other day. Students will get back into their groups and bring their materials basket to the group table. (2 minutes)
2. The teacher will distribute the ipads and explain that the students’ task will be two-fold: First they need to find websites that will help them collect data (refer to guiding questions) and second the group will need to compile written research on the notecards. Neon index cards will be used for this activity. (3 minutes)
3. Students will work individually on the ipads and write down facts about gasoline (neon yellow), gas consumption (neon pink), and its environmental impact (neon blue). (10 minutes)
4. Students will then share the information they collected within their group, and put aside duplicate and unnecessary notecards. (5 minutes)
5. As a whole class, the teacher will ask each group to share one fact, writing down the facts on the board. The other groups will put aside duplicate notecards. Once all of the notecards are exhausted, the teacher will ask the students to look at the board. The teacher will reintroduce the Big Idea which was presented as the Hook: Forces, Motion, and Math all have an impact on traffic management. Students will respond to this idea and discuss, while referring to their notecards, review the essential question -- What is the most efficient, and optimal route for cars to travel in a congested area? The students will then share what they feel are the essential questions concerning the guiding question, “How can we understand how families use gas? How can we share what we just learned with people in this school? The teacher will guide students to design a survey asking parents in the school about gas consumption and ultimately designing an awareness campaign to disseminate information they learned from their survey and recent research (10 minutes)
6. Students will raise their hands and contribute a possible question for the survey. The teacher will write down the questions. When done, the students will put their heads down on their desks and do a silent vote for each question (students can vote on their favorite 5). (10 minutes)
7. The teacher will erase the least popular questions and show the students questions for the survey. (1 minute) Students will save their calculations and notecards in a designated team basket. This survey will be typed up by the teacher and students will distribute it to parents afterschool.
8. On the following day, students will view the collected surveys. (10 minutes)
9. Each group will be in charge of determining one or two of the following: mean, median, mode, min, max, outliers, mean average deviation, percent increase and decrease (if applicable), sampling size, and the populations surveyed. (10 minutes)
10. Back as a whole class, the students will share their data facts. Keeping in mind the important research facts they gathered yesterday, students will brainstorm aloud what message they should convey to parents on a poster board. They can also brainstorm different methods of campaigning (tasks) – coming up with a flyer, email, brochure, slogan and logo, a chant or rhyme, a song, a short speech, etc. Students should also consider which graph -- a scatterplot, line graph, line plot, line graph, or bar graph might be helpful to use in the campaign.(15 minutes)
11. Students will volunteer for various awareness campaign tasks. These tasks will be completed for homework. (5 minutes)
12. On the following day, the students will share tasks completed for homework and organize how best they should present this, and when, to parents, students, and teachers of the school. They will also practice their presentations. (40 minutes)
13. Upon principal approval, students will present their campaigns either before school, afterschool, or during a PTO evening meeting.

* **Key Vocabulary** to be learned:
  + Measures of central tendency, mean, median, mode, min, max, outliers, mean average deviation, scatterplot, line plot, bar graph, percent increase, percent decrease, sampling size, populations, associations in bivariate data

**Student Instructions**

All student instructions will be oral and the following key reminders can be written on the

blackboard: Red = I need help immediately, Yellow = I am having trouble and need advice, Green = I have no problem

Neon yellow = data on gasoline facts, Neon pink= gas consumption, Neon blue = gas and its environmental impact

**Formative Assessments:**

The utilization of the traffic lights will allow the teacher to assess which students need assistance with the content or tasks required. The teacher will walk around and check each student’s individually written index cards to assess that he/she is on the right track for gathering facts.

Data facts on notecards.

Tasks completed as homework assignment.

**Summative Assessments:**

Half of the questions on the post-test will assess the above math objectives.

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| **Differentiation:** |

Students with ADHD will be allowed to stand up, take water breaks, and squeeze a stress ball throughout the activity. The teacher will repeat the directions slowly to ESL students and ask if there are any questions they might have. The teacher will write key vocabulary words and their definitions on large colored cards and hang them on the wall for the students to refer to. Students with physical disabilities will be assisted with writing on the board or calculating the mean. Advanced students will be asked to find the mean average deviation for each data set (boys and girls reaction times) and share their conclusions with the class.

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| **Reflection:** |

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| **Name: Joanne Baltazar Vakil** | **Contact Info:** [**jvakil@dis4u.org**](mailto:jvakil@dis4u.org) | **Date: 7/24/14** |

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| **Lesson Title : Don’t Overreact! Reaction Time and Other Driver Behavior Issues on the Road** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **3** |
| **Activity Title: Reaction Time Lab** |

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| **Estimated Lesson Duration:** | **240 minutes** |
| **Estimated Activity Duration:** | **40 minutes** |

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| **Setting:** | **Science Lab or classroom** |

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| **Activity Objectives:** |

Students will be able to:

1. Investigate if reaction time can be measured and/or improved.
2. Practice organizing data into data tables
3. Tabulating the mean
4. Compare reaction time of boys vs. girls
5. Graph and analyze classroom data.

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| **Activity Guiding Questions:** |

1. What is reaction time? What is a stimulus? What parts of the body are involved with reaction time? What are some naturally occurring reaction times? What are some reaction times that can be improved with practice? How can reaction time affect drivers?

2 – 5) How can we compare this information?

| **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. |
| ☒ 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 | ☒ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☐ Attendto 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 |

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

Forces have magnitude and direction.

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

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| **Materials**: |

Yardsticks, stopwatches, colored sticky notes

Stoplights (prepared in previous lesson)

Students will have a worksheet of the Reaction Time Lab

<http://www.education.com/science-fair/article/reaction-time/>

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| **Teacher Advance Preparation:** |

The teacher will prepare all lab materials: yardsticks and stopwatches, worksheets of the lab

The teacher will also prepare the video clip for students to view <http://www.youtube.com/watch?v=LU8eNkZ4ZrA>

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| **Activity Procedures:** |

1. The teacher will show a clip of reaction time and driving. Students will be asked to take a few notes on key words or concepts mentioned in the video on sticky notes. <http://www.youtube.com/watch?v=LU8eNkZ4ZrA> (5 minutes)
2. The students will discuss some of the vocabulary and concepts heard in the video clip. The teacher will help then reintroduce the Big Idea which was presented as the Hook: Forces, Motion, and Math all have an impact on traffic management. Students will respond to this idea and discuss what forces are involved while driving (and stopping the car). The teacher will hear the responses and review the essential question -- What is the most efficient, and optimal route for cars to travel in a congested area? The students will then share what they feel are the essential questions concerning the guiding question, “What is reaction time?” (10 minutes)
3. The teacher will then pass out a lab worksheet to each student. The teacher will remind the students to use their stoplights during lab to communicate if they need assistance. The lab partners (pre-designated) will gather their materials for the lab, read the directions, and begin collecting data. (10 minutes)
4. The class will come back together and each student will record his/her data on the whiteboard. Students will separate the data into two categories, girls and boys. (5)
5. Each student will calculate the mean for each category. The teacher will walk around to help individual students. Students finished early can help their neighbors. (7 minutes)
6. The teacher will pass out graph paper for students to compare the mean reaction time for boys v. the mean reaction time for girls. (3 minutes)
7. The class will close by the teacher asking students to brainstorm what other reaction time factors may affect the safety and efficiency of a traffic management system. Each student will select two factors to research on (write 5 facts on a notecard with website citation) for homework to share back in class the following day. Also for homework, students will write down two sentences under the graph completed in class analyzing the data and graph.

**Formative Assessments:**

The utilization of the traffic lights will allow the teacher to assess which students need assistance with the content or tasks required.

Calculation of mean, creating a data table, graphing and analyzing data.

**Summative Assessments:**

Half of the questions on the post-test will assess the above math objectives.

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| **Differentiation:** |

Students with ADHD will be allowed to stand up, take water breaks, and squeeze a stress ball throughout the activity. The teacher will repeat the directions slowly to ESL students and ask if there are any questions they might have. The teacher will write key vocabulary words and their definitions on large colored cards and hang them on the wall for the students to refer to. Students with physical disabilities will be assisted with writing on the board or calculating the mean. Advanced students will be asked to find the mean average deviation for each data set (boys and girls reaction times) and share their conclusions with the class.

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| **Reflection:** |

**REACTION TIME LAB** 

**Objective:**

To investigate the difference in reaction times between boys and girls.

**Research Questions**

* Is the reaction time between boys and girls different?
* Can you improve your reaction time?
* Can all reaction times be improved?

Reaction time is the length of time it takes to respond to a stimulus. Reaction time is important when driving, when playing sports, in emergency situations, and in many day-to-day activities. Reaction time depends on nerve connections and signal pathways. Reaction time is the measurement of how long it takes for brain and nerves to react to a stimulus.

**Materials:**

* 10 boys and 10 girls between the ages of 10 and 12
* ruler
* stopwatch
* paper
* pencil

**Experimental Procedure:**

1. Gather the necessary materials.
2. Gather 10 boys and 10 girls who are similar in age to participate in your experiment.
3. One at a time, test each volunteer’s reaction time by having the volunteer sit beside a table with his or her arm on the table and his or her hand extending off the edge of the table. Hold the ruler so that its bottom end is just between the volunteer’s thumb and index finger. Without warning, release the ruler while the volunteer closes his or her fingers as quickly as possible on the ruler. Note how many inches the ruler fell by looking where the volunteer grasped the ruler. Use the chart below to determine the volunteer’s reaction time. Repeat the procedure 4 times, recording each reaction time.
4. After testing the reaction time of the volunteer, determine the average reaction time by adding the reaction times together and dividing by five (the number of tests). Record the results.
5. Repeat steps 3 and 4 for each volunteer.
6. After completing the reaction time test with each of your volunteers, analyze the data and draw a conclusion.

**Terms/Concepts:** reaction time: the time between a stimulus and a response stimulus: something that causes an action or response response: a reaction to a stimuli sensory receptors: parts of your body that respond to stimuli; Reaction time is the length of time it takes to respond to a stimulus. Reaction time depends on nerve connections and signal pathways from the skin (touch), eyes (sight), ears (sound), tongue (taste), and nose (smell) to the brain. Some reaction times occur naturally such as blinking to cleanse the eyes. Other reaction times are the result of a choice and can be improved with practice such as learning to swing a baseball bat. Athletes work hard to improve their reaction times.

From: <http://www.education.com/science-fair/article/reaction-time/>

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| **Lesson Title: Stop and Go!** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title: Design a Traffic Management System and**  **Model** |

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| **Estimated Lesson Duration:** | **240 minutes** |
| **Estimated Activity Duration:** | **200 minutes** |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:** |

Students will be able to:

1. Use the engineering design process to simulate one or two models of a busy intersection and test out a solution for the safest, most efficient traffic management system given a set of constraints.
2. Understand a car’s movement to have magnitude and direction and use vocabulary such as speed and velocity.
3. Demonstrate Newton’s 3 laws of motion
4. Collect, organize, graph, and analyze data.

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| **Activity Guiding Questions:** |

1. How do cars move around in traffic? What is the difference between a roundabout, an intersection with a stop sign or a traffic light? What are the pros and cons to using these? When is each system best used? How exactly does a stop sign and traffic signal work? What is the definition of a safe intersection?
2. 3) How fast can vehicles travel on each type of system?

4) How can we find out information about crash rates?

How do crash rates compare before and after a traffic management system is constructed?

Who collects this type of information?

Who oversees traffic management?

How can we compare this data?

How can we graph this data?

How can we compare crash rates before a traffic system is constructed with crash rates after a

system is constructed?

| **Next Generation Science Standards (NGSS)** | |
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| **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. |
| ☒ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **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)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☒ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☒ Reason abstractly and quantitatively | ☐ Attendto 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 |

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

Forces have magnitude and direction. (PS8. 2 ONLS)

Understanding Sampling 7.SP.1, 7.SP.2

Using Mean and Mean Absolute Deviation 7.SP.3, 7.SP.4

Making Comparative Inferences about Two Populations 7.SP.3, 7.SP.4

Simulations 7.SP.8.c

Investigate patterns of association in bivariate data 8.SP.A.1, 8.SP.A.2, 8.SP.A.3, 8.SP.A.4

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| **Materials**: |

3 Poster papers of a hand-drawn street intersection with a stop sign, with a stop light, and a roundabout

Markers

Oversized, laminated word cards featuring vocabulary (motion, speed, velocity, acceleration, direction, magnitude, force, Newton’s three laws, inertia)

Vocabulary words (listed above) written on index cards (number of cards equivalent to number of students)

Box of toy cars, fire trucks, jeeps, police cars, etc.

One or two small doll figures

Yardsticks, stopwatches, colored sticky notes

Stoplights (prepared in previous lesson)

Colored paper for students to make stop lights and stop signs

Glue

Wood strips for sign handles

20 – 30 Battery operated cars (optional; if time permits)

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| **Teacher Advance Preparation:** |

Pre-draw a poster paper of a street intersection

Write out vocabulary words (one word per index card) onto index cards. (For example, for twenty students, each of the vocabulary words would be on two different cards, except for two which would be only written once on one card in order to add up to twenty cards)

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| **Activity Procedures:** |

* 1. The students will gather around a table in the middle of the classroom. The table will feature three different posters of street intersection bases (hand-drawn street intersection with a stop sign, with a stop light, and one roundabout) and toy cars. Each student will receive one vocabulary card on an index card.
  2. The teacher will review vocabulary cards of ***motion, speed, velocity, acceleration, direction, magnitude, and force*** with the toy cars. Each time the teacher uses a vocabulary word the word vocabulary card will be taped up to the board. If a student is holding the same vocabulary card being mentioned, he/she will raise it up high each time the word is spoken.
  3. The teacher will introduce the vocab cards ***inertia*** and ***First Law of Motion***, also called the Law of Inertia, “Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.” This will be demonstrated by pointing out that the cars on the table will not move unless a force is applied. This will also be demonstrated by placing two doll figures in a toy jeep. Students will see how inertia works. The teacher will point out the difference between **balanced** and **unbalanced forces** and write these terms on the board (no vocabulary cards for these terms).
  4. The teacher will introduce the vocab card ***Second Law of Motion***, “The relationship between an object’s mass m, its acceleration a, and the applied force F is F=ma.” Placing a small car and big truck side by side with a ruler behind their position, the teacher will demonstrate how far each vehicle will move with the same force. In explaining the equation, the teacher will note the difference between mass and weight.
  5. The teacher will introduce the vocab card ***Third Law of Motion***, “For every action there is an equal and opposite reaction.” The students will observe what happens to a car if another car slams into it, noting its direction and describing its speed. (Steps 1-5 total of 10 minutes)
  6. Students will go into their research groups from the first activity and “play” with the toys. As they work, they will hold up a stop light to indicate their progress. Each group will need to demonstrate the laws of motion and if possible, they will try to come up with an alternate way to show the laws other than a way demonstrated by the teacher. The teacher will walk around the class, heading towards groups with “red lights” requesting for assistance first. (10 minutes)
  7. For the remainder of the class, the teacher will reintroduce the Big Idea which was presented as the Hook: Forces, Motion, and Math all have an impact on traffic management. Students will respond to this idea and discuss what forces are with the cars while on a street intersection. The teacher will hear the responses and review the essential question -- What is the most efficient, and optimal route for cars to travel in a congested area? The students will then share what they feel are the essential questions concerning the guiding question, “Would an intersection with a stop sign or stop light, or a roundabout be the most efficient traffic management system given a set of constraints?” (The constraints will include the following: a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), and a maximum of six entrance ways into the congested area.)
  8. The teacher will guide the students to the Challenge based learning activity – Design two models that will show the most efficient traffic management system (an intersection with a stop sign or stop light, or a roundabout), given a set of constraints (as mentioned in step 7) (20 minutes)
  9. Students will begin the next day by understanding and redefining their Challenge. Using notecards, everyone will individually write down at least 7 items he/she feels are the necessary steps to complete the challenge. (9 minutes)
  10. A scribe will begin writing out the steps in flow chart like form on the board as the teacher calls on each student to add to the flow chart (disregarding duplicate suggestions from other students). (10 minutes)
  11. The teacher will confirm that data collection planning is appropriate. Students will need to collect and organize the number of crashes, time, distance traveled, speed) in order for them to analyze the data. (3 minutes)
  12. For the remainder of the class, students will be in their groups and design possible intersection schemes with the following constraints: a maximum testing of 30 vehicles, a range of speed (to be determined once human pace and battery operated vehicle speed are calculated), and a maximum of six entrance ways into the congested area. Students will devise “rules of the road.” (18 minutes)
  13. For the third class of this activity, the students will practice implementing their rules of the road and using “human cars” test out their design simulation while recording the number of crashes, time, distance traveled, and speed of cars. The simulation will be observed by another group of students and two teachers, who will provide assessment and input concern the efficiency and safety of the model selected. The rubric for the assessment of the challenge will be put together by the teacher – some factors to consider are: number of entrance ways, speed travelled, number of vehicles, number of crashes. For efficiency and safety, these factors can be compared before and after the redesign of the model to see if there was numerical change and improvement. Once the simulation is complete, input will be given and the students will take the remainder of the class to “redesign” their simulation, by either adjusting distance, speed, entrance way design, number of vehicles, etc. Homework assignment for that evening will be to reflect on how the simulation model went.
  14. For the fourth class of this activity, students will do a second simulation in front of a group of students and two teachers implementing their new design model. The group of students and two teachers will reassess the efficiency and safety of the system and the class will determine if there was an improvement in their prototype. (40 minutes)
  15. The final class will include a post-test and written reflection comparing the original prototype and redesign. If time permits, students may have the opportunity to begin considering using battery-operated vehicles as another way of modeling the traffic system design. If time does not permit but student interest continues, such an activity can take place afterschool as an optional enrichment. (40 minutes)

**Formative Assessments:**

The utilization of the traffic lights will allow the teacher to assess which students need assistance with the content or tasks required

Notecards for design flowchart

Reflection homework assignment

Calculation of speed during challenge activity

**Summative Assessments:**

Half of the questions on the post-test will assess the above math objectives. The other half of the questions on the post-test will assess Newton’s laws, concepts of speed, calculation of speed, and definitions of magnitude and direction.

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| **Differentiation:** |

Students with ADHD will be allowed to stand up, take water breaks, and squeeze a stress ball throughout the activity. The teacher will repeat the directions slowly to ESL students and ask if there are any questions they might have. The teacher will write key vocabulary words and their definitions on large colored cards and hang them on the wall for the students to refer to. Students with physical disabilities will be assisted with writing on the board or calculating the mean. Advanced students will be asked to find the mean average deviation for each data set (boys and girls reaction times) and share their conclusions with the class.

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| **Reflection:** |