Using NASCAR® To Teach Physical Science: Focus on Chemistry

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Background

The school where I teach physical science and chemistry for grades 9 through 12 is the largest high school in the county with approximately 2750 students representing over 33 nationalities. Because of its proximity to the inner city as well as its location in an affluent neighborhood, students who attend the school encompass a large socioeconomic as well as geographic area. The attendance zone includes several homeless shelters and a home for pregnant girls. A wide range of academic courses (core and elective) including standard level, honors level, International Baccalaureate Middle Years Program (MYIB), International Baccalaureate Diploma Program (IB) and Advanced Placement Program (AP) are offered. Programs and services for the visually and hearing impaired, exceptional children, and English language learners provide added support for these students, many of whom are part of the inclusion program.

My current teaching assignment includes both physical science and chemistry. My physical science classes are standard level courses that satisfy the physical science/lab credit required for graduation. The classes are populated with students ranging from ninth grade to twelfth grade. Several students are repeating the course for the second time or are taking the course because they were unsuccessful previously in a general chemistry course. At this time, two thirds of my teaching load is physical science. One section is approximately 50% English language learners and 3 students with learning disabilities. This presents additional challenges as these students have difficulty with scientific terminology, science concepts, mathematical computation and literacy (reading).

Introduction

Capturing the interest of the student and helping him/her make connections to the content is often a frustrating task given the desire of today's student to have things in an instant. Technology has put music, video, and even research at the fingertips of the student and educators must continually reinvent their lessons to compete with the "attention deficit" caused by constantly changing content, images, sound, and communication. The purpose of this unit is to integrate the popular sport of NASCAR® with the concepts taught in physical science and give students a more themed approach to learning the content. The theme also provides opportunities to collaborate with the automotive technology instructor at the school so that students can experience hands-on learning.

The birth of stock car racing also provides an interesting history lesson. In the 1920's, the 18th Amendment banned the commercial production and distribution of liquor (know as prohibition). A person could make their own personal “moonshine” and many moonshiners would make and sell it to others. As a means to transport the illegal brew, moonshine makers would use their personal cars to deliver the goods and go relatively unnoticed by law enforcement. As the competition between moonshine makers increased and the need to get the product to the customers faster and be able outrun law enforcement, the moonshiners began to modify their cars to make them faster. Competitors bragged about their fast cars and soon weekends were spent racing against each other. Stock car racing was born. The popularity of the sport has increased since World War II and today it has a large fan base throughout the country. The National Association of Stock Car Auto Racing (NASCAR ®) was formed by Bill France, Senior in 1947 to help to unify the sport in terms of organization and rules. It is now the governing body for the sport. Racing is a local favorite with many racing teams and shops, a major speedway, a drag way and the NASCAR® Hall of Fame located nearby making access to events, tours, and exhibits easy.

Rationale (Objective)

Several sciences are required by the State of North Carolina Department of Public Instruction as part of the standard course of study to earn a high school diploma: earth science, biology and a physical science. Physical science is a general science course that consists of 9 weeks of introductory chemistry and nine weeks of introductory physics. The NASCAR® them will be integrated into several content topics such as the study of matter (materials), chemical and physical properties, chemical reactions, energy, and motion during the course with a portion of the activities centered on an aspect of automobile racing or automobile design and function. Learning opportunities will incorporate reading, writing, research, group and individual assignments, class presentations, and technology. The incorporation of 21st century skills will be essential in this unit as students will demonstrate communication of information, data collection and dissemination, and other skills The essential standards for physical science include the following goals: (1) understand chemical bonding, chemical interactions and properties of matter, (2) understand types of energy, energy transfer, and conservation of energy, (3) understand motion in terms of speed, velocity, acceleration and momentum, (4) understand the relationship between forces and motion, and (5) understand the relationship of energy to work and power. This unit seeks to address content for goals 1, 2, and 5 which pertain to the chemistry content of the course.

Chemistry and NASCAR®

The first nine weeks of the semester focuses on the study of matter including chemical and physical properties, atomic structure, chemical reactions, acids, bases and energy. Matter is any substance that has mass and volume and can be classified as pure substances (elements and compounds) or mixtures (solutions, colloids, and suspensions). All forms of matter have unique chemical and physical properties.

Building the Car (materials science)

Materials used in building a racecar include various metals, thermoplastics such as polycarbonate in windshields, nylon netting, and polymers such as Kevlar® and Nomex® in helmets and suits (polymers). Metals are used extensively in building the frame and exterior of a car but racing officials dictate which metals can be used for frames and exterior panels in order to control the cost. Because of the arrangement of atoms in metals and the metallic bonds that hold the atoms together, metals are ductile, malleable, and very good conductors of heat and electricity. Pure metals such as gold or silver are very ductile and do not offer the strength needed. This is evident in the gold flake that is used in art and cake decorating. It is very thin and fragile. Instead metal alloys are used for different parts of the car because the physical properties such as density, ductility, thickness, and strength are important to functionality and driver safety. Roll cages, for example, must be sturdy and strong and require steel that is durable and can be bent into shape. Other parts of the car such as fenders are crafted from large sheets of metal either by hand cutting, hydraulic stamping or using the English wheel[i]. Metal fabrication is not a new process. Blacksmiths did the job by hand in a laborious process that involved heating the metal until it became soft and using hammers to pound it into shapes such as horseshoes before it cooled. Metals must withstand shaping and re-shaping and not become brittle or break.

Steel is an alloy of iron and carbon plus a mixture of other elements. Above 2.1% carbon, it is called cast iron and casts easily without cracking. Cast iron is strong in compression and is ductile. At lower carbon amounts it is called low or high carbon steel which can be tremendously stronger in tension. The performance of steel can be changed by adding other metals to create alloys that increase various features such as heat treatability to form complex shapes. Heat treatment is the process of heating a metal up to its melting point or annealing temperature, quenching it quickly to a low temperature to modify the crystal structure, and then tempering back to an intermediate temperature to modify the physical characteristics of strength, ductility and brittleness.

Body panels are made of steel that is a mixture of iron, 0.1 % manganese and 0.3-0.5% carbon[ii]. The chassis, on the other hand, is made from steel that has a higher percentage of carbon (referred to as high carbon steel). The higher carbon content produces steel that is strong and can withstand the forces and pressure that the car experiences during the race. Often in the process of mixing the molten elements together, gases from the air get trapped in the mixture as it cools. If oxygen reacts with the carbon, carbon dioxide is produces which causes holes to form in the steel similar to the holes in bread that are left when the bread rises and the carbon dioxide vaporizes. These defects in the material reduce the strength. To remedy this problem, the aluminum is added to the molten steel to react with the nitrogen. The product of this synthesis reaction is aluminum nitride which improves ductility.

Polymers are used in other parts of the car such as the rear and front bumpers as well as the driver's helmet. Polymers are macromolecules composed of repeating units or chains of atoms. Polymers can be from natural sources such as plants or created from synthetic materials. There are a variety of uses for polymers. The properties of a polymer depend upon the type of polymer. Bouncy balls are made of a rubber polymer that is very springy giving them the ability to bouncy very high. Rubber can also return to its original shape when stretched. Polycarbonate is a polymer that is used in race car windows and commercially in eyewear. It is light weight, thin and sturdy unlike traditional glass windows and windshields. Dupont® developed an amazingly strong yet lightweight polymer whose fibers are strong even at high temperatures.[iii] This material is marketed as Kevlar® and is used in bullet proof vests. Race teams create a composite material using Kevlar® and resin to mold bumpers for the car. The result is a lighter part that is still as strong as the steel in other parts of the car. Other applications of polymers include body fillers that fill in spaces. They form a cross-linked network of chemical bonds which gives the fillers strength. If you wreck your car, chances are the body shop may have used body filler to smooth out damaged panels prior to sanding and re-painting.

Rubber is a natural polymer from the sap of Hevea trees that grow in South America. One of the first uses of rubber historically speaking was by the British who discovered that it would erase pencil marks so it was used in the manufacture of pencil erasers. It is used today in the manufacture of heavy truck tires. Natural rubber is strengthened and made more durable through a process called vulcanization that was first used in the early 1600's. Today's passenger car tires, however, are mostly manufactured using synthetic compounds such as silicon. Auto racing is a spring, summer, and fall sport and often the tires are subjected to extreme heat on the track in the summer months. Track surfaces vary from asphalt to concrete which causes tires to wear differently. Higher temperatures cause the outer layer of the tire to melt and subsequently this melted layer is sloughed off by the track. Because race tires are driven so hard, they are compounded to balance between traction (and stickiness) and wear for the particular track temperature. If a summer race tire is used in winter, it would be too hard to corner as well. If a winter race tire is used in the summer, it would wear out in one lap. Because most of the tracks are designed where the cars are making left turns, the right side tires hold most of the weight of the car going around the corners. This causes the right side tires to wear faster. Left side tires are composed of a softer compound to balance wear. One manufacturer makes all NASCAR® racing tires. Drivers complain almost continuously about the tires being too hard or wearing out too quickly. It is a balancing act that is necessary but unappreciated.

Tires for NASCAR® race cars do not have the tread like passenger cars. Passenger car tires are grooved to help prevent hydroplaning on wet roads. Hydroplaning is not a problem with race cars because NASCAR races are not held in rain. The lack of a tread pattern on racing tires is due to the need for heat dissipation.

The tires are filled with compressed nitrogen instead of air because nitrogen does not have oxygen to corrode, oxidize, and shorten the life of the components of the tire. Moisture can vaporize due to the intense heat produced by the friction of the tires on the pavement. Gay-Lussac's Law indicates that as the temperature of a gas rises, the kinetic energy increases and the pressure increase due to the increase in particle collisions. With the rising temperature, the gas expands and causes the tire pressure to increase which can lead to poor vehicle control. Race tire pressures are set to a lower pressure to compensate for the natural rise in temperature during race conditions (as are the pressures on a passenger car). For a passenger car, the pressure in the tire rises about 1 pound per square inch (psi) for each 10° F change in temperature. [iv]As previously mentioned, the right side of the car bears the most weight so the tires are inflated to a higher pressure. Racing tires are a major expense on race day with each tire costing between $350 and $400.

The chemistry of engine combustion

Chemical reactions are the basis for the formation of compounds. There are five basic types of reaction studied in a physical science course: synthesis, decomposition, single replacement, double replacement and combustion. The engine of a race car is an internal combustion engine that uses gasoline as the fuel. The combustion reaction converts the potential energy and chemical energy in the fuel to kinetic energy that powers the car according to the following chemical reaction:

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O + \text{energy}$$

The reaction is an exothermic reaction and causes the gases to expand rapidly. It is important to note that liquid gasoline does not burn but the vaporized fuel mixed with air does. It is important to note that fuel and air only burn in a small ratio range of air to fuel (typically about 10:1 to about 18:1) about the chemically optimum stoichiometric ratio of 14:1. It is curious to think that gasoline mixed with air won't burn but outside this air/fuel ratio range, it just will not light off. This combustion occurs in the combustion chamber above the piston.

The machinery of an engine

Pistons move up and down in each chamber or cylinder and the crankshaft converts the up and down motion to rotational motion. This turns the wheels. As the pistons move down toward the bottom of the cylinder, the intake valve opens to let the fuel and air mixture in. The intake valve closes and the piston begins its upward journey to the top. As it does, it compresses and generates pressure on the fuel/air mixture. The spark plug generates a spark to ignite the fuel/air mixture and start the combustion reaction. This is known as the power stroke. With the valves closed, the expanding gases force the piston back down. The exhaust valve opens and the rising piston pushes the gases out of the combustion chamber and down the exhaust pipe. Each cylinder operates at a different interval because the energy needed is only produced during the power stroke.[v] NASCAR® race cars have 8 cylinders, each containing a piston and spark plug, arranged in a V shape in order to reduce engine vibration (thus the V8 designation). A typical NASCAR® engine is capable of producing 800 to 850 horsepower (hp). Consumer automobiles may have a similar engine but produce much less horsepower (typically less than 300 hp). Race engines achieve this greater horsepower by reducing friction, opening up the airways and lightening the piston and valve train to increase engine speed and air flow. The cost of this lightening process is a very short engine life (and a very high dollar amount).

Engine cooling

Engine problems can take their toll on a race car and cost the team point positions and money. Most race engine parts are designed to withstand the extreme heat and pressure but occasionally engine problems will end the race day prematurely. When drafting another car during a race, the airflow to the radiator will be reduced and the engine can overheat. Thermal insulators such as rubber or plastic are not good choices to help with heat transfer because the electrons in these materials move less. Metals have metallic bonds with mobile electrons and are capable of moving heat from areas of hot to cold. Even with the best thermal conductors the engine still needs help getting rid of the heat.

Water circulates through the engine block and the heat is transferred to the moving water molecules. The water flows to the radiator where the heat is transferred once again to the metal atoms that compose the fins of the radiator and finally to the air molecules that are in contact with the fins.[vi]Since it is a closed system, the cooler water flows back to the engine and the process cycles again. The boiling point of water is 212° Fahrenheit (100° Celsius) at normal atmospheric pressure (1 atm). However, the temperature of the water circulating from the engine block can reach temperatures over the boiling point. One of the unique physical properties of water is boiling point elevation when pressurized. Engineers pressurize the cooling system so that the water temperature can rise above 212°F before it reaches boiling. It is important to note that street cars use anti-freeze to prevent freezing and cracking of the engine block in winter and to prevent corrosion in the engine. Race cars use pure water because it conducts heat away better and because in a crash, it makes less of a slippery antifreeze mess on the track.

Fuel, Power and Energy

While the components of the chassis, the parts of the engine, the safety features and the tires are all very important, the ultimate goal to get everything to work together to win a race is power. Power is the rate at which energy is produced or used. “Most NASCAR® engines have a maximum output of around 850 horsepower which is equivalent to 151 food calories per second.”[vii] A person can produce about one-tenth of a horsepower. A race car engine produces about 3.5 times the horsepower of a regular street car engine. The engine must be able to convert potential energy (PE) of the fuel (present in the chemical bonds) to kinetic energy (KE) to move the car. A good analogy would be fuel: car energy as food: energy in our body. The fuel source for race cars is a higher octane than the gasoline used in passenger cars. The higher octane means the fuel/air mixture can withstand higher pressures before auto igniting but gives no indication of how much energy is produced from the combustion process.[viii] The amount of energy depends upon the amount of energy stored in the chemical bonds of the fuel before combustion and after combustion in the bonds of the products of reaction. This is related to the hydrogen to carbon ratio of the fuel. The higher the ratio, the more energy produced.

The Law of Conservation of Energy reminds us that energy is not lost but conserved. In the internal combustion engine "75 percent of the energy from the gasoline is converted to heat that is either removed by the cooling system or expelled as exhaust gases."[ix] This energy does not contribute to the power needed to make the car move. Cars also use energy to run electronics, lights, air conditioning, windshield wipers, motors in doors and windows, and other devices. A NASCAR® race car at a short track like Bristol, Tennessee may run 16 powerful electric fans to help cool water, oil, brakes and to keep the driver cool.

Strategies

During the course of the unit, students will be engaged in learning opportunities that will facilitate collaboration, problem solving, research, writing, and sharing of information. Core essential standards coupled with writing and reading tasks will frame the content, activities and assessment. Writing tasks will triangulate texts from a variety of sources including literature, art, music, and multimedia.

NASCAR® is a popular regional sport with many racing shops within an hour's drive of the city. Two major races in the Sprint Cup series are held at the nearby speedway. There is also a drag strip and dirt track next to the speedway. Student familiarity with the sport is varied. To generate interest and to frame the theme of the unit, a brief history of will be presented along with some short video clips of races. After viewing the clips, students will be instructed to write a one paragraph response to the following prompt: "What role does science play in auto racing?" Responses will be shared with a partner and then with a small group. Each group will decide on one role to share with the class and display it on the group white board.

Vocabulary development is an important tool for understanding. English language learners present challenges due to language deficiencies in English and added difficulty of scientific vocabulary. An emphasis will be placed on the vocabulary of the sport as well as science content vocabulary. Students will keep a personal dictionary of terms in their notebooks that will provide a resource for assignments and assessments. Word walls, word association images, sentence development and graphic organizers will be utilized to help students synthesize new terminology.

Each topic of study will be introduced through an anticipation guide or writing probe that students will complete and share with a partner. This will give an indication of the student's prior experience and knowledge of the topic as well as give students an opportunity to interact with their peers. Responses will be shared with the class and students will be given an opportunity to ask questions. Students will keep the anticipation guide in their notebook for review at the end of the lesson. At that time, students will be able to compare their prior knowledge with what they have learned and write a journal response indicating what was learned and what questions still need to be addressed.

The study of matter involves classifying matter into specific types. A graphic organizer will be constructed so that students understand the process of classification from a broader category to more specific classification. Examples of each type of matter will be available for students to observe, photograph and insert into their graphic organizer using the computer or their cell phone camera/scanner. Students can also choose to draw their own image to represent each type of matter. This strategy will give English language learners a visual example as a resource in their notes. As the lesson evolves, the periodic table will be introduced to show the classification of elements into metal and non-metal types and the properties of each. Students will explore these properties through a lab exercise. Prior to performing the lab, students will construct a simple conductivity tester using a 9-volt battery. This device will be used to test samples to determine electrical conductivity.

Differentiating chemical and physical changes form the basis for understanding types of chemical reactions. Students will study the following reactions: synthesis, decomposition, single replacement, double replacement and combustion. As a part of the study of reactions students will learn to identify type using the balanced equation and complete the chemical reactions lab. Combustion reactions will focus on the reaction taking place in a combustion engine. A presentation of the process will explain to students the mechanical working of a combustion engine. Animations showing two-stroke and four-stroke engines can be found at www.animatedengines.com. Using computers, students will research gasoline and diesel engines and their environmental impact. Using their research, students will prepare a computer generated presentation of their choice. Possible products can include a movie or public service announcement, a slide presentation, or a short booklet. This project will allow students to collaborate with peers and communicate research findings to other students.

Energy, work and power will be studied and students will design a lab in which they determine the amount of work they would have to do to burn off a snack food (fuel). Each student will determine how long it takes to climb a flight of stairs at normal pace and at a faster pace. Using this information, students will calculate the work needed at each pace. This activity will be used in conjunction with the energy from food activity. Students will also determine how much of the chosen snack would have to be consumed to power a racecar for one minute.

Students will investigate potential and kinetic energy using toy race cars, toy skateboards, marbles, and a race track assembly developed by members (myself included) of the Charlotte Teacher's Institute NASCAR seminar in collaboration with Dr. Peter Tkacik, seminar professor.[x] See appendix for diagrams and schematics.

Classroom Activities

Vocabulary Development

The following list of terms is essential to the understanding of the concepts taught in this unit.

air pressure	camshaft	chassis	contact patch	valve
rod	piston	engine block	radiator	alloy
fabricator	quenching	annealing	metal	non-metal
matter	energy	element	compound	Joules
heterogeneous mixture		homogeneous mixture		insulator
chemical change		chemical property		conductor
physical change		physical property		calorie
endothermic		exothermic		Calorie

Read the list of vocabulary terms. Highlight any terms that you do not know. In your notebook in the personal dictionary section, draw the squares template below for each term. Label your squares as shown in the template. For each term, write a definition in your own words and draw an image or insert a picture to help you remember the term. Write a sentence using the term. Finally, reflect on the term and definition and decide what the term is like or not like and record your thoughts in the last square.

Term	Picture
Definition	Sentence
"What it is"	"What it is not"

Building a Conductivity Testing Device:

Students will build a simple conductivity tester using a 9-volt battery, a holiday light, ruler or paint stirring paddle, some copper wire and electrical tape. The instructions can be accessed at http://www.exo.net/~emuller/activities/chemistry_summer_2007/Conductivity%20tester.pdf. YouTube ® also has video that shows how to construct a tester. The tester will be used to test the conductivity of metals in the exploring metals lab that follows.

Lab: Exploring the Properties of Metals

Metals are used in many everyday things such as jewelry, wiring, roofing, piping and automobiles. Metals are chosen different jobs depending upon the properties needed. To increase strength, metals are often mixed with other metals to create alloys. One of the unique characteristics of the bonds that form between metal elements is the present of mobile electrons which give the metals malleability.

Objective:
Students will observe physical the properties of several metals. Students will record their observations and measurements in a data table.

Equipment Materials:

triple beam or electronic balance	ruler	graduated cylinder	conductivity tester	crucible	hammer or rubber mallet

Metal Samples(obtained from Stock Car Steel, Inc.)

Aluminum	Copper	Tin	Zinc	Iron
Lead	Steel (high carbon)	Steel (low carbon)	Tungsten	

Safety:

Wear goggles when testing for melting point, malleability, ductility and conductivity.

Procedure:

1. Observe each metal and record all observations in the data table. Be sure to include color, luster, texture, hardness, shape, corrosion, estimated weight and strength.
2. Using the balance, determine the mass of each metal sample. Record in the data table.
3. Determine the volume of each metal sample. Record in the data table.
4. Calculate the density of each metal and record in the data table.
5. Using a hammer or rubber mallet, pound each metal and record whether it is easily dented or reshaped.
6. Using the conductivity tester, determine if the metal conducts electricity. Record.
7. Light Bunsen burner. If your sample is pellets, place 2 or 3 pellets in a crucible. Set up a ring stand, iron ring and clay triangle assembly. Place crucible in the center of the clay triangle. Light burner. Heat the metal for 5 minutes and observe for melting. Heat for 5 additional minutes. Observe. If the metal is still solid, record the melting point as high. If melting is observed, record as low melting point.

Data Sheet:

Metal	Observations	Mass (g)	Volume (cm^3)	Density (g/cm^3)	Malleable Yes/no	Conductor Yes/no	Melting point (high/low)

Data Analysis:

1. You are a metal artist who makes sculptures for sale at the local art store. You are creating a sculpture that has many angles. Based on the information in your data table, which metal would you choose to create the sculpture? Explain reasons for your choice using specific data from your table.
2. Using your reference table, determine the actual density for each metal. Calculate your percent error.
3. Give reasons for any error that exceeds 5%. Review your techniques and procedure to determine what could be done next time

Building a Bomb Calorimeter or combustion calorimeter:

Students will build a simple calorimeter to determine the energy in some common food materials. This activity will tie in with the study of energy changes and heat transfer that happens as the heat of the combustion in the engine is carried away by the water that circulates through the engine. Simple calorimeters can be constructed from foam coffee cups or soda cans. The following website has step-by-step instructions on how to build one from a soda can. It can be accessed at
http://www.ehow.com/how_4893595_make-simple-calorimeter.html.
YouTube, as well as searching the Internet will produce additional resources for building a calorimeter using different materials such as foam coffee cups. The basic concept is the same.

Calorimetry Lab

Potential energy is stored in foods. The amount varies depending upon the type of food. The human body uses food as an energy source like cars use gasoline or diesel fuel as an energy source. This activity explores the conversion of potential energy in food to heat and light energy through the combustion or burning process. A calorimeter is used to "measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel, which is surrounded by water, under controlled conditions"[xi].
Note: Each group can test all samples or a sample can be assigned to a group depending upon the time available.

Purpose

To calculate the quantity of heat produced when a designated mass of food is burned.

Materials

Calorimeter (commercial or student made) Thermometer	Food samples: Doritos® chips, pretzels potato chips, low-fat potato chips, popcorn,
Water	Electronic balance

Safety:
Goggles should be worn. Care should be exercised when handling hot equipment. Tie back long hair and secure loose clothing. Be sure all materials are extinguished before disposal.

Procedure
1. Obtain a calorimeter.
2. Weight the empty calorimeter using the balance. Record.
3. Measure 200ml of water using a graduated cylinder. Pour into the calorimeter. Weigh the calorimeter and the water. Record. Calculate the mass of the water and record.
4. Take the temperature of the water and record in the data table. The temperature should be about room temperature (25-27 degrees Celsius). If not, allow the water to sit until it reaches the temperature range.
5. Obtain food sample. Using a balance, measure the mass of the food sample. Record type of sample and mass in the data table. You should 2-8 grams of sample. If you have more, remove some.
6. Using a lighter, ignite the food sample. This may take a minute for the sample to catch. Be patient. Allow the sample to completely burn. Record the highest temperature of the water just before the food is completely burned and flame goes out. Record.

Type of food sample	
Mass of food sample	
Mass of empty calorimeter	
Mass of calorimeter and water	
Mass of water	
Volume of water	
Initial temperature of water	
Final temperature of water	
Change in temperature	

Specific Heat (C_p) of water	

Calculations

1. Using the formula $Q = mC_p\Delta T$, calculate the heat produced by the food sample in Joules.
2. If 1 Calorie = 4.18 Joules, calculate the number of Calories in the food sample.
3. How many joules of heat would you expect to be produced from the burning of an entire serving?
4. What ingredients in your food sample would be responsible for supporting the burning process?
5. Obtain the calories per serving information for your food sample from the nutrition label or from your teacher. Calculate your percent error using the following formula:

$$\% \text{ error} = \frac{actual - experimental}{actual} \times 100$$

Conclusion

Write a paragraph discussing the results obtained from your food sample and how it compares to other food samples tested. Which foods contain the most calories? Which foods contain the least calories? What is your percent error? What sources of error can you identify and how do they contribute to your percent error? What modifications can be done to improve the lab? What further testing might need to be done?

Extension Activity

Students will design a lab to determine how much exercise such as stair climbing would have to be done in order to burn off 1 serving of the snack food tested. They will use their information from the calorimetry lab and the lab they design to determine the amount of snack that would have to be consumed to power a race car for one minute.

Investigating Potential and Kinetic Energy

Potential energy is the energy that a body or object possess as a results of its position. It is the product of the mass of the object multiplied by the acceleration due to gravity and the height of the object. Kinetic energy is the energy of an object or body with respect to its motion. It is related to the mass and velocity of the body. Potential energy is converted to kinetic energy and vice versa. Therefore, kinetic energy equals potential energy. Joules is the metric standard unit. Both can be calculated using the following formulas:

$$PE = \text{mass} \times \text{gravity} \times \text{height}$$

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

Objective:

Students will determine the potential energy and kinetic energy of a toy race car, toy skateboard and a marble at different heights. Using the data, students will derive the velocity of each object for a given height.

Materials

Toy race car	meter stick
Toy skate board	marble
Race track assembly (see appendix)	electronic balance

Safety

Use caution when assembling the track or changing height of the track. Edges may be sharp. Hinge assembly may pinch fingers. Wear goggles.

Procedure

1. Assemble track and position track at lowest height.
2. Measure height and record.
3. Measure mass of car and record.
4. Measure the length of the track in meters.
5. Place car at top of ramp. Allow gravity to accelerate it. Record time it takes for the car to roll from top of ramp to bottom.
6. Repeat procedure 5 times.
7. Change height of track. Repeat steps 2, 4 and 5 for this height.
8. Change height of track. Repeat steps 2, 4, and 5 for this height.

Data

Vehicle type	
Mass of vehicle	
Length of track	
Height #1:	
Height #2:	
Height #3:	

Calculations

1. Calculate the potential energy of the vehicle at each height.
2. If $KE = 1/2mv^2$ and $PE = mgh$, calculate the velocity of the vehicle.
3. Calculate the velocity of the vehicle using the displacement and time data

   Analysis Questions

   1. Explain the relationship between height and potential energy.
   2. Compare the velocity calculations. What is the percent difference? What could account for the difference?
   3. What do you think the PE would be if the vehicle is sitting flat on the track?

Class Research and Presentation

Students will be assigned to groups of four. Each group will choose from the list of topics below. The group will research and design a computer generated product to share with the class.

Research topic list

1. Gasoline or diesel: Which fuel has most impact on the Environment?
2. Is NASCAR harmful to the environment?
3. Alternative fuels for racing: Pros and Cons
4. What is NASCAR’s carbon footprint? How can it be reduced?
5. How do race teams dispose of old parts, tires, etc? Do they recycle? How do they participate in promoting a better environment?

Appendix 1. Implementing the Common Core Standards

PSc. 2.1: Understand types, properties, and structure of matter.

- 2.1.1. Classify matter as homogeneous, or heterogeneous, pure substance or mixture, element or compound, metal, nonmetal or metalloid, solution, colloid or suspension.
- 2.1.2. Explain phases of matter and the physical changes it undergoes.
- 2.1.3. Compare chemical and physical changes that matter undergoes.
- 2.1.4. Compare physical and chemical properties of matter.

The unit addresses the classification of matter as well as chemical and physical properties and changes through the investigation of the properties of various metals and non-metals. Some of the metals are used in the building of race cars.

PSc. 2.2: Understand chemical bonding and chemical interactions.

- 2.2.5. Classify types of chemical reactions.

The unit covers the standard during the study of chemical reactions. The combustion reaction is studied in relationship to the combustion engine.

PSc. 3.1: Understand types of energy, energy conservation and energy transfer.

- 3.1.1. Explain thermal energy and its transfer.
- 3.1.2: Explain the law of conservation of energy in a mechanical system in terms of kinetic energy, potential energy, and heat.

The standard is addressed as students investigate the heat transfer involved in the cooling process of the engine. The process of fuel combustion in a gasoline powered engine is studied as well as the conversion of potential energy to other forms such as kinetic energy.

Appendix 2. Fasteners and track for the force and moment ramp kit.

Fasteners from McMaster-Carr

Line		Description
1	97008A616	Zinc-Plated Steel Spade Head Thumb Screw with Shoulder, 1/4"-20 Thread, 1" Length, packs of 25
2	96659A106	18-8 Stainless Steel Type A SAE Flat Washer, 1/4" Screw Size, 5/8" OD, .05"-.08" Thick, packs of 50
3	92001A321	18-8 Stainless Steel Wing Nut, 1/4"-20 Thread Size, 1-3/32" Wing Spread, packs of 25

Blu Track; Qty 1, Item #1100, description 30.48 Meters or 100 feet of BluTrack PRO (ON-LINE ONLY)

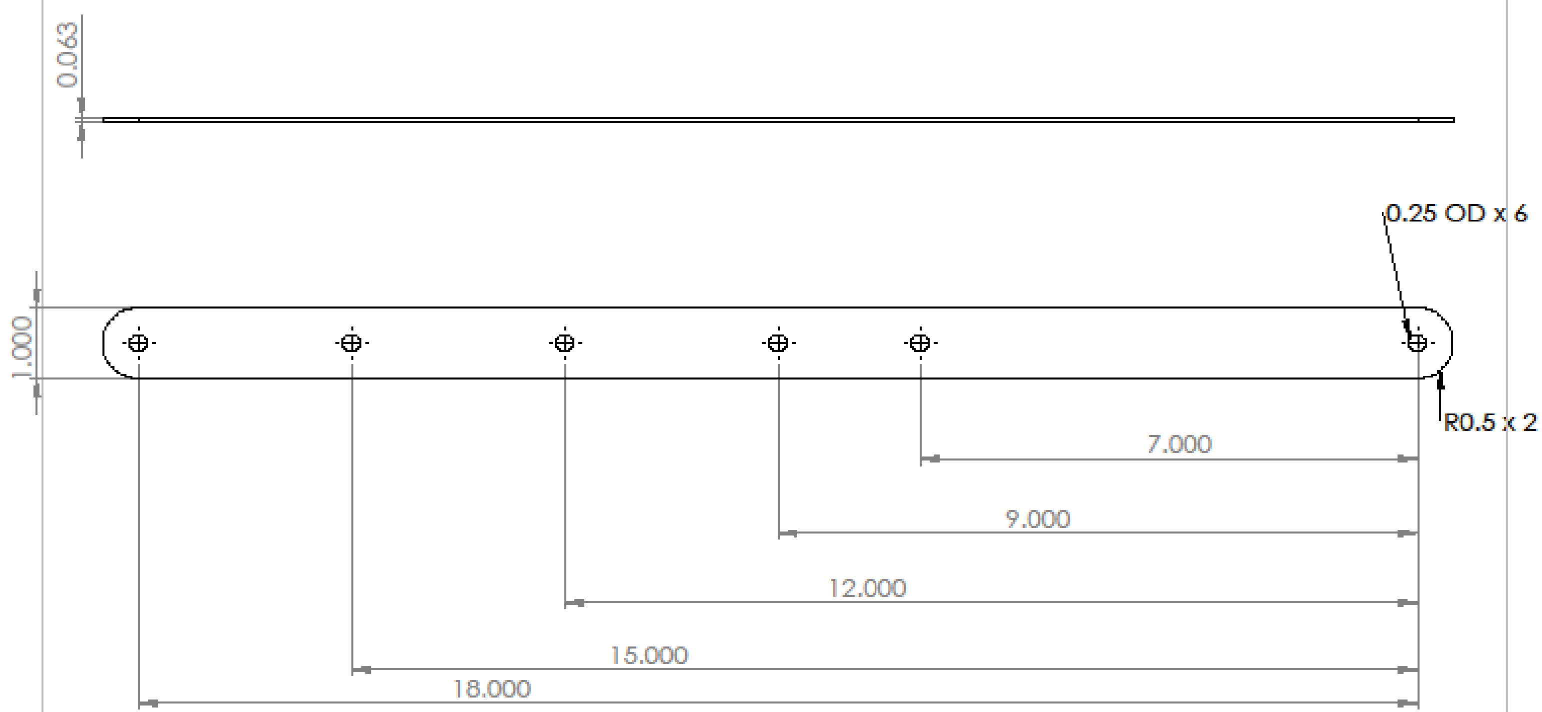
http://www.shop.blutrackpro.com/product.sc?productId=7

Appendix 3. Ramp Drawings

- The material we used was 16 gage Stainless Steel although regular sheet metal is fine.
- We then cut the parts out, deburred them, and then polished everything.
- We used wing nuts for easy assembly; however, a ¼”–20 nut and bolt tighten just fine with fingers for this job.
- Our track was BluTrack:

  Qty 1, Item #1100, description 30.48 Meters or 100 feet of BluTrack PRO (ON-LINE ONLY)

  http://www.shop.blutrackpro.com/product.sc?productId=7



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 304 Stainless Steel	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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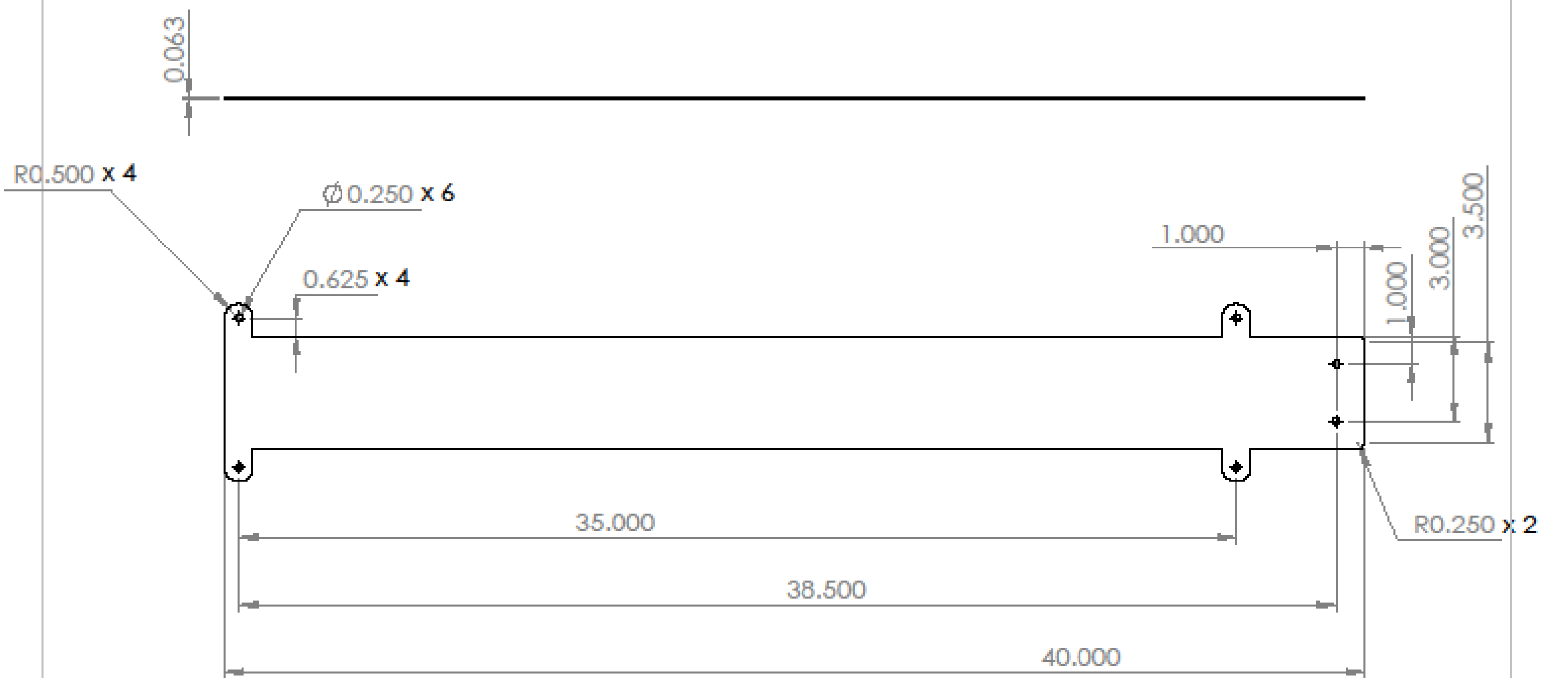
UNC Charlotte Motorsports Engineering

TITLE:

SIZE	DWG. NO.	REV
A	Ramp Columns	

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL 304 Stainless

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

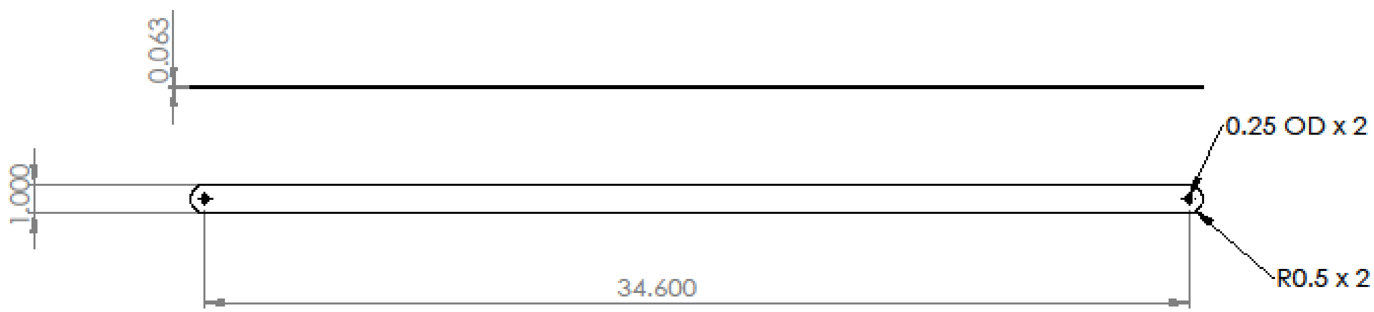
UNC Charlotte Motorsports Engineering

TITLE:

SIZE A DWG. NO. Ramp REV

SCALE: 1:10 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
304 Stainless Steel

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

UNC Charlotte Motorsports Engineering

TITLE:

SIZE A | DWG. NO. Ramp Base | REV

SCALE: 1:10 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

Appendix 4. Ramp images

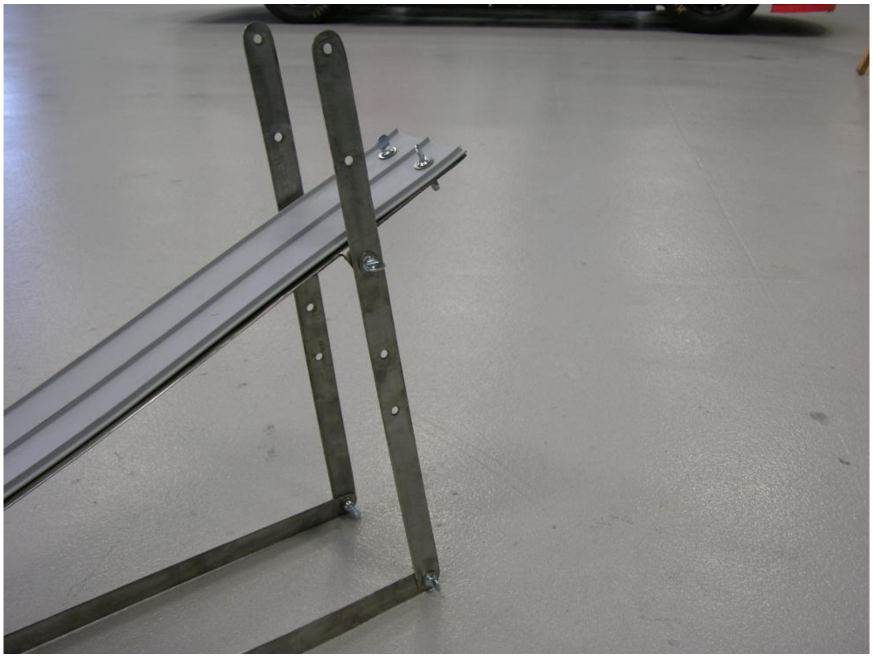

Figure 1. Adjustable height struts

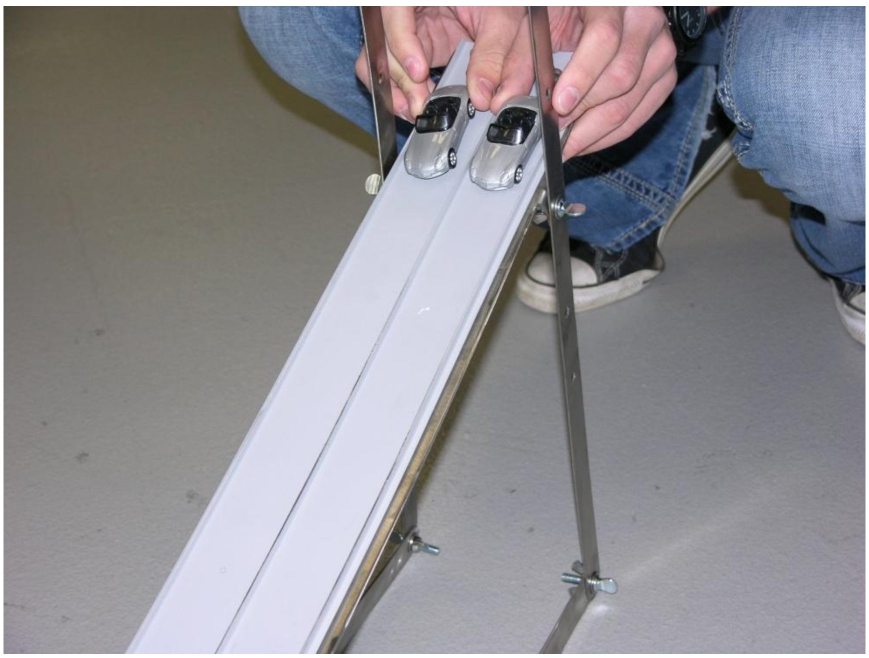

Figure 2. The starting line

Figure 3. Wing nut and wing bolt fasteners

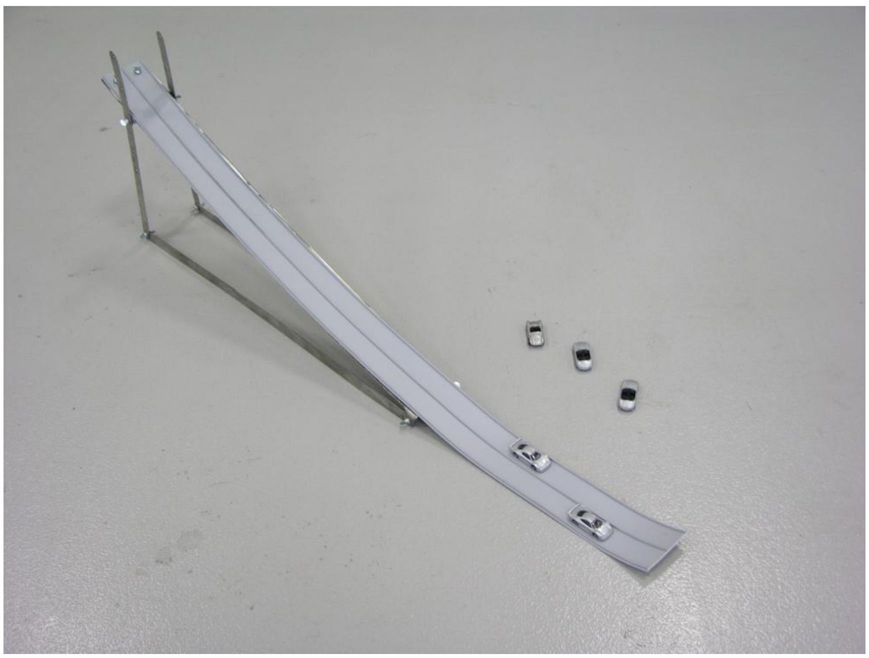

Figure 4. The ramp as used.

Notes

[i] Leslie-Pelecky, Diandra. *The Physics of NASCAR.*

[2] ibid.

[iii] ibid.

[iv] ibid.

[v] ibid.

[vi] ibid.

[vii] ibid.

[viii] ibid.

[ix] ibid.

[x] Tkacik, Peter, & CTI fellows. Race track assembly.
[xi] IKA. http://www.oxygenbombcalorimeter.com.

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