Newton's Laws of Motion in a Motorized World

Lisa Clark Ashworth

Rationale:

Having previously taught the force and motion unit for the past four years in a fifth grade classroom, I find that students often struggle with the abstract concepts of balanced and unbalanced forces, movement, inertia, gravity, friction, acceleration, velocity, and mass. I have found that students need to actively "experience" these concepts in a science classroom, rather than just study them in a textbook. They need lots of hands on experiences along with real world examples of how force and motion works in our modern world in order to adequately grasp their meaning and impact on our everyday lives.

Fifth grade student's ride in motor vehicles (cars, buses, trucks, planes, etc.) every day and they often experience these vehicles as play toys in their homes. During this force and motion unit, I want my students to be able to gain a better understanding of the basic concepts through experiencing a variety of activities that deal with designing, building, and testing a variety of miniature vehicles that illustrate these concepts. I also want my students to test these vehicles on a variety of surfaces on different incline ramps in order to kinesthetically grasp the concepts of inertia, gravity, momentum, balanced and unbalanced forces, mass, acceleration, and friction.

The city of Charlotte, North Carolina, is a major center for the automobile racing sport known as NASCAR. Since our fifth grade classroom is located in such a popular area for NASCAR, my students have the opportunity to learn more about this sport and it relates to the physics' concepts of force and motion. They will also be able to gain an understanding of some of the basic concepts of mechanical engineering as it relates to NASCAR by examining Newton's Laws and how they relate to motorized vehicles.

Introduction:

Barringer Academic Center is an elementary school in Charlotte, N.C., that contains students in kindergarten through fifth grade. The school has students that have a wide range of abilities. There are students who perform at a basic academic level all the way up to those who perform at a high academic level. Our school also contains a science lab where each classroom receives additional science instruction once a week for forty minutes to reinforce the North Carolina Standard Course of Study objectives (NCSCoS). My classroom includes fifth graders who are considered exceptionally gifted, and they are able to comprehend concepts in reading, writing, math and science that range two to four years above their current grade level. I would like for my students to learn some basic engineering concepts that relate to Newton's Laws of Motion and more especially

NASCAR. In applying these engineering concepts, students will be able to comprehend the strong connection between math and science in a real world occupation such as engineering. I will add these math and science engineering concepts such as aerodynamic drag, draft, turbulence, turning force, center of gravity, centripetal force or acceleration and down force to my current force and motion unit vocabulary as I develop this unit. By designing a unit of study of "hands on" force and motion experiments that can incorporate math and science engineering concepts, students will be able to better grasp the basic principles of force and motion in a fun and interesting way. By including these basic engineering principles, I will be able to take my students to a higher level of learning and differentiate the curriculum in order to meet their academic needs and potential.

Background Information on NASCAR:

According to Greg Fielden's book, *NASCAR: The Complete History,* "the first recorded closed-circuit auto race in the United States took place in September 1896 at a horse-racing track in Narragansett Park in Rhode Island."[i] From the early 1900s to 1947, a variety of automobile speed tournaments were organized from Daytona Beach, Florida to Atlanta, Georgia to Salisbury, North Carolina. Most of these races were carried out on sand or dirt tracks. NASCAR was officially born in 1947 when an early leader in the racing world, Bill France, decided to organize the National Association for Stock Car Auto Racing along with thirty-five other men in Daytona Beach, Florida. In May of 1949, Bill France organized a legendary event for NASCAR at the Charlotte Speedway that was a 150-mile race for stock late-model cars run on a red dirt track. This was important event in NASCAR racing history as it is still run today in Charlotte and known as the Coca-Cola 500 race which is held every year on Memorial Day Weekend.

In Mark Bechtel's book, *He Crashed Me So I Crashed Him Back*, he labels Daytona Beach Florida as the "birthplace of speed." He describes the beach sand in Daytona Beach as a perfect surface for race car drivers by explaining, "the sand on central Florida's Atlantic Coast comes from the shell of the coquina clam, unique to the area, and the fine, round grains naturally pack themselves in a surface that is as hard as asphalt." [ii] Asphalt had not been perfected at this time and Daytona Beach's sand was perfectly smooth and it required neither construction nor upkeep. In 1979, the Daytona 500 was remembered as a significant race because it was aired in its entirety for the first time on television, occurred during a giant north eastern snowstorm, and had a dramatic finish which resulted in a fist fight between two leaders that crashed out in the last lap. Therefore, the significance of NASCAR was broadcasted worldwide.

Greg Fielden states that NASCAR in the 1990s became the second most popular professional sport in America behind the National Football League. By the early 2000s, all major networks such as ABC, CBS, NBC, ESPN, and FOX were fighting over the rights to televise NASCAR races. Fielden attributes the increased emphasis on science and engineering research to a seven-year project known as the "Car of Tomorrow." This project was led by NASCAR vice president Gary Nelson. The requirements for the “Car of Tomorrow” are to have more of an emphasis on safety and cost rather than aerodynamics. With an economic recession affecting all facets of life, NASCAR needed to adapt to the economic situation with changes in design cost. Stock cars under the COT are made four inches wider and two inches taller than the previous models and the windshield is set at more of an upright angle, while adding a boxier front bumper. One additional improvement for safety includes moving the roll cage three inches to the rear and four inches to the right. In addition, the blade-type spoiler was replaced with a larger attached wing. These new design requirements were established for all stock cars which has now changed the future of design in the sport. The “Car of Tomorrow” made its first appearance in 2007 and it continues to be modified today with a continued focus on safety and cost reduction.

Fielden asserts, “Perhaps more than at any other time in NASCAR history, the team landscape is changing, and those that remain are facing a challenging future. But NASCAR’s position as the number-two sport in the country remains solidly intact, and the future continues to look bright for America’s most exciting motorsport.” [iii]

Content Objectives:

Force and Motion is a unit in the 5th grade science curriculum that is taught for approximately eight weeks of the school year. Fifth grade students are tested on this unit in May of every school year as a part of their North Carolina Fifth Grade Science EOG Test. This year, North Carolina is changing from NCSCoS to New State Essential Standards and Common Core Standards. According to these new standards in North Carolina for 2012-2013, fifth grade students will receive their instruction for the *Force and Motion* unit during the first quarter of the school year. The underlying objective for this unit is to show students the connection between “forces” and “motion” in our everyday lives and the relationship between these two concepts.

There are four major clarifying objectives that all fifth graders in North Carolina are expected to achieve while they learn about the concepts of force and motion.

- First, students are expected to be able to explain how factors such as gravity, friction, and change in mass affect the motion of objects.
- Secondly, they are expected to infer the motion of objects in terms of how far they travel in a certain amount of time and the direction in which they travel.
- Thirdly, they are expected to be able to illustrate the motion of an object using a graph to show a change in position over a period of time.
- Lastly, they are expected to predict the effect of a given force or a change in mass on the motion of an object.

Fifth grade students receive instruction that includes how Newton's Laws of Motion apply to our daily lives along with specific vocabulary terms. The current list of unit vocabulary for Force and Motion encompasses force, inertia, gravity, friction, speed, velocity, acceleration, momentum, balanced forces, unbalanced forces, action, reaction, work, simple machine, lever, fulcrum, as well as Newton's First, Second, and Third Laws to and also Newton's Law of Universal Gravitation.

The force and motion unit is very enjoyable to teach, but it is often challenging for some students to grasp the concepts and relate them to real life without many "hands on" experiences during the teaching of this unit. We have a grade level competition of "egg drop" where students design contraptions made from recycled materials used to protect a raw egg that is dropped from approximately 10 feet off the pavement. We also have an "invention convention" where students design useful simple machines from recycled materials and demonstrate them for the rest of the school. Students have to combine their background knowledge of simple machines and force and motion vocabulary while coming up with an original creative design. Fifth grade students love to design "balloon rockets" that they launch along a string using plastic straws to carry them along the string. In this curriculum unit, my students will take the "balloon rockets" a step further by designing a balloon jet race car. I have also used matchbox cars with wooden block ramps and rubber bands to demonstrate force and motion concepts. While engaging in this force and motion unit, students will extend this activity by testing matchbox cars on a pre-constructed ramp where the ramp height can be raised or lowered to experiment with the concepts of inertia, gravity, speed and acceleration. The ramp will contain two lanes for comparing the modifying force and motion effects on the cars and the ramps. The surface of the ramps will also be modified by adding sand or water to experiment with the concept of friction. Students will also modify match box cars with modeling clay to experiment with the concepts of aerodynamic drag, draft and down force. By designing more activities using moving vehicles and ramps, I believe that fifth grade students will be able to understand the basic concepts of what forces make objects move. I believe that students need lots of kinesthetic activities to help them comprehend the concepts in this unit. Experimenting with motor vehicles is an excellent real world application for the fifth graders who will learn the force and motion concepts of this unit.

Instructional Content Vocabulary: (As defined by NCSCoS in 5th Grade Science Objectives)

Acceleration: Change in velocity with respect to time.

Action: The force one object applies to a second, as in Newton's third law of motion, which states, *for every action, there is an equal but opposite reaction.*

Balanced Forces: This is where all of the forces on an object cancel one another out.

Distance: An interval between two points in time.

Force: A push or pull exerted by one object on another, causing a change in motion.

Friction: A force that opposes the motion of one object moving past another.

Fulcrum: The pivot point of a lever.

Gravity: The force of attraction between any two objects due to their mass.

Inertia: The tendency of a moving object to keep moving in a straight line or of an object to resist a change in motion.

Lever: A simple machine made of a rigid bar and a fixed pivot point, called the fulcrum.

Mass: A measure of the amount of matter in an object.

Matter: Anything that has mass and takes up space.

Motion: This is the process of moving or changing place or position.

Momentum: This is the force or speed of movement.

Reaction: The force with which an object responds to an action, as in Newton's third law of motion.

Simple Machine: A machine with few moving parts, making it easier to do work. Examples of simple machines include a lever, screw, fulcrum, inclined plane, etc.

Speed: This is how fast an object's position changes with time at any moment.

Unbalanced Forces: This is where a certain force is either only partially canceled or not canceled at all by other forces.

Velocity: The speed of a moving object taken together with its direction of travel.

Work: The use of force to move an object a certain distance.

Newton's Laws*:*

Newton's First Law of Motion (Law of Inertia): Objects at rest remain at rest and objects traveling at a steady rate in a straight line continue that way until a force acts on them. This law can be tested in this unit by racing match box cars on a flat track and inserting obstacles during the test runs.

Newton's Third Law of Motion: This states that for every force/motion, there is an equal and opposite force/motion. This law can be demonstrated below in Figure 1. Students will design a balloon jet race car like the one below to experiment with this law.

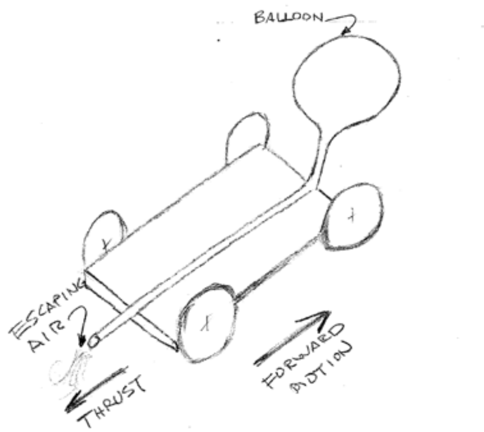


Figure 1: Balloon jet race car

Newton's Second Law of Motion: This is an equation to show how acceleration is related to force and mass i.e. F = ma. This equation says the acceleration is found by dividing the force by the mass. This law shows how changing a force isn't the only thing that affects acceleration; changing the mass also affects acceleration.

The subsequent drawing (Figure 2) illustrates how the acceleration of two different cars is affected by the same force when their masses are different. Students will experiment with this concept by racing two cars that have very different masses. Students will experiment with these two cars on both a flat surface and a ramp with two lanes in order to compare the effects of this law. Students will use scales and stop watches to be able to calculate the equation of F = ma.

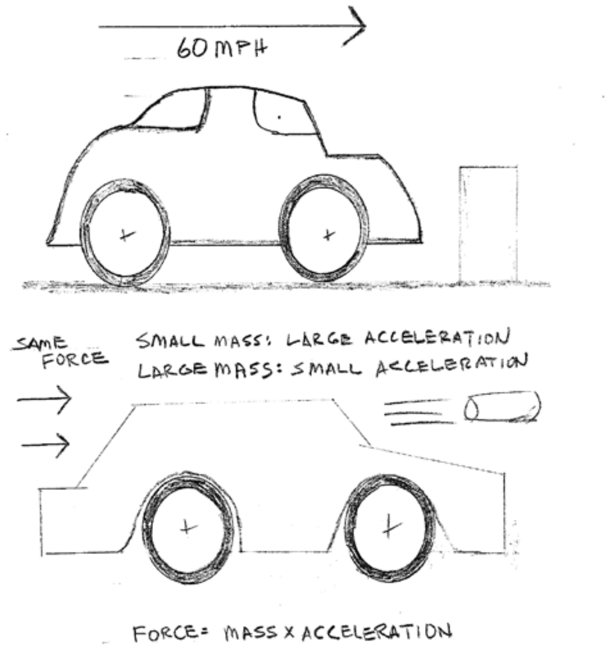


Figure 2: The effects of mass on acceleration

Engineering concepts: (As defined in *The Science of NASCAR*)

Aerodynamic drag: Air drag forces which act on the body of the car always opposing the car's motion.

Draft: This is when two cars are close together and the front cars drag is dominated by pushing the air out of the way and the second cars drag is dominated by the vacuum of pulling the trailing air along in its wake. Because the drag on each car is less than a single car (pushing and pulling the air all by itself), they can go three to five mph faster together than a single car.

Turbulence: In a draft, the second car is pushing through air being dragged behind the front car. However, even though this air is generally going forward, there is considerable back and forth buffeting. This rough air is often referred to as 'turbulence' and shakes up the second, causes it to run hot, and lose the critical traction inducing down force on its wings or spoiler.

Lateral force: The force that is generated between the tires and the track used for cornering.

Center of gravity: The theoretical center of the car's mass. This includes the center of mass left to right, front to rear, and height off of the ground.

Centripetal force: The inward pointing force of the track on the car's tires as a car rounds a turn. This is the same force in a string when a ball on a string is swung around in circles.

Acceleration: Any change in motion of an object. In auto racing, this is how fast the car's speed changes including lateral acceleration going around a turn.

Down force: This is the force that is exerted downward by the aerodynamics of the car, and the down force increases with the square of the speed of the car. Example: At 90 mph, you may have a down force of 500 pounds. At 180 mph, you would have a down force of 2,000 pounds. Since tires traction is directly related to contact force, greater tire traction can be gained if aero loads are added to the weight of the car. This is particularly useful when you consider that vehicle acceleration is due to that traction force divided by the mass.

Instructional Strategies:

This fifth grade science unit should take approximately four to six weeks to teach. It is important for students to have lots of hands on activities in order to adequately grasp the concepts associated with force and motion. In addition to class discussions, *Discovery Education* videos,physical science assessment probes, reading about force and motion concepts in their textbook, *MacMillan/McGraw-Hill North Carolina Science,* students will participate in a large variety of hands on experiments.

The first strategy in the teaching of this unit will be instruction of background knowledge. Students will begin the unit with background knowledge of important vocabulary concepts. Background information concerning the history of motor vehicles along with a brief history of NASCAR will also be presented as beginning activities for this unit. The classroom discussions will include how these vocabulary concepts are implemented in NASCAR. Students will discuss how the design of the race cars and the tracks in NASCAR are impacted by the understanding and implementation of force and motion concepts. Students will be able to understand how the sport of NASCAR is not just a car race to see who finishes first, but a sport that is largely dependent on force and motion concepts in science. Students will also view several force and motion videos from *Discovery Education* to serve as background information for this unit.

The second major strategy in the teaching of this unit will offering hands-on instruction opportunities. Students will conduct and participate in projects, laboratory experiments, cooperative learning, think-pair-share activities, as inquiry based instruction using the scientific method. By utilizing background knowledge and multiple hands-on experiences, students will be able to connect the science concepts of force and motion with their everyday experiences in a motorized world.

Classroom Lessons and Activities:

Activity One: Background Vocabulary Concepts of Force and Motion

Students will begin this unit by constructing a science vocabulary journal of the vocabulary previously listed in this document. Students will be asked to define the vocabulary concept and then illustrate the word with a picture involving an automobile to better illustrate the meaning of this force and motion concept. Students will also be able to view two force and motion videos that review these force and motion vocabulary concepts. The videos contain a short quiz at the end of the video that will help students with mastery of the vocabulary.

Activity Two: Simple Machine Exploration

Students will explore the concepts of simple machines as they relate to automobiles and race cars with exploration activities on the website "Edheads". The link for this website is http://www.edheads.org/activities/simple-Machines/. Students will explore activities involving windshields, gears, racecar tires, racecar wings and even NASCAR flags that demonstrate how simple machines work. Following this activity, students will create their own simple machine out of recyclable materials that incorporates one or more of the simple machines (gears, tires, wings, etc.) from this previous website activity. Their invention should roll like an automobile does but with the force coming from the student rather than fuel. They will present their simple machine inventions that relate to cars in a "mini-fair" to other students in fifth grade.

Activity Three: Balloon Jet Race Car:

In addition to constructing balloon rockets to race on a string, pairs of students will be given supplies to construct a balloon jet race car in order to demonstrate Newton's Laws. The supplies that will be needed are a sturdy piece of cardboard, straws, balloons, a pencil or dowel rod for an axle, and wooden spools or circular pieces of wood for wheels. Students (in partners) will be given the opportunity to construct their vehicle and test it with the balloon for propulsion. This activity will help students understand how to construct a small vehicle to illustrate Newton's Laws.

Activity Four: Force and Motion Web Games

Another excellent website for students to practice activities that involve force and motion and automobiles is http://science.pppst.com/motion.html . This website contains games, activities, and power points to help students understand the basic concepts of force and motion in a fun, interactive method. This is a great review of the vocabulary of this unit, and there are several interactive games on this website for students to interact with that involved motorized vehicles. Students will write a reflection of their favorite game and give ideas for other games that can be added to this website.

Activity Five: Website Simulation of Ramps and Cars

Before students participate in the matchbox/track activity below, they can simulate the activity on the internet in an interactive track activity using cars, ramps and gradients. This website is found on the "BBC" website called *Forces In Action.* The website link is http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtmle. Students should use the scientific method for reflection of this activity. Students will write a hypothesis and conclusion in their science journal for their experiment using different weights and gradients on the cars and ramps in this activity.

Activity Six: Two Physical Science Probes in Force and Motion (Probes are from *Vol. 1Uncovering Student Ideas in Physical Science: 45 New Force and Motion Assessment Probes* by Page Keeley and Rand Harrington)

The first probe is called "Checking the Speedometer", and it informs students on how to check the accuracy of a speedometer on a car. Students are given a simulated activity of recording the distance of a car for a consecutive series of mile markers on a straight highway where the car is going at a constant speed. The probe asks the students to evaluate the data on the table given to determine if the speedometer is accurate. The activity culminates with having the students discover how someone can find the speed of a car. This assessment probe involving speed and Newton's Laws is found on page thirty-five of this probe compilation.

The second probe is called "NASCAR Racing" and it involves a discussion concerning a NASCAR newspaper article using the word velocity numerous times throughout the article. The probe asks students to reflect in written and verbal discussion concerning a conversation about the difference in the meanings of speed and acceleration as they pertain to velocity. The conversation statements for critical thinking include:

Silas: "I think *velocity* is the term used when something moves really fast."

Jade: "I think *velocity* is the scientific word for *speed*. *Speed* and *velocity* mean the same thing."

Ayla: "I think the words *velocity* and *acceleration* mean the same thing."

Omar: "I think *velocity* describes the *speed* and the *direction* in which something moves."

LaVonn: "I think it is the *rate* at which the *speed* of something is changing."

Terrell: "I think it is used to describe the average *speed* when something moves at different *speeds*."

Students will discuss and write about which person has the best idea about what the word velocity means. This activity is a good discussion provoking activity and it is found on page fifty-one of the physical assessment probe.

Culminating Activity:

Students will modify matchbox cars by adding a simulated wing or spoiler that they can test to grasp the concepts of balanced and unbalanced forces, movement, inertia, gravity, friction, acceleration, velocity, and mass. Students will each be given two ounces of modeling clay to modify the matchbox cars by molding wings or spoilers to increase the drag of the car. Students will use these modified cars to test the different concepts of force and motion as they relate to race cars.[iv]

Student will also use matchbox cars of different shapes, sizes, and weights to help with their understanding of these concepts as they relate auto racing. Students will have an opportunity to test matchbox cars on ramps of varying heights and varying surfaces (sandpaper, wet, sandy, red dirt) to better understand the concepts of inertia, acceleration, mass, gravity, and friction. Students will be able to race two matchbox cars at the same time down the ramps with different friction surfaces and varying heights to better demonstrate a comparison of the heights and surface materials that impact day to day driving and even auto racing.

The two drawings below are examples of ramps that will be used for testing the matchbox cars: (Figures 3 and 4).

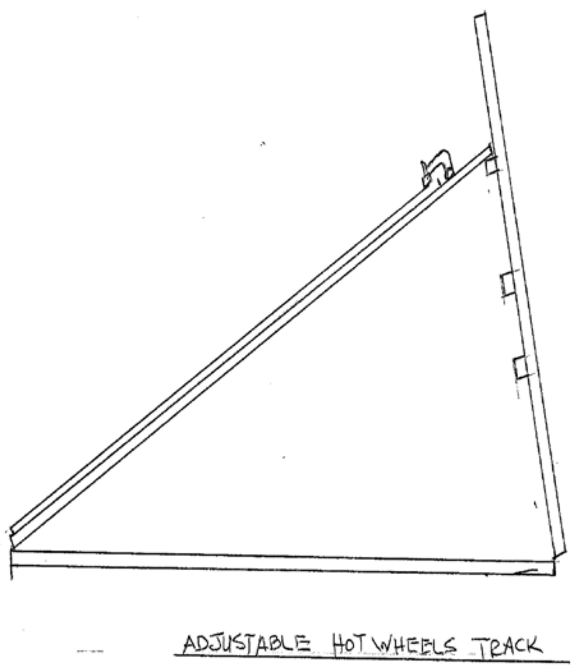


Figure 3: Adjustable Hot Wheels track

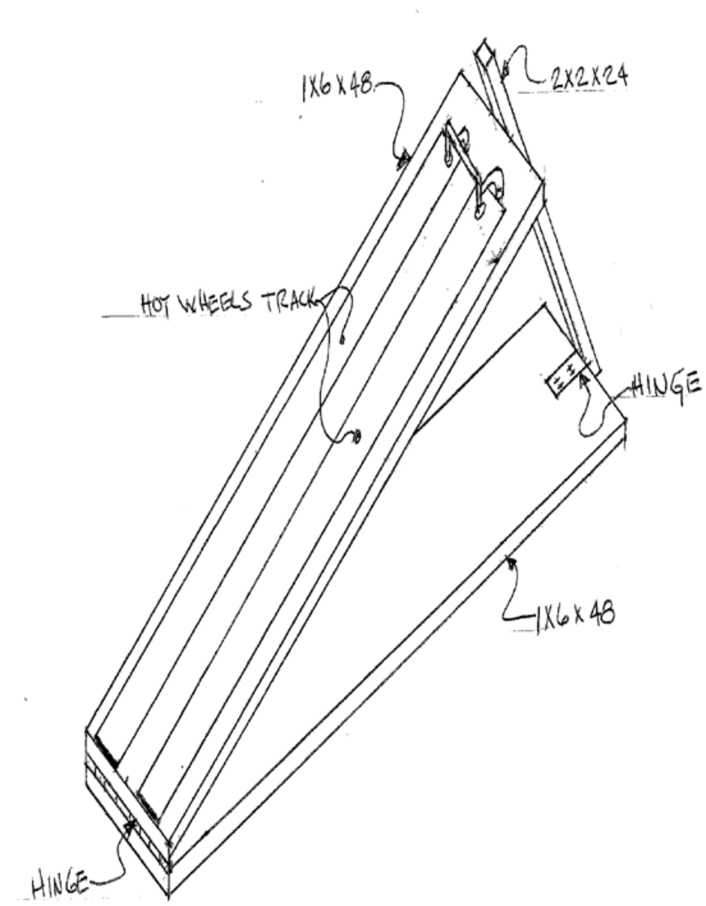


Figure 4: Isometric view of Hot Wheel track

Assessments:

Students will be provided several physical science/force and motion assessments at the end of this unit. One assessment will be the vocabulary journal and vocabulary test that provide an excellent review tool for the North Carolina Science EOG Test in May. Another assessment will be several newspaper articles from *The Charlotte Observer* on the sports page on NASCAR. Students will look for key vocabulary words that they have studied during this unit such as speed, velocity, and acceleration and present an oral summary to the class of what they have learned about these words as they relate to NASCAR[v].

Works Cited:

Bibliography for Teachers

Bechtel, Mark. *He crashed me so I crashed him back: the true story of the year the King, Jaws, Earnhardt, and the rest of NASCAR's feudin', fightin', good ol' boys put stock car racing on the map*. New York: Little, Brown and Co., 2010. Print. This source was used for background history information of NASCAR.

Fielden, Greg. *NASCAR the complete history*. Lincolnwood, IL: Publications International, Ltd., 2007. This source was used for background history information of NASCAR.

Keeley, Page, and Rand Harrington. *Uncovering Student Ideas in Physical Science, Volume 1 45 New Force and Motion Assessment Probes.*. Arlington: National Science Teachers Association (NSTA), 2010. This is a collection of force and motion activities to help students think critically about these physics concepts.

Pelecky, Diandra L. *The Physics of NASCAR: the science behind the speed*. New York: Plume, 20092008. Print. This source was used for vocabulary and technical information to explain the science of NASCAR as it relates to the fifth grade unit of force and motion.

http://www.edheads.org/activities/simple-Machines/. This is a great interactive website for students regarding simple machines.

http://science.pppst.com/motion.html This is a great website for games dealing with force and motion concepts.

http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtmle. This is a great website for conducting online science experiments dealing with force and motion concepts and Newton's Laws.

http://www.discoveryeducation.com This website has great videos and video quizzes for helping students better understand the concepts related to force and motion and

Bibliography List for Students

Daniel, Lucy H. *Macmillan/McGraw-Hill science*. New York: Macmillan/McGraw-Hill, 2005. This is the student science textbook for fifth grade.

Keeley, Page, and Rand Harrington. *Uncovering Student Ideas in Physical Science, Volume 1 45 New Force and Motion Assessment Probes.* Arlington: National Science Teachers Association (NSTA), 2010. This is a collection of force and motion activities to

help students think critically about these physics concepts. Fifth grade students love to experiment with the activities in this book.

Robertson, William C., and Brian Diskin. *Force and motion*. Arlington, Va.: NSTA Press, 2002. This book is a great source for students to master their force and motion vocabulary concepts and gain a better understanding of Newton's Laws and how they work in everyday life.

List of Materials for Classroom Use

Beaver, John B., and Barbara R. Sandal. *Simple machines*. Greensboro, N.C.: Carson-Dellosa, 2002. This is a great resource for teachers and students for a simple machines classroom project.

The following documents show a list of materials needed to construct a classroom ramp for students to use and test with different matchbox cars in order to gain a better understanding of force and motion concepts.

Appendix 1. 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 2. Ramp Drawings

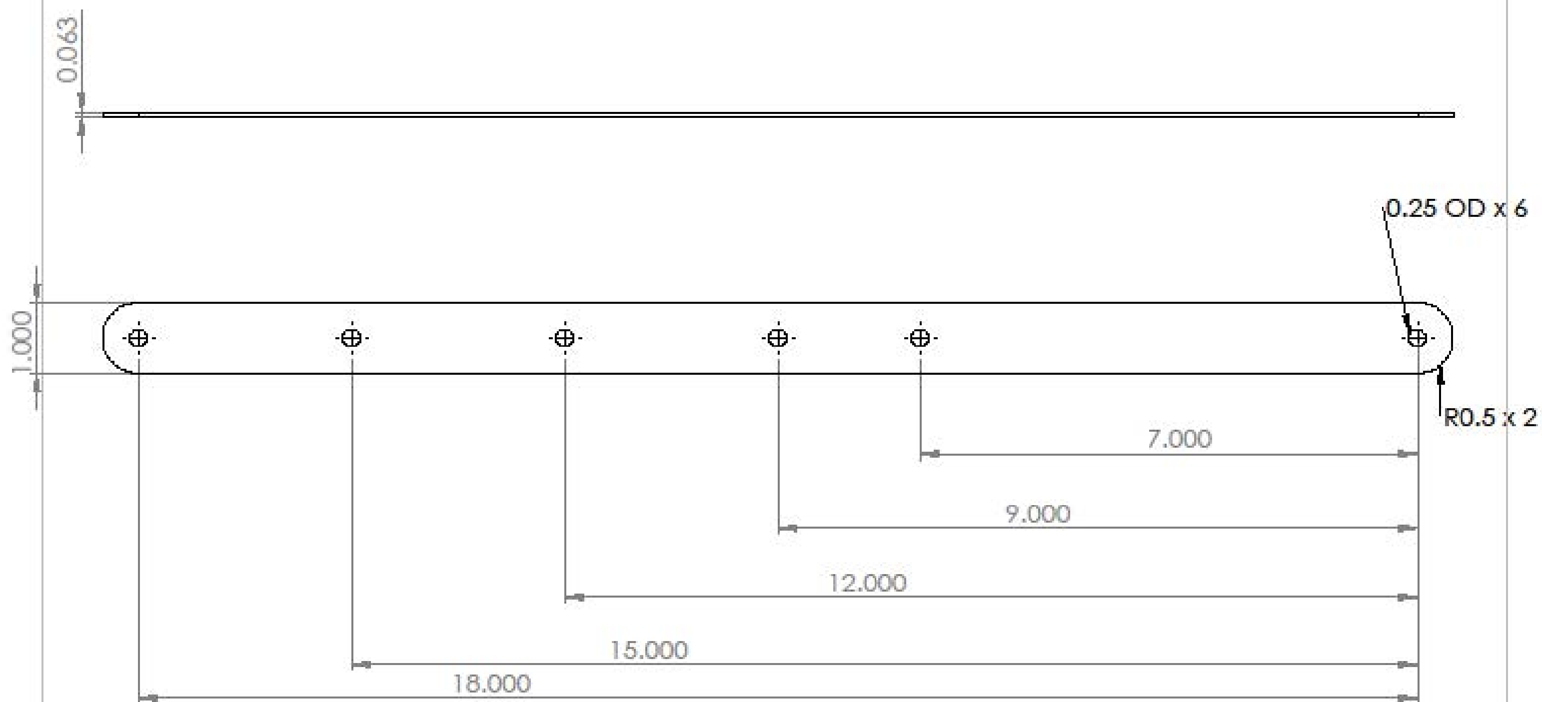
***The material we used was 16 gage Stainless Steel although regular sheet metal is fine.

***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



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:

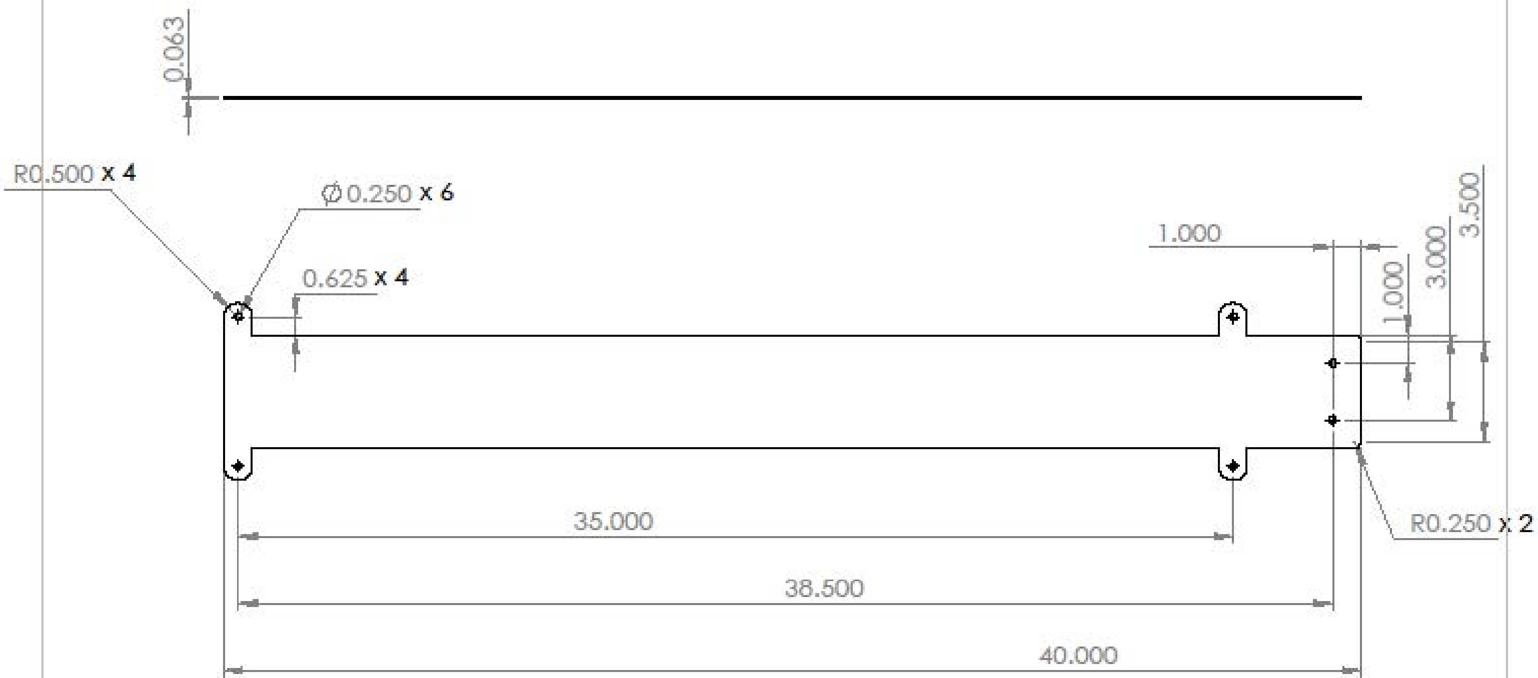
UNC Charlotte Motorsports Engineering

TITLE:

SIZE A DWG. NO. Ramp Columns REV

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

5 4 3 2 1



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

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

COMMENTS:

UNC Charlotte Motorsports Engineering

TITLE:

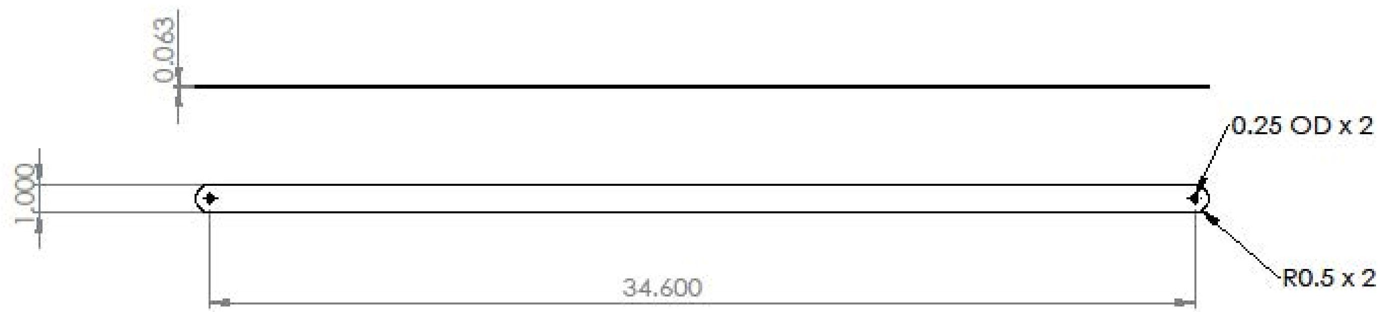
SIZE A DWG. NO. Ramp REV

SCALE: 1:10 WEIGHT: SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

DO NOT SCALE DRAWING

5 4 3 2 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	UNC Charlotte Motorsports Engineering
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN			TITLE:
			CHECKED			
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL 304 Stainless Steel	COMMENTS:			SIZE A DWG. NO. Ramp Base REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:10 WEIGHT: SHEET 1 OF 1

5 4 3 2 1

Appendix 3. Ramp images

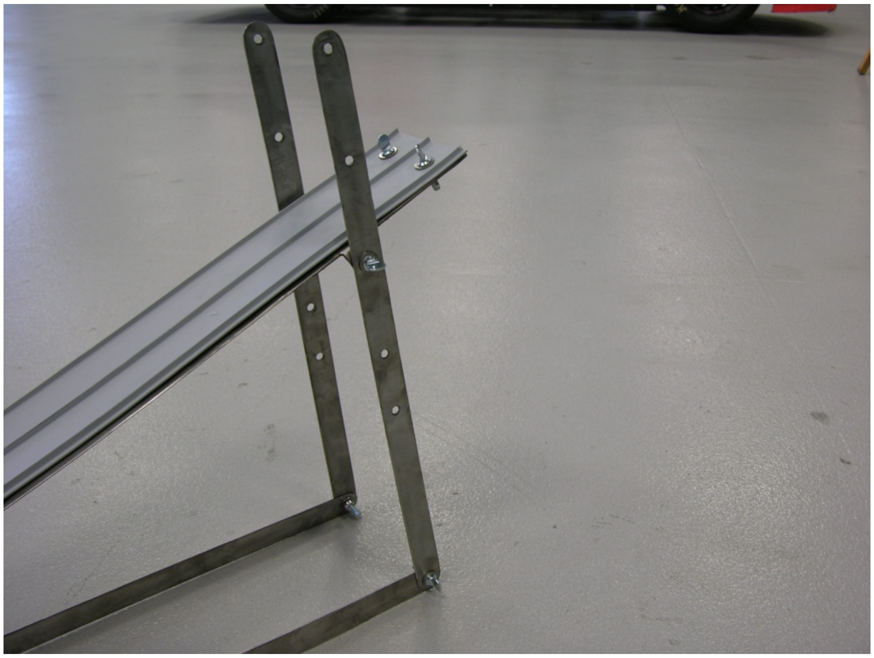


Figure 1. Adjustable height struts

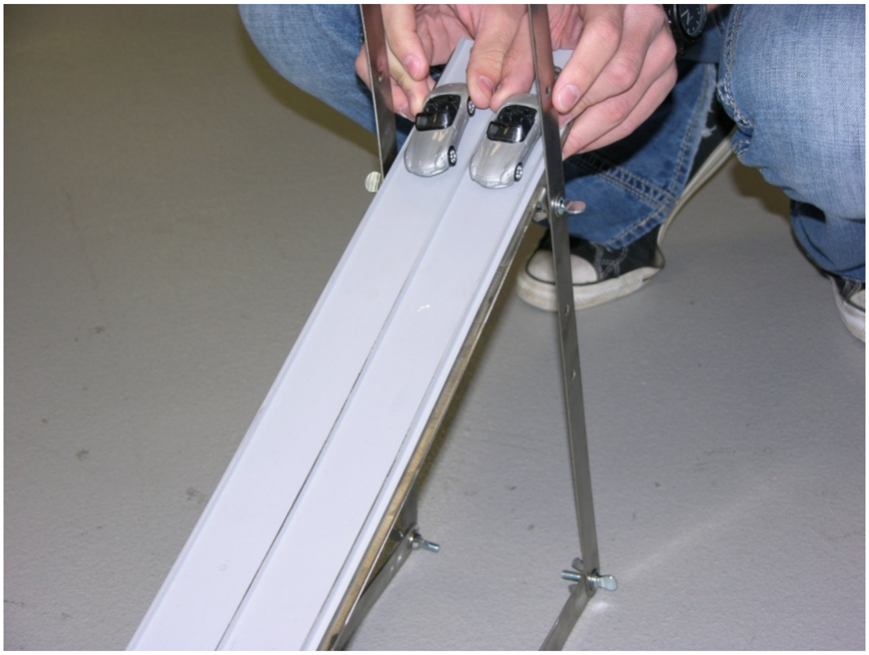


Figure 2. The starting line

Figure 3. Wing nut and wing bolt fasteners

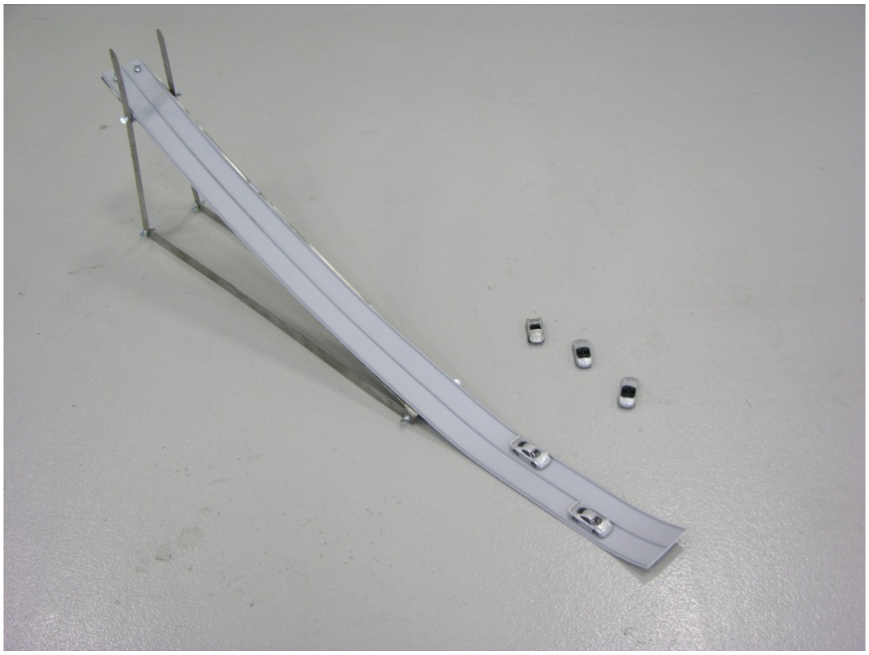


Figure 4. The ramp as used.

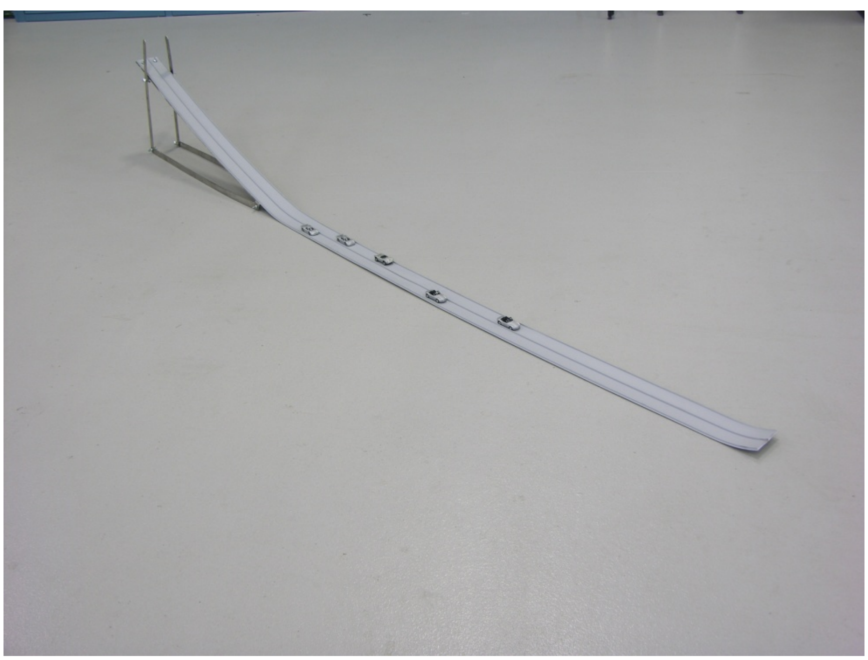


Figure 5. Ramp with 10' track.

Figure 6. Car with standard clay load set up for high drag.

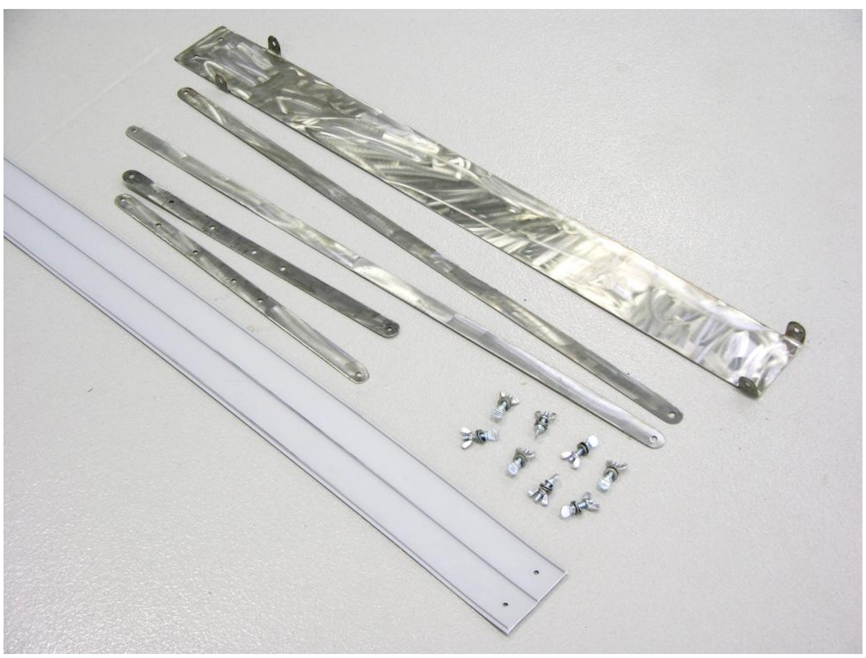


Figure 7. Disassembled track ready for storage.

[i] Fielden pg. 150
[ii] Bechtel pg 75
[iii] Fielden pg. 477