Racing to Success

The finished student designs showed a high degree of individuality. Students learned that mass and drag were two major factors in their design's performance.

By Thomas Ogle

Subject: Computer-aided design (CAD)

Audience: Teachers, teacher educators

Grade Level: 6–8 (Ages 11–14)

Technology: 3-D design software, spreadsheets

Standards: *NETS•S* 3, 5, 6; *NETS•T* II (http://www.iste.org/standards)

Using Professional 3-D Design Software to Build CO_2-Powered Cars in Middle School Science

I teach design and technology at Warner Middle School in Farmington Hills, Michigan, a comfortable and diverse community in suburban Detroit. In 1995, the Farmington Board of Education adopted a new student profile it hoped to achieve by 2007, the year students then in kindergarten would graduate from high school.

A colleague and I designed a course we named 2007, because the 10-week, Grade 8 course was designed to address some of the profile's key attributes: Knowledgeable Thinker, Thoughtful Problem Solver, Quality Producer, Effective Communicator, and Collaborative Team Member.

The idea for this course came out of the starting gate when a teacher across the hall and I discovered we were teaching many of the same topics—she in science class, and I in technology class. We wanted to join forces to teach these topics, and fortunately, the Farmington district offered the perfect conduit for doing so: the academic extension, a 10-week, interdisciplinary module with a theme. In the academic extension we designed, 24 students used both science and technology texts and learned how physics concepts apply in the world outside of school. (*Editor's note:* See the online supplement for the course outline, rubrics, and other course materials.) Included on our team was the informational technology teacher. Her course goals were met by having the students produce the engineering reports. The computer teacher worked with these students for the last two weeks of the unit. (She had other class sections to teach during the activity.)

A Flight of Imagination

The point of building a CO_2 car, of course, is not just to build a CO_2 car; it's to learn about science, technology, and design through hands-on problem solving. For greater effect, and before turning to the CO_2 cars, we opened the module with a completely different experiment designed to simulate the challenge.

We started learning about transportation systems on a large scale using the marine, terrestrial, and atmospheric and space environments. Next, we engaged the students in a simple activity where they had to get a balloon to travel a fixed route on a piece of fishing line stretched across the room.

Through this process, students learned about mass and force, and saw vivid illustrations of Newton's Third Law (for every action there is an equal and opposite reaction). On the third day, the students were ready to turn their attention to CO_2 cars.

The Design Portfolio

At this point, we directed the students to begin creating their design portfolios. We explained that other than a safety test to ensure they were ready to use equipment in our machine lab, there would be no written tests. Their grades would be based on their portfolios, a classroom version of the engineering report. I handed them a worksheet titled "Steps in the Design and Problem-Solving Process," which guided them through the nine steps familiar to every technology teacher and engineer:

1. Identify problems and opportunities
2. Investigate and research
3. Frame a design brief
4. Generate possible solutions
5. Choose a solution
6. Develop working model
7. Produce product and solution
8. Test and evaluate
9. Redesign

Most middle school–age children need help with organizing. This worksheet served a dual purpose. It helped to teach the steps of the engineering process and provided an outline of the documentation for their portfolios. I will also use it as a framework here to tell the story of 2007.

1. Identify Problems and Opportunities. In the first pages of their portfolios, students defined the four environments in which humans transport; land, sea, air, and space. They also explored useful design features, such as smooth surfaces and aerodynamic contouring, and Newton's laws and key science concepts such as gravity, force, motion, and friction.

2. Investigate and Research. We encouraged the students to do extensive research into what other schools were doing with CO_2 cars. Much of this research took place over the Internet, and a number of portfolios included pages printed from CO_2 Web sites. I've included some of the best for reference. (*Editor's note:* See Resources on p. 25 for URLs.)

The students also described the six subsystems or components of which vehicles are composed—propulsion, structure, support, control, guidance, and suspension. Students made lists of design considerations such as, "What should the shape of the vehicle be?"

3. Frame a Design Brief. To help define the design challenge, we showed the students the CO_2 cartridge that would power their racecars. The "light bulbs" immediately began to go on. A CO_2 cartridge is essentially compressed gas inside a steel container. When this gas is released, it results in a situation of unbalanced forces. This was another example of Newton's Third Law: an equal and opposite reaction, which in this case propels the car. The students began to make connections with rocket systems that propel spacecraft, as well as to our initial balloon experiment. Once they understood that all these things work exactly the same way, Newton's Third Law became a reality instead of an abstraction.

Next, the students recorded their design briefs in their portfolios: "I will design, fabricate, test, and evaluate a vehicle powered by a carbon dioxide cartridge. It will travel 20 meters in less than 1.5 seconds." We encouraged students to name the specifications their design would meet and to explain the scientific hypotheses underlying the challenge.

4. Generate Possible Solutions. The design phase and its documentation came next. Students prepared at least four hand-drawn sketches demonstrating their ideas and included them in their portfolio. After narrowing these ideas to two and drawing top and side views of each, they were ready to tackle computer-aided design (CAD).

5. Choose a Solution. Students were then asked to choose the single best design, which they would use CAD to render in a detailed production draw-

ing that would be used as the pattern for their prototypes and final models. In the early years of 2007, we used a 2-D CAD system. Two years ago, I learned that Parametric Technology Corporation (PTC), a company that makes product development software, had started "Design & Technology in Schools," a program that gave its Pro/DESKTOP 3-D design software to schools at no cost. In addition, PTC allowed students to load the free software on their home computers. The only prerequisite was for the teacher to take a two-day training course in how to teach with Pro/DESKTOP. Once this was done, I received my license and installed the software in my classroom.

I wondered how middle school students would react to this complex 3-D software that was actually used in industry. I was amazed at the facility they showed after just a few days. They were able to take the software home when I assigned them homework. Their ability to practice and explore the software beyond the time allowed in class resulted in their CAD learning curve being reduced from the eight days typical of the 2-D system we had been using to five days.

On the first day of the CAD unit, the students designed a virtual block to scale in digital form that represented the actual wood block they would shape into racecars. This "digital product," a highly realistic digital representation of the actual physical product, enables designers to explore lots of design variations and versions before moving to expensive and time-consuming physical models. I taught them about constraints and dimensioning and set up a basic profile. I also taught them to use the "Extrude" and "Project" features because they would need to add and subtract material. Extrude and Project control how a solid form is created from the 2-D sketch. This is the power of the software.

Many of the students became deeply engrossed in designing and experimenting with the software. I've seen many of them discover things on their own and become so excited that they jump up to show a friend. As kids understand what "tools" on the menu screen can achieve they show each other how to build upon classroom lessons in creating additional ideas to their designs.

One of the great benefits of Pro/DESKTOP is that when you make a serious mistake, you can simply throw your virtual block away and start over again. Less drastic changes and "backsteps" can be made at any time using the program browser tool. By creating a digital representation of the physical product before using actual materials, designers save both time and money. The software allows students who aren't good sketchers to do beautiful work, which fills them with pride and motivation. The students' 3-D CAD drawings have now become one of the more impressive parts of their design portfolios.

To challenge those students who became very proficient in Pro/DESKTOP, I ask them to draw the wheels using the "Revolve" command. Students that might miss the instruction on Revolve, can still complete their assembly by importing the wheels and axles into the design from a parts library. The students used their production drawings as their patterns and these, too, went into their portfolios.

6. Develop a Working Model. Once the students felt their designs had met all their specifications, I gave them pieces of polystyrene to make prototypes. They shaped the polystyrene with files, saws, sandpaper, and a hot wire cutter.

To test the prototypes, they set them in a low velocity wind tunnel with a little bit of theatrical smoke. The swirling smoke showed how the

air traveled over the shape of their cars. Students recorded the changes they decided to make and why. The students who understood that too much material would cause drag removed material from their cars. I did not lead students to the changes needed; instead, I allowed them to discover the needed adjustments on their own.

7. Produce Product and Solution. If the changes were major, they went back to Pro/DESKTOP to overhaul their designs. If changes were minor, they moved on to the fabrication stage. The next decision was whether to make their cars out of basswood, which is knot-free and easy to carve, or the lighter balsa, which can break when the cars are very narrow. After completing the "which material will I use for the CO_2 vehicle?" worksheet, students use the following proportion to make their decision.

$$\frac{\text{Mass of prototype}}{\text{Mass of styrene block}} = \frac{\text{Vehicle}}{\text{Mass of Basswood or Balsa block}}$$

The students shaped their wood blocks by subtracting material using band and scroll saws, flex-shaft rotary tools, and belt and disk sanders. Then they attached two sets of wheels to their cars.

8. Test and Evaluate. When the dragsters were shaped, we again tested them in the wind tunnel. On their portfolio "Dragster Data Sheets," they recorded the amount of drag the vehicle produces in a 40 mile per hour wind as well as the lift coefficient for the front and rear wheels. They continued removing material and sanding, keeping the cars symmetrical and monitoring mass to see if they needed to reduce it further.

We also inserted plastic drinking straws in the wood to create dry bearings, applied a small amount of lubricant and conducted a roll test. The object was for the car to run smoothly and not veer left or right.

The students recorded the data. All of this testing and recording would lead to an understanding of why some cars would move better than others on race day. At this point, we took digital photos of all of the racecars, to adorn the covers of the students' portfolios.

Race and Postmortem

The race in a 20-meter Pitsco drag strip, a quarter-mile to scale, was an exciting moment. We placed the CO_2 cartridges in the dragsters, and at the start of each race, punctured the cartridge with an opener. The cars shot off, attaining speeds as high as 50 miles per hour.

After the students raced the cars, they built Excel spreadsheets showing each car's average speed, mass, and drag as well as the results of an earlier roll test that measured the friction, distance, and how far off center the vehicle went.

Initially, we compared the mass of the vehicle with the speed using Excel's chart wizard to create bar charts. Students who thought higher mass would increase momentum quickly saw they were wrong: if something has less mass, it goes faster. As the mass decreases, the speed increases. But then they noted some exceptions, and this discovery led to the realization that drag and friction also influence the speed of their vehicles.

We asked students to write final essays explaining the conclusions they had drawn from the performance data and how they would change their cars if they were to do it all over again. These essays completed the portfolios. Many students with computers at home handed in slick, full-color portfolios, but others turned in neat manually produced portfolios that were equally impressive. As exciting as the race had been, reading these portfolios—and the evidence they provided that students had learned about force and motion—was to me the most exciting part.

Conclusions

I believe the three enhancements that were mentioned at the outset of this article set 2007 apart from many classes offering the CO_2 race car experience. Keeping a portfolio to document the design process developed the students' organizational and communication skills that are essential in virtually any career path. Creating their designs with 3-D CAD software helped them to think in three dimensions, while capturing their imaginations, building self-esteem and leveling the playing field among children with varying drawing abilities. Analyzing the winning vehicle after the race reinforced throughout this unit the students' understanding of the science concepts that underpinned everything.

Another heartening result of 2007 was the confidence it gave girls when they, too, found out they could understand and work with technology. Initially, a number of the girls didn't believe they could do this. They said they weren't sure they'd have good ideas, they were afraid to use the machines, and they had never done anything like this before. But as the weeks went by, and the girls' success rate equaled those of the boys,' they gained confidence. They enjoyed competing against the boys—especially when they won!

After my colleagues and I had taught 2007 for six years, budget constraints forced the district to reduce funding for this team-teaching. I continue to teach the course myself, as an elective rather than an academic extension. The class continues to be popular, but it usually attracts only boys. Having a daughter of this age, I've concluded that this is a class that, given a choice, girls feel they would not have any interest or ability to participate. This is unfortunate, because CO_2 cars not only taught the girls technology, design, and science, they also gave them a real sense of accomplishment. However when this activity is part of a requirement, the majority of girls find it worthwhile. My hope is that the team-teaching of this unit will be reinstated at some time in the future. For both boys and girls, studying design and technology is one of the best ways I know to prepare students for success in an increasingly technological world.

Resources

Mr. C's CO_2 Racing Resources: http://co2.technologyeducator.com/welcome.htm
Keith Holledge's CO_2 Dragsters Links Page: http://www.bundabershs.qld.edu.au/co2-drag/link05.htm
PTC: http://www.ptc.com/for/education
TrackStar—Carbon Dioxide Racers: http://trackstar.hprtec.org/main/display.php3?option=text&track_id=529

Tom Ogle is a design and technology teacher at Warner Middle School in Farmington Hills, Michigan. Tom has been teaching for 12 years. He is also a part-time instructor at Eastern Michigan University in the College of Technology. Previously, he was a recording engineer and an assistant department store buyer.

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Course Outline
for
8th Grade Academic Extension

Teacher: Mrs. T. Wallace
Subject: Computer Skills
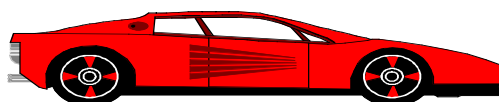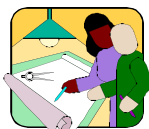
Room: 126

Engineering/Technology/Science/Computers/Language Arts/Math/Art/Creativity

Overview

In this class, students explore and evaluate academic subject matter via informational technology. Students bring recorded data from their 2007 class to evaluate in our classroom as their culminating project. The skills that the students learn are real-world applications of informational technology. Industry has given Warner encouragement to continue teaching these concepts, as these talents are sought after in college graduates applying for careers in the real world. The teams of students and teachers rotate through my program on a ten-week schedule. I team teach with the Technology and a Science teacher in the beginning of the cycle and then team with a Science and Language Arts or Mathematics teacher to complete the final project. The integrated thematic unit offers substantial skills that the students cannot afford to miss. In addition to learning specific technology skills, our class environment reinforces responsible citizen behavior of all students.

Specific Content

Our classroom is rich in basic knowledge of computer software, hardware and guidelines for each. We review topics such as word processing, spreadsheets and keyboarding. As some of the students have not had one or more of these in the past, it is introduced as a basic and reviewed, also. We introduce the students to many new topics, specifically advanced spreadsheet techniques using formulas. Although there is no testing, the students are required to abide by all policies: computer lab rules, acceptable use policy of the network and all rules stated in the student code of conduct book.

Requirements

Project	Points	Homework
Evaluation of the C02 Dragster Format: Bound booklet of spreadsheets, charts and summaries that assess the student's personal C02 Dragster. The student also evaluates the other student's cars in this assessment.	100 Specifically: 90-100= A 80-89=B 70-79=C 60-69=D 0-59=E	The student is given ample time to complete the project in class. However, if excessive absences hinder completion, the student is required to do the work after school on their own time. If done at school, prior arrangements with Mrs. Wallace must be made.

Evaluation

If the student completes each project, they will not fail the course. The grade depends on the amount accomplished and quality of the completed assignment.

<p align="center">8th Grade Academic Extension
"2007"</p>

Instructions for Final Analysis of the CO2 Dragster
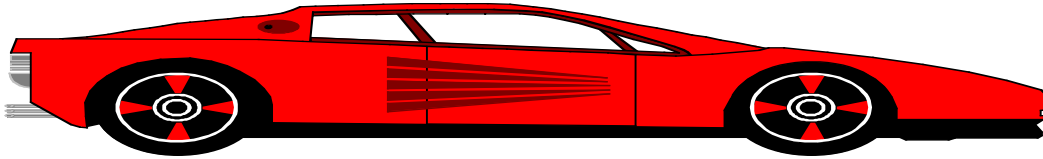
You have been applying the scientific method to solve a problem. You created a hypothesis, designed an experiment to test it, collected data from the test and now you will do step four of the scientific method. You will evaluate and explain your data as it applies to your hypothesis. This instruction sheet will give you the information needed to successfully evaluate your experiment.

Summary of events:

You raced a car designed and built by you.

You have the time that it took your vehicle to travel 20 meters.

You have results on all other tests done to your vehicle.

You need to develop charts on the following: Mass V. Speed, Speed V. Drag, Rolltest Distance V. Mass and one of your choice. (i.e. Speed V. Rolltest)

I. **Spreadsheet One "Main Data Sheet"**

    A. Although you placed data in the file already, please access the shared file again to get the whole class information and then re-save to your last name directory.

        1. double click on **MS Excel**, choose file, open, click on My Documents, scroll down to Vol.1 on wms_01 G, choose shared files, choose 2007-6 (6th Hour) or 2007-7 (7th Hour).

        2. After opening this spreadsheet, save it to your own directory before proceeding. (File, Save As, Click on "My Documents", scroll down to your last name, click on your last name, go down to the box that says "File name" and type in 2007, choose save.)

        3. Put the average speed column in order (i.e. descending is most popular for examining data),

            a. Click on the cell below "Average Speed"and drag to highlight all data in this column. Click on Data from the menu bar above, Click on sort, sort, choose average speed, descending, ok. You will be able to do this step after taking notes from my demonstration. Save again.

Chart One "On Your Own: Mass V. Speed"**:**

(Includes one chart, one spreadsheet and one paragraph of explanation)

CHOOSE THE COLOR PRINTER BEFORE MOVING FORWARD! (HPDESKJET 1120-C)

    A. This chart, spreadsheet and paragraph will be made entirely by you.

        1. With the main data sheet under your own file on the screen, not the shared file, you may begin.

        2. Highlight the entire list of names only. Choose edit, copy NOT CUT! Click on sheet 2 (a tab near the bottom left of the open dialog box). You should see a new spreadsheet with no information. Click in the first cell and choose edit, paste. (Ctrl-V is a shortcut for paste and can also be used here) The list of names should appear. Save this before going on. (File, Save As, type in the file name "mass v. speed").

        3. Go back to the main data sheet (do this by clicking on sheet 1 tab). Highlight the entire mass column, choose edit, copy NOT CUT! Go back to the spreadsheet called "Mass V. Speed" (sheet 2) and click on the first cell in the next free column next to the names, and choose edit, paste. (or ctrl-v)

4. Go back to the main data sheet (do this by clicking on sheet 1 tab). Highlight the entire speed column, choose edit, copy NOT CUT! Go back to the spreadsheet called "Mass V. Speed" and click on the first cell in the next free column next to the mass, and choose edit, paste special. (Paste Special will carry the formula with the data. It will not work if you merely choose paste) Once in the Paste Special Dialog box, choose values and OK.

5. Now you will have a spreadsheet that contains Names in one column, mass in the next column and speed in the next. Make sure that the data in the speed column is sorted before moving on. If not, follow the directions in step A3 above, but using this spreadsheet. This will sort the data from greatest to least. Along with the numbers going in order, the names and speed columns will change to go along with the data that has been sorted. ***You cannot make your graph until this step is done. It will not turn out correct and you won't be able to examine any data.***

6. Highlight the columns labeled Name, Mass and Speed. Choose Insert, Chart. Make chart selections that will demonstrate your data appropriately.

7. Copy the chart and spreadsheet into a word-processed document that defines work and interprets your results. (Refer to your notes. Make sure that the handlebars are on the object you want to copy before choosing edit, copy. Remember to minimize excel after doing the copy command, and maximizing word to past it there)

8. Below the spreadsheet and chart, type a paragraph that explains the following questions:

    a. What does the chart and spreadsheet explain?

    b. Define all science terms (i.e. mass is… speed is…) from your science text.

    c. What was your hypothesis?

    d. How did you get your data? (i.e. I used a triple balance beam to find the mass of my vehicle)

    e. What information can be figured out by analyzing the data? (your hypothesis was either correct or incorrect, most of the time or all of the time, etc.)

    f. What caused the exceptions to your hypothesis? (i.e. The performance of Jason Smith's vehicle proved my hypothesis wrong. His vehicle had a high mass, and very low drag. He placed 3rd in the race. The reason for this might be because of the car's <mark>low drag.</mark>)

9. **Put footer at the bottom of the page that includes your last name and hour.**

10. **Before printing, remember to, spell-check, have a *teacher check your work* and print preview your work**.

III. Chart Two: "On Your Own: Speed V. Drag":

(Includes one chart, one spreadsheet and one paragraph of explanation)

A. You will follow the same procedure as listed above for chart one, but will make a new chart with different data. This data will include columns labeled: names, speed and drag. Order your data in ascending or descending order for either speed or drag, not both. Follow the procedure above to make the spreadsheet, chart and paragraph.

IV. Chart Three: "On Your Own: Rolltest V. Mass":

(Includes one chart, one spreadsheet and one paragraph of explanation)

A. You will follow the same procedure as listed above for chart one, but will make a new chart with different data. This data will include columns labeled: names, rolltest and mass. Order your data in ascending or descending order for either rolltest or mass, not both. Follow the procedure above to make the spreadsheet, chart and paragraph.

V. Chart Four: "On Your Own: Your Choice of two variables i.e. Speed V. Rolltest":

(Includes one chart, one spreadsheet and one paragraph of explanation)

A. You will follow the same procedure as listed above for chart one, but will make a new chart with different data. This data will include columns labeled: names, and two variables of your choice. Order your data in ascending or descending order for either variable, not both. Follow the procedure above to make the spreadsheet, chart and paragraph. This one will demonstrate deeper analysis of the CO2 dragster results.

VI. Final Step: Essay

A. This essay needs to be in essay format and include a thesis, interest, introductory paragraph, three body paragraphs and a concluding paragraph. After looking at all the graphs and given data, write your essay describing three ways you would change your car to improve its results. Hint: examine your hypotheses and draw conclusions that your data supports. The changes would be ones made *after* you raced the car. The essay should have a title at the top of the page, and should be on one page only (when possible). In order to do this, make your text 1.5 spaced and size 12 or 10 font. Make sure to place a footer at the bottom of the page that includes your last name and hour. Good Luck!
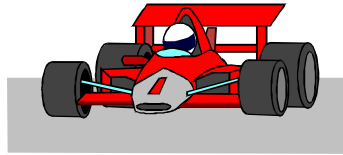
Analysis of the CO2 Dragster via Informational Technology

The student was able to collect and analyze data from tests on a prototype and true type. The student was able to create all parts to the project: title page (20), graphs (20), spreadsheets (20), paragraphs (20), for each area required and a final essay about how to implement changes in vehicle design (20).   /100

Comments: _____

The student was able to effectively use the available resources: printer and computer.
/100

(Color required when available) (50) The student was able to create a title page to include the vehicle name, a graphic that represents the vehicle, the designer's first name, last name and hour. The work should display evidence of utilizing *Word Art* and be printed in color.(50)

comments: _____

The student was able to sort data from **one** category (such as the mass of the vehicle), in ascending or descending order. Once sorted, it correctly corresponded with the car designer's original data. (Create a graph with the data in a logical format) (33.3 each)   /100

Comments: _____

The student was able to create a sub spreadsheet from a master spreadsheet, duplicate and manipulate the data (such as copy, paste and paste special) and perform timely edit functions with alpha and numeric data, with values for true resolution. (Format cells to hundredth's decimal value place)The student was able to navigate between two applications to merge the data for analysis. (Spreadsheet to spreadsheet, create a graph from the data, transfer to word document and add a paragraph – all one page) (33.3 each)   /100

Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form. (Located below graph and spreadsheet) **(Mass v. Speed)**   /100

Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form.   /100

(Located below graph and spreadsheet) **(Drag v. Speed)**
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and   /100
editing skills to the alpha and numeric data, and summarize findings in paragraph form.
(Located below graph and spreadsheet) **(Mass v. Rolltest)**
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and   /25
editing skills to the alpha and numeric data, and summarize findings in paragraph form.
(Located below graph and spreadsheet) **(Rolltest v. Speed-EXTRA CREDIT)**
Comments: _____

The student analyzed results of the data and compiled a descriptive essay in thesis   /100
format, using desktop publishing skills.
Comments: _____

Name	**Time 1**	**Time 2**	**Avg. Time(m/s)**	**Distance (m)**	**Avg. Speed**	**Mass (g)**	**Drag (g)**	**Rolltest (m)**
Lindsey Silberschein	1.49	1.37		20		78.3	16	
Amy Cosola	1.01	0.95		20		46.1	26	3.38
Chris Pawlukiewicz	1.1	1.01		20		57	14	6.68
Bethany Nestor	1.37	1.21		20		78	25	6.75
Amanda Halaboou	1.28	1.05		20		65.5	26	6.68
Michelle Rosen	1.44	1.04		20		56	24	6.29
Adam Weintrob	1.01	1.01		20		51	22	5.49
Danielle Goodman	1.04	0.97		20		42	12	
Daniel Coats	1.19	1.21		20		72.8	20	
Joshua Rabinowitz	1.56	1.65		20		74.8	18	6.2
Dan Perach	1.29	1.19		20		72.5	20	6.27
Sanar Yaldo	1.4	1.14		20		72	20	4.59

The above spreadsheet is a sampling of the data compiled from the Co2 Vehicle Races in Applied Technology. The Informational Technology Teacher inputs the data from the students' Data Sheets (retrieved from the science or applied technology teacher). Once the students come down to the Informational Tech teacher's room, the file created (above), will be retrievable from the G directory, or shared files for student access. The students then save to their own file, and manipulate the chart to make new charts. (See "Instructions for Final Analysis of the CO2 Dragster" handout-attached) The informational technology teacher demonstrates the making of the first chart on the PC presenter, as students take notes. Students then go back, with a copy of the handout, and with notes, creates the 4 charts, saving them all to their own H directories, on separate files for each chart, named respectively: Mass V. Speed, etc.

The informational technology teacher will complete the above spreadsheet, including formulas for the above blank columns. In the Average Time column, it is averaging column B and C, labeled Time 1 and Time 2, respectively. The formula to be placed in the cell D2 is =SUM(B2+C2)/2. This formula will give the average time between the two, measured in seconds. Once the first one shows up, by striking enter, highlight the entire column, and choose Edit, Fill down to copy and transfer the formula and its results all the way down to the last student.

In column F, Average speed, it is taking the distance the car traveled divided by the average time. The formula to be placed in the cell F2 is =(E2/D2). This formula will give the average speed, (distance over time), measured in meters per second. Once the first one shows up, by striking enter, highlight the entire column, and choose Edit, Fill down to copy and transfer the formula and its results all the way down to the last student. See below for a chart that is complete, ready for students to manipulate. Once students begin, they need to remember to save it to their own directory before making changes, and to sort by

average speed (descending), before moving on. (Directions on how to do this, see the Instructions sheet. (Section IA3a)

Name	Time 1	Time 2	Avg. Time(m/s)	Distance (m)	Avg. Speed	Mass (g)	Drag (g)	Rolltest (m)
Lindsey Silberschein	1.49	1.37	1.43	20	13.99	78.3	16	
Amy Cosola	1.01	0.95	0.98	20	20.41	46.1	26	3.38
Chris Pawlukiewicz	1.1	1.01	1.06	20	18.96	57	14	6.68
Bethany Nestor	1.37	1.21	1.29	20	15.50	78	25	6.75
Amanda Halaboou	1.28	1.05	1.17	20	17.17	65.5	26	6.68
Michelle Rosen	1.44	1.04	1.24	20	16.13	56	24	6.29
Adam Weintrob	1.01	1.01	1.01	20	19.80	51	22	5.49
Danielle Goodman	1.04	0.97	1.01	20	19.90	42	12	
Daniel Coats	1.19	1.21	1.20	20	16.67	72.8	20	
Joshua Rabinowitz	1.56	1.65	1.61	20	12.46	74.8	18	6.2
Dan Perach	1.29	1.19	1.24	20	16.13	72.5	20	6.27
Sanar Yaldo	1.4	1.14	1.27	20	15.75	72	20	4.59

Reminders to students would be to resize columns for proper fit, label columns, and to pay attention to column header details.

Directions for the Informational Technology Teacher
Grade/Subject: 8th Grade 2007 Rotation-
Informational Technology Section

Name	Time 1	Time 2	Avg. Time(m/s)	Distance (m)	Avg. Speed	Mass (g)	Drag (g)	Rolltest (m)
Lindsey Silberschein	1.49	1.37		20		78.3	16	
Amy Cosola	1.01	0.95		20		46.1	26	3.38
Chris Pawlukiewicz	1.1	1.01		20		57	14	6.68
Bethany Nestor	1.37	1.21		20		78	25	6.75
Amanda Halaboou	1.28	1.05		20		65.5	26	6.68
Michelle Rosen	1.44	1.04		20		56	24	6.29
Adam Weintrob	1.01	1.01		20		51	22	5.49
Danielle Goodman	1.04	0.97		20		42	12	
Daniel Coats	1.19	1.21		20		72.8	20	
Joshua Rabinowitz	1.56	1.65		20		74.8	18	6.2
Dan Perach	1.29	1.19		20		72.5	20	6.27
Sanar Yaldo	1.4	1.14		20		72	20	4.59

The above spreadsheet is a sampling of the data compiled from the Co2 Vehicle Races in Applied Technology. The Informational Technology Teacher inputs the data from the students' Data Sheets (retrieved from the science or applied technology teacher). Once the students come down to the Informational Tech teacher's room, the file created (above), will be retrievable from the G directory, or shared files for student access. The students then save to their own file, and manipulate the chart to make new charts. (See "Instructions for Final Analysis of the CO2 Dragster" handout-attached) The informational technology teacher demonstrates the making of the first chart on the PC presenter, as students take notes. Students then go back, with a copy of the handout, and with notes, creates the 4 charts, saving them all to their own H directories, on separate files for each chart, named respectively: Mass V. Speed, etc.

The informational technology teacher will complete the above spreadsheet, including formulas for the above blank columns. In the Average Time column, it is averaging column B and C, labeled Time 1 and Time 2, respectively. The formula to be placed in the cell D2 is =SUM(B2+C2)/2. This formula will give the average time between the two, measured in seconds. Once the first one shows up, by striking enter, highlight the entire column, and choose Edit, Fill down to copy and transfer the formula and its results all the way down to the last student.

In column F, Average speed, it is taking the distance the car traveled divided by the average time. The formula to be placed in the cell F2 is =(E2/D2). This formula will give the average speed, (distance over time), measured in meters per second. Once the first one shows up, by striking enter, highlight the entire column, and choose Edit, Fill down to copy and transfer the formula and its results all the way down to the last student. See below for a chart that is complete, ready for students to manipulate. Once students begin, they need to remember to save it to their own directory before making changes, and to sort by average speed (descending), before moving on. (Directions on how to do this, see the Instructions sheet. (Section IA3a)

Name	Time 1	Time 2	Avg. Time(m/s)	Distance (m)	Avg. Speed	Mass (g)	Drag (g)	Rolltest (m)
Lindsey Silberschein	1.49	1.37	1.43	20	13.99	78.3	16	
Amy Cosola	1.01	0.95	0.98	20	20.41	46.1	26	3.38
Chris Pawlukiewicz	1.1	1.01	1.06	20	18.96	57	14	6.68
Bethany Nestor	1.37	1.21	1.29	20	15.50	78	25	6.75
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Adam Weintrob	1.01	1.01	1.01	20	19.80	51	22	5.49
Danielle Goodman	1.04	0.97	1.01	20	19.90	42	12	
Daniel Coats	1.19	1.21	1.20	20	16.67	72.8	20	
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Dan Perach	1.29	1.19	1.24	20	16.13	72.5	20	6.27
Sanar Yaldo	1.4	1.14	1.27	20	15.75	72	20	4.59

Reminders to students would be to resize columns for proper fit, label columns, and to pay attention to column header details.

NAME_____   /1000pts.
HOUR_____   /25pts. Extra Credit
                                         /   pts. Total
                                         Final Grade:_____

Analysis of the CO2 Dragster via Informational Technology

The student was able to collect and analyze data from tests on a prototype and true type. The student was able to create all parts to the project: title page (20), graphs (20), spreadsheets (20), paragraphs (20), for each area required and a final essay about how to implement changes in vehicle design (20).   /100
Comments: _____

The student was able to effectively use the available resources: printer and computer. (Color required when available) (50) The student was able to create a title page to include the vehicle name, a graphic that represents the vehicle, the designer's first name, last name and hour. The work should display evidence of utilizing *Word Art* and be printed in color.(50)   /100
comments: _____

The student was able to sort data from **one** category (such as the mass of the vehicle), in ascending or descending order. Once sorted, it correctly corresponded with the car designer's original data. (Create a graph with the data in a logical format) (33.3 each)   /100
Comments: _____

The student was able to create a sub spreadsheet from a master spreadsheet, duplicate and manipulate the data (such as copy, paste and paste special) and perform timely edit functions with alpha and numeric data, with values for true resolution. (Format cells to hundredth's decimal value place)The student was able to navigate between two applications to merge the data for analysis. (Spreadsheet to spreadsheet, create a graph from the data, transfer to word document and add a paragraph – all one page) (33.3 each)   /100
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form. (Located below graph and spreadsheet) **(Mass v. Speed)**   /100
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form. (Located below graph and spreadsheet) **(Drag v. Speed)**   /100
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form. (Located below graph and spreadsheet) **(Mass v. Rolltest)**   /100
Comments: _____

The student was able to apply critical thinking skills, correct vocabulary, grammar and editing skills to the alpha and numeric data, and summarize findings in paragraph form. (Located below graph and spreadsheet) **(Rolltest v. Speed-EXTRA CREDIT)**   /25
Comments: _____

The student analyzed results of the data and compiled a descriptive essay in thesis format, using desktop publishing skills.   /100
Comments: _____

T. Wallace   C02 Rubric for 2007   1999