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| **Name:**  Paula Butler | **Contact Info:** butlerp@countryday.net | **Date:** 3/10/14 |

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| **Lesson Title :**  Internal Combustion Engines | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **4** |
| **Activity Title:** The Challenge: Proposing the Best New Car/Fuel Combination For a Small Town Police Department |

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| **Estimated Lesson Duration:** | 6 class periods of 47-minutes each |
| **Estimated Activity Duration:** | 3.5 class periods of 47-minutes each, including a double lab bell |

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| **Setting:** | The chemistry classroom. |

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| **Activity Objectives:** |

Upon completion of the activity, students will be able to:

* research (individually) advantages and disadvantages of different fuel choices and engine types
* propose (individually) a choice of vehicle, engine, and fuel that takes into consideration the constraints and parameters of the challenge (police vehicle, cost, mileage, location, etc.)
* communicate within the group what they learned from their research
* analyze and evaluate the fuel and vehicle choices as a group
* propose (as a group) an optimum choice of new police vehicle, considering fuel efficiency, cost, and environmental impact, as well as other challenge parameters
* revise and refine the proposal, based on feedback from the instructor and an engineer (iterative change)
* create an effective PowerPoint presentation to convey their proposal and reasoning
* communicate and present their proposal to the class

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| **Activity Guiding Questions:** |

* What are the advantages and disadvantages of different fuel choices and engine types?
* Do different fuels and engines have different environmental impact?
* Are different fuels equally available in various locations in Minnesota (E85, diesel, etc.)?
* Do various fuels and engine types respond equally well in the cold winters of Minnesota?
* What are some specific vehicle choices that would take advantage of desirable fuels or engines?
* Which vehicle(s) would meet the budget constraint of a small town—including the ongoing cost of purchasing fuel?
* Which vehicle(s) would be best suited for the needs of a police department (back seat room for arrested suspects, sufficient engine power for high speed chases, etc.)?
* How can the group discuss their research findings so that each member’s voice is heard?
* How can the group analyze and evaluate the various ideas to arrive at a single proposal?
* Can the group incorporate iterative design, revising their ideas during preliminary discussions and incorporating feedback from their instructor and an engineer?
* How can the group most effectively communicate their proposal and reasoning to the class?

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

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

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

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

AP Chemistry Curriculum Framework 2013-14

* Science Practice 2: The student can use mathematics appropriately.
* Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
* Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.
* Science Practice 5: The student can perform data analysis and evaluation of evidence.
* Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, representations in and across domains.

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

* Student Handout – Final Project Instructions
* Teacher Grading Rubric

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| **Teacher Advance Preparation:** |

* Consideration needs to be given to parameters or “boundaries” of the challenge. It might be helpful to visit a local police department to find out what sort of budget is typically allocated for a new police vehicle, how many miles are typically driven per year, etc.
* It is important to create a handout for the students to clarify project expectations.

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| **Activity Procedures:** |

* On the first day of this activity, students will be reminded of the challenge and parameters. (The choice of vehicles, for example, will be limited to those running on carbon-based fuels as opposed to electric or hybrid vehicles.)
* Students will be given the handout with instructions for the individual research component as well as the final project.
* Students will then be given time to brainstorm in their groups—deciding how they want to approach the challenge. The students may want to divide up the research—there are many different ways this could be done. Each student should have a significant role.
* Students will return on the second day with the results of their individual research. They will need time to work in their groups again to compare notes, share ideas, and evaluate their tentative proposals for vehicle, engine, and fuel choices.
* After the students have had some time to work, the teacher and COFSP Fellow (a senior engineering student) will rotate among the groups to offer feedback about their tentative proposals. The students should then revise and refine their proposals, based on the feedback, as part of the iterative piece in the Engineering Design Process.
* Students need time to plan and develop their PowerPoint presentations.
* It will be valuable for the students to have 10-15 minutes on the third day to fine tune their group presentations and to finalize who is saying what.
* Students will make their presentations in front of the class, and there should be time allotted for the teacher and/or other students to ask follow-up questions.
* Other “housekeeping” items to complete are the end-of-unit surveys and the post-unit assessment.

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

* Student knowledge and understanding will be informally and continually assessed during the project by walking around, listening to group discussions and debate, and asking questions or providing feedback.
* More formally, the teacher and COFSP Fellow will visit each group, listen to their tentative proposal, and provide specific feedback to be used as an iterative piece of the group’s Engineering Design Process. The group should use this feedback to revise and refine their proposal.

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

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

* This activity was well suited to visual, verbal, and social learners. The research and subsequent discussions among group members appealed to the verbal or linguistic learners, as did the group presentations and fielding of questions. The creation and presentation of the PowerPoint slides catered well to the visual learners. Finally, the students with a social or interpersonal learning style enjoyed having a chance to interact with their peers quite intensively as they sifted through different ideas, arrived at a group consensus, and designed their presentation together.

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

* The timing of this activity was less than optimal in a couple of ways. One is that the students would have benefited from an extra day to do their research and to reflect on what they had learned. The students felt rushed, and so did I. Also, it was the last week before Spring Break, and some of the students had as many as three *other* tests or quizzes, in addition to their presentation, on that final Friday. Everyone was exhausted.
* It would have been nice to be able to dedicate one day to simply having the students present their projects, rather than trying to do the post-unit assessment and survey all on the same day! It was an overload of information and “tasks” to complete, although we did have a double lab bell in which to do it.
* On the other hand, we were able to bring the entire unit to a close before Spring Break, as planned, and that felt satisfying.
* A number of students expressed their positive feelings about this activity. The social learners, in particular, mentioned benefiting a lot from being able to work for several days in a group, researching and designing a proposal together.
* I was quite impressed by the students’ performance on the research portion of the project. I didn’t know whether the students would really buy in, and do some significant learning on their own, or whether they would quickly grab a few facts from the internet to simply get credit. Their work showed that they were willing to grapple with many complexities that surround the topics of fuel efficiency and emissions, such as whether or not ethanol is superior to gasoline as a fuel in terms of its environmental impact.
* My original concern at the start of the whole unit—that the groups would all end up “converging” on one particular type of fuel or vehicle—was unfounded. I had become even more concerned about that possibility when I discovered “police packages” on the internet; certain cars are selected and outfitted with police devices such as speakers, sirens, lights, etc. There are a handful of choices that have become standard vehicles in police departments across the country. I thought the students would gravitate to those. The students surprised me, however, by asking if they needed to feel “limited” to standard police vehicles. I said “no!”—that they should feel free to think outside the box, selecting a vehicle they think to be best based on the parameters we had set—and allowing some extra money that could be used to customize it for police use. One group chose an E85 vehicle, another chose a diesel vehicle (with special consideration given for starting it in the cold Minnesota winters), and several others decided to stick with traditional gasoline vehicles. All of the groups were able to defend their choices, based on data they had collected and their own reasoning.
* The most gratifying aspect of the activity was seeing how the challenge promoted higher level thinking among the students as they conducted research, analyzed data, evaluated information (that was sometimes ambiguous or contradictory!), considered parameters, collaborated with their peers, created a proposal, and presented it to the class. The students clearly felt a sense of “ownership” of their knowledge which far surpassed a typical learning sequence.