Solar Sprint's 3 D Guide

Activity Learning Outcomes

After completing this activity, students will have achieved the following learning outcomes:

- Students will understand how an engineer takes an idea from paper to a 3-D printed prototype.
- Students will understand what CAD is and how it is used by engineers.
- Students will understand what CAM is and how it is used by engineers.
- Students will develop a design solution using given design constraints.
- Students will evaluate competing conceptual design solutions using a decision matrix for decision making.
- Students will collect and interpret data gathered by physical experiments.
- Students will plan and execute an experiment.
- Students will use experimental data to compare and draw conclusions that lead to an improved design solution.
- Students will discuss the intended/unintended consequences of design changes.
- Students will apply the mathematical concept of ratios to improve their design solution.
- Students will understand the difference between the mass and weight of their vehicle.

Standards Addressed

This classroom activity was specifically developed to address the Next Generation Science Standards Engineering, Technology, and Applications of Science (ETS) performance expectations. Specifically, this activity addresses the following Middle School (6-8) Engineering Design performance expectations:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1 -2. MS-ETS1-3. MS-ETS1-4.Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

For information on additional standards addressed by this classroom activity, please review Appendix A.

Engineering Notebook

Purpose

The purpose of the *Engineering Notebook* is to document students' work and guide them through the engineering design process. The *Engineering Notebook* relies on supplemental content contained in the *Competition Catalog.*

How to Use

Each student should be given an *Engineering Notebook* that he or she is expected to complete. While students will work in teams to complete many of the activities in their notebooks, each student will be expected to turn in a notebook for grading.

Experiments

There is one experiment template included in the *Engineering Notebook.* The purpose of the experiment is to allow students to learn the experimental process (engineers often call this designing experiments). The worksheets that the students complete before planning their experiment are intended to give them ideas and a template to work from when planning their experiment.

In addition to the lecture on experiments, the"Resources"section of the *Competition Catalog* contains information on experiment planning that the students can refer to.

Many students will struggle when trying to plan their own experiment. To help them, you may point them to Step 3 in the"Decision Matrix"section of the *Engineering Notebook.* Step 3 contains a list of technical questions that the team identified and then set aside earlier. If that doesn't do the trick, here are some experiments that you can suggest:

- What is the effect of tire size on the_of the car? The blank could be speed, acceleration, or hill-climbing ability.
- What is the effect of the battery location on the car's ability to climb a hill?
- Is a front- or rear-wheel-drive car better at_?
- What gear/pulley ratio will produce the fastest car?

Students will typically need two full class periods (sometimes three) to plan and complete the experiment.

Competition Catalog

Purpose

The purpose of the *Competition Catalog* is to provide a central information resource for each student team. The *Competition Catalog* contains the official costs, weights, and build times of each of the components. In addition, the catalog contains additional information on key concepts and a glossary of terms.

How to Use

Each student team should have one copy of the *Competition Catalog.* The catalog can be reused for multiple class periods.

A copy of the *Competition Catalog* is provided in Appendix D. In addition, a digital (PDF) file of the catalog is included in the disc that was provided with this curriculum. The provided template may be photocopied for use only within the classroom. Please do not copy or distribute this teacher's guide. By honoring our copyright, you enable us to invest in research for education.

Print Day Guidance

Each team will be allowed one class period to use the 3-D printer. Before using the printer, they should have completed the“Decision Matrix”section of the *Engineering Notebook.* Make sure to thoroughly review the information that was provided with your 3-D printer and complete some test prints before working with students. The following is the suggested process for meeting with each team on their print day:

1. Confirm that they have completed their *Engineering Notebook* through (and including) the ”Decision Matrix”section.
2. Review which parts they would like to print with the team. Hint: You might ask them to come with a print list.
3. Discuss with the team which worksheet(s) they plan on completing. If they plan on complet- ing the“Gears Versus Pulleys“worksheet, make sure they print the proper pulleys required for that experiment.
4. Review the Afinia 3D Printer machine with the students. Make sure to point out:
    A. The build platform
    B. The material spool
    C. The extruder head
    D. The x-y gantry
5. Prepare the machine for a new print.
6. Open the printer software and add the agreed upon parts to the build.
    A. It is likely the students’ parts won’t all fit on the build plate. Work with the students to down-select.
    B. If there is time and student interest, let them arrange the parts on the tray
7. After you are ready, execute the build. Make sure to point out that the software is slicing the CAD model into layers that the machine can build. CAM translates CAD files into machine code.
8. Allow the students to watch the build.
9. Allow the students to remove the parts and clean the build plate for the next team.

Design Review Presentations

Each team should be required to give a design review presentation to the class. This presentation should be five to seven minutes long. Allow about three minutes of questions so

that the total length of each presentation is approximately 10 minutes.

For the presentation, students should use their vehicle as a visual aid and be allowed to write on a flip
chart or whiteboard as needed. Students should describe:

- The most difficult design decision they made and how they made it.
- Unique features of their vehicle.
- How they have improved their vehicle based on the experiment they performed.

Teams may have one designated presenter if they desire, but they should all stand at the front of the class. It should be made clear that questions can be directed to any student.

Some questions to ask include:

- What is the gear/pulley ratio of your drivetrain?
- Have you done anything to make the car lighter/heavier?
- Were there any changes you made that didn't improve performance like you
expected?