LESSON GUIDE

# Solar Car

| | |
|---|---|
| Level | Advanced |
| Academic Connections | Engineering, Aerodynamics, Design Thinking, Presentation and Communication |
| Core Concepts | Computer Aided Design (CAD), Design, Design Optimization, Assembly |
| Duration | 2-3 weeks |

Design, 3D print and assemble a working solar car.

## LEARNING OBJECTIVES

By the end of this workshop, the student will be able to:

- Identify and apply the steps in the design process.
- Gather and apply information pertinent to design planning.
- Plan and organize the project.
- Create concept and scaled sketches of design ideas.
- Use appropriate design tools to create CAD drawings and full-scale 3D printed models.
- Report and reflect on their experience with the design process using a suitable oral and/or written format.

## ESSENTIAL QUESTIONS

- What makes a solar-driven design feasible?
- How is solar energy converted to kinetic energy (to move the car)?
- How can solar energy be stored for later use?

## ESSENTIAL DETAILS

When developing the design consider aerodynamics, rolling resistance, torque, the gear ratio, bearings and the wheel base. The car must:

- Move with sunlight
- Include three or four wheels
- Have an on/off switch
- Fit within the following maximum overall dimensions:
- Length: 10 inches (254 mm)
- Width: 5 inches (127 mm)
- Height: 5 inches (127 mm)

The following parts of the solar car can be 3D printed:

- Frame
- Body
- Rims
- Mounting brackets for axle and motor
- Gears

## REQUIREMENTS

- Educator PC with access to:
  - Microsoft PowerPoint
  - QuickTime
  - Internet connection
- Projector
- 3D printer
- CAD design tool
- Digital caliper
- Solar motor (Tamiya solar motor 01-CY604 recommended)
- Solar panel (Tamiya solar panel 1.5V-%00mA recommended)
- Wheel bearings
- Axles
- Switch
- Wire and wire cutters

## DESIGN PROCESS: RESEARCH

To facilitate research, students are encouraged to visit reputable design sites to explore a variety of solar car designs. The following video and tutorial are excellent resources to support project workflow.

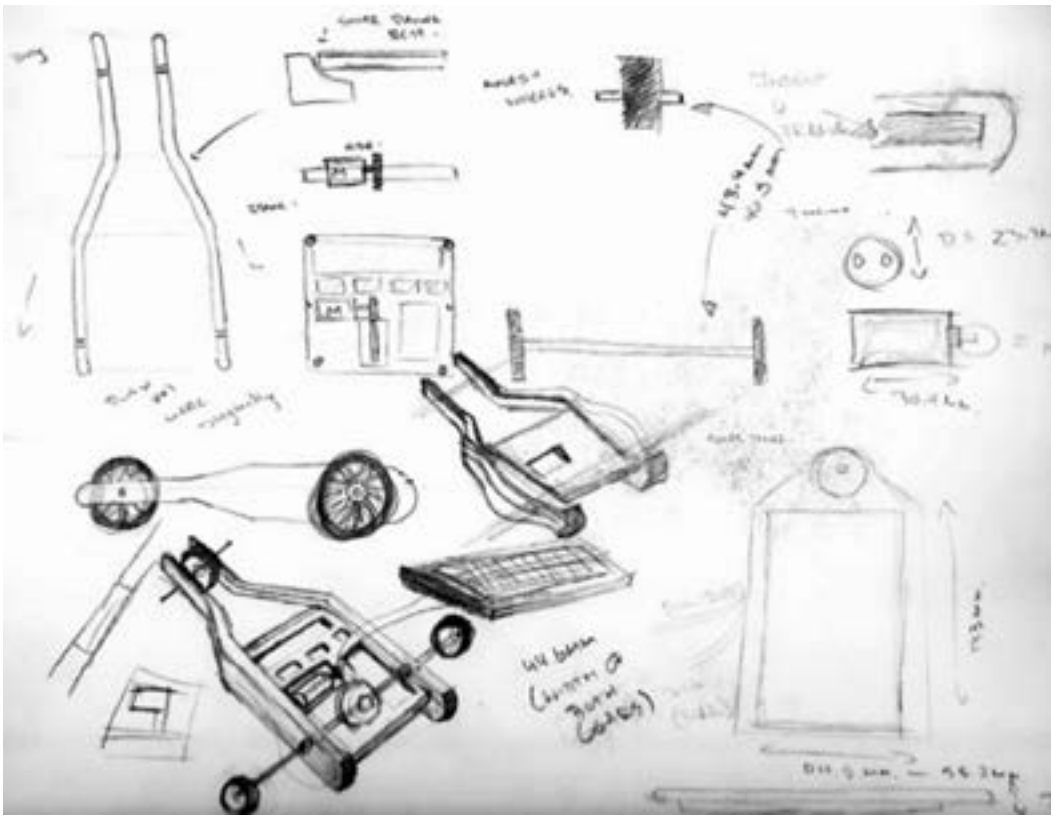
**Video: "Tamiya Solar Eagle: Vintage Solar RC Car"** https://www.youtube.com/watch?v=sqqQpkv4hio

**Online tutorial: Tamiya Solar Car Assembly Kit**

http://www.tamiyausa.com/items/geniuseries-educational-kits-50/solar-mechanics-series-42000/solar-car-assembly-kit-76001

## DESIGN PROCESS: CONCEPT

Concept sketches: Refer to the Designer's Toolkit in the Getting Started section at: http://www.stratasys.com/3DLC.



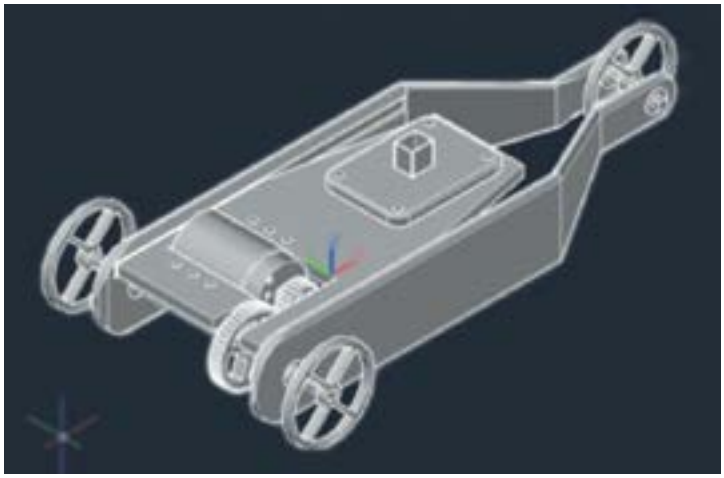
## DESIGN PROCESS: DEVELOPMENT

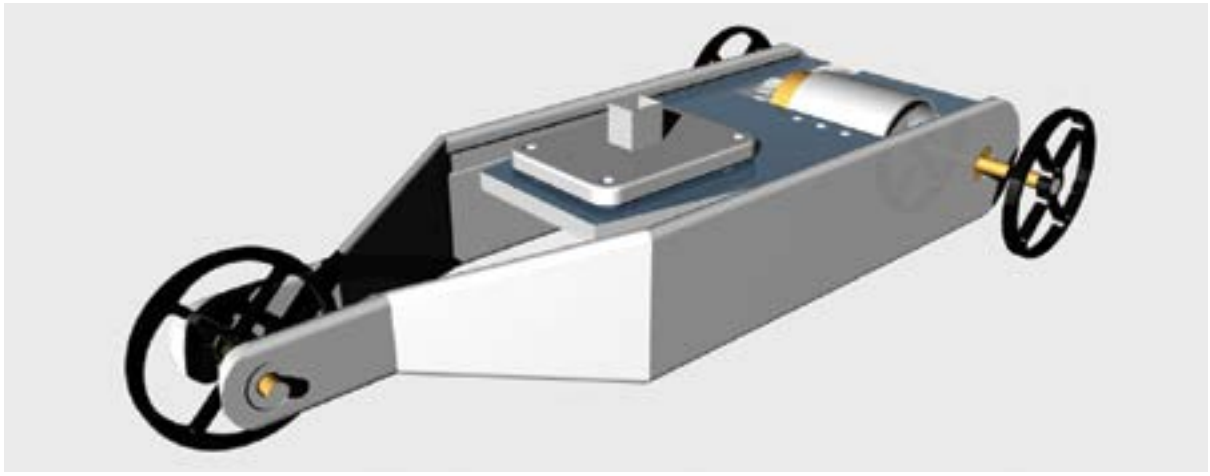
### 3D CAD MODELING

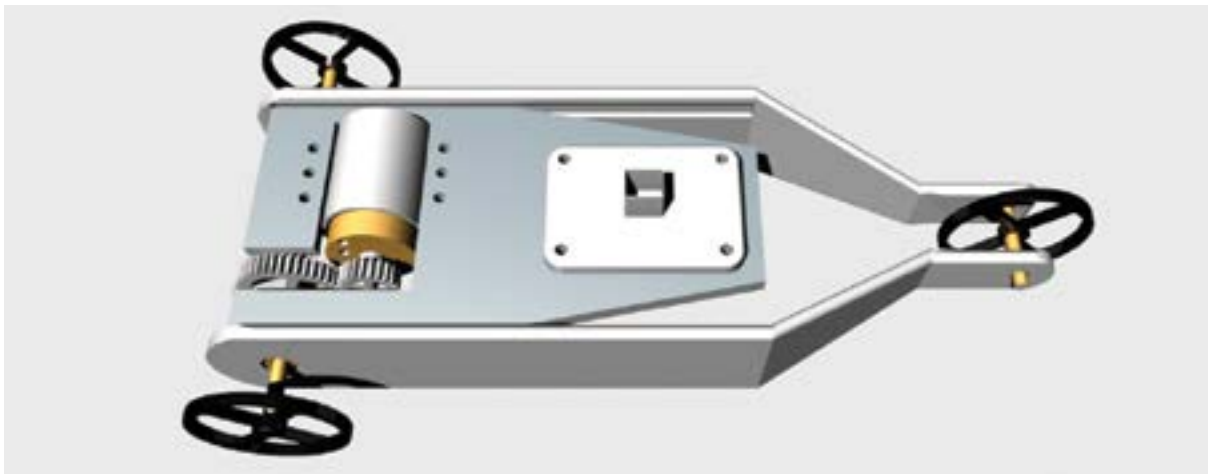
Concept sketches can be used to develop the 3D CAD model. Ensure concept sketches include accurate measurements. The 3D CAD model should include all of the required components listed in the project description.

Gears can be challenging to design in CAD. Some CAD software programs like Autodesk Inventor and SolidWorks have technology that uses input of certain specifications needed to design gears.

## CAD RENDER IMAGES

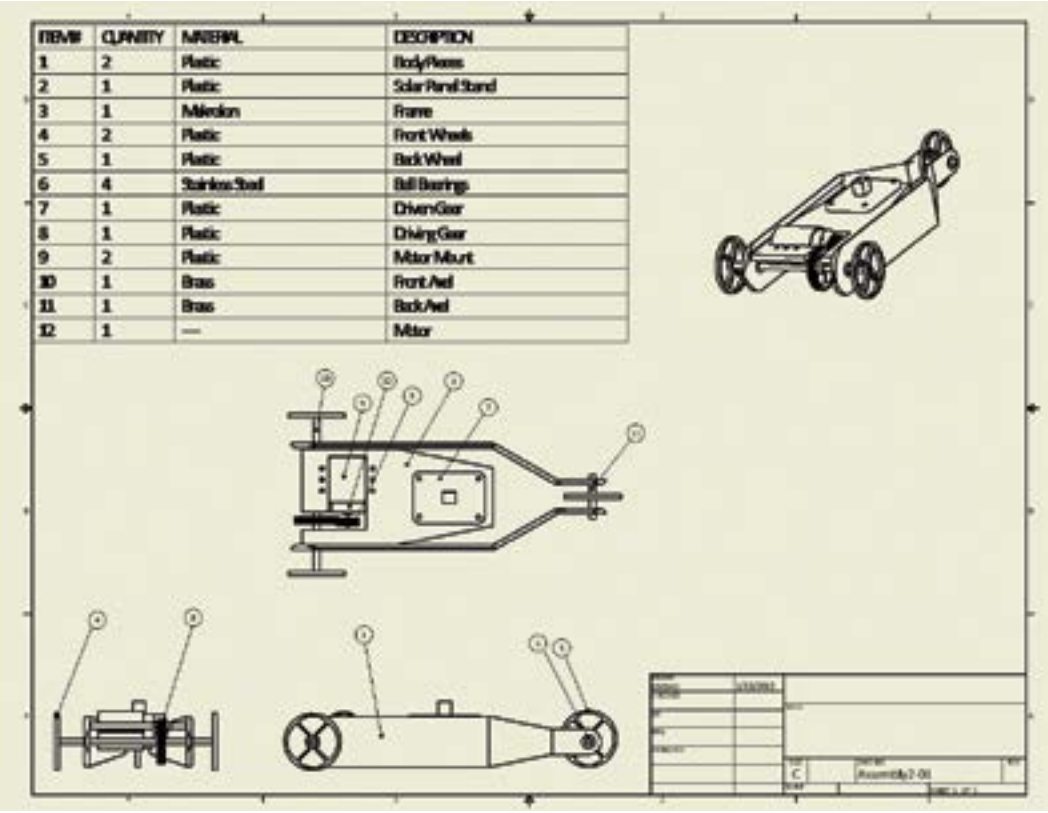






## DESIGN PROCESS: DEVELOPMENT

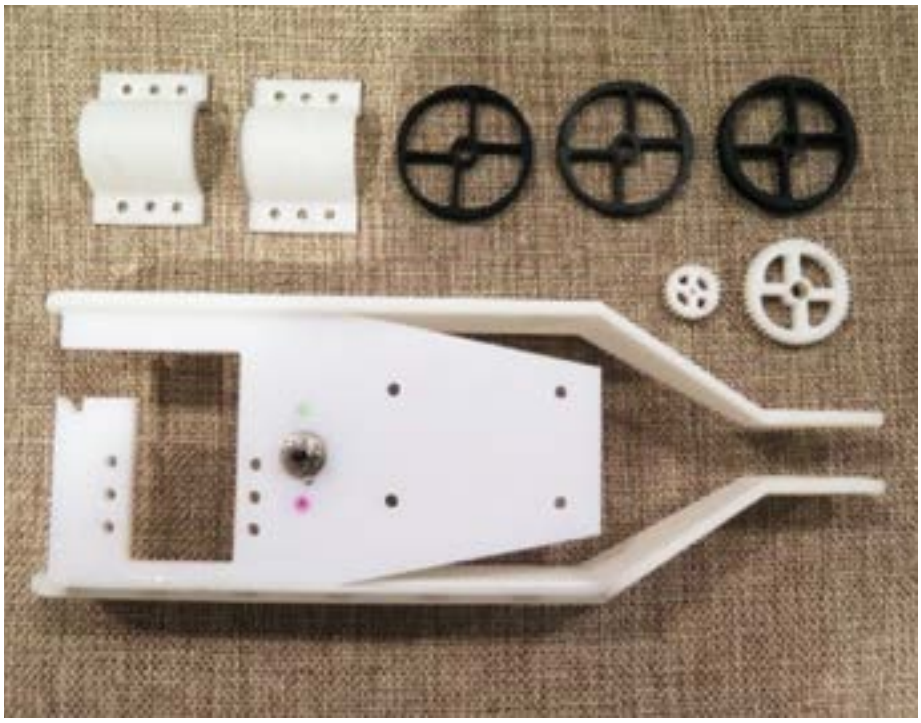
Autodesk Inventor and SolidWorks also have the option of generating technical drawings and orthographic views from the original 3D CAD model. This option generates an assembly drawing that models a professional engineering workflow.



| ITEM# | QUANTITY | MATERIAL | DESCRIPTION |
|---|---|---|---|
| 1 | 2 | Plastic | Body/Pieces |
| 2 | 1 | Plastic | Solar Panel Stand |
| 3 | 1 | Meridian | Frame |
| 4 | 2 | Plastic | Front Wheels |
| 5 | 1 | Plastic | Back Wheel |
| 6 | 4 | Stainless Steel | Ball Bearings |
| 7 | 1 | Plastic | Driven Gear |
| 8 | 1 | Plastic | Driving Gear |
| 9 | 2 | Plastic | Motor Mount |
| 10 | 1 | Brass | Front Axel |
| 11 | 1 | Brass | Back Axel |
| 12 | 1 | — | Motor |

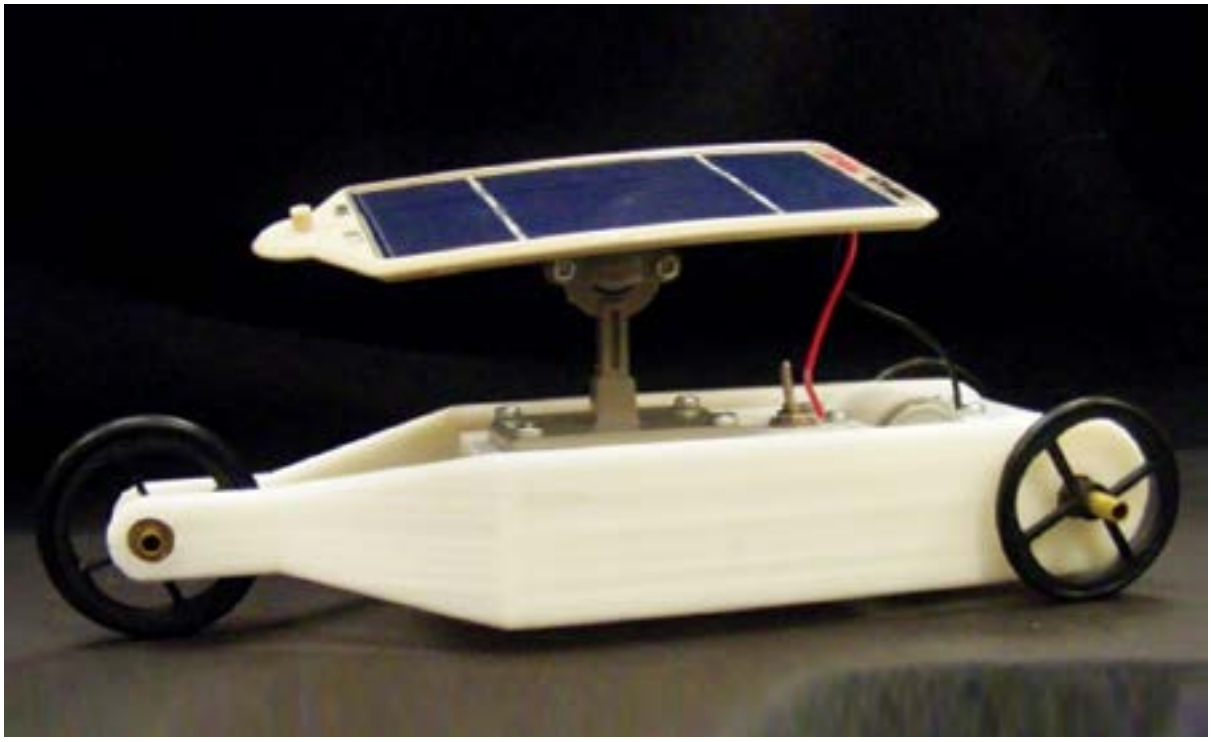
## DESIGN PROCESS: FORMALIZATION

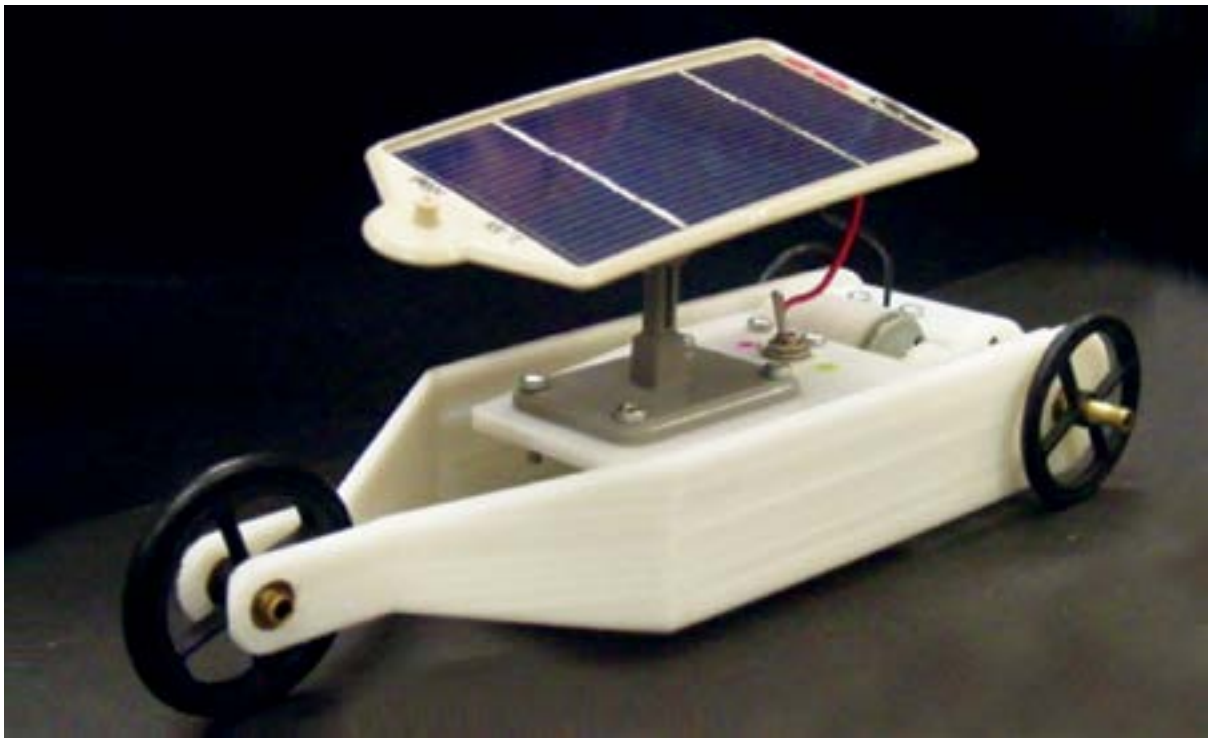
It is important to note different model fill settings are recommended when 3D printing the various components of the solar car. Small parts or parts with fine detail such as the gears, rims and motor mounting bracket should be 3D printed on the solid fill setting. Large parts such as the frame and side rails should be 3D printed on the sparse fill setting.



3D printed solar car components before assembly.

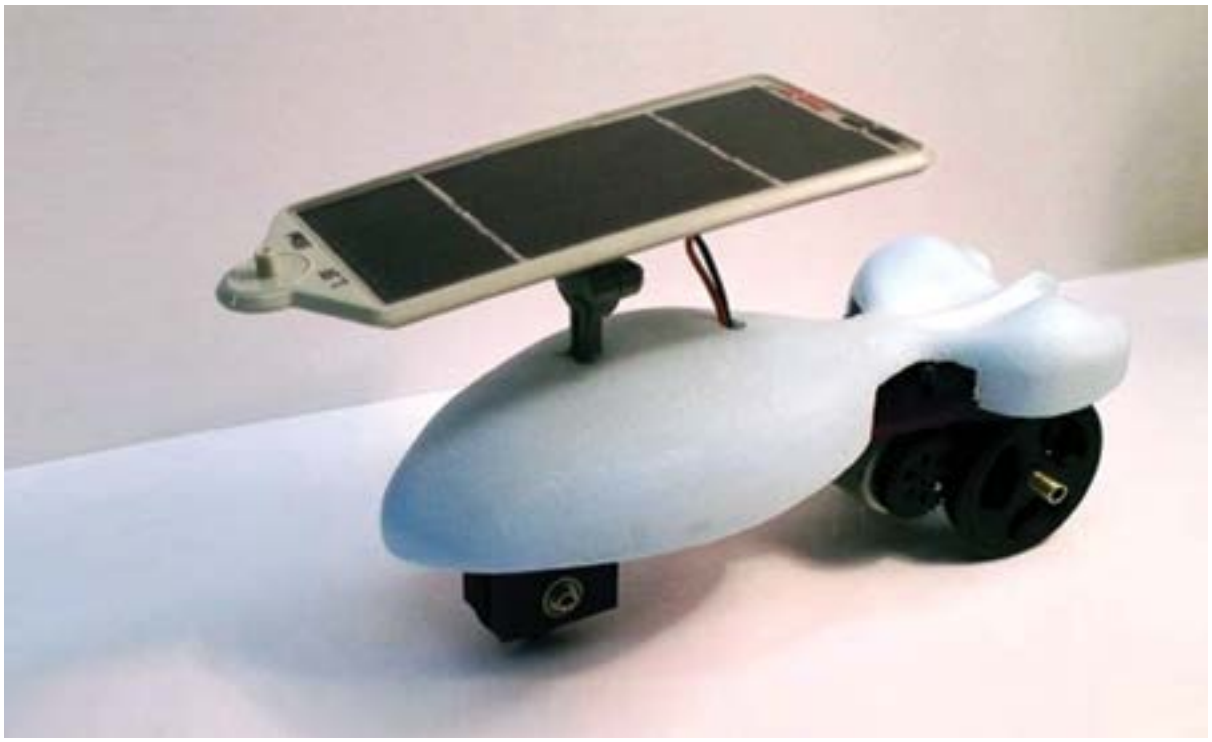
Additional materials needed for the solar car before assembly.





Assembled 3D printed solar car.

## STUDENT EXAMPLES



These student projects followed the same project workflow.

## ASSESSMENT

Drawing and Use of CAD

| LEVEL | LEVEL 1 (50-59%) | LEVEL 2 (60-69%) | LEVEL 3 (70-79%) | LEVEL 4 (80-100%) |
|---|---|---|---|---|
| **Knowledge/ understanding**<br><br>**3D drawing concepts** | 3D CAD drawings are incomplete or illegible. Dimensions are not present. 3D design features and tools have not been used. | Dimensions are used inconsistently. There is limited use of 3D design features and tools covered in class. | Most dimensions are present and meet the design criteria. Most 3D design tools and features have been used properly. | All dimensions are present and meet the design criteria. All 3D design tools and features have been used correctly. |
| **Thinking/ Inquiry**<br><br>**Level of complexity** | Drawings consist of basic shapes that do not challenge the student's design skills. | Drawings consist mostly of basic shapes with few elements that challenge the student's design skills. | Drawings contain some elements that challenge the student's design skills. | Drawings contain complex shapes that challenge the student's design skills. |
| **Application**<br><br>**Design integrity** | Final product does not resemble original scaled sketches. | Final product reflects a few elements of the original scaled sketches. | While some relatively complex features could not be accomplished, the final product reflects most elements of the original scaled sketches. | Despite some relatively complex features, the final product closely resembles the original scaled sketches. |

## PRODUCT DESIGN

| LEVEL | LEVEL 1 (50-59%) | LEVEL 2 (60-69%) | LEVEL 3 (70-79%) | LEVEL 4 (80-100%) |
|---|---|---|---|---|
| **Knowledge/ understanding**<br><br>Design criteria | Student met none of the design criteria outlined in the Essential Details. | Student met some of the design criteria outlined in the Essential Details. | Student met most of the design criteria outlined in the Essential Details. | Student met all of the design criteria outlined in the Essential Details. |
| **Thinking/ Inquiry**<br><br>Creativity, originality and design considerations | The student's product is unoriginal, borrowing largely from other sources. Student cannot explain their design decisions. | The student's product is simple and predictable, or borrows mostly from other sources. Student cannot satisfactorily explain their design decisions. | The student's product is unique and demonstrates independent thought. The student can explain their design decisions. | The student's product is highly imaginative. They incorporate surprising or elaborate features that reflect creativity and personality, and can explain their rationale. |
| **Application**<br><br>Appearance | Final product does not work as expected, and student has not improved the design over multiple iterations. | Final product does not work as expected, but the student has improved the design over multiple iterations. | Final product works as expected and student has improved the design over multiple iterations. | Final product works as expected, and student has made novel or innovative improvements over multiple iterations. |

## SUGGESTED RESOURCES

### GEAR SYSTEMS

Students will explore gear systems in 2D and 3D models while learning about speed, force, motion, tolerance, and layer thickness.

### ROCKET

Covers all topics necessary to pass the Certified SolidWorks Associate (CSWA) exam while designing and 3D printing a rocket. Although the SolidWorks rubric is discussed here and the course is designed to prepare students for the CSWA exam, the lesson can accommodate a range of 3D CAD packages.

**To access additional 3D Learning Content and resources visit:**

**http://www.stratasys.com/3DLC**

## ACKNOWLEDGEMENTS

Stratasys would like to express our deep appreciation to Mike Santalupo, design teacher at John Paul II Catholic Secondary School in London, Ontario, for his valuable and constructive contributions to this lesson. His expertise, experience and eagerness to promote 3D printing in the classroom have been essential to developing this resource for teachers everywhere.

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