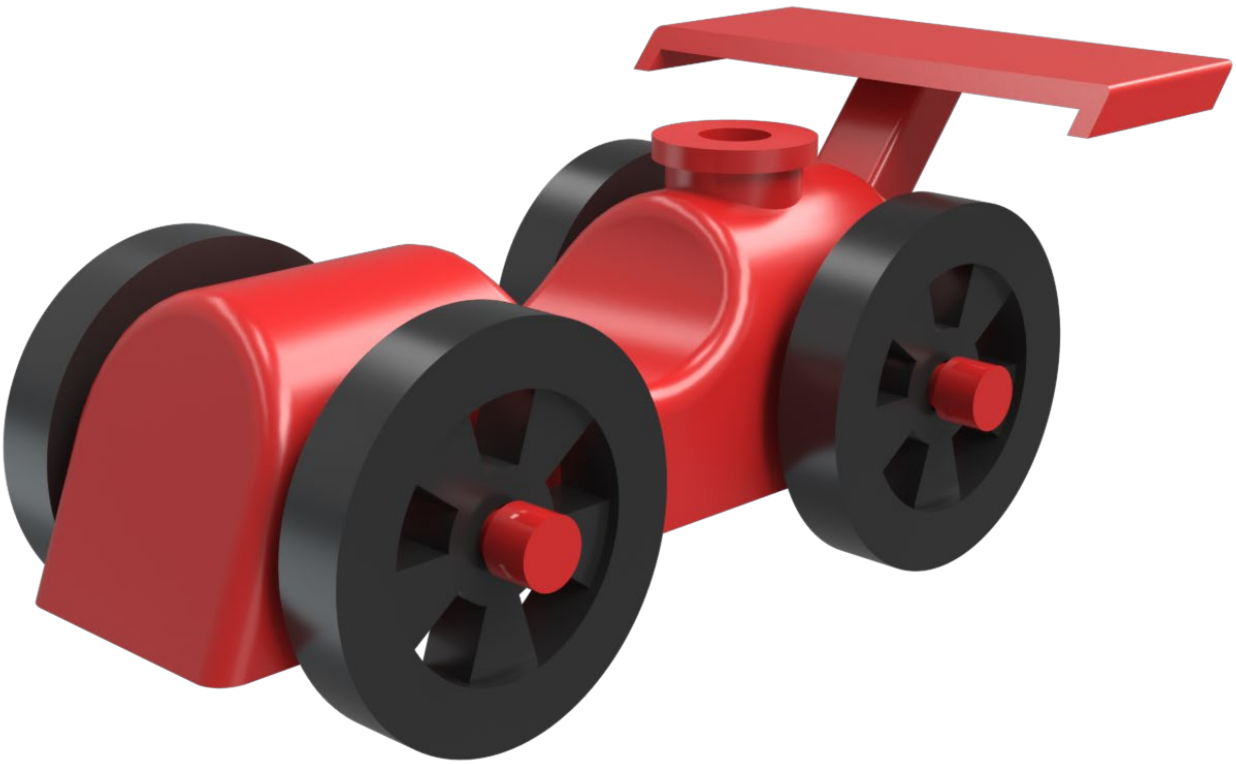
SOLIDWORKS

DESIGN PROJECTS

TEACHER GUIDE

3DEXPERIENCE



BALLOON-POWERED RACERS

DASSAULT SYSTEMES

INTRODUCTION/GENERAL GUIDELINES

Welcome to the Design Projects Teacher Guide for the Balloon-Powered Racers. This activity presents a wide range of possibilities for the instructor. The individual components are simple enough for beginners to learn the basics of designing with CAD, and is suitable for individuals and teams to eventually design and build their own racer.

It is recommended that you have a completed model to pass around the class during the Presentation. As an instructor, you have several resources at your disposal:

Overview PDF

- The initial document that introduces the project providing a brief overview.

1. **Teacher Guide**
   - This document contains information that corresponds to the sections of the Presentation PowerPoint (see below). Each section discussed in this guide provides further details on how you can use the PowerPoint.
   - Also included are additional ideas you may want to use to enhance the activity in the classroom or adjust it for different skill levels.
2. **Student Guide**
   - This document is intended to share with the students and provides basic guidelines for the activity such as deliverables, tips for creating the individual components and 3D printing guidelines.
3. **Presentation PowerPoint**
   - The PowerPoint is used to introduce the project to the class.
   - Feel free to expand any part of the presentation such as history, design concepts or any STEM related materials.
4. **Video**
   - The video is located on YouTube, and is intended to provide an overall approach to how the model could be created in CAD.
   - You may want to watch it together with the students in class.
   - LINK TO YOUTUBE VIDEO
5. **Step-by-Step Course**
   - This is where every step of the design process is demonstrated in short easy to follow video clips.
   - LINK TO STEP-BY-STEP

BACKGROUND

This section is intended to provide students with an introduction to both race cars and the physics principles behind balloon-powered motion.

Racing Inspiration

The balloon-car design was inspired by several iconic early racers, such as the Alfa Romeo 158, Cooper T43, and Lotus 49. These vehicles were among the most advanced of their time, featuring streamlined bodies, open cockpits, and exposed wheels—all trademarks of early Grand Prix racing. This simplified version gives students a starting point, but discussing how innovations in science and technology evolved racecar design over time, could spark ideas for design challenges as students build upon the model.

Physics Concepts

At the core of this project is Newton's third law: *for every action there is an equal and opposite reaction*. When the balloon deflates, the escaping air propels the car forward. Students will also explore concepts like friction, inertia, and energy transfer—transforming kinetic energy stored in the balloon, into kinetic energy.

Design & Manufacturing Concepts

- **Design Intent** – It is always best to have a clear definition of how a product should look, function and feel to the user. This is referred to as form, fit and function. Spend some time discussing this vital step in the process of designing a solution to a problem.

- **DFM/DFAM (Design for Manufacturing, Design for Additive Manufacturing**) - In addition to Design Intent, the concepts of DFM/DFAM are equally important. When designing anything, the question, "How will this be made?", should be considered. This particular project is designed to be 3D printed. As such, it is important that students understand the capabilities of the machine you have available.

- **Tolerancing –** When designing for 3D printing, it's important to apply the right tolerances based on your printer's capabilities so components assemble smoothly and function as intended.

- **Nesting -** In manufacturing, nesting refers to laying out cutting patterns on raw material to minimizing waste during manufacturing processes, such as laser cutting. In 3D printing, it is the process of laying out parts to fit on the bed of the 3D printer to print several components at one time. It is important to discuss how parts should be prepared for manufacture, specifically 3D printing.

COMPONENT DESIGN

This section contains slides for each of the components. The purpose of this section is to discuss how Design Intent and DFAM is to be applied to each part.

For detailed dimensions and step by step instructions for the parts, refer to the **LINK TO STEP-BY-STEP**, in the **ADDITIONAL RESOURCES** section below.

3D PRINTING

This section provides an opportunity to discuss the specific ways the individual components will be given tolerances in the CAD model, and how they will be oriented and prepared for 3D printing on whatever machines that are available to the students in the classroom.

It is recommended that you predetermine your printer's tolerances in order to accurately print the snap-fitting pieces (axle caps and spoiler). The dimensions that exist in the current project are general guidelines to get close to accurate snap-fits for these pieces. Also, be sure to develop classroom procedures for using machines, and have a method for keeping account of materials used. One thing you may want to do is have the students calculate the cost of each project. The way the components are designed and oriented on the 3D printer, will have an impact on this. This can also be an opportunity to discuss sustainability, being mindful of the environmental impact we have when designing and making things.

CLASS DISCUSSION

Included in this section are a couple questions to get the conversation started. The intent here is for you to tailor the discussion to suite your specific course goals and students needs. Some ideas may include:

- How does the balloon make the car move forward?
- How is the rotational motion of the wheels converted into the lateral motion of the car?
- How can we alter the design to improve performance (speed, endurance, or reliability)? Could changing the wheel size, exhaust diameter, or adjusting the weight distribution help?
- What household items could be used to modify the design, and how might they affect the results?
- Why do we need space between the axle and the wheel? What might happen if it were too tight or too loose?

PROJECT TASKS (ASSESSMENT CRITERIA)

Depending on the goals of the class, at a minimum students should be able to accomplish the following tasks.

1. Create the following racer components in CAD:
    - Main body
    - Wheels
    - Axle Caps
    - Spoiler
2. Create an assembly of the car in CAD.
3. Print the physical components on a 3D printer.
4. Assemble the Balloon-Powered Racer.
5. Race against other students in a drag racing style competition.
6. Iterate on the design—Experiment in CAD or utilize external household items enhance the model.

Some other possibilities for assessment may be in the following categories:

- **SUSTAINABILITY** – – Did the project minimize waste material necessary for 3D printing fabrication?
- **ASSEMBLY** – Do the 3D printed components fit together properly based on their intended purpose, i.e. do the wheel rotate and do the axle caps snugly snap onto the axles?
- **MANUFACTURABILITY** – Do the components fit within the parameters of the 3D printer?
- **PERFORMANCE** – Does the balloon propel the racer forward effectively and consistently?

ADDITIONAL RESOURCES

LINK TO DOCUMENTS

LINK TO YOUTUBE VIDEO

LINK TO STEP-BY-STEP

The following sections do not correspond to the PowerPoint, and are included here for added benefit.

ADVANCED OPTIONS

For more experienced students, you can challenge them with more advanced concepts and tasks that encourage creativity, engineering principles, and real-world application. Below are some ideas that could be suitable for this level:

Enhanced Body and Wheel Designs

- **Splines, Curves, and Surfacing:** Encourage students to go beyond basic geometries by using splines and surfacing tools to create more aerodynamic or stylized spoilers and car bodies. This provides glimpses into real-world car body design.
- **Wheel, Exhaust, and Weight Modification:** Have students test different wheel sizes or adjust exhaust diameter and location. Prompt them to use simple materials (e.g., coins, tape, cardboard) to shift weight distribution or stability, and justify their results using physics principles.

Dynamic Simulation and Testing

- **Testing and Data Analysis:** Have students run physical tests, using measurement devices such as rulers, cameras, or sensors, to collect race data. Ask them to graph or calculate acceleration or distance traveled, or even estimate drag or frictional losses.

Collaboration

- **Team Based Design:** Assign roles such as design, fabrication, and testing, to mimic real world engineering and collaboration. Require collaborative design review and task management between students.

Competition and Tracks:

- **Drag Racing Tournament:** Host a structured competition where cars are judged on factors such as speed, endurance, or deign creativity. Let students present or pitch their design choices and the science behind them.
- **Obstacles and Tracks:** Have either pre-built tracks, or have students design dynamic racing elements, like ramps, curves, or barriers, in CAD that can also be fabricated. This adds purpose to the iterative design process, challenging students to design for specific terrain.

By including these advanced design elements, students will be pushed to develop critical thinking skills and a deeper understanding of physics principles and engineering concepts.

EDUCATIONAL CONCEPTS

This project is an engaging way to connect real world engineering thinking with STEM concepts taught in the classroom. Below are example topics:

SCIENCE

- Explore Newton's laws of motion, specifically the third law, to discuss how the balloon propels the car forward.
- Discuss energy transfer: from potential energy in the balloon to the kinetic energy of the moving car.
- Investigate friction present on the wheels and axles and how drag may slow the car down due to the design.

TECHNOLOGY

- Teach students to use 3D modeling for creating their dragster designs.
- Demonstrate how 3D printers work, from slicing software to the actual printing process.
- Emphasize the importance of DFAM, Designing for Additive Manufacturing, by minimizing waste through smart design.

ENGINEERING

- Talk about how exhaust design, wheel size, and body shape affect performance.
- Introduce inertia and moment of inertia in the context of wheel size and mass distribution.
- Compare how the balloon performs to a real internal combustion engine.
- Discuss how different F1 designs through the years approach aerodynamics to improve speed and handling.

MATHEMATICS

- Use measurements or equations to determine unknown variables such as velocity, distance travelled, and acceleration.
- Challenge students to estimate material costs, factoring in 3D printer filament usage and design complexity.
- Calculate specific dimensions and tolerances needed to complete a custom body, wheel, or spoiler design in CAD.