



# Engineering Design Challenges for Every Season

Test your students' design skills with these fun, real-world CAD challenges that prepare them for a career in engineering



# Harness the Power of Projects in Your Engineering Classes

## Design projects challenge students to think like professional engineers and solve rewarding, real-world problems

The best way to get students interested in engineering: Make it fun! At SolidProfessor, we love engineering (just ask our [co-founder Tony Glockler](#)), but it can be tough to get kids on board. We've repackaged each of our engaging design challenges to make them easier to use in the classroom and show students just how awesome engineering can be.

## Encourage students to develop an engineering mindset by solving real-world problems

Design challenges are projects that take students through the entire design thinking process, from receiving a problem statement to conducting research, asking questions, designing a model, and presenting the solution. By encouraging students to partake in the entire design thinking process, they get a much better idea of what it's really like to be a professional engineer. They discover that engineering is about problem-solving and finding creative solutions for complex issues, not sitting in a dark room crunching numbers.

Developing an engineering mindset is crucial for students who want to pursue engineering as a career — and even for those who don't. Employers look for students who can demonstrate they have both hard skills and soft skills, and design challenges foster the development of both.

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### Soft Skills vs. Hard Skills

- **Soft skills:** More intuitive, people-oriented skills often associated with emotional intelligence. Soft skills include: collaboration, communication, attention to detail, creative thinking, and leadership.
- **Hard skills:** Formally taught technical skills like programming or CAD. Hard skills include: computer-aided design, strength of materials, thermodynamics, electrical theory, applied physics, and machining.

## Find creative ways to use these design challenges in your classroom

To start using these design challenges, here are just a few ways to leverage them in your classroom:



**In-class group project:** Break students up into small teams and give them ample class time each week to progress through the various steps of the assignment. There are a few different ways to break up the actual design work. Make each student responsible for designing a specific body. Then, the students can come together at the end to assemble their bodies. Or, students in small groups can take turns adding in a few features before passing the files off to the next person. Both provide valuable insights into how professional teams communicate throughout the design process and spot errors in their model.

**Each step in the process can be turned into smaller assignments that lead to the final presentation.**



**Individual homework assignment:** For more advanced students, these design challenges make for interesting homework assignments. Each step in the process can be turned into smaller assignments that lead to the final presentation. We also advise leaving some class time for students to be able to ask questions and get input on their models.



**Self-paced learning:** You can increase — or decrease — the difficulty of any design challenge, which makes it easy to customize them on a student-by-student basis. Assign a challenge as an ongoing project throughout the semester that students can work on when they've finished other assignments. Or, encourage students to focus on different aspects of the challenge depending on their strengths and weaknesses. Each challenge is flexible enough to serve your students however you see fit.



**Online learning:** If you have a completely online class, these design challenges can all be completed and turned in digitally. For the presentation portion, students can video their presentation or turn in written summaries.



## Customize each design challenge based on your students' CAD proficiency

The design challenges outlined in this e-guide provide students with a framework for solving fun, real-world problems. At SolidProfessor, we've sent these design challenges out to thousands of engineers in the industry and received hundreds of entries, which are used as examples in this e-guide. The goal of each challenge: get students to think like an engineer and test their CAD skills while having fun in the process. It's the ultimate win-win-win situation.

Each design challenge comes with

- A unique problem statement
- Design parameters
- Suggestions for making the challenges easier or more difficult
- Reflection points
- Research questions
- Presentation framework
- Examples of models designed by industry professionals
- Grading rubric

Feel free to print out any of the three challenges and hand them out to students as is. Or, use them as a starting point so you can add your own flair. Each challenge comes with three levels of difficulty, giving you the option to make the assignments easier or more advanced. We've also included notes for educators and a grading rubric in the section titled "[Additional Resources for Educators](#)."



## Give students access to online CAD, CAM, BIM, and engineering theory tutorials to help them efficiently create more advanced designs

As your students work through these design challenges — as well as other engineering assignments — they'll hit setbacks. Maybe they'll find an error in their design tree that they just can't figure out. Or, perhaps they'll get stuck trying to add motion to their model. SolidProfessor is here to help.

We provide online engineering training resources to help schools and professionals

- Troubleshoot problems in their CAD software
- Learn new skills to design more efficiently
- Prepare for certification exams
- Brush up on engineering theory

Each online course comprises short, to-the-point videos that are easy to watch anytime, anywhere.

“I set out to find a resource that I felt would be beneficial to our students and help our teachers develop professionally. I reached that goal with SolidProfessor.”  
— John Crow, Career and Technical Education Specialist, Katy Independent School District

## Fill out the SolidProfessor Technology Grant form to receive our training resources for up to 90% off the commercial price

At SolidProfessor, we offer our Technology Grant program exclusively to schools to make our online resources accessible to all students and educators. The Technology Grant program helps schools on tight budgets gain full access to our Library of 5,000+ training videos for just a fraction of the regular price.

Any educators or school administrators interested in learning more about SolidProfessor can [fill out the Technology Grant request form](#). Or, feel free to give us a call at (619) 269-8684 or email us at [info@solidprofessor.com](mailto:info@solidprofessor.com).



# Celebrate 4th of July in Style

## Design fun, patriotic sunglasses that will be affordable enough to manufacture in bulk

### The situation

Rocket Media, the country's largest entertainment company, is throwing a 4th of July party to end all parties. Fireworks, check. Hundreds of hamburgers, check. Music, double check. Rocket Media wants to provide every partygoer with a pair of the coolest, most patriotic sunglasses to wear during the bash. They've hired a few different engineering firms to submit their unique sunglasses designs, and your company, Boss Engineering, was selected as a contender. Your job is to design sunglasses that not only stand out in a crowd of festive celebrators but also are affordable enough to be manufactured in bulk.

### Design parameters

Your sunglasses need to be both creative and practical. They must be one-size-fits-all so any partygoer can wear them. Your sunglasses must also be designed so Rocket Media can manufacture them at the lowest possible cost, preferably for \$3 a pair or less. Designs will be judged on creativity, the elegance of design, and adherence to criteria. Submit an image or gif of your design, plus the CAD files.

### Set your difficulty level

**Level 1:** Use the current instructions, with the option to remove pricing constraints and/or start with a model of sunglasses and focus on adding decorations.

**Level 2:** Design flip-up sunglasses and add motion to the model to show the flipping action.

**Level 3:** In addition to all the previously stated criteria, create a pair of sunglasses that can fold up and fit into a glasses case that is 7" L by 4.5" W.

### Ready, set, design!

**Reflection:** To kick off the project, reflect on all the parts that comprise a pair of sunglasses, including the rims, end pieces, bridge, hinges, lenses, screws, nose pads, and arms. Consider the relative cost of mass producing heavily designed sunglasses. Finally, keep the deadline in mind, since the company must have the sunglasses ready to go and in-hand before the 4th of July party.

**Research:** In this phase, research different sunglasses models and pricing so you can start planning out your design. Research how to create all the parts that comprise sunglasses, how to add design elements without inflating the cost, and what an appropriate per unit cost is for manufacturing sunglasses. You'll need to answer these questions in the research phase:

- What is the right head size to model your sunglasses on?
- How will you add the lenses to the model, and how will you design your sunglasses with that in mind?
- How do added elements or thickness of material impact pricing?
- What features do your sunglasses need to include?
- Do you want the sunglasses to be able to fit over regular glasses?



**Discovery:** Compile all the information you've gathered to start planning out your model. This is a good time to meet in small groups and/or with your instructor to discuss what you've discovered in your research.

**Application:** Now, it's time to start designing!

**Communication:** Once you've completed your designs, it's pitch time! Create a presentation to sell your sunglasses to Rocket Media. Your presentation must include pricing information (per the instructions) and a walk-through of your model. Explain why your model meets all the criteria and should be chosen by Rocket Media.

## Examples from the pros

For inspiration, check out these examples of patriotic sunglasses designed by fellow students and professional engineers.



# Your Spookiest CAD-loween Assembly

## Design a scary, multi-body assembly that catches haunted house visitors by surprise

### The situation

The Graveyard Shift, the state's largest creator of haunted offices, is ready to pull out all the spooky stops for Halloween. In particular, they want visitors to jump with fright at every turn, even at the end of the tour. Just as guests leave the haunted office, The Graveyard Shift wants a spooky prop to pop out and give visitors one last surprise. They want your company, Boss Engineering, to design this prop. It must be a multi-body assembly and it must have the element of surprise. The Graveyard Shift isn't concerned about cost, but they do want to make sure that the prop is appropriate for visitors aged 13-21.

### Design parameters

All assemblies must comprise at least two bodies, and at the minimum, one of the bodies must move. The Graveyard Shift prioritizes assemblies that have the potential to surprise guests but are still appropriate for visitors in their primary age range of 13-21 years old. Models will be judged on creativity, the elegance of design, and adherence to criteria. Submit a gif of your design plus the CAD files.

## Set your difficulty level

**Level 1:** Focus less on adding motion to the model and instead work on creating well-designed multi-body assemblies. Animation can be optional but it doesn't need to be driven by mass or gravity.

**Level 2:** Add Basic Motion to your model, taking into consideration the effects of mass, springs, gravity, and physical collision detection.

**Level 3:** Add Motion Analysis to your model, accounting for a much wider range of physical interactions, like impact effects, damping, force, momentum, and more.

## Ready, set, go!

**Reflection:** During this phase, consider what kinds of displays belong in a haunted office. Come up with a few ideas for what you'd like to design and consider what makes it "scary." Think about how you'd like to display your prop and what display requirements you'll need to account for in the design process. It's also important to reflect on the different types of materials that can be used.

**Research:** Dive into what you need to know in order to start designing your assembly. You'll need to answer these questions in the research phase:

- How big should the display be?
- Does it need to be hidden or can it be in plain sight?
- Is it appropriate for the specified age range?
- Does the design need to be reset after each use?
- What parts need to be involved in the assembly?
- How heavy will the prop be?
- What bodies need to be included in your assembly?



**Discovery:** Compile all the information you've gathered to start planning out your model. This is a good time to meet in small groups and/or with your instructor to discuss what you've discovered in your research.

**Application:** Now, it's time to start designing!

**Communication:** Once you've completed your designs, it's pitch time! Create a presentation to sell your prop design to The Graveyard Shift. Your presentation must illustrate why the design is scary, how it will surprise guests, and how it will be displayed in the haunted office. Don't forget to mention why you think this prop is appropriate for the designated age range.

## Examples from the pros

For inspiration, check out these examples of CAD-loween assemblies designed by fellow students and professional engineers.



# A Sled that 'Sleights' the Slopes

## Design a sled that earns “Best in Snow” in both safety and speed

### The situation

Winter sports company Ice Dogs wants to win the coveted “Best in Snow” award this year. The premier sled award, Best in Snow is given to the year’s safest and speediest sled. The competition starts out with a safety inspection, in which judges look for at least two grip points for riders to hold onto, as well as additional safety features. After passing the safety inspection, the sled also needs to win a downhill speed race. Ice Dogs wants your company, Boss Engineering, to design the model for an award-winning sled.

### Design parameters

The sled must have at least two grip points for the rider to hold on to. It also needs to be fast and maneuverable. Models will be judged on creativity, the elegance of the design, and adherence to criteria. Submit an image or gif of your design, plus the CAD files.

### Set your difficulty level

**Level 1:** Focus on designing a model that adheres to the original instructions.

**Level 2:** Make your speedy sled model even safer by including brakes and steering, as well as the two grip points.

**Level 3:** In addition to the previously stated criteria, the sled needs to be made entirely out of ABS plastic and hold the weight of two 90-pound kids with a factor of safety of 3.

Ready, set, go!

**Reflection:** Consider what parts comprise a sled, such as a handlebar, runner, the sled body, rails, etc. It’s also important to think about the pros and cons of different sled styles like the two-rail design or the saucer. Think about how sleds move down a hill, how they interact with snow, and what makes a sled fast and safe.

**Research:** Safety and speed are the key elements in this challenge, so you’ll need to spend time researching aerodynamics and safety features of sleds. You’ll need to answer these questions in the research phase:

- What does safety mean in the context of sledding?
- How do sleds interact with snow and how does that affect their speed?
- What materials work best for building this type of sled?
- What adverse weather or landscape conditions should you account for in your design?
- What makes a sled design durable?
- How will the sled be transported?
- How many bodies will be required to complete your sled?

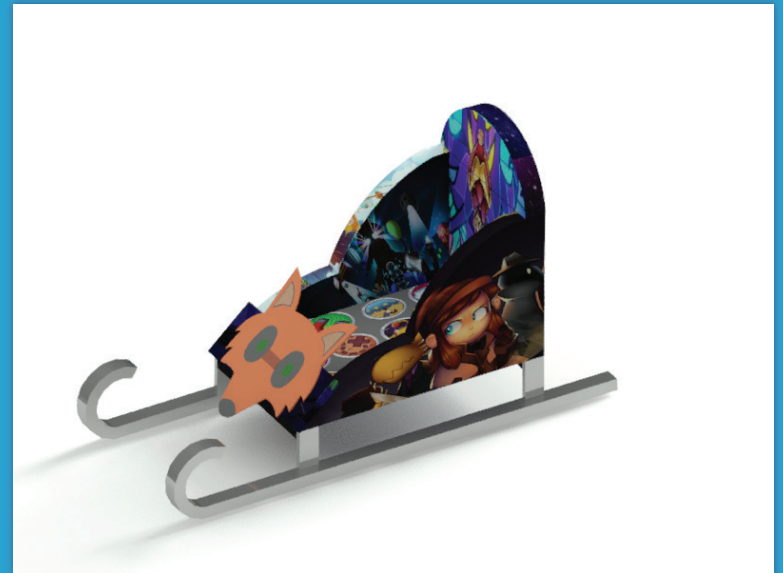
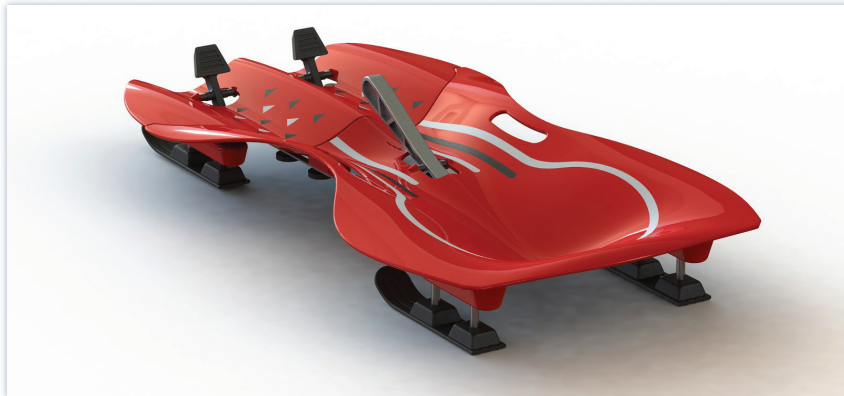
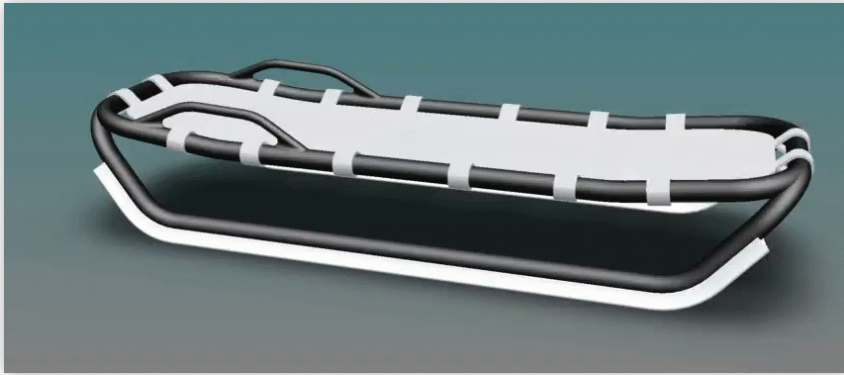
**Discovery:** Compile all the information you’ve gathered to start planning out your model. This is a good time to meet in small groups and/or with your instructor to discuss what you’ve discovered in your research.

**Application:** Now, it’s time to start designing!

**Communication:** Once you've completed your designs, it's pitch time! Create a presentation to sell your sled to Ice Dogs. Your presentation must illustrate how fast the sled is, what safety features you've included, what materials you used, and why it's the best contender for winning Best in Snow.

## Examples from the pros

For inspiration, check out these examples of sleds designed by fellow students and professional engineers.




# Additional Resources for Educators


## Customize each challenge for your students and download a grading rubric


These customizable design challenges are incredibly easy to implement in any classroom. Within each design challenge section, choose the level that challenges your students' current CAD skills. Then, use the following grading rubric to determine how well they met the criteria of the design challenge.


### Explanation of grading rubric


We've broken the grading criteria into a five different categories, which we've described below. All scores are on a four-point scale, but you can adjust this as you see fit.

 **Thoroughness of research:** In this category, you're looking at whether the student followed the research prompts and considered the various conditions impacting their design. The design and presentation will both reflect whether the student researched the topic thoroughly enough, but you can also have them turn in their research.

 **Overall creativity of design:** The goal of these challenges is for students to critically think about the situation and create a model that uniquely solves the problem. Designs built on pre-existing models (unless approved by you) or with minimal decorations/creative elements will not receive top marks. However, designs that show a unique approach or clear creative thinking will receive more points.

 **Adherence to challenge criteria:** Students must meet all challenge criteria outlined by the prompt and difficulty level you selected. If the prompt asks for two grip points and a student only includes one, they will not receive full points in this category.

 **Elegance of design:** This refers to how efficiently the student designed the model. You can look for things like fully defined sketches, where applicable, and a design tree that can withstand updates. The number of features or sketches isn't as important as how they're put together to make the final model. If all the geometry is in one sketch that you can't make sense of easily, take away a few points. The same thought process applies to assemblies. It's like judging the elegance of a sentence: The best, most refined sentence isn't the one that uses the biggest words; it's the one that uses the right words.

 **Effectiveness of the presentation:** Students should treat their presentation like a product pitch. They should have in-depth knowledge about their model and why it solves the problem(s) outlined in the design prompt. Students should be able to answer questions about how they designed their model, why they chose that particular design, and why it's the best option for the client.

## Do You Have Feedback for SolidProfessor?

Contact us at [info@solidprofessor.com](mailto:info@solidprofessor.com) or 619-269-8684.

## GRADING RUBRIC FOR SEASONAL DESIGN CHALLENGES

	BEGINNING 1	DEVELOPING 2	ACCOMPLISHED 3	EXEMPLARY 4	SCORE
<b>THOROUGHNESS OF RESEARCH</b>	Conducted minimal research; has a limited understanding of the topic. Only answered a few of the research questions.	Conducted some research; gained some understanding of the topic. Answered at least half of the questions.	Conducted most of the required research; has a good working understanding of the topic. Answered almost all of the research questions.	Conducted all of the required research; has a great working knowledge of the topic. Answered all of the research questions and potentially answered extra questions.	
<b>OVERALL CREATIVITY OF DESIGN</b>	Very minimal creativity in the design; very simplistic with limited unique features.	Some creativity in the design; somewhat simplistic with a few unique features.	Design exhibits creativity and contains many features that are unique to their model.	Design displays a very high level of creativity with many unique features and elements.	
<b>ADHERENCE TO CHALLENGE CRITERIA</b>	Met less than half of the design criteria.	Met about half of the design criteria.	Met more than half of the design criteria.	Met all of the design criteria.	
<b>ELEGANCE OF DESIGN</b>	Used inefficient design techniques to create their model; design tree can't handle any updates and might even have unsolved errors. Unable to make sense of geometry.	Used somewhat efficient design techniques to complete their model; design tree can handle some updates but doesn't contain any errors. Can make sense of the geometry, but it's challenging.	Used efficient design techniques; the design tree handles updates easily and contains zero errors. Geometry might not be seamless, but it's easy to follow and sketches are nearly fully designed.	Used incredibly efficient design techniques; the design tree handles updates and contains zero errors. Sketches are fully designed. Leverages fewer features to achieve the same result.	
<b>EFFECTIVENESS OF PRESENTATION</b>	Was not prepared for the presentation and seemed disorganized; did not demonstrate a high level of knowledge about the model or the topic. Didn't present a compelling argument for their design.	Was somewhat prepared for the presentation and displayed a base level of knowledge about the topic. Communicated some of the benefits of their design.	Prepared for the presentation and well-versed on the topic. The presentation was somewhat disorganized and met most — but not all — of the criteria.	Very prepared for the presentation and demonstrated a high level of knowledge about the topic. Very effectively communicated the benefits of their design.	
<b>TOTAL POINTS</b>					