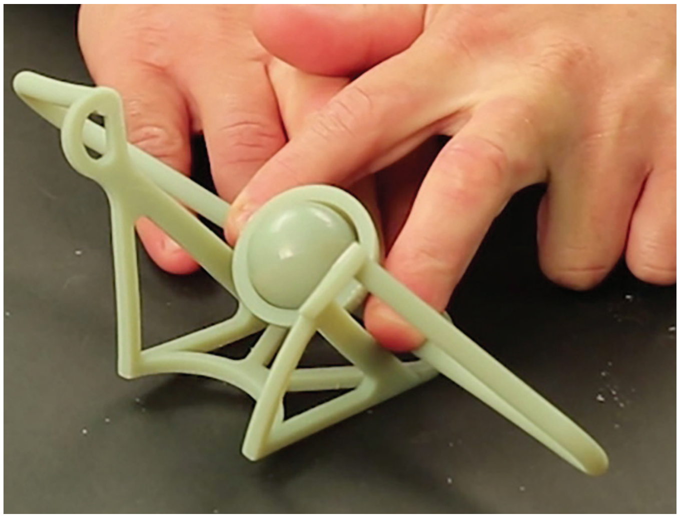
LESSON GUIDE

Catapult



Level	Intermediate to Advanced
Academic Connections	Science, Engineering, Design Thinking, Design for Manufacturability, Hands-On Learning
Core Concepts	Design, Design Optimization, Engineering Design, Print Optimization, Computer Aided Design (CAD), Assembly
Duration	2 – 3 weeks

In this project, the goal is to design a catapult that can throw a 3D printed ball as far as possible.

LEARNING OBJECTIVES

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

- Design and print a catapult that launches a 3D printed ball.
- Research historic catapult and trebuchet designs for design inspiration.
- Learn about various spring designs.

REQUIREMENTS

- Educator PC with access to:
  - Microsoft PowerPoint
  - QuickTime
  - Internet connection
- Projector
- 3D printers
- CAD design tool

ESSENTIAL QUESTIONS

Use these questions to guide students' understanding:

- What is the most effective historic design (catapult, trebuchet, crossbow)? Can you think of a new design that is more effective given the lesson guidelines?
- What is the most effective spring design given the model material properties (tension, flexure, torsion)?
- How can 3D printing technology allow you to create a more effective design (complex shapes and profiles, weight savings by "trimming" non-load bearing areas, 3D printing your design)?

PROCESS WORKFLOW

DESIGN GUIDELINES

1. The ball is a 3 cm diameter printed model (weight ~13 grams).
2. When ready to launch, the device must be smaller than 20 x 20 x 20 cm.
3. The device must weigh less than 50 grams.
4. The entire device must be made of 3D printed material (no springs, rubber bands, adhesives, bolts).
5. The device may be composed of several parts but they must fit within one printer tray. They must also connect without external means (no adhesive, bolts, etc.).
6. The device must have a trigger that fixes it at the launch-ready position and allows activation and launch.

DESIGN TIPS

1. The minimal wall thickness that can be reliably printed is 0.6 mm. For the size constraints of the competition the thickness of the spring component should be in the range of 5-8 mm.
2. For the trigger you can print axles and moving parts in one model. Simply leave a clearance of 0.1-0.2 mm and enough access to remove the support material.
3. Use smooth fillets in corners since sharp corners can cause premature failure. Printing a smooth, complex design is just as easy as printing a box.
4. Know the material limitations. Look at the material datasheet. Consider printing a simple model to get the feel and design accordingly.

OPTIONAL

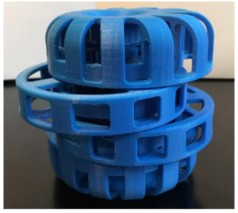
1. Look at the part arrangement on the printer tray and make sure the load bearing faces that will be under tension are printed in gloss mode as this will ensure they are as strong as possible.
2. Use mechanical analysis/simulation software to help you reach an optimal design.
3. Print prototypes of your design, test them and improve them accordingly.
4. You can make your design modular. For example, the frame will be constant but you can use it to test various spring designs.

Safety – Wear safety goggles

SUGGESTED NEXT LESSONS

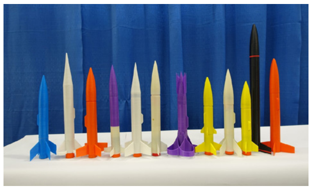
GEAR SYSTEMS

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



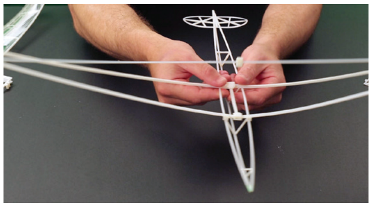
ROCKET

Covers all topics necessary to pass the Certified SolidWorks Associate (CSWA) exam while designing a 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.

GLIDER CHALLENGE



Design a glider composed of several parts, but they must fit within one printer tray.

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

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