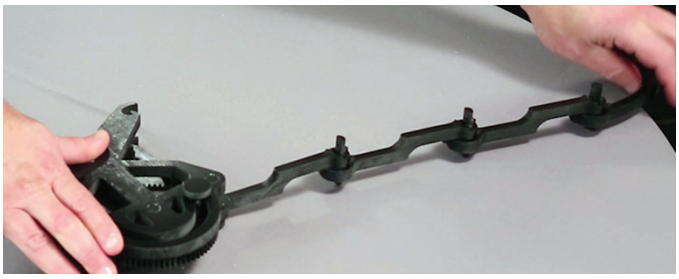
LESSON GUIDE

Multiplier Challenge



Level	Advanced
Academic Connections	Engineering, Design for Manufacturability
Core Concepts	Engineering Design, Engineering Analysis, Print Optimization, Computer Aided Design (CAD)
Duration	2 – 3 weeks

In this challenge, the goal will be to see how far a device can reach by using only small movement. The device you will design needs to multiply the small movement and create a movement as large as possible.

LEARNING OBJECTIVES

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

- Create a unique device that multiplies a small movement to create a large movement.
- Research and learn about different mechanisms and movement multipliers.

ESSENTIAL QUESTIONS

1. What type of mechanisms can multiply movement?
   a. Gears
   b. Levers
   c. Screws
   What are the benefits of each? Which are easiest to apply with 3D printing?
2. How can 3D printing technology enable you to print complex structures without assembly?
3. How can you build parts that work directly from the machine?
4. When you multiply movement, you also multiply the force required for the input. Since there is no load on the moving end, the force is required mainly to overcome friction. How can you design your structure for minimal friction?

DESIGN GUIDELINES

1. Build a structure that translates a small input movement into a large output motion.
2. The entire structure must be smaller than 20 x 20 x 5 cm.
3. The input movement must be shorter than 10 cm and directly cause the output movement (no springs or throwing parts).
4. The entire structure must be printed in one piece – no assembly allowed.

REQUIREMENTS

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

CHALLENGE OVERVIEW

We have included guidance for this challenge, as well as design tips and additional material on our education webpage, including a video. http://www.stratasys.com/3DLC

The video shows some other devices that will give an idea of what is possible and how to approach this challenge. One design is based on louvers and is similar to a vehicle or laboratory jack. However, where a jack takes large movements and translates them into small movements but with a lot of force, this device works in reverse and takes small movements and multiplies them. This design is similar to a pantograph arm. You will see in the video that all the parts were printed together, including the axles that connect the louvers.

The second concept is based on gears. It is a little less efficient, but more complex and interesting. In another design, you can see the gears and axles that release after 90 degrees of rotation. You can view the designs we came up with on the video. But now we would like to move the challenge back to you and see how far you can go.

DESIGN TIPS FOR FDM®

1. The minimal wall thickness varies depending on the layer thickness. For load bearing parts, the minimum wall thickness is approximately the width of two contours.
2. The structure must be printed in one piece, but you can design moving parts into it (axles, meshing gears, etc.). As a design rule of thumb, leave a clearance of 0.31 - 0.51 mm (0.012 -0.020 in.) between parts in the X/Y-axis (machine dependent – please

reference Best Practices – Building Assembly Parts, available in the Advanced Applications section at http://www.stratasys.com/3DLC). Clearance equal to at least double the layer thickness for the Z-axis is recommended.

3. Consider the need for support removal. Determine the crucial structural elements and remove other parts to allow cleaning the support material from internal parts of the mechanism. (See FDM Best Practice – Assemblies for additional tips.)

OPTIONAL

1. Use the motion study capability of the CAD software to help you verify and improve your design.
2. Print prototypes, test them and improve the design.

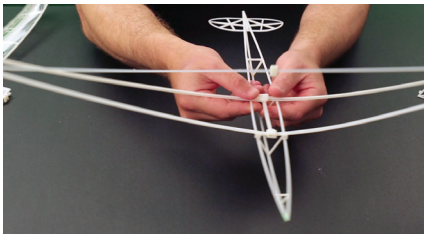
SUGGESTED NEXT LESSONS

WEIGHT SUPPORT CHALLENGE

In this challenge, the goal will be to build a structure that can support a weight suspended above a surface.

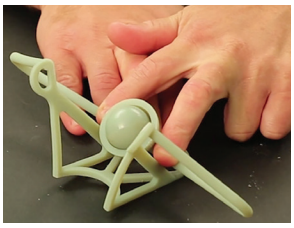
GLIDER CHALLENGE

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



CATAPULT

Design a catapult that can throw a 3D printed ball as far as possible.



To access additional 3D Learning Content and resources visit:

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

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