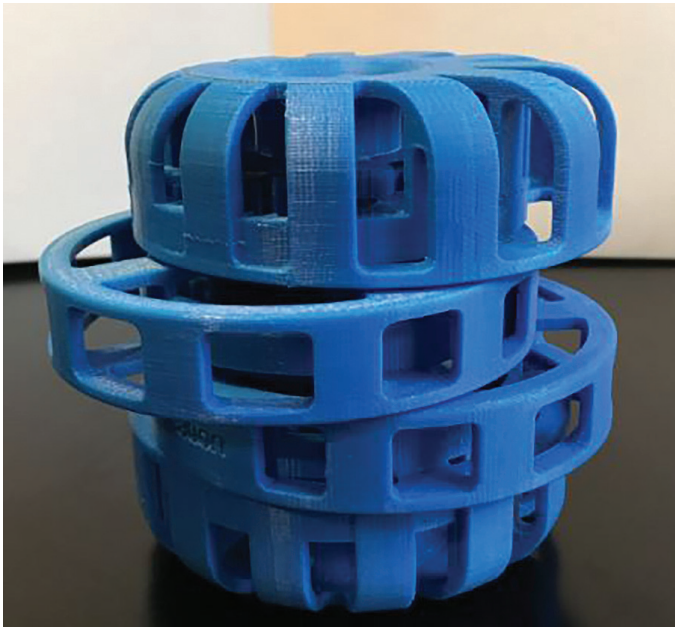
LESSON GUIDE

Gear Systems



Level	Intermediate
Academic Connections	Engineering, Design Thinking, Science, Prototyping, Design for Manufacturability
Core Concepts	Computer Aided Design (CAD), Engineering Design, Design Optimization, Print Optimization
Duration	2 -3 weeks

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

LEARNING OBJECTIVES

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

- Build a gear system in CAD.
- Convert 2D gear drawings to 3D models.
- Design systems with 3D printing technology in mind, including minimum tolerance and material thickness.

ESSENTIAL QUESTIONS

Use these questions to guide students' understanding:

- How do you interact with a 3D design differently than a 2D design?
- Are gear systems obsolete? Will they ever be?
- What must be considered when scaling a gear system to a larger or smaller size?

REQUIREMENTS

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

TOPICS/ AGENDA

CLASSROOM

Gear Systems

Format: Lecture

Learning aids: Gear Systems PPT

Preparation: Print PPT lecture notes (see Resources below).

COMPUTER LAB

Designing Gears In Cad

Format: CAD Instruction

Learning aids: Educator Provided Content*

Preparation: Develop Lesson Plan
Introduce formulas for determining gear specifications given tooth count and diameter. Teach students how to redesign 2D gear drawings as 3D models using photographs or old blueprints.

CASE STUDY

Format: Lecture

Students are introduced to the operating principles of gear systems and learn the advantages and limitations of 3D printing them.

Learning aids:

- Da Vinci Case Study (PPT)
- Gear System Case Study (PPT)
- Gear Ball Case Study (PPT)
- Gear System 16 (STL)
- U05 FDM Da Vinci (STL)
- U05 FDM Gear System 26 (STL)

Review one of these case studies with students to highlight the challenges and advantages of 3D printing gear systems.

Preparation: Print PPT notes, 3D print model STL files.

ASSIGNMENT

Gear Systems

Option 1: Gear System (STL)

Requirements:

1. Design a system that uses more than one gear to produce motion.
2. Consider the trade-offs between speed and force and document your design decisions.
3. Consider the tolerance and layer thickness capabilities of the 3D printer you'll use, and document design decisions related to those capabilities.

Option 2: Da Vinci Machine (STL)

In this assignment, you'll get inside the shoes of a great artist, inventor and engineer.

1. Find a da Vinci machine sketch and reproduce it using CAD.
2. Consider the ways in which 3D printing differs from Renaissance-era fabrication technologies and adjust the designs accordingly.
3. Consider the tolerance and layer thickness capabilities of the 3D printer you'll use, and document design decisions related to those capabilities.

Documentation & Presentation

Both options require documentation and a final presentation. Your presentation should include a video of your final product in action and should demonstrate your use of Design Thinking. As you work, be sure to address your problems, challenges and lessons learned. Include the following:

Material use: What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? Why?

Technology: What design challenges have you encountered as a result of the 3D printing technology you used?

If you had access to other fabrication technology, what would you have chosen? Why?

Wall thickness: Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this?

Details: Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost?

Holes and Gaps: Have you encountered any tiny holes or gaps? How did you fix this?

Have you been able to resolve some of your issues by increasing the scale of your model or did you have to significantly alter your design?

HOMEWORK REVIEW

Students will present their gear model to peers and exchange feedback.

CLASSROOM

KINEMATIC MODELS

Format: Lecture

Learning aids: Educator-Provided Content*

Preparation: Recommended Resources:

Kinematic Models Digital Library (Cornell University) - http://kmoddl.library.cornell.edu/

CASE STUDY

Format: Additional Gear Case Study Review

Learning aids: Printed Case Study

Review one or more of these case studies with students to highlight more challenges and advantages of 3D printing gear systems.

- Da Vinci case study
- Gear System case study
- Gear Ball case study

RESOURCES

Case Studies are available in the Lessons and Labs section at http://www.stratasys.com/3DLC

COMPUTER LAB

Format: Instructor Aided Review

Students will improve upon the gear system they began designing and incorporate feedback from their peers. Use lab time to aid and advise students as needed, encouraging model complexity. Students will need to complete their models as homework if they do not finish in class.

ASSESSMENT

ESSAY QUESTION

Describe the unique considerations involved when designing a gear system for 3D printing.

Multiple-Choice Questions

1. Two or more gears working in tandem are called what?
   A. Torque
   B. Cog
   C. Rack
   D. Transmission

2. What are the advantage(s) of using gear systems?
   A. Gear teeth prevent slippage
   B. Few elements can create great force
   C. Decreased power creates more force
   D. Gear systems are easy to design and manufacture

3. Force transmitted from a small gear diameter to a larger gear diameter is
   A. Increased
   B. Decreased
   C. Stays the same
   D. None of the above

4. In spur gear systems, the tooth profile is
   A. Inclined to the axis of rotation
   B. Vertical to the axis of rotation
   C. Parallel to the axis of rotation
   D. None of these

5. If two discs are fixed by an axis, their radial velocity and acceleration is equal.
   A. True
   B. False

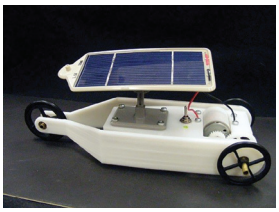
6. What important element must we consider when re-scaling a gear system design?
   A. Space between the elements
   B. Recommended minimal element thickness
   C. Removal of support material is still possible
   D. None of the above

* (If you have a lesson plan you'd like to share with the Stratasys Education Community, contact us at edu.curriculum@stratasys.com. If we add it to our curriculum, you'll be eligible to receive free FDM or PolyJet materials for your 3D printer.)

SUGGESTED NEXT LESSONS

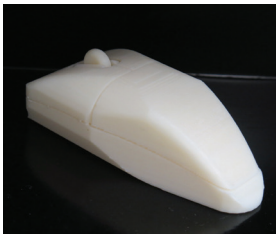
SOLAR CAR

Design, 3D print and assemble a working solar car. When developing the design consider aerodynamics, rolling resistance, torque, the gear ratio, bearings and the wheel base.



COMPUTER MOUSE

Keeping the users of your product in mind, design a wireless mouse that will provide optimum comfort and performance.



MULTIPLIER

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

To access additional 3D Learning Content and resources visit:

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

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