# Lesson Plan for 3D Modeling Project #8

INTERLOCKING BRICKS

In Section 8 of the 3D Modeling Course, learners are introduced to true 3D objects. Previously, 3D objects have been created by extruding 2D shapes. Learners should have completed to Section 8 or further before attempting this project.
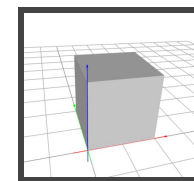
The new keywords in Section 8

Command SPHERE to create spheres, specifying the radius.
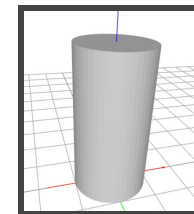
```
S = SPHERE(1)
SHOW(s)
```
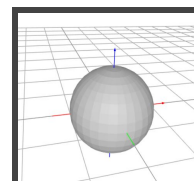
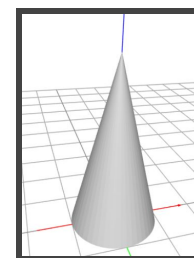Command CUBE to create cubes, specifying the edge length

```
c = CUBE(2)
SHOW(c)
```

Command CYLINDER to create cylinders, specifying the radius and height.

```
y = CYL(1, 4)
SHOW(y)
```

Command CONE to create cones, specifying the radius and height.

```
n = CONE(1, 4)
SHOW(n)
```

Learners should know

MOVE() and ROTATE() commands (Sections 6 and 7) to move pieces into place.
COPY() to make copies of objects (Section 5)
BOX() and SUBTRACT() to create the outside of the brick (Section 2 and 3, and further developed in Section 9).
RING() (Section 2) can be extruded with PRISM() (Section 3) to create the tubular structure. TUBE() is taught in Section 9 (next section).
Commands based on a radius will center the object on the origin.
Commands based on SQUARE, CUBE, RECTANGLE have the origin as the vertex on the lower left corner.
SCALE() can be used to adjust the fit. It is taught later in the course in Section 15.
However, instructions for SCALE and the other commands are also found in the List of Commands in the Help Menu of the PLaSM app.
How to export STL files using the export menu in the viewer.

Modeling hints

NCLab Projects are exploratory by nature, so we do not provide answer keys.
Encourage experimentation and collaboration. Some guidance:

- Break down the complex shape into simple components.
- Plan COPY, MOVE, and ROTATE transformations.
- Decide on dimensions (if the whole class wants to fit their printed bricks, they will need to use similar dimensions).
- Build just one brick. Once the brick is successfully designed, then copies can stacked to build figures such as the stack of bricks in the illustration.
- Use the List of Commands in the Help Menu for help with writing the commands correctly.
- Have a pile of toy bricks handy for reference.

3D Printing hints (if you plan to print the STL files)

Make sure the shapes are physically connected (no gaps or significant overlaps).
Use the WELD() command at the end of the script to correct some issues with printing.

Tolerances may not be perfect if trying to fit more than one brick together. The size of the STL file can be adjusted on the slicer software (either a standalone software or the input of the printer itself) or by using the SCALE command to correct the fit.

The bricks can be printed at a small scale, so several STL files can be printed at the same time. You may want to print with support matrix if available to keep the dimensions as precise as possible while printing. Make sure that you orient the bricks so that the base of the brick rests on the printing surface to minimize distortion.

ABS plastic is the material used to make real interlocking bricks. It is available on some printers. PLA (more common) can be used but is more fragile.

Printing is a slow process. Start the run early in the day. Print a batch that can be completed while someone is there to supervise the print run.

Finishing the blocks requires small tools such as **craft knives and pliers.** Learners should be trained in the safe use of these tools. If printed with a support material, the pieces may need soaking in warm water (PVC glue type materials) or other solutions to clean the pieces.

Materials, supplies, computer and account requirements

Each learner needs their own NCLab account for access to the PLaSM app (found in Creative Suite -> 3D Modeling -> PLaSM. Remind them to save their PLaSM and STL files to their NCLab folder. The STL file requires downloading to a local drive for export via portable drives or media, or as an email/message attachment.

Desktop, laptop PC or MAC computers, Chromebooks. iPads can be used but are not 100% compatible. Other tablets and phones are not supported.

Internet connection for each user.

Toy interlocking blocks as physical models.
Craft knives and pliers, containers of warm water (or other solvents as needed) for 3D print cleanup if printing.
Journals or sketch paper for planning design and taking notes on dimensions.

Overarching Understandings

By building a 3D model:

Geometry: Demonstrate understanding of
Mathematical properties of geometric shapes such as cylinders.
Transformations (translation and rotation) to position shapes.
Construction of complex geometric models from basic shapes.
Engineering: Demonstrate understanding of the design cycle by planning, creating, and testing a computer model.
Algorithms and Programming:
Perform operations on objects.
Use object parameters.
Break a complex programming task into components.
Comment and organize a program so that it is easy to read and edit.

Specific Objectives

Basic Modeling: Create an interlocking brick, a **complex 3D object** using Constructive Solid Geometry. Modeling includes 3D and extrudable 2D basic shapes that are copied, translated, and rotated into position as needed. Interlocking bricks require **precise dimensions** in order to fit.
Advanced Modeling: Create a figure composed of several bricks. Users familiar with Python lists (taught in Sections 19 and 20) may wish to automate this process. Create a modified version of the design suitable for 3D Printing.
Printing: Plan and print bricks, including time and material costs and design constraints.
Collaboration: Decide on design criteria and constraints. Collaborate on writing the script (if applicable). Provide constructive feedback to peers. If teaching as an Engineering Design Cycle, try alternative methods and/or materials and evaluate the results.

Grading Schemes:

Points can allocated for completion of each step, a program that runs successfully, degree of precision, documentation (commenting code, journaling), understanding of code structures, professionalism when interacting with team.

Suggested sequence

Introduction (10 minutes. Longer if planning to print)	Create a Modeling Plan (10 minutes)	Write Model Script (1 to 2 hours depending on complexity), can be multiple sessions)	Share PLaSM or STL files (as URL for viewing) or prep STL file for printing (30 minutes +++ for printing)	Wrap up Discussion, Gallery Walk (15 minutes)
Examine real bricks. Read instructions together. If printing, discuss expected dimensions, constraints	Peer discussions. Sketches. Agreement on dimensions	Individual or as teams. Create and test PLaSM script. View and critique files. (Peer review)	Prep for printing, print, post process.. Or Share URL's for viewing (common document or other location)	Display and view final 3D prints. Test different pieces for fit (optional). Share experience, suggestions for success, future projects.

The Modeling Process

Gather ideas. Research. Sketch. Brainstorm.	Draw a flowchart or diagram "whiteboard". Break down tasks. Determine costs.	Write script. Test. Comment. Repeat.	Export an STL file. Prep. Print. Post process.	Share. Review. Adjust. Repeat.

This slideshow may be helpful in understanding the modeling and printing process.
3D Modeling and Printing with NCLab

Shareable/printable instructions

The following pages are a copy of the Project Instructions.

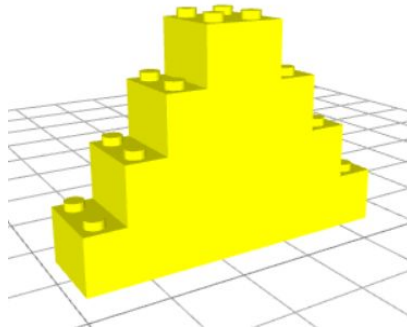# 3D Modeling Project #8

INTERLOCKING BRICKS

Make interlocking blocks that snap together.

Before You Start

Go to the Creative Suite, open a new PLaSM CAD project, and save it as Project-8 in the folder course-3D-projects/.
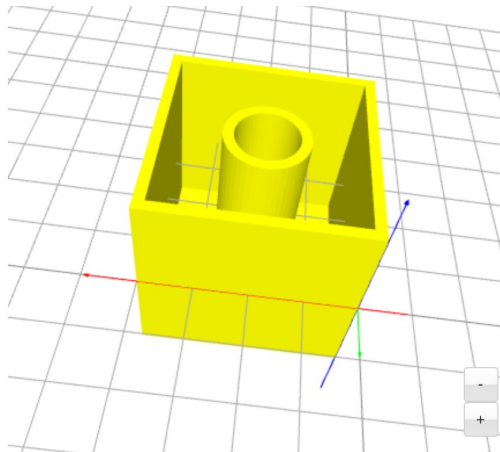
Project Goal

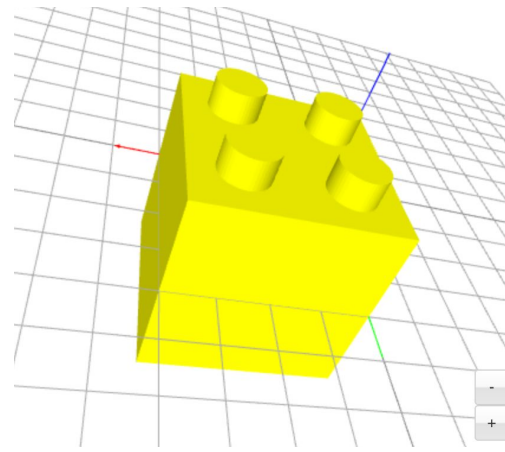The goal of this project is to build a interlocking brick or model of your choice!

Interlocking Bricks

Your bricks should interlock. This means that the bottom should be able to lock together with the top of another brick when pushed together.
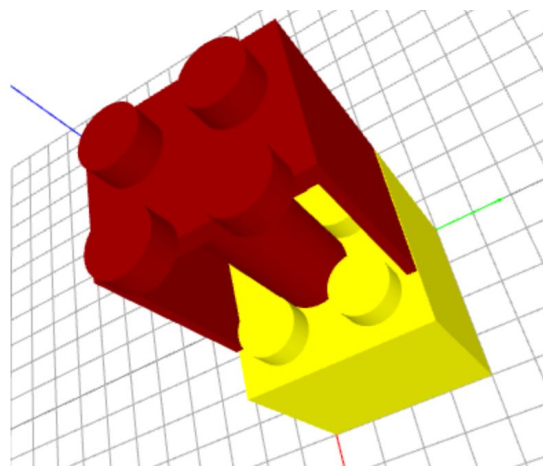
Here is an example of one possible design:

The bottom of the brick

The top of the brick

In engineering, clearance is a term for a gap between two surfaces. In this example, there needs to be very little clearance between the four pegs and the center ring. If the center ring is too small, the surfaces will not touch. If the center ring is too big, they will intersect!

The two surfaces have very little clearance.

Design Your Own

How else might you design a brick that is interlocking? Can you create another shape that has an interlocking base?

Useful commands for this project are: SUBTRACT(), SCALE(), and ROTATE().

Project Checklist

Your project will be finished when:

1. You have finished your 3D model.
2. Your program is saved as Project-8 in folder course-3D-projects/.