

# LESSON GUIDE



## Designing a Multiplier

### Guiding Design Questions

1. What type of mechanisms can multiply movement?
  - a. Gears
  - b. Levers
  - c. ScrewsWhat 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 Tips for 3D Printed Parts Using PolyJet Technology™

1. The minimal wall thickness that can be reliably printed is 0.6 mm. For load bearing parts, the preferred wall thickness is over 1.5 mm with a column diameter over 2.5 mm.
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 ~0.1-0.3 mm between parts.
3. Consider the need for support removal. Determine the crucial structural elements and remove other parts to allow cleaning of the support from internal parts of the mechanism. Create holes that allow support removal from difficult to reach areas (between mating parts, between an axle and its sheath). When cleaning the parts, immersion in a basic solution (1% NaOH) for a few hours softens the support and can help in its removal from hard to reach areas.

### Lesson 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.

**Optional:**

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

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