SMARTSERVO

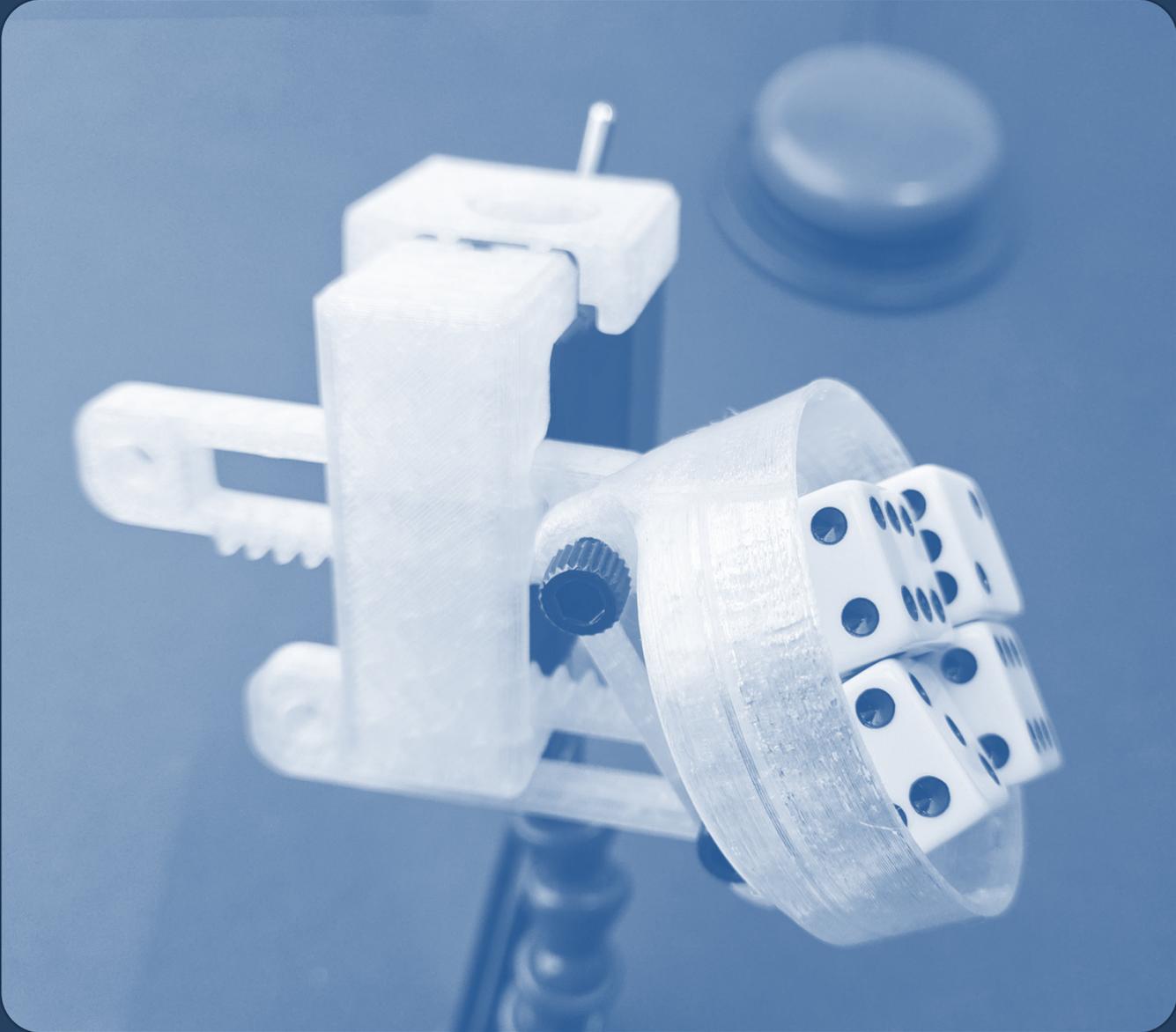## LINEAR MOTION:
GAME ASSISTANCE KIT

SMARTSERVO PROJECT

LINEAR MOTION: GAME ASSISTANCE KIT

Version 1.0 | Published: June 17, 2025 | Author: Judson Wagner, Wagner Labs LLC

Commercial Use & Smart Servo Requirement

For commercial use, bulk educational licensing, or use outside of traditional educational settings, please contact Wagner Labs LLC.

Hardware Requirement: This guide requires **Smart Servo devices** to complete the projects and activities described. Smart Servos are available through the Smart Servo Store and authorized distributors.

About the Smart Servo Project

The Smart Servo Project empowers inclusive innovation by providing accessible tools for creating assistive technologies and engaging STEM education. Our mission is to bridge technology and compassion through community-driven maker education.

Support our mission by purchasing Smart Servos and sharing our resources with your educational community.

Contact Information:
Judson Wagner | Wagner Labs LLC
Email: **Judson@WagnerLabs.net**
Website: **WagnerLabs.net/SmartServo**
Smart Servo Store: **WagnerLabs..Store**

Client: James Parker, Age 28

About Me: I'm a social worker who enjoys board game nights with friends and clients at our community center. I have limited grip strength and fine motor control due to a brachial plexus injury from a motorcycle accident three years ago.

My Challenge: During game nights, I struggle with rolling dice because I can't grip them properly or shake them in my hands. This makes me feel left out of games that rely heavily on dice rolling, and I often need others to roll for me.

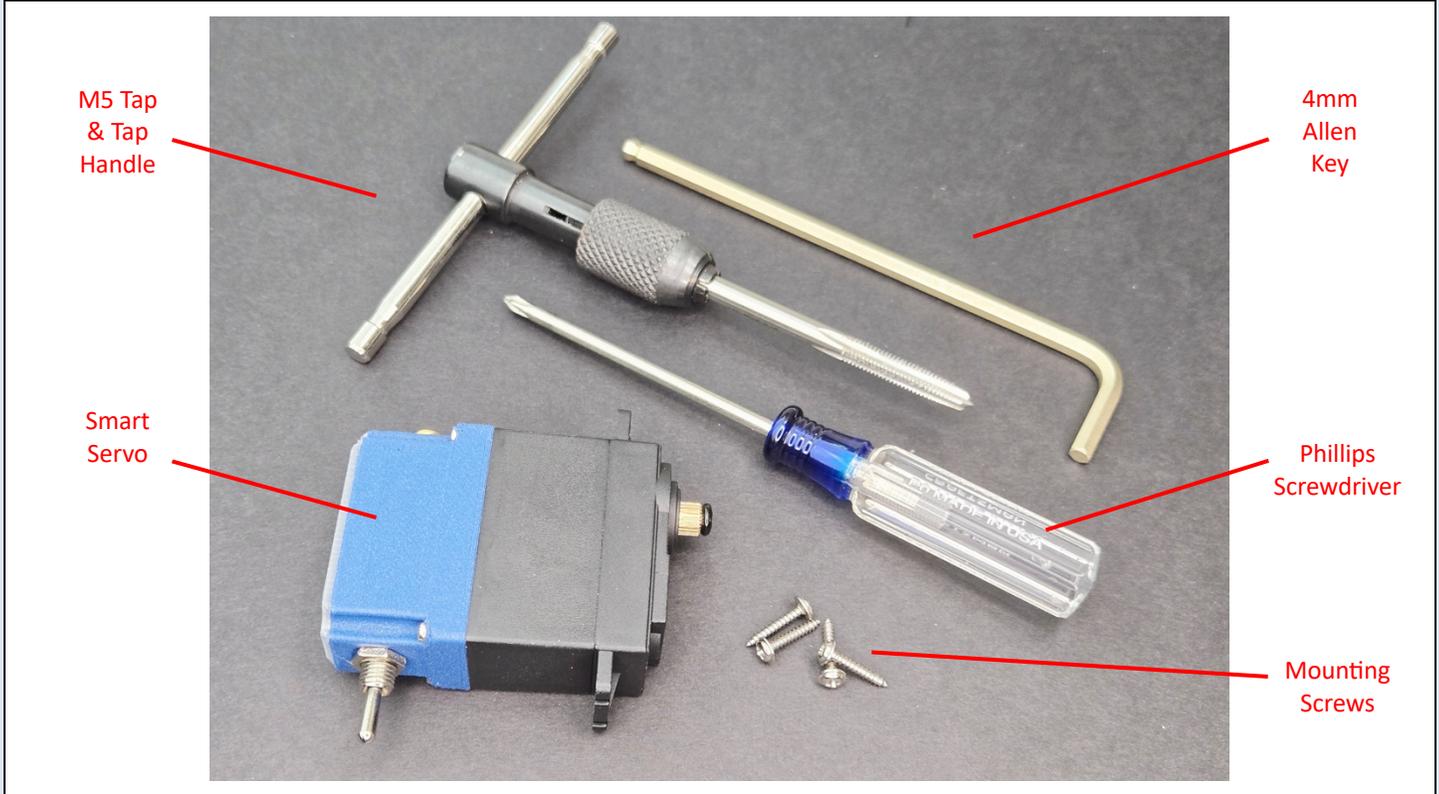**Technical Need:** A dice-rolling device that can hold multiple dice and tip them out with consistent action, allowing me to participate independently in board games and tabletop activities.

Let's now investigate our kit and see if we can get started on something that can assist James.

STEP 1: Lay out all the components that are new in this kit.

Rack Cover

Racks

Tilt Cup

Drive Gear [12T]

M5 Socket Screws

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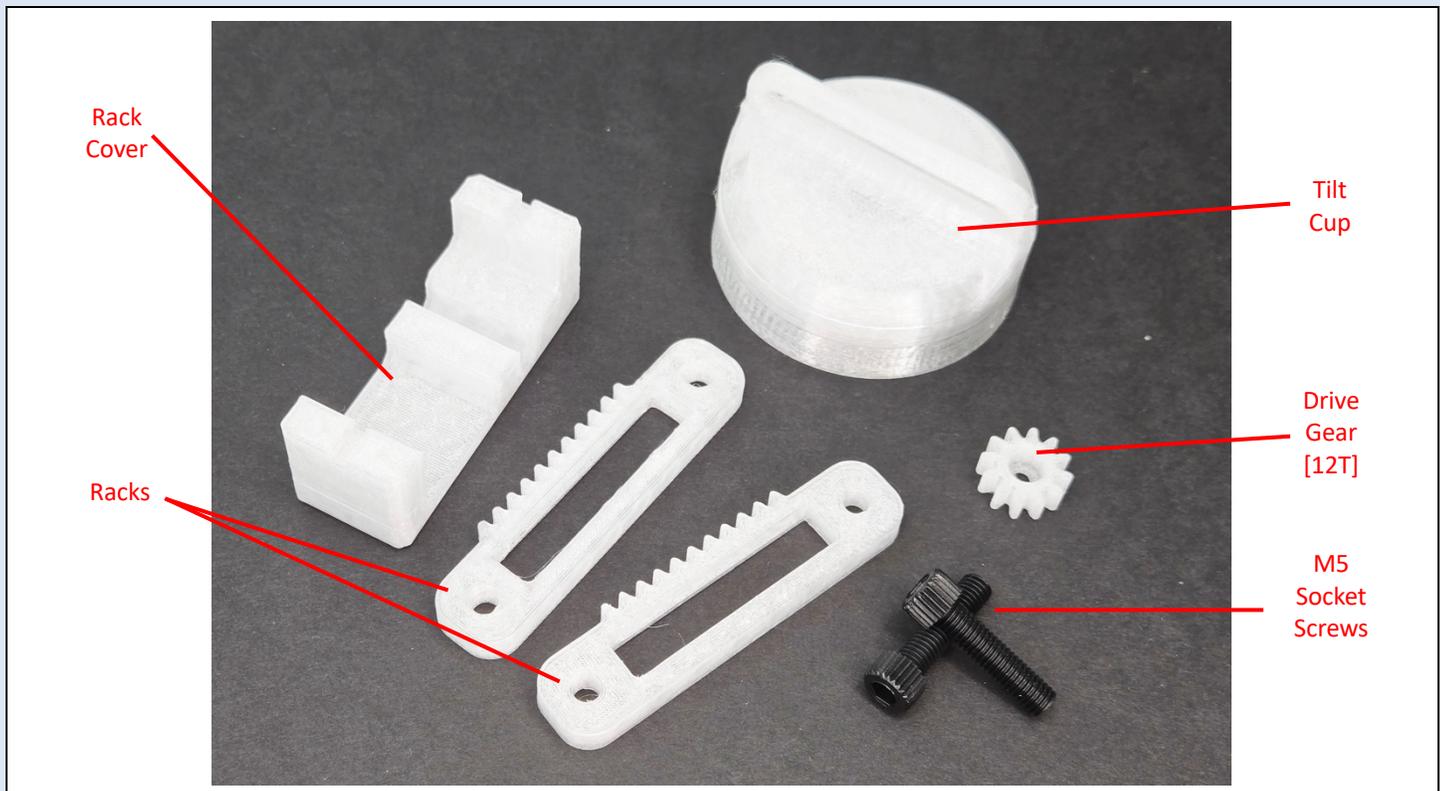
STEP 2: Make sure you have these items from your previous kits.

M5 Tap & Tap Handle

4mm Allen Key

Smart Servo

Phillips Screwdriver

Mounting Screws

STEP 3: Identify the four 4.3mm holes in each of the Racks, Tap them with a M5 thread, and make sure that the M5 socket screws can be screwed in by thumb.

STEP 4: Connect the 12T Drive grear to the Smart Servo spline and screw it down.

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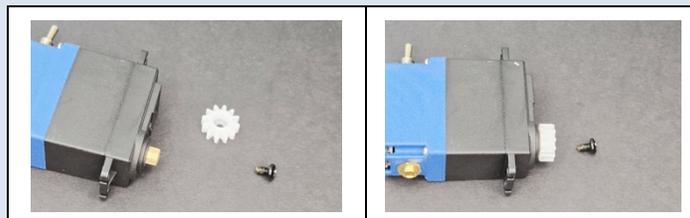
STEP 5: Before connecting the Racks to the Rack Cover, lubricate the surfaces where these parts will meet. Using a sharp pointy object to scape small bits from bar soap and rubbing on these surfaces works well.
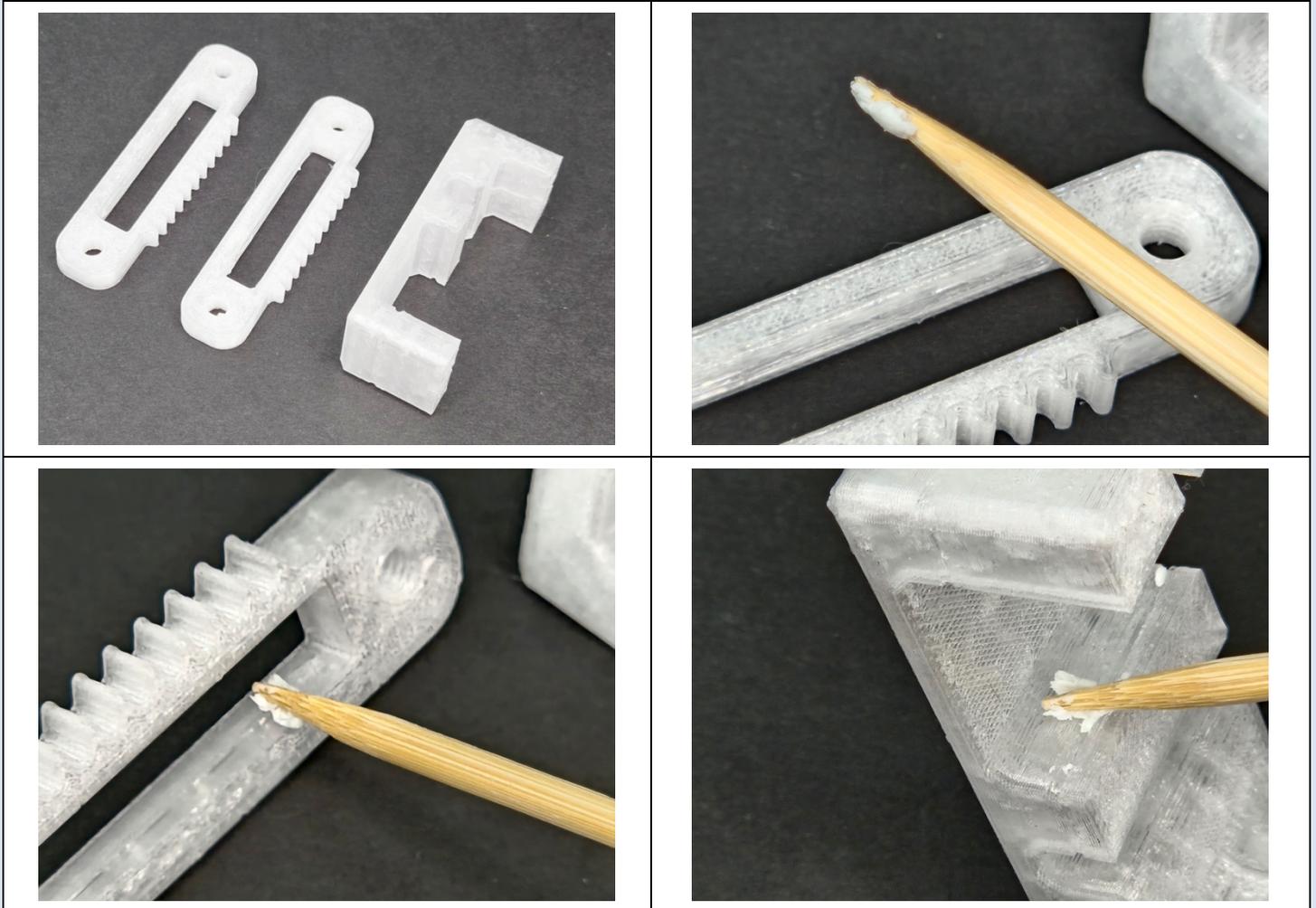
STEP 6: Press the Racks, teeth-side-in, onto the Rack Cover. Expect that the Racks will need to felex as they are pressed on. There is a point where they will snap into a position.

Center, flex, and press down

Racks will snap in when flush at this point
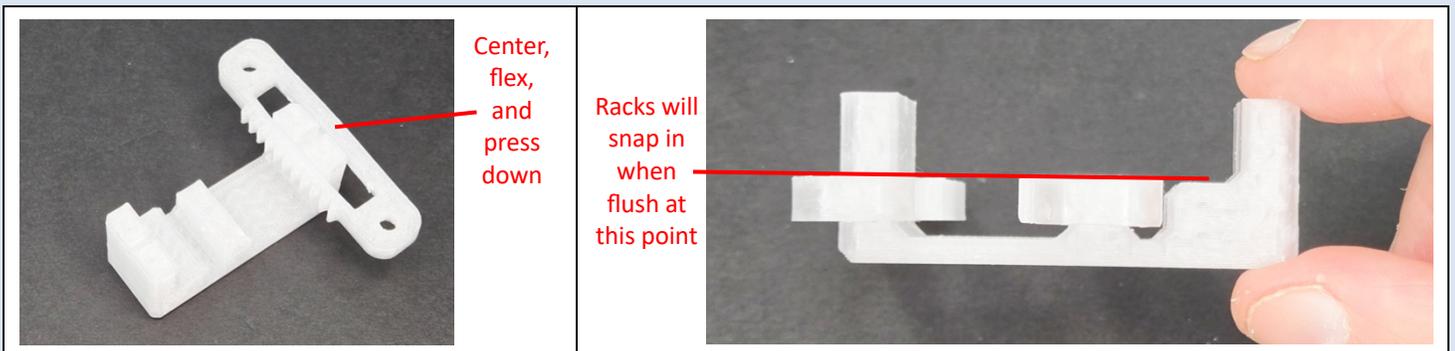
STEP 7: Slide the Racks back and forth to let the soap work its way across the surfaces. Add more soap if the racks don't move smoothly to the most extreme positions.
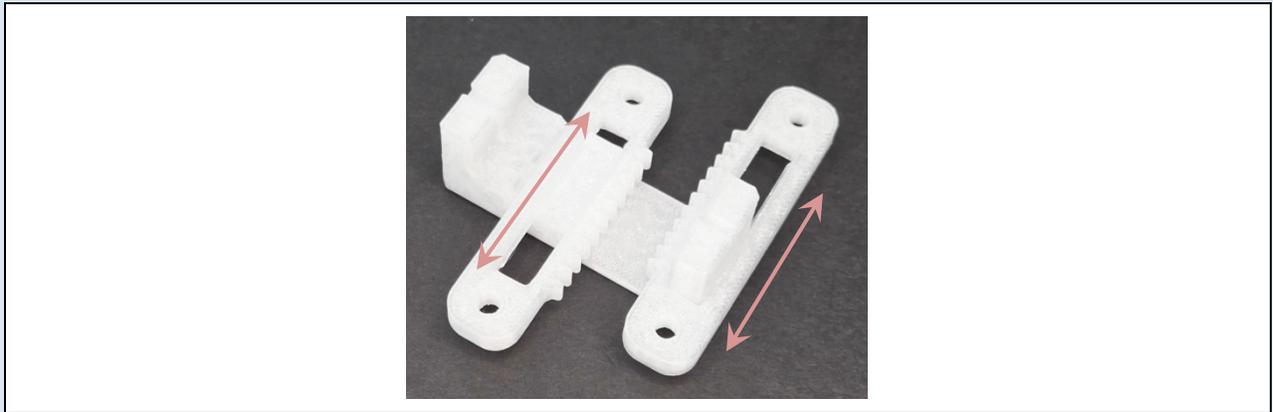
STEP 8: Flip your Rack and Rack Cover over. Double check that the Drive Gear on the Smart Servo is at an extreme position a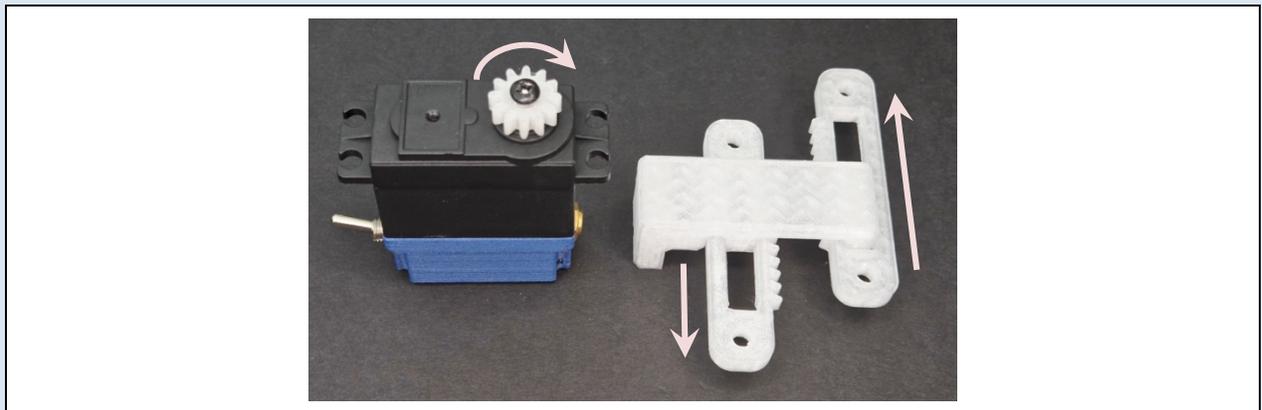nd can only rotate one way initially (double check with the test button and adjust your coding accordingly if necessary). Also slide the Racks to extreme positions to match the movements of the Drive Gear.

STEP 9: With gentle persuasion, work the Racks over the Drive Gear. Allow the racks to move out of their extreme position by a couple millimeters to allow the gear teeth to mesh.

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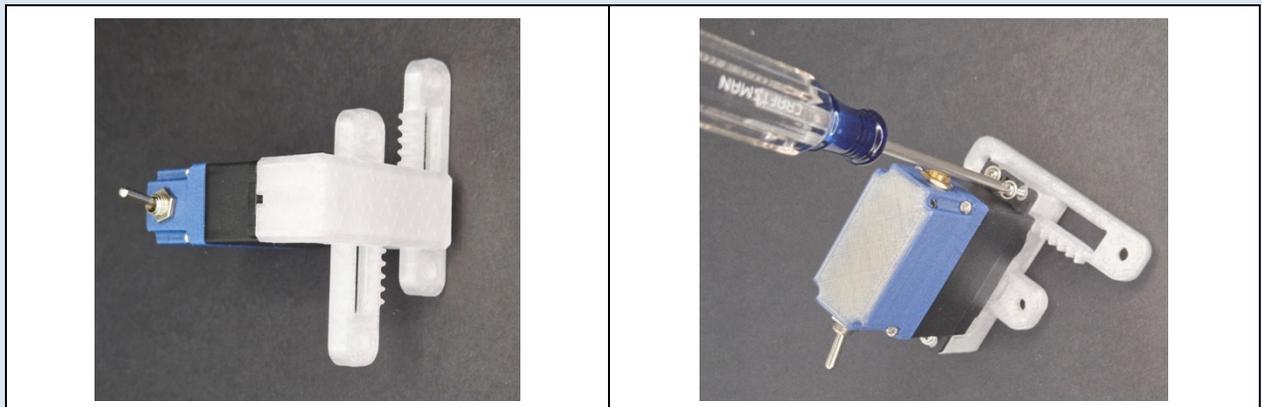
STEP 10: Slide two M5 Socket Screws into the slots under the Tilt Cup (you should not need to screw these in). Then use the 4mm Allen Key to screw the holes in the Racks that were previously tapped. Don't screw down tight as the M5 screws will need to slide within the slot during operation.
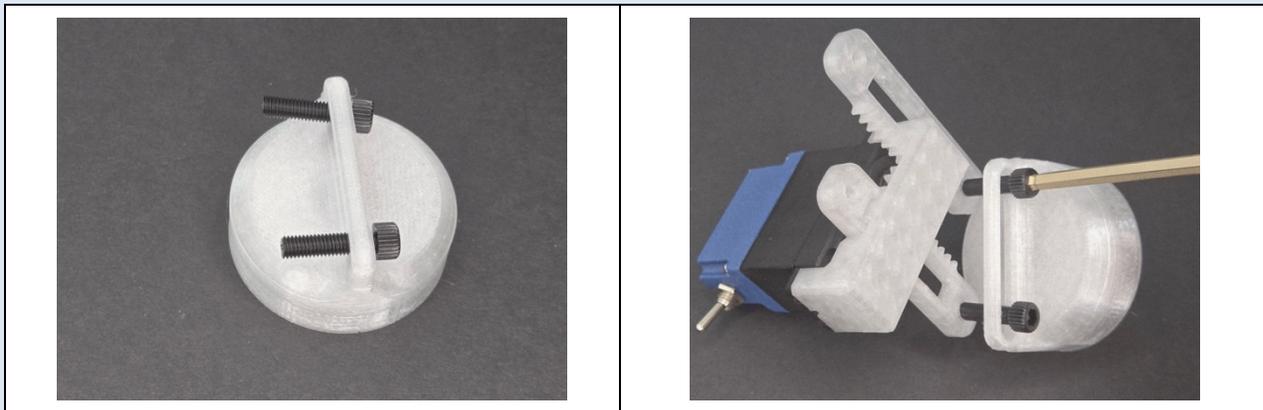
STEP 11: Now test your dice tipper and see how it works.

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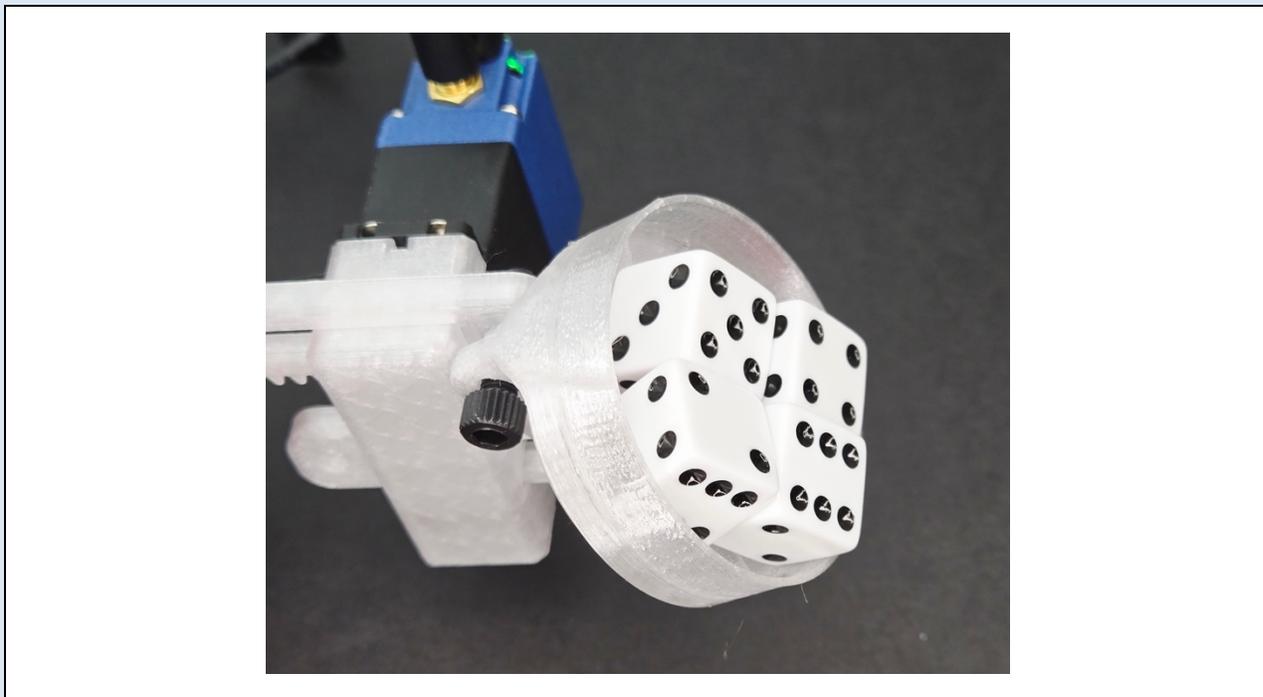
CONGRATULATIONS!

You just created a linear motion system using rack and pinion mechanics. Take a moment and re-read James' request. Does this dice roller meet his needs for game night participation? What follow-up questions might you ask him about the games he plays most often?

REMINDER ABOUT CODING SNIPS

If you want to return your code to the original "factory setting", just copy and paste from here: tinyurl.com/SmartServoSnips
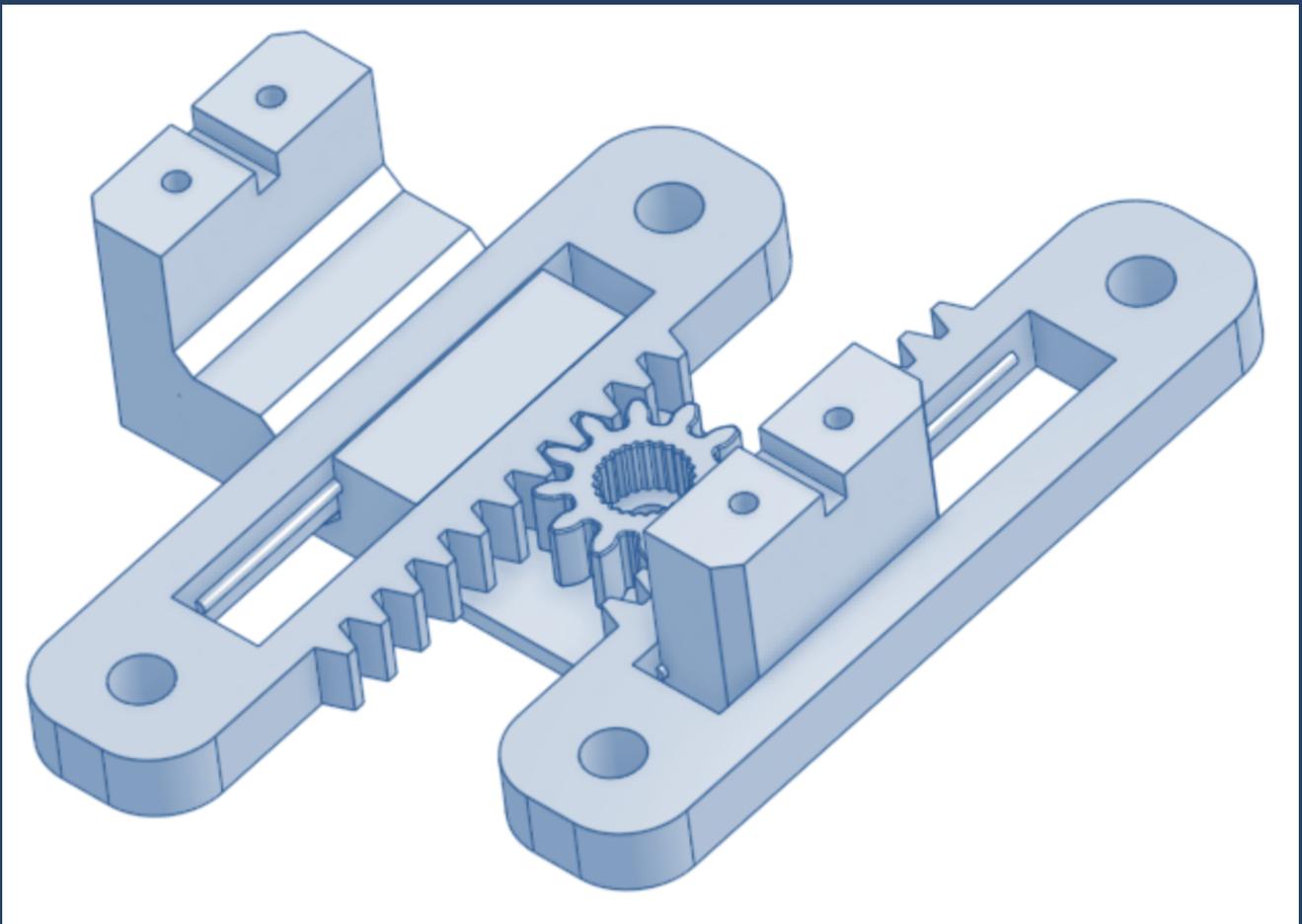
3D PRINTING FILES

If you're able to 3D Print, download the 3D parts used in this project here:
tinyurl.com/SS-STL-DICE

THE BIGGER PICTURE

TRANSFORMING MOTION IN YOUR DICE ROLLER

From Spinning to Sliding: The Challenge of Motion Conversion

Your Smart Servo can only do one thing: rotate back and forth. But your dice roller needs to tip forward and back - a completely different type of motion called linear movement. The rack and pinion mechanism solves this fundamental engineering challenge by transforming rotary motion (spinning) into linear motion (straight-line movement). When the pinion gear rotates, its teeth push against the rack's teeth, forcing the rack to slide in a straight line.

Nearly every machine you encounter uses motion transformation. Motors naturally produce rotary motion because spinning is efficient and easy to generate electrically. But most tasks require different types of motion - pushing, pulling, lifting, or sliding. Engineers must constantly convert the motion they have into the motion they need.

Rack and Pinion in Everyday Life

The rack and pinion transformation appears in surprising places once you start looking. When you turn a car's steering wheel (rotary motion), rack and pinion gears convert that rotation into the side-to-side sliding motion that turns the wheels. 3D printers use rack and pinion systems to convert motor rotation into the precise linear movements of the print head. Camera tripods use rack and pinion mechanisms to smoothly raise or lower the camera in a straight line.

What makes rack and pinion particularly valuable is their precision and reversibility. The gear teeth lock together, preventing slipping or backlash - the system moves exactly as commanded with no play or wobble. This makes rack and pinion ideal for applications requiring accuracy, like machine tools and robotic arms that need to reach precise locations repeatedly.

Other Ways to Transform Motion

Rack and pinion is just one solution to motion transformation. Engineers have developed dozens of mechanisms, each with unique advantages. Cam mechanisms convert rotation into complex push-pull patterns - your car's engine uses cams to open and close valves thousands of times per minute. Lead screws and ball screws convert rotation into linear motion using threaded rods instead of gear teeth - perfect for applications needing extreme precision or very slow, powerful movement. CNC machines, 3D printers, and airplane landing gear mechanisms often use screw-based motion conversion.

Choosing the Right Transformation

Engineers must consider many factors when selecting a motion transformation mechanism. How much force is needed? How precise must the motion be? How fast should it move? Does it need to be reversible? Your dice roller needs moderate speed, doesn't require extreme precision, and must reverse direction - rack and pinion is ideal. A car jack needs high force and precision but not speed - a lead screw works better.

Understanding motion transformation opens your eyes to the hidden mechanical intelligence in everyday objects. That simple tipping motion in your dice roller represents the same engineering thinking that powers steering systems, manufacturing equipment, and robotic surgery tools.

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