DETAILED HAND ARMATURE

FOR STOP-MOTION ANIMATION

Technical Design & 3D Printing Guide

Ball-and-Socket Joint System
5 Fingers with 14 Articulated Joints

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1. Overview

The hand is one of the most expressive parts of a stop-motion puppet, requiring precise articulation for gestures, object manipulation, and emotional communication. This armature design provides independent control over each finger segment through a ball-and-socket joint system, enabling natural movement and stable pose retention during animation.

Unlike simplified hand designs that group multiple fingers together, this detailed armature treats each finger as a separate mechanical system with its own joint hierarchy. This approach allows for complex hand poses such as typing, playing instruments, or subtle emotional gestures that would be impossible with less sophisticated constructions.

2. Joint Anatomy

2.1 Ball-and-Socket Structure

Each joint consists of three primary components: a precision ball, a matching socket, and an optional tensioning mechanism. The ball rotates freely within the socket while friction between the surfaces maintains the selected position. This design provides smooth, natural movement in all directions while preventing unwanted drift between animation frames.

Component	Material	Size Range	Function
Joint Ball	Tough/Engineering Resin	2.5-4.0 mm diameter	Rotating element
Joint Socket	Standard/Tough Resin	3.0-5.0 mm ID	Captures ball, provides friction
Bone Segment	Standard Resin	2.0 mm diameter	Connects adjacent joints
Palm Base	Standard Resin	48 x 24 x 15 mm	Anchors finger assemblies
Wrist Joint	Engineering Resin	3.9 mm diameter	Connects hand to arm

Table 1: Hand Armature Component Specifications

3. Finger Specifications

3.1 Joint Count per Finger

Finger	Joints	Bones	Total Length	Range of Motion
Thumb	2 IP + CMC	2	70% of Middle	Opposition + Flexion
Index	3 (MCP, PIP, DIP)	3	95% of Middle	Flexion + Adduction
Middle	3 (MCP, PIP, DIP)	3	Reference (100%)	Flexion Only
Ring	3 (MCP, PIP, DIP)	3	95% of Middle	Flexion Only

Pinky	3 (MCP, PIP, DIP)	3	80% of Middle	Flexion + Abduction

Table 2: Finger Joint Configuration

3.2 Segment Lengths (6 cm Hand Scale)

Finger	Proximal	Middle	Distal	Total
Thumb	11 mm	10 mm	-	21 mm
Index	14 mm	10 mm	8 mm	32 mm
Middle	15 mm	11 mm	9 mm	35 mm
Ring	14 mm	10 mm	8 mm	32 mm
Pinky	11 mm	8 mm	6 mm	25 mm

Table 3: Bone Segment Lengths

4. Printing Guidelines

4.1 SLA Printer Requirements

Parameter	Minimum	Recommended	Notes
XY Resolution	35 microns	50 microns	Finer for better joint fit
Layer Height	25 microns	50 microns	Affects vertical tolerances
Build Volume	68 x 68 mm	120 x 68 mm	For full hand kit
Resin Type	Standard	Tough/Engineering	Joints need durability

Table 4: SLA Printing Requirements

4.2 Orientation Guidelines

Proper print orientation significantly affects joint quality. Balls should be printed with their polar axis vertical to minimize layer lines on the friction surface. Sockets benefit from angled orientation (30-45 degrees) to reduce suction cup effects and ensure uniform curing of interior surfaces. Bone segments can be printed horizontally for faster build times.

5. Post-Processing

5.1 Cleaning Procedure

1. Remove parts from build plate using plastic scraper

2. Submerge in 99% IPA for 10-15 minutes (or 5 min in ultrasonic cleaner)

3. Remove supports while resin is still soft (before UV cure)

4. Rinse in fresh IPA for 2 minutes to remove residue

5. Air dry or use compressed air for internal socket areas

6. UV cure according to resin specifications (typically 10-30 minutes)

5.2 Joint Fitting

After curing, test fit each ball in its corresponding socket. If friction is too high, lightly sand the ball surface with 600-800 grit sandpaper in a circular motion. Apply a small amount of silicone grease or PTFE dry lubricant to improve movement while maintaining pose stability. The ideal joint should move smoothly but require deliberate force to change position.

6. Part Count Summary

Part Type	Quantity	Per Finger	Total
Joint Balls	3 per finger + tips	14	15 (+ 1 wrist)
Sockets	2 per finger	10	11 (+ 1 wrist)
Bone Segments	2-3 per finger	13	13
Palm Base	-	-	1
Wrist Assembly	-	-	2 (ball + socket)

Table 5: Complete Part Inventory

7. Using the Blender Script

The provided Python script generates all hand armature components directly in Blender. Two modes are available: assembled hand for preview and part kit for printing. The script creates properly dimensioned balls, sockets, and bones with correct tolerances for SLA printing.

Script Execution:

1. Open Blender (3.x / 4.x / 5.x)

2. Go to Scripting workspace

3. Create new text block (Ctrl+N)

4. Paste script content

5. Run Script (Alt+P)

6. Export: File -> Export -> STL

Adjustable Parameters:

The script includes configurable settings at the top of the file: HAND_SCALE controls overall size (default 60mm), JOINT_BALL_RADIUS sets ball diameter (default 3mm), and JOINT_TOLERANCE adjusts the gap between ball and socket (default 0.2mm). Modify these values before running the script to customize for

different puppet sizes or printer characteristics.