



Ruaridh Murdoch

Portfolio - March 2026

2nd Year Design Engineering, Imperial College London

Teach-By-Touch

Year 2

Academic

Mechatronics

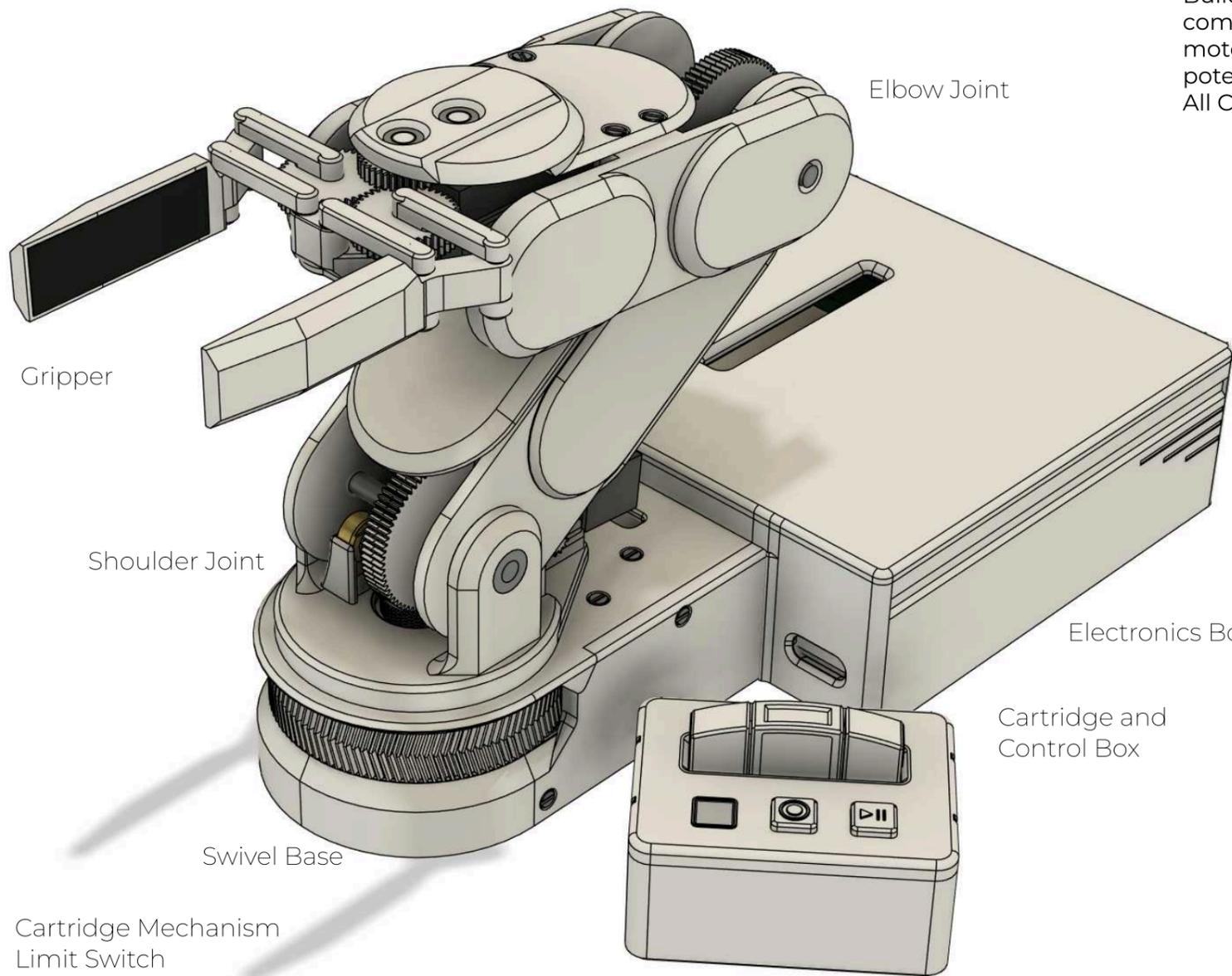
Prototyping



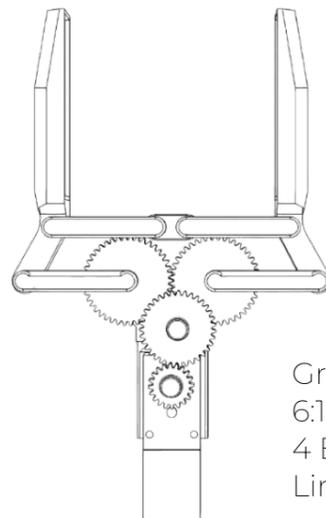
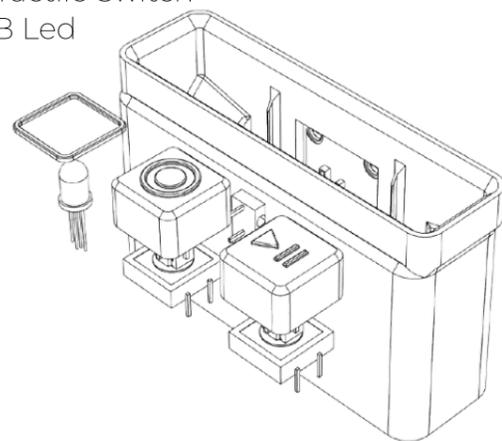
A cartridge-controlled robotic arm where the user becomes the "programmer" by physically moving the joints.

THE BRIEF

Build something resourceful - no expensive components. We built servo-like joints from 5V DC motors, 3D-printed gear reductions, and 10kΩ potentiometers instead of buying integrated servos. All CAD and firmware written from scratch.

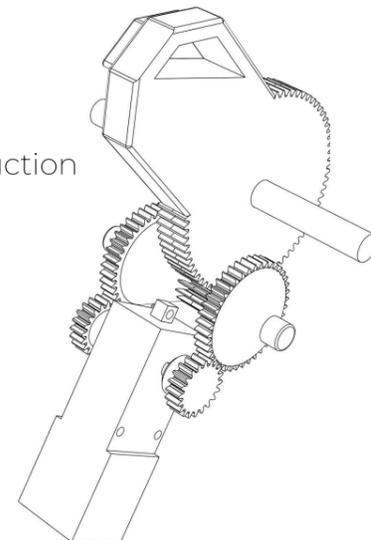


Cartridge Mechanism
Limit Switch
RGB Colour Sensor
2 x Tactile Switch
RGB Led

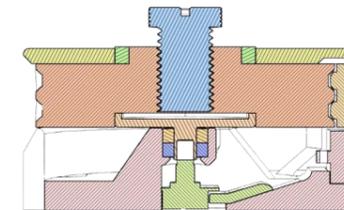
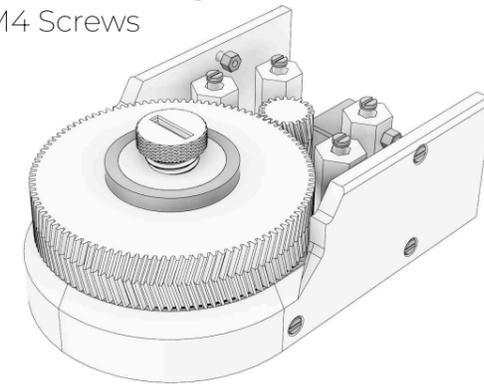


Gripper Mechanism
6:1 Gear Reduction
4 Bar Parallel Linkage

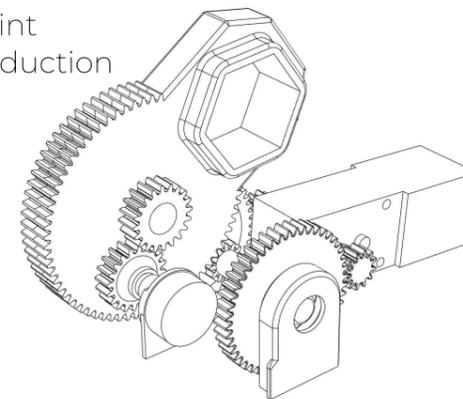
Elbow Joint
12:1 Gear Reduction



Swivel Base
5.2:1 Gear Reduction
40mm Bearing
M4 Screws



Shoulder Joint
24:1 Gear Reduction



INTERACTIVITY

Insert a coloured cartridge to select a slot. Press record and move the arm by hand - joint angles are logged from the potentiometers. Press record again to save. Press playback to replay. Swap cartridges to switch between sequences.

SET CARTRIDGE



RECORD



PLAYBACK



SOFTWARE

Finite state machine:
Idle → *Record* → *Playback* → *Pause*
Potentiometers sampled every 25ms, up to 800 frames (~20s). Playback uses time-based sync so motion replays at original speed. Recordings stored as CSV on SD card, indexed by cartridge colour.

MECHANICS

All gear ratios calculated for required joint torques. Designed to snap or screw together for easy assembly and disassembly.



Aerodynamic Cabriolet

Year 2 Academic CFD Thermofluids

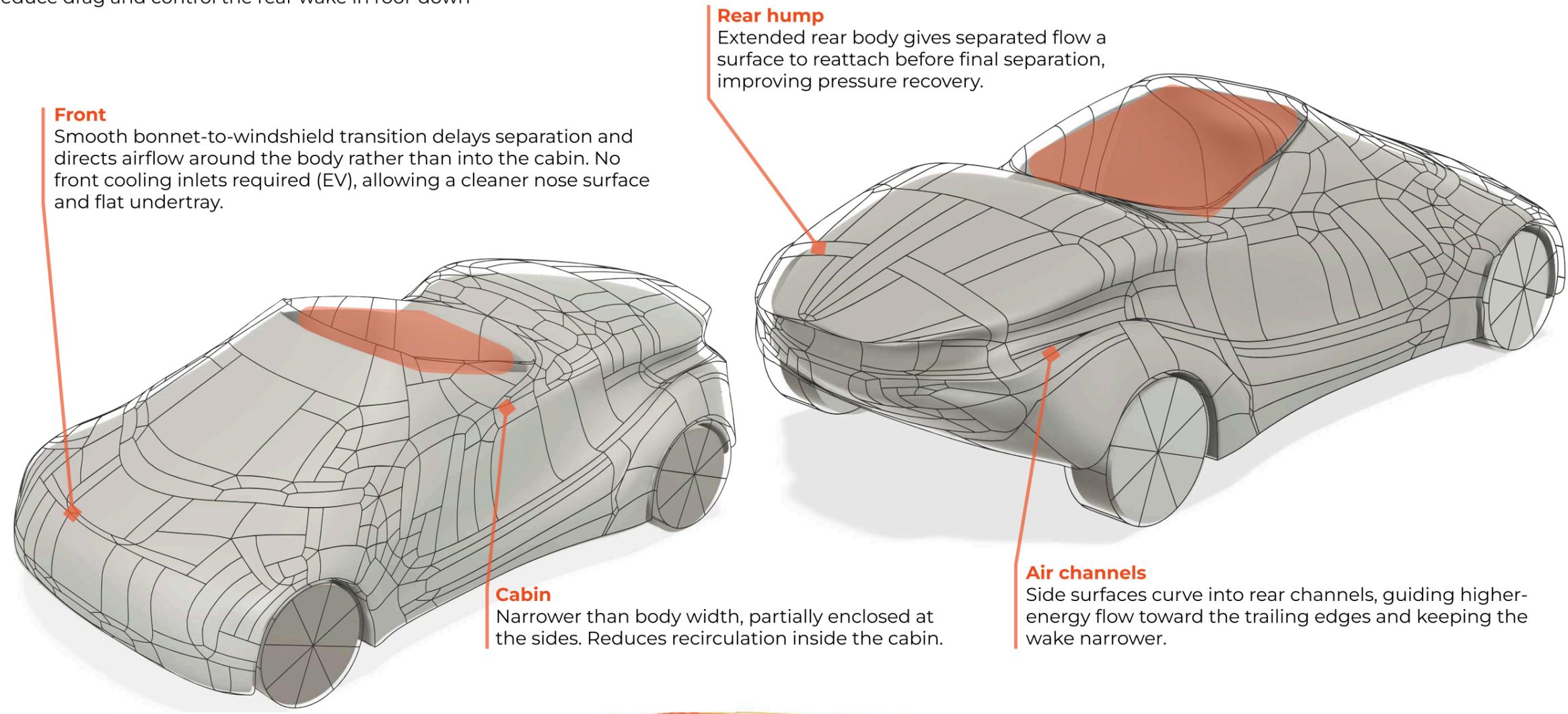
A four-seat electric cabriolet designed to reduce drag and control the rear wake in roof-down conditions.

THE PROBLEM

In mainstream cabriolets, airflow passes over the open cabin with minimal shaping, exiting unmanaged at the rear. This causes early separation, a large wake, and increased drag.

The BMW 4 Series Convertible goes from Cd 0.28 (roof up) to 0.33 (roof down) — drag increase driven entirely by unmanaged cabin flow.

- DESIGN OBJECTIVES**
- Reduce overall drag
 - Improve rear pressure recovery
 - Control wake growth
 - Manage airflow entering and exiting the open cabin



CFD RESULTS

Drag Coefficient **0.458**
Lift Coefficient **0.135**

Comparable to the Mercedes-Benz SL600 (Cd = 0.45). Main weakness: large high-pressure stagnation region at the nose. Rear shaping effective, separation occurs further downstream.



WIND TUNNEL TESTING

3D-printed model tested at 10.5, 20.5, and 31.5 m/s. Cd and wake behaviour closely matched CFD predictions at the highest speed, validating the simulation.



Imperial Wind Tunnel

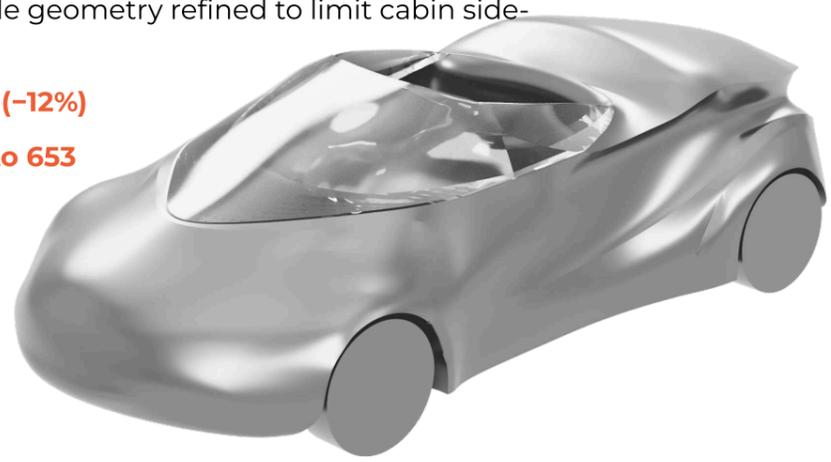


23:1 Scale

IMPROVEMENTS

Nose reshaped to reduce stagnation, windscreen lowered to reduce frontal area, side geometry refined to limit cabin side-entry flow.

Cd reduced to 0.405 (-12%)
Drag force reduced to 653 N from 758 N (-14%)



Perfect Pantograph

Year 2

Academic

Product

Mechatronics

Ongoing

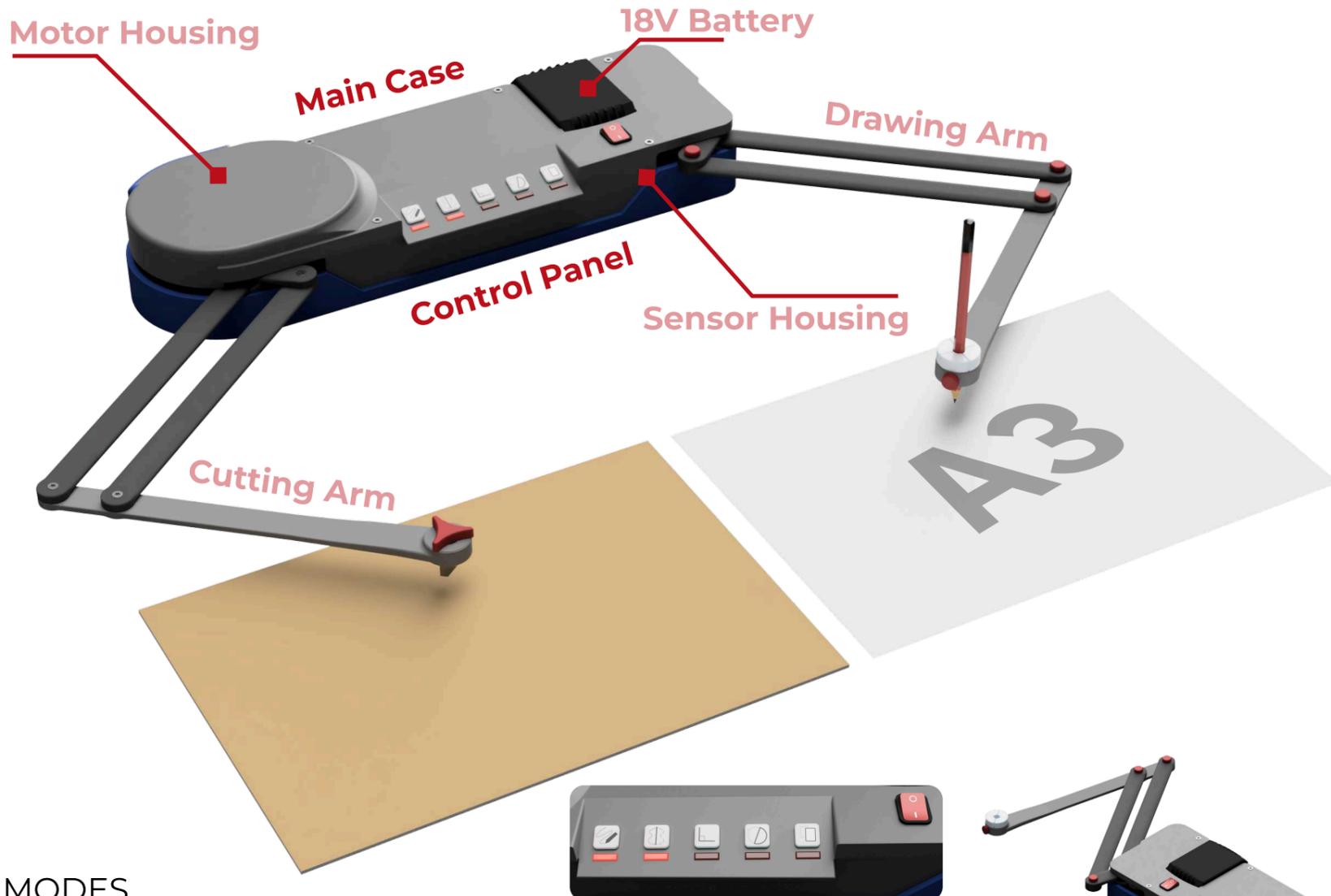
A desktop cutting tool that translates hand-drawn shapes into precise cardboard cuts.

THE PROBLEM

Lo-fi prototyping is one of the most valuable stages of the DT process - it builds practical skills and lets students iterate, explore and evaluate ideas before committing to manufacture. But students avoid it. Craft knives are inaccurate for curves, 65.2% report cuts or burns, and 47.8% avoid tools entirely for fear of ruining their work. Students skip prototyping and go straight to making - producing worse outcomes and losing the skills the stage is meant to build.

HOW IT WORKS

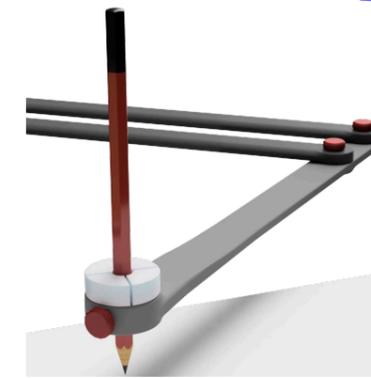
The student moves a stylus to sketch their shape. A mirrored cutting arm reproduces the movement in real time, pressing a blade through cardboard. On-board processing perfects the input before cutting - the output is always cleaner than the hand that drew it.



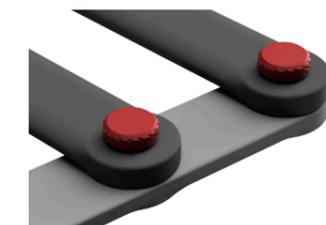
Case Design
Over-moulded
ABS for stiffness



Swivel Blade
Swappable System



Pencil Clamp



Tightening Knobs
For varying resistance

TECHNICAL

Sensing: 10kΩ rotary potentiometers at arm joints · 250k linear slider for pen height (20mm travel)

Actuation: NEMA 17 steppers via belts · MG996R servo for blade pressure

Blade: Swivel head self-aligns to direction of travel - no rotation motor needed

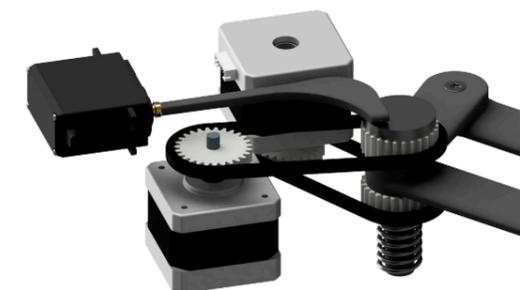
Power: 18V cordless drill battery slots into base

Housing: ABS 3mm wall · Torx screws restrict student access · A3 cutting footprint

Sensor Mechanism



Actuator Mechanism



Case

50mm

300mm

300mm

Pencil

MODES

Stabilisation



Smooths shaky input so lines cut cleanly.

Symmetry



Mirrors your path across a central axis as you draw.

Axis Only



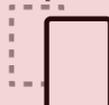
Locks movement to axis for straight cuts.

Perfect Circle

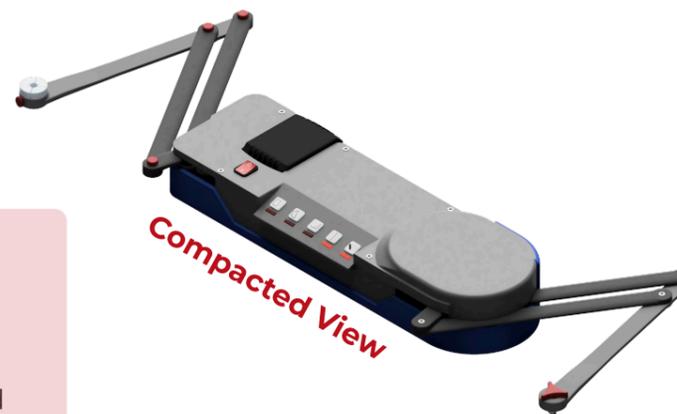


Fits your drawing to a clean circle automatically.

Repeat



Stores and replays the path again for batch cuts.



Compacted View

Arm Design

4-bar parallel linkage for stable planar motion

Same components on both arms for easier manufacture/assembly

ONGOING

Currently, iterating and manufacturing this into a full product.

Rhythm Rush

Year 1

Academic

Product

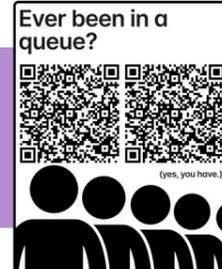
A motion-tracked dance battle for concert queues - up to 4 players compete based on creativity, speed, and beat-matching.

THE PROBLEM

80% of event queuers say long queues are one of the most significant drawbacks of attending. People are physically together but socially disconnected - 55.9% do nothing but use their phone. The opportunity: transform dead waiting time into social engagement.

RESEARCH

Surveys, interviews, observations and stakeholder role-play sessions across concert and event contexts. Journey mapping revealed the biggest drop in experience happens at the start of the queue - before the energy of the event kicks in.



DEVELOPMENT



Characters

Low-poly style with simplified limbs. Practical benefit: no need to track fingers or complex joints. Each character has a near-monochrome colour palette for clear identification, with unique hairstyles for personality. Proportions, lighting and colour iterated through multiple stakeholder co-design sessions.

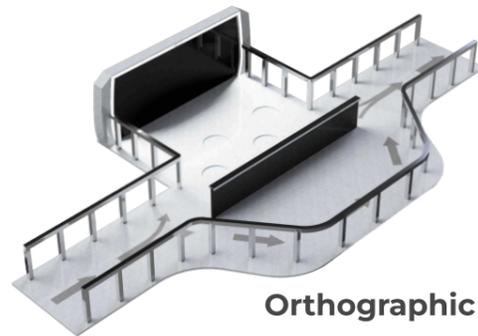
Environment

Dark background with neon concert lighting. Stakeholders strongly preferred this over plain spotlights — high contrast and atmosphere-consistent.

THE DESIGN

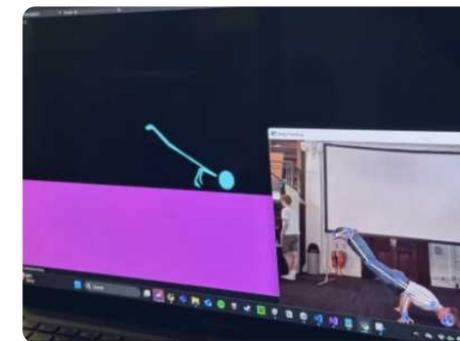
4 players step onto marked zones in front of a large screen. Body-tracking cameras map movement onto low-poly avatars. Players dance freely - scored on creativity, beat and speed, not technical accuracy. A dance guide eases in hesitant players. When the song ends, an exit prompt keeps the queue flowing.

Junction system: every person can play, spectate, or bypass entirely - participation is never forced.



Orthographic CAD

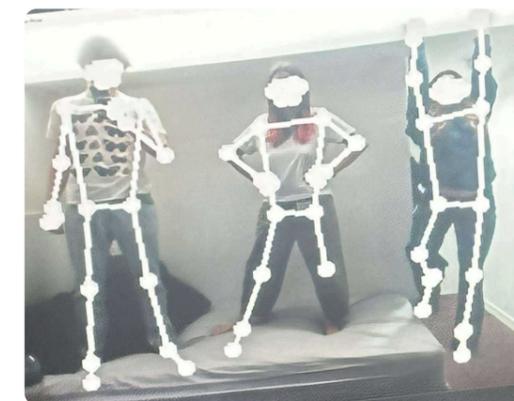
Body tracking



Built in Python using Google's MediaPipe. Landmark points placed on limbs animate the on-screen character in real time. Camera sits ~2m from players at 1m height.



Final Render



Screen split in quarters so each side tracks one player independently - prevents the system confusing players with each other. Medium model complexity chosen for best balance of accuracy and speed.

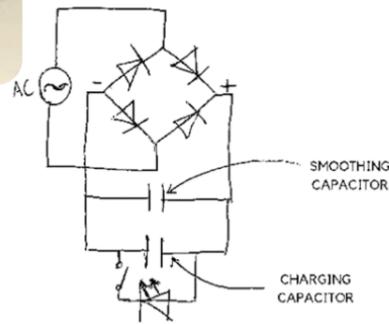
Smaller Projects

WIND TURBINE

2024 Personal Mechatronics

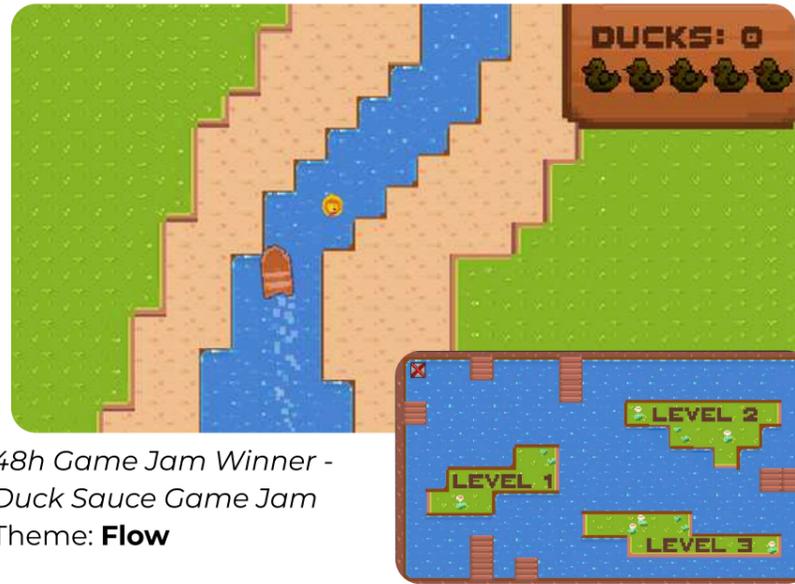


A fully 3D-printed vertical wind turbine with a custom generator, rectifier circuit, and casing, designed, built, and iterated from scratch.



DUCK JAM

2023 Game Jam



48h Game Jam Winner - Duck Sauce Game Jam
Theme: **Flow**

Autoscrolling river game where collecting ducks layers a live melody.
3 levels, each building a full musical track.
Focus on playful mechanics + music integration.

ABYSSAL

2024 Game Jam



48h Game Jam Winner - Duck Sauce Game Jam

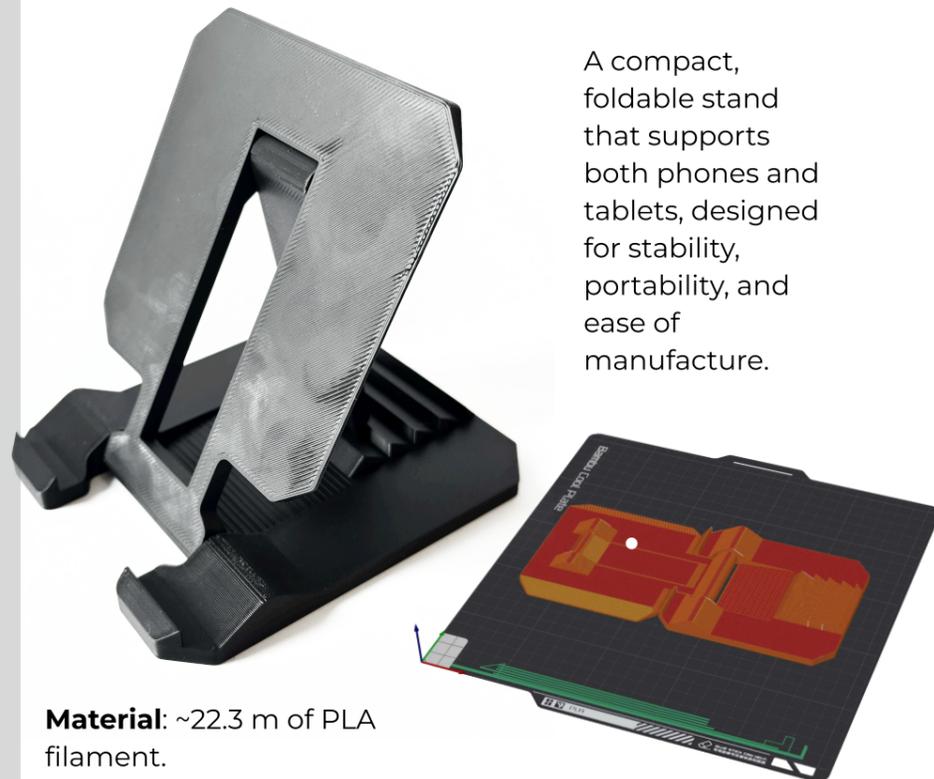
Theme: **Discovery**

2D underwater exploration with narrative discovery. Realistic lighting, oxygen + battery management. Custom audio system with environmental echo and lore-driven storytelling.



3D PRINTED PHONE STAND

Year 1 Academic Prototyping



A compact, foldable stand that supports both phones and tablets, designed for stability, portability, and ease of manufacture.

Material: ~22.3 m of PLA filament.
Print Time: ~1 hr 39 min.

UNNAMED WIZARD GAME

2025 Personal Game Ongoing

Online multiplayer card-battler with unique spell combos and binding mechanics. Designed UI in Figma → implemented in Unity. Features unlocking cards, codex discovery, and custom animations.



DODGY DOUBLE DECKER

2024 Personal Game



3D bus-driving game with exaggerated, bouncy physics. Implemented controller support and an online leaderboard database.