



**University of Idaho**

College of Engineering

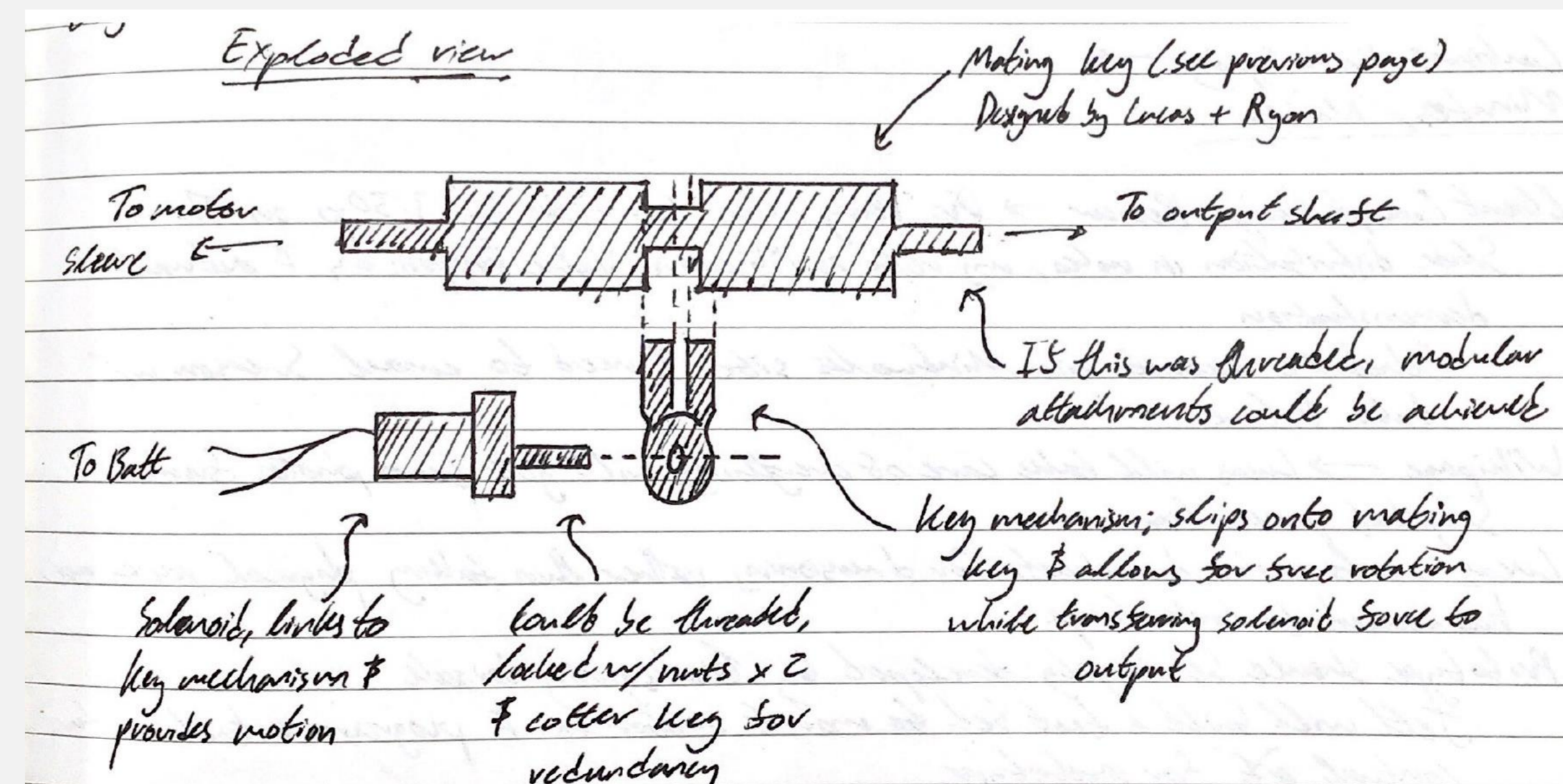
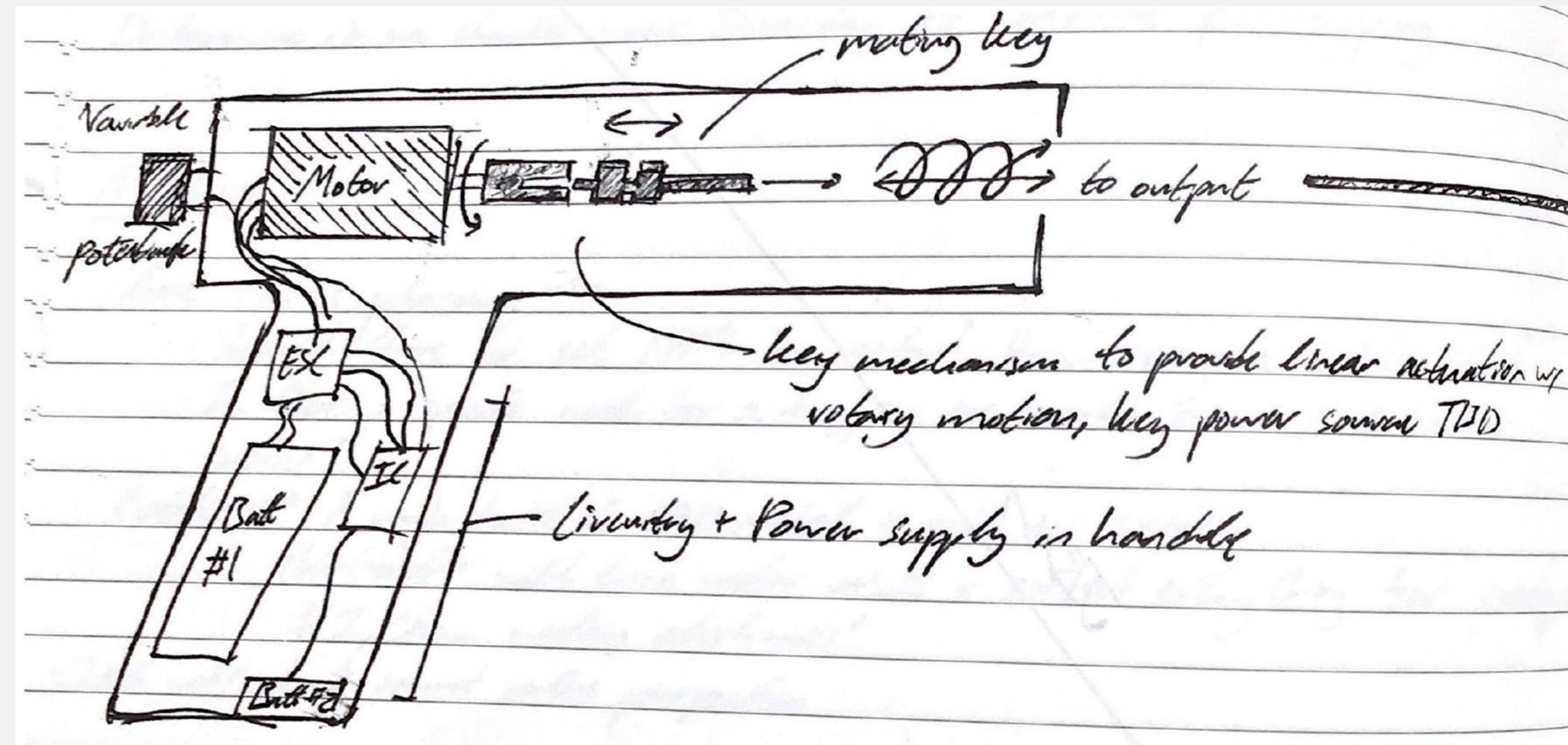
# **CONCEPT DESIGN REVIEW**

**THE \$1500 SHAVE CLUB**

# OVERVIEW



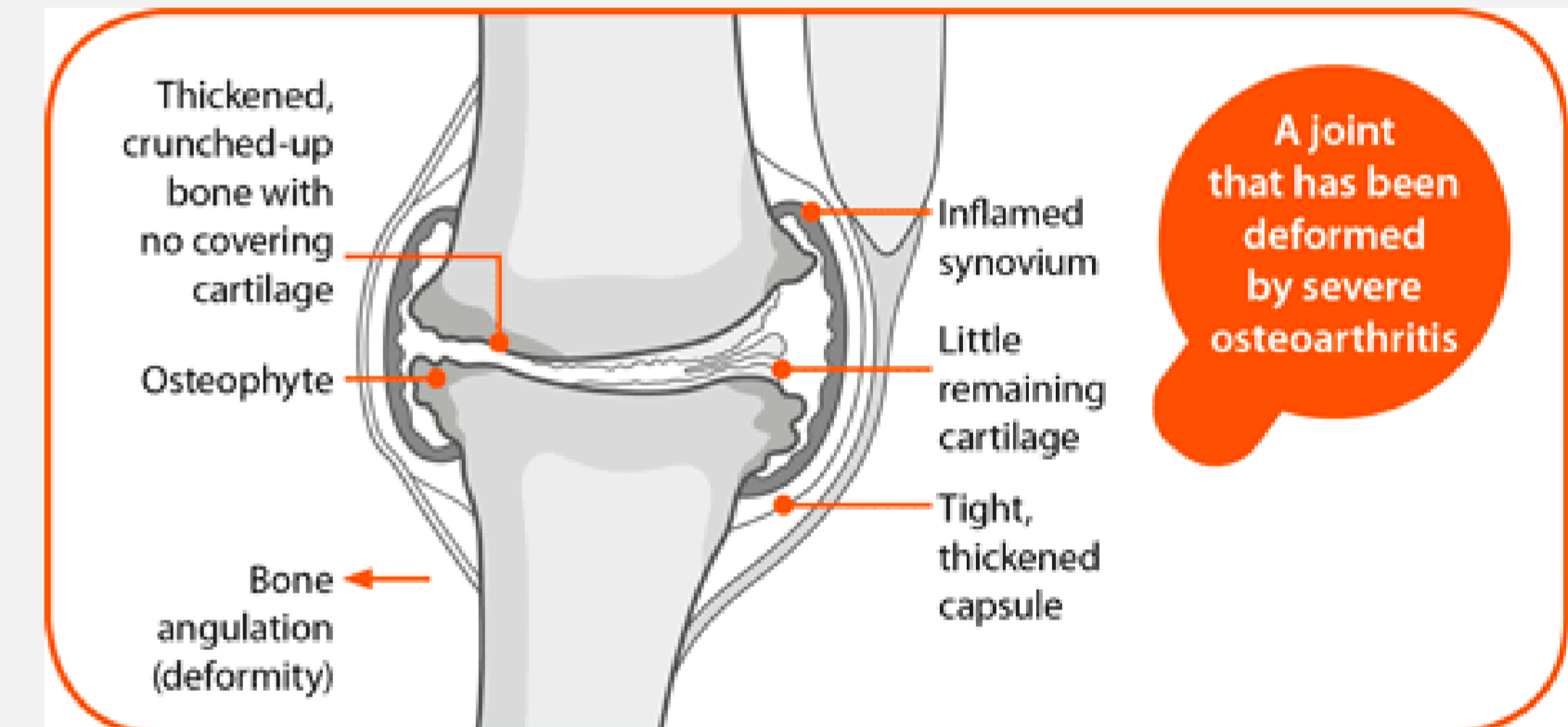
- I Project Objective
- I Design Value Proposition
- I Product Requirements
- I Conceptual Development
  - CAD Model
  - Arduino Code
  - Prototype Demonstration
- I Risk Identification
- I Concept Recommendations
- I Validation Approaches
- I Project Budget
- I Project Schedule



# PROJECT OBJECTIVE

I The objective of this project to refine and finalize a previously developed arthroscopic surgical device for the following purposes:

- To allow for appropriate sanding of bone and cartilage surfaces
  - Random orbital sanding
- To ready the device for testing and manufacturing
  - Testing
  - Manufacturing
    - Expediting manufacturing
    - High fidelity machining



# DESIGN VALUE PROPOSITION

I Arthritis is characterized by roughening of a joint

- Cartilage, bone breakdown leading to chronic pain and inflammation
- ~750,000 annual knee arthroscopies occur in the US, many for arthritic pain management
  - Current technologies and limitations
  - Arthroscopic tooltips are designed for single-use
    - Increases out of pocket cost
- Reusable arthroscopic tooltips could help lower costs as well
  - Lessen pain and lower rehabilitation time

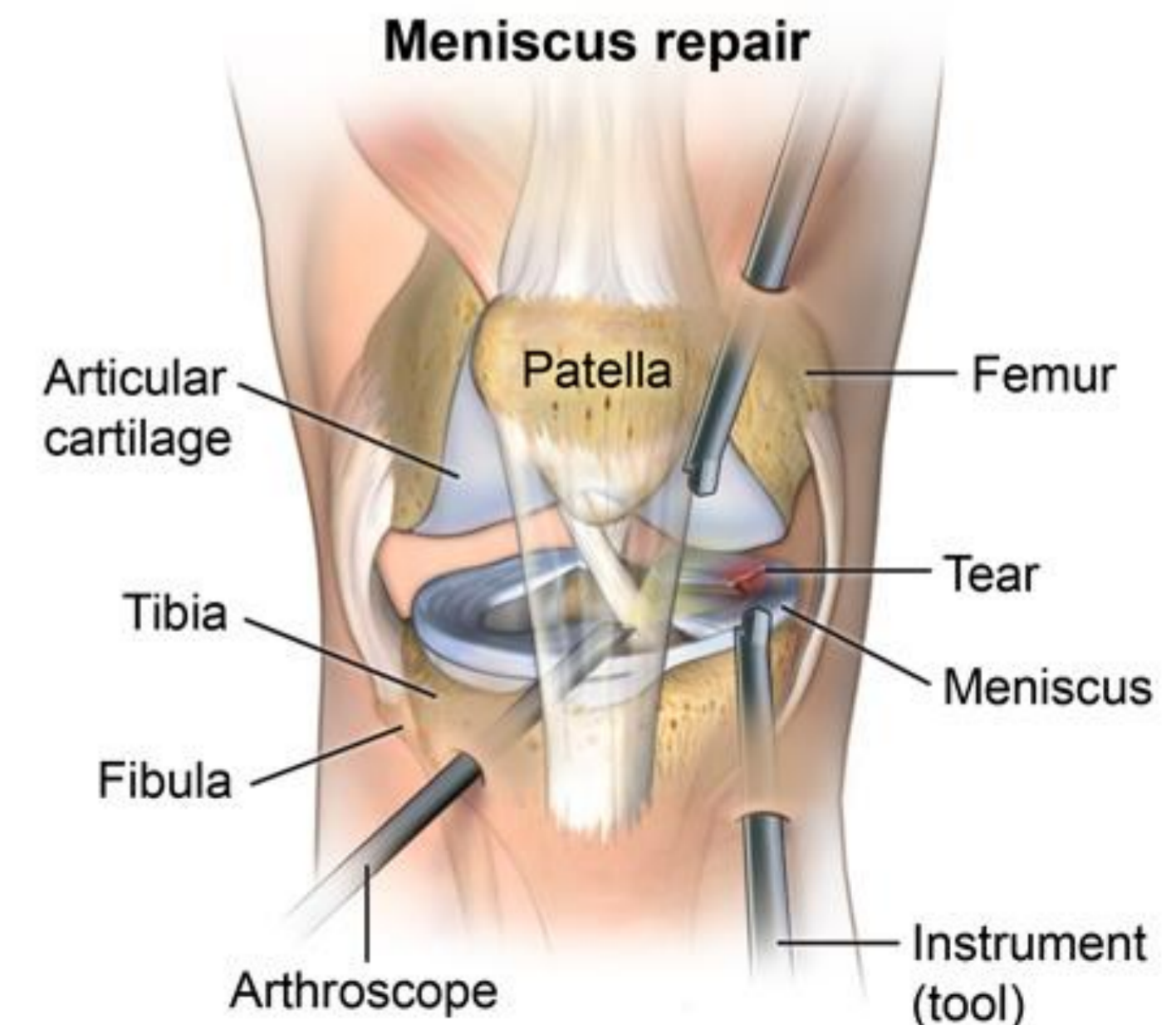
I Our device will incorporate random-orbital sanding into the shaving platform, modular tooltips, better ergonomics, and user comfort than traditional arthroscopic tools

- Purpose of device

# PRODUCT REQUIREMENTS

As surgical tools need to be capable of varying functions, we selected the following development criteria:

- I Variable speed output with 900-6000 RPM oscillation settings
- I Random orbital sanding action within a pistol-grip device
- I Maximum output shaft diameter of 4mm
  - Output shaft should be able to withstand corrosion in saline-rich environments
- I Compatibility with 100-400 grit shaver heads/burs
  - ~300 grit shaver heads/burs have been previously noted to work the best
- I Reliable two-hour battery life
- I Compatibility with existing surgical suction pumps
  - Debris removal during shaving (condyle, menisci cartilage, bone fragments)
- I The device should be reusable, and compatible with different shaver heads
  - Autoclaving (60kPa, 150 degrees Celsius)

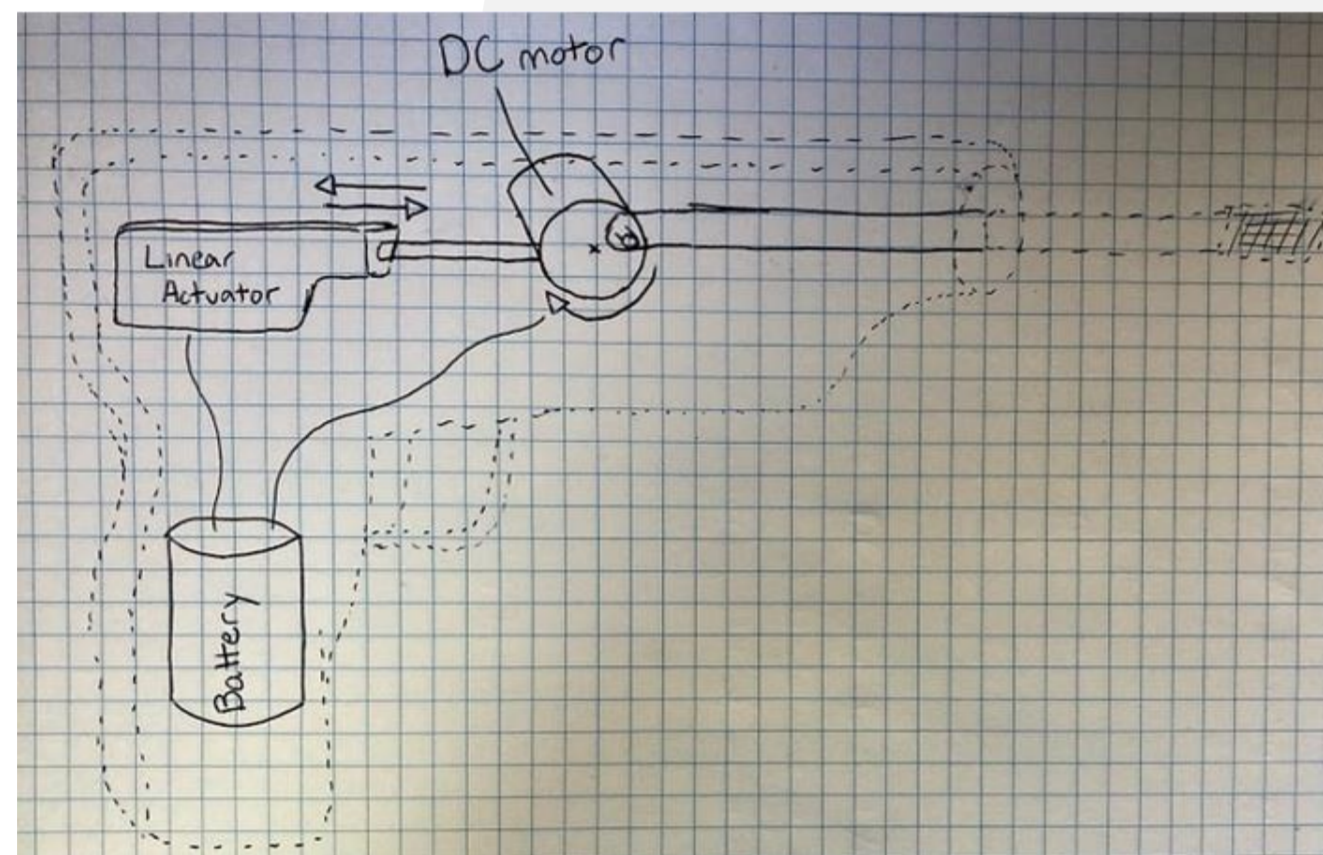


# CONCEPTUAL DEVELOPMENT

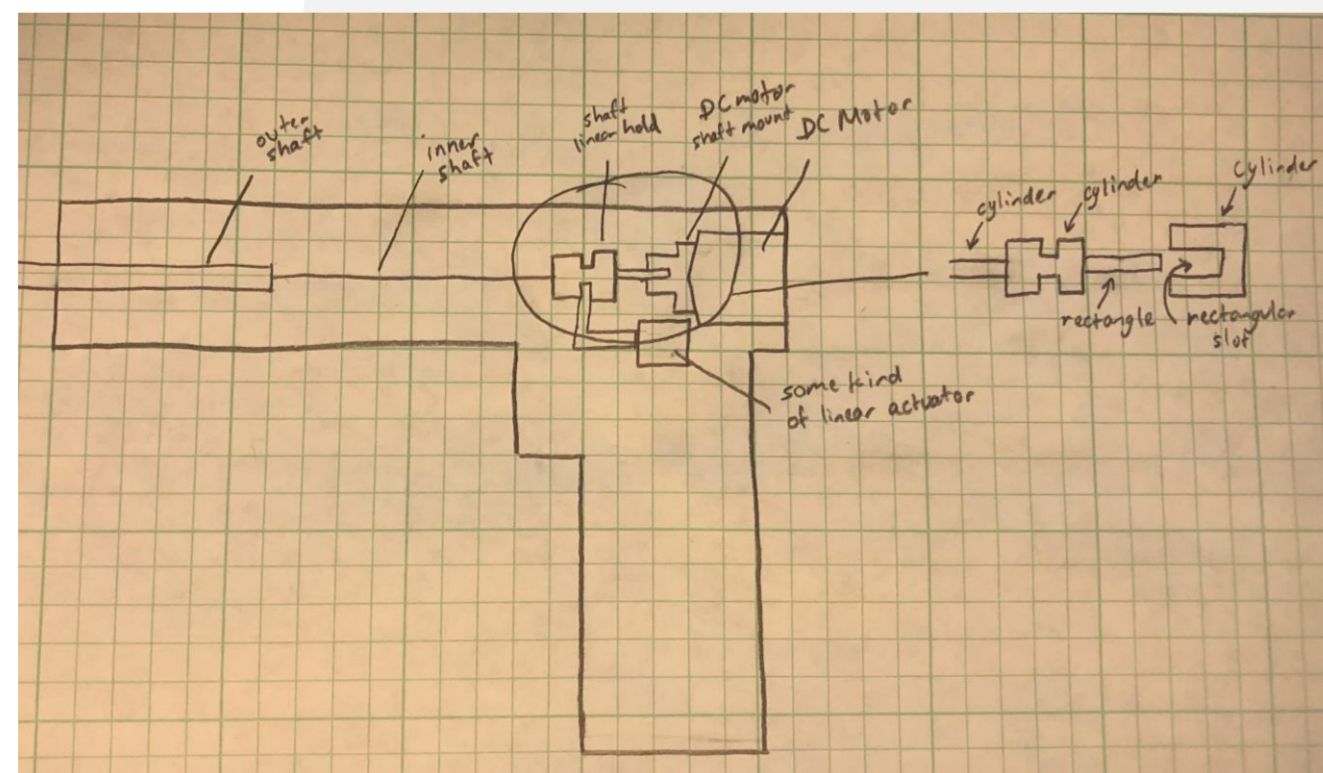


I During initial brainstorming we had two main design concepts to achieve orbital sanding

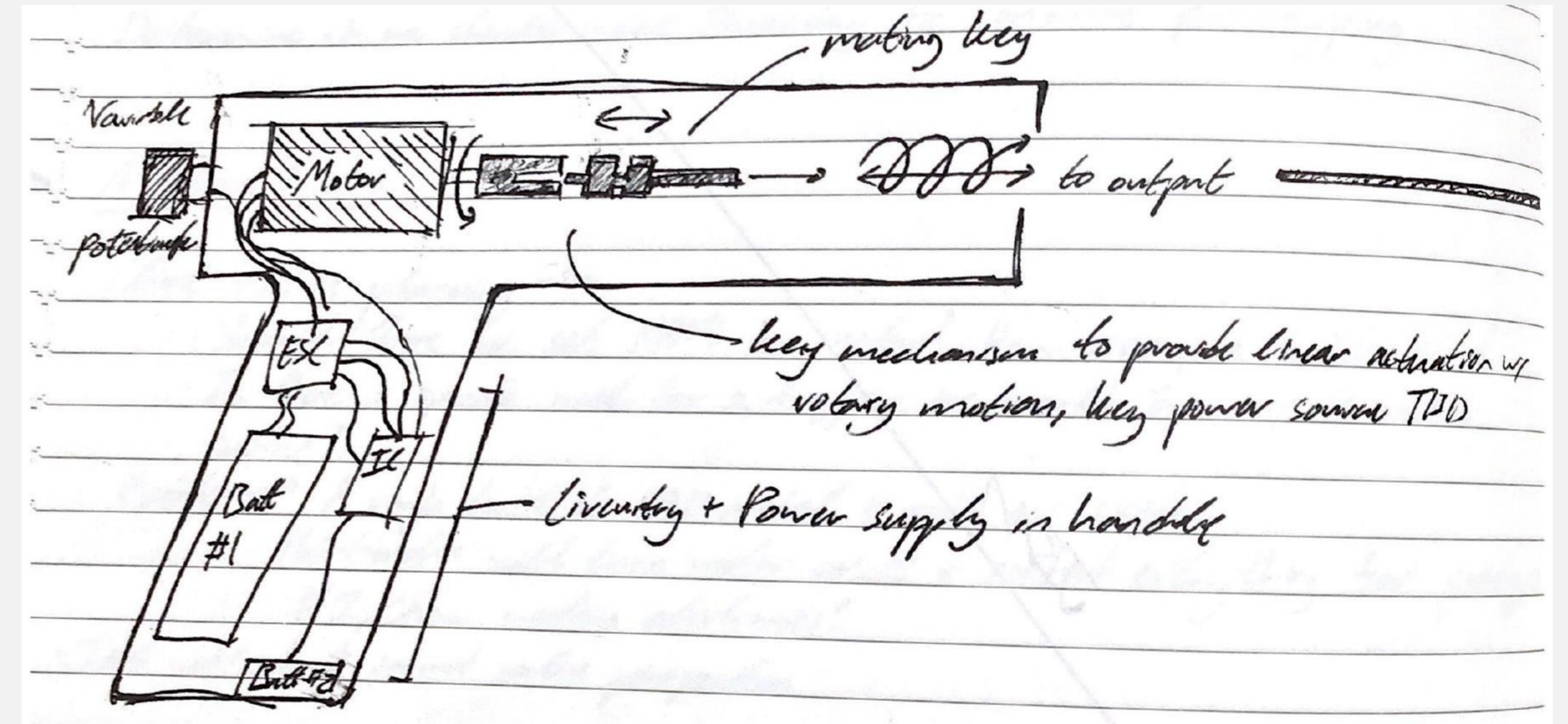
- Sawzol Design with DC Motor and Linear Actuator



- Rotational DC Motor with Linear Solenoid



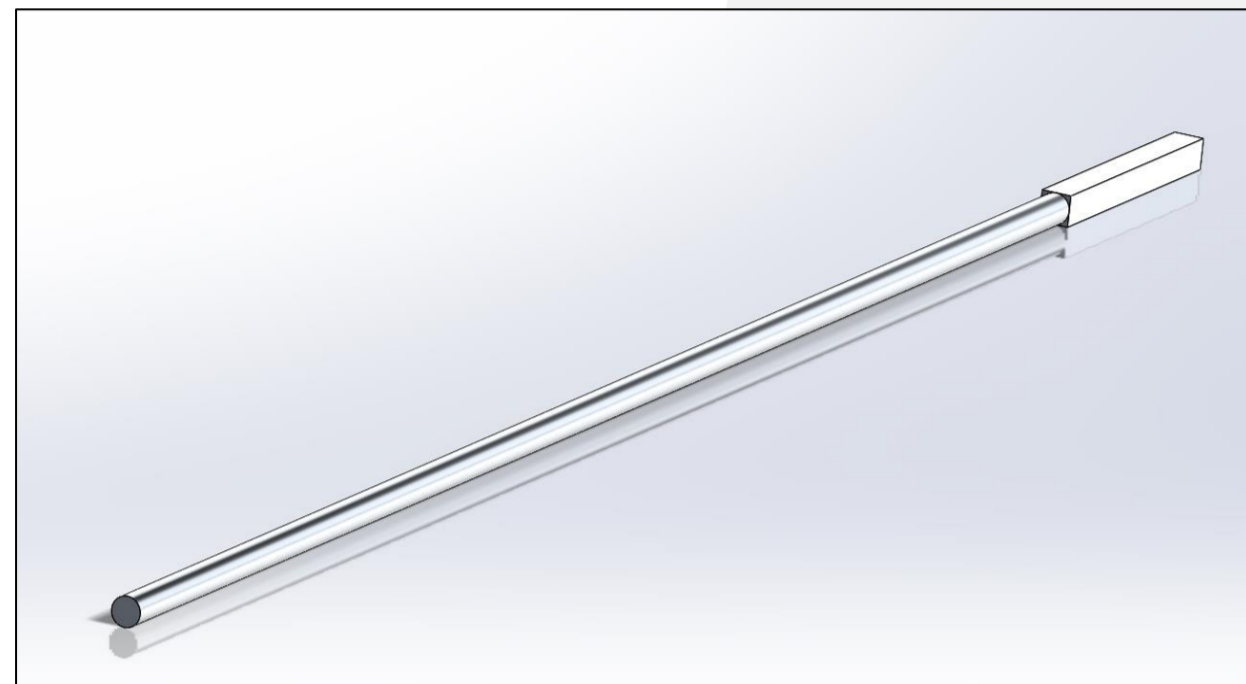
I After prototyping considerations, we decided on using the rotational DC motor with a linear solenoid fashioned below:



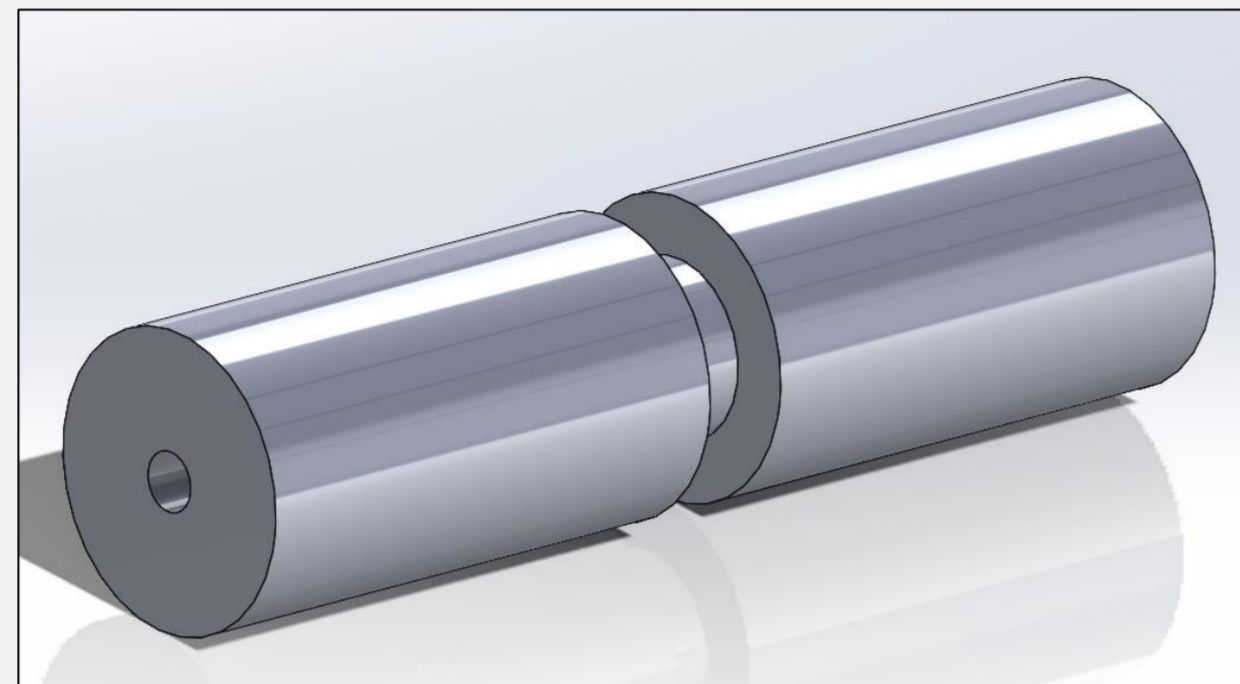
- Completed orbital sanding CAD model
- Completed Arduino code for DC motor and potentiometer
- Beginning 3D printing large scale model of system in action



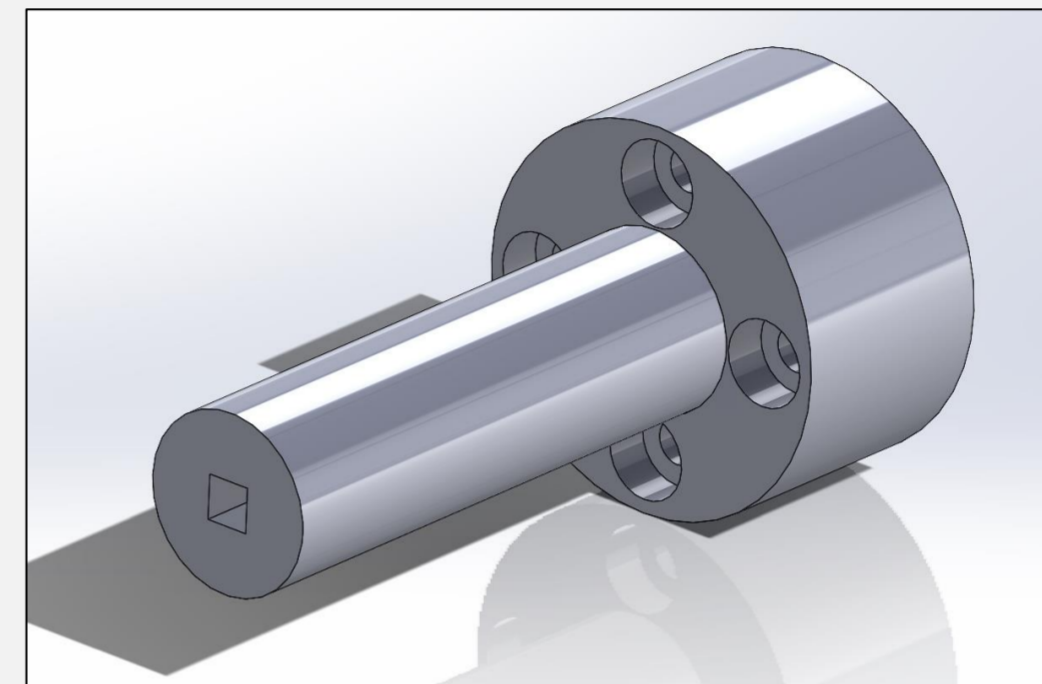
# CAD ORBITAL SANDING MECHANISM



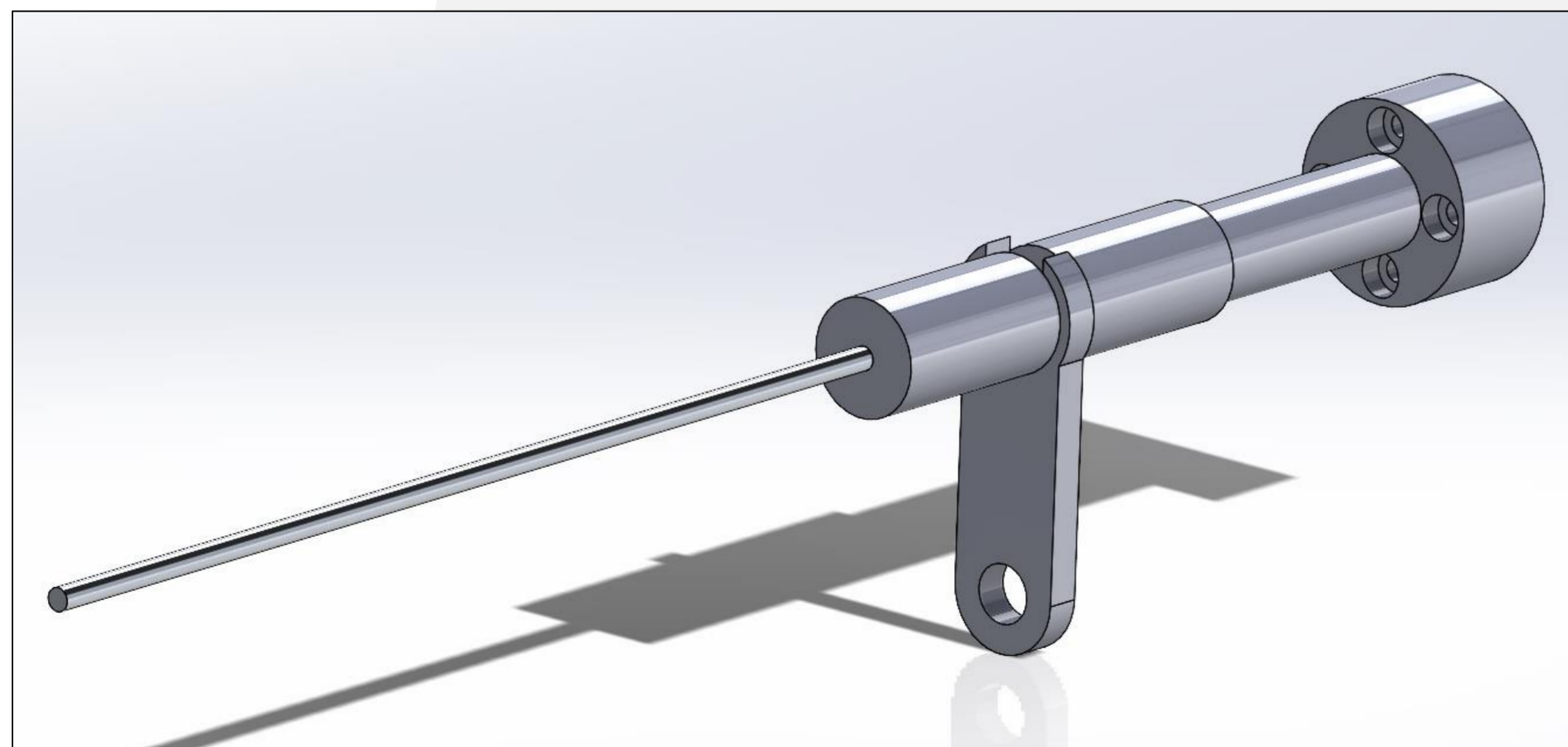
Inner Rod



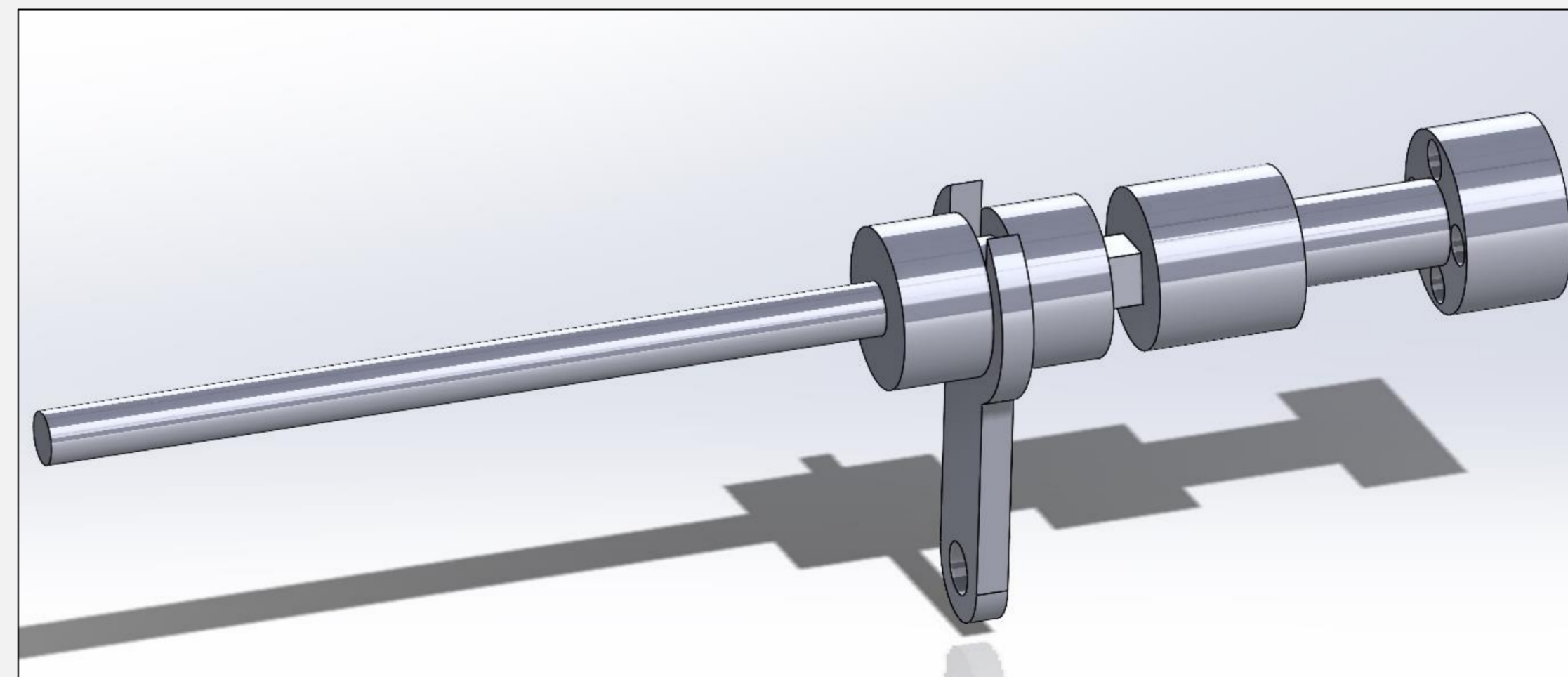
Linear Actuation Mount



Motor Mount



Planned Orbital Sanding Mechanism



3D Printable Scaled Prototype Model

# ARDUINO CODE



```
// constants won't change
const int BUTTON_PIN = 7; // Arduino pin connected to button's pin
const int Motor_PIN = 9; // Arduino pin connected to LED's pin

// variables will change:
int motorState = LOW; // the current state of LED
int lastButtonState; // the previous state of button
int currentButtonState; // the current state of button

#include <Servo.h>
Servo ESC; // create servo object to control the ESC
int potValue; // value from the analog pin

void setup() {
  Serial.begin(9600); // initialize serial
  pinMode(BUTTON_PIN, INPUT_PULLUP); // set arduino pin to input pull-up mode
  pinMode(Motor_PIN, OUTPUT); // set arduino pin to output mode

  currentButtonState = digitalRead(BUTTON_PIN);

  // Attach the ESC on pin 9
  ESC.attach(9,1000,2000); // (pin, min pulse width, max pulse width in microseconds)
}

void loop() {
  lastButtonState = currentButtonState; // save the last state
  currentButtonState = digitalRead(BUTTON_PIN); // read new state

  if(lastButtonState == HIGH && currentButtonState == LOW) {
    Serial.println("The button is pressed");

    // toggle state of Motor
    motorState = !motorState;

    // control Motor according to the toggled state
    digitalWrite(Motor_PIN, motorState);

    potValue = analogRead(A0); // reads the value of the potentiometer (value between 0 and 1023)
    potValue = map(potValue, 0, 1023, 0, 180); // scale it to use it with the servo library (value between 0 and 180)
    ESC.write(potValue); // Send the signal to the ESC
    Serial.print(potValue);
  }
}
```

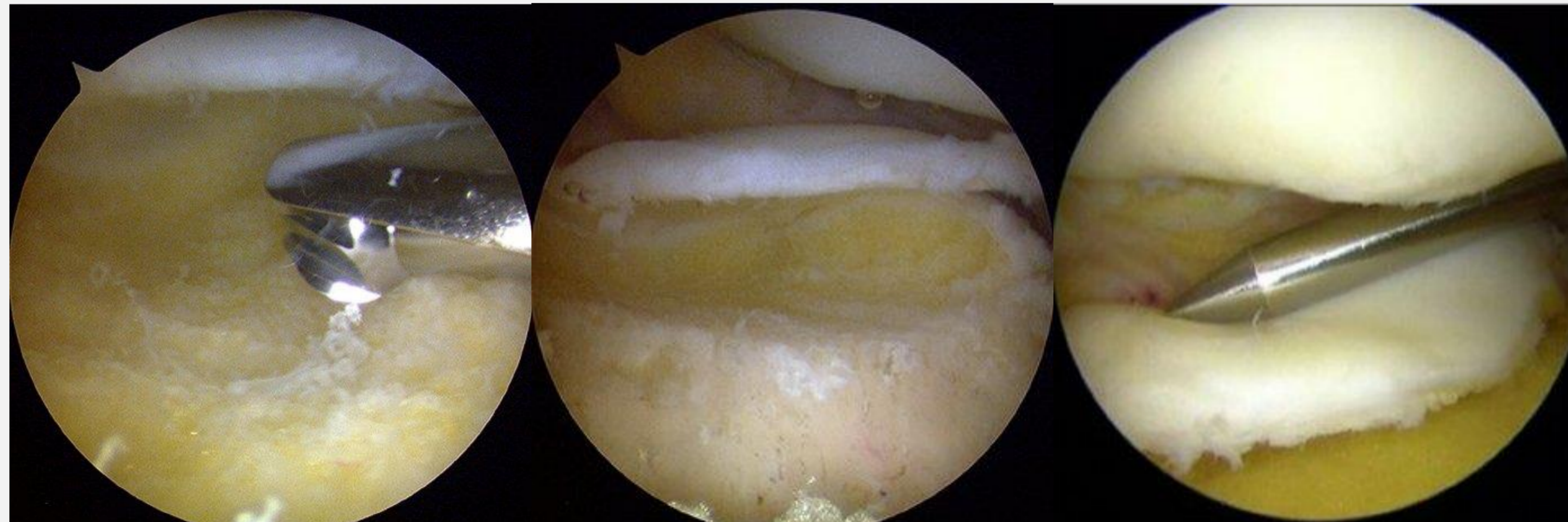




# **PROTOTYPE DEMONSTRATION (JETT)**

# RISK IDENTIFICATION

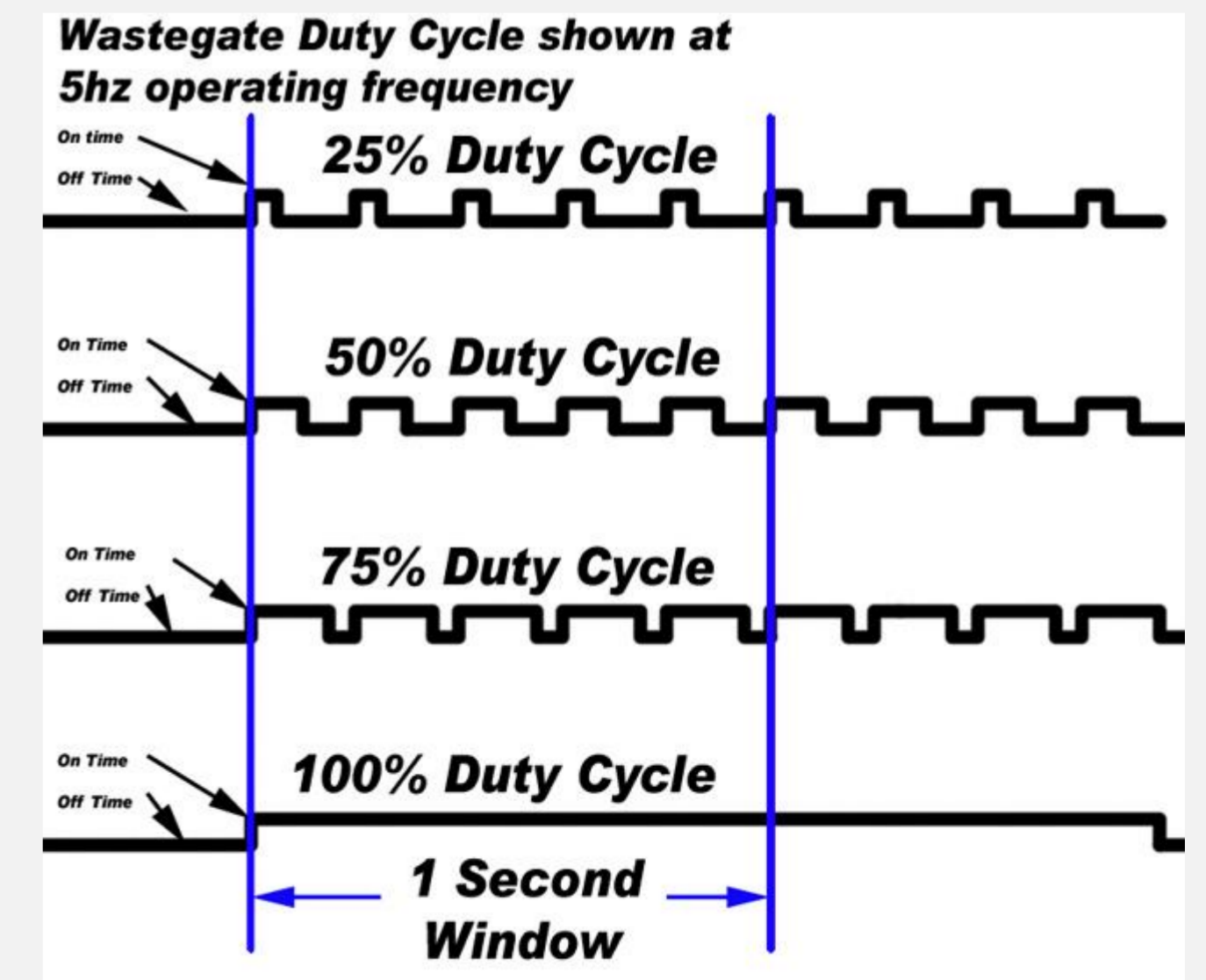
- I Shaver Head Fracture
- I Vibrations From Linear Actuation
- I Grooves Left Behind
- I Solenoid Overheating
- I Poor Angle Control
- I Lifetime of Product
- I Battery Life



# CONCEPT RECOMMENDATIONS

## POSSIBLE RISK SOLUTIONS

- I Fracture: Shaver head and shaft in one piece
- I Vibrations: Add mass to the handle by machining with surgical grade alloys
- I Groove: Add linear action to rotation of the shaver-head, use a surface with grit for finer shaving/sanding of cartilage and bone
- I Angle: Pistol-Grip for easy angle manipulation
- I Lifetime: Create final prototype with high factor of safety
- I Battery: Test high-quality battery options
- I Solenoid Overheating:  $Duty Cycle = 100 \times \frac{time\ on}{(time\ on + time\ off)}$



# VALIDATION APPROACHES



Requirement	Test	Test Subject	Target Date
Motor and servo are able to be activated by pulling the trigger	Ensure all electronics work properly when a toggle switch is pressed	Prototype #1	11/7/20
Prototype #1 battery life will last for two hours	Ensure that the device can be powered at maximum shaving speed for two hours	Fully Functional Prototype #1	11/13/20
Frequency Output	Ensure that the device has a variable speed output between 900 and 6000 RPM	Fully Functional Prototype #1	11/7/20
New battery must conform to comfortable handle size	Ensure that the battery can be stored securely in handle and that new handle is comfortable.	Fully Functional Prototype #1	11/13/20
Maximum outer shaft diameter between 4 and 6.5mm	Ensure that inner mechanics can achieve orbital sanding motion via the narrow shaft	Fully Functional Prototype #1	11/13/20
Compatible with 100-400 grit shaver heads	Ensure that head design does not have interference with shafts on Solidworks, test with actual components	Fully Functional Prototype #1	11/21/20
Final Prototype battery will last for two hours	Conduct mathematical analysis, Test fully working circuit to battery failure	Fully Functional Final Prototype	4/29/21
Compatible with surgical suction pumps	Model suction pump in solidworks then test for interference in assembly	Fully Functional Final Prototype	4/29/21
Tip can be easily swapped out and sterilized via autoclave	Check that design can be disassembled in 3 minutes; handle casing can be autoclaved	Fully Functional Final Prototype	4/29/21
Bone must be shaved	Ensure that the motors are able to overcome friction force to be able to shave bone	Fully Functional Final Prototype	3/4/21
Smooth shaving surface must be achieved	Qualitatively identify smoothness via feel after manual sanding of cartilage and bone vs. device	Fully Functional Final Prototype	3/4/21
Device must be thermostable	Ensure that circuit does not overheat	Final Prototype	3/4/21

Requirement	Test	Test Subject	Target Date
Device must operate reliably under load	Shave cartilage and bone separately to ensure full shaving head articulation for > 1hr	Fully Functional Final Prototype	3/4/21
Multiple End Attachments	Making sure that the shaver can have different shaving heads on the output shaft.	Final Prototype	3/4/21
Make device compatible with current Operation Room batteries	Power Device with Currently Used Batteries.	Fully Functional Final Prototype	3/4/21
Make device able to switch from predetermined motor speeds.	Change speed of motor with buttons	Fully Functional Final Prototype	3/4/21
Ensure that handle components are durable enough for back-to-back surgeries	Shave bone for > 1hr, disassemble and reassemble handle with new tip (simulate sterilization), and retest	Fully Functional Final Prototype	4/29/20

# PROJECT BUDGET



- Total Spent: \$111
- Budget Remaining: \$1389

Capstone Project Budget Template - Fall/Spring										
Project: Smooth Arthroscopic Shaver										
Last Updated: 11/4/2020										
	Year								Item Total	
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr		
<b>Equipment/Tools:</b>										
Prototypes			\$ 80	\$ 80	\$ 18	\$ 18	\$ 80	\$ 18	\$ 294	
Miscellaneous				\$ 5	\$ 10		\$ 10		\$ 25	
<b>Travel:</b>										
Trip to hospital				\$ 15			\$ 15		\$ 30	
									\$ -	
<b>Supplies / Parts / Services:</b>										
Stainless steel					\$ 12				\$ 12	
Prototypes				\$ 10	\$ 200	\$ 250	\$ 200	\$ 50	\$ 710	
Linear Actuator									\$ -	
Power Supply		\$ 17							\$ 17	
Servo Motor		\$ 13							\$ 13	
DC Motor		\$ 16							\$ 16	
Speed Controller		\$ 16							\$ 16	
Battery Charger		\$ 14							\$ 14	Expenses
Potentiometer		\$ 10							\$ 10	
Microcontroller		\$ 9							\$ 9	
Solenoids		\$ 8							\$ 8	\$ 1,161 Subtotal
<b>Shop Usage (est. Hrs):</b>										
			3	10	25	25	30	25	118	
									0	
									0	
									0	
									0	
									0	
									0	
										Graduate Student Support \$ - including fringe
										Shop Overhead \$ -
										University Overhead \$ 58 5% of all expenses
									<b>\$ 1,219</b>	<b>\$ 1,500</b>
										\$ 281 Budget Excess





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**QUESTIONS?**

THANK YOU FOR LISTENING!