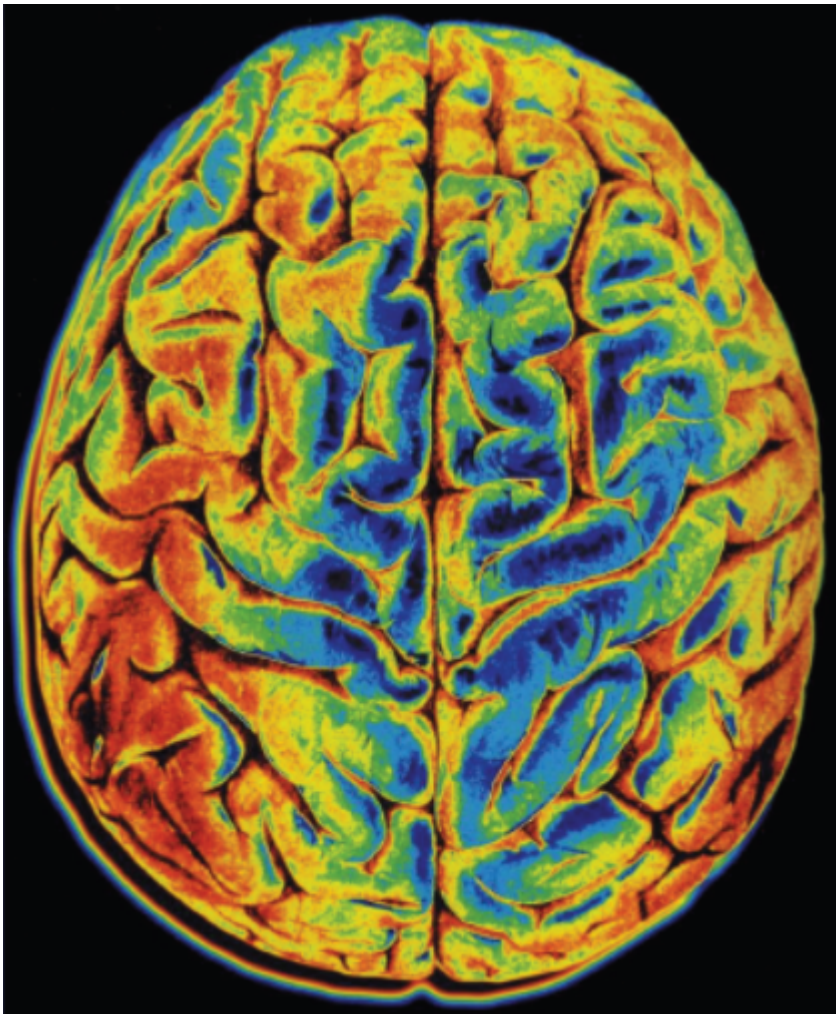
Lotus Meditation Assistive Device Using EEG to Measure State of Mind



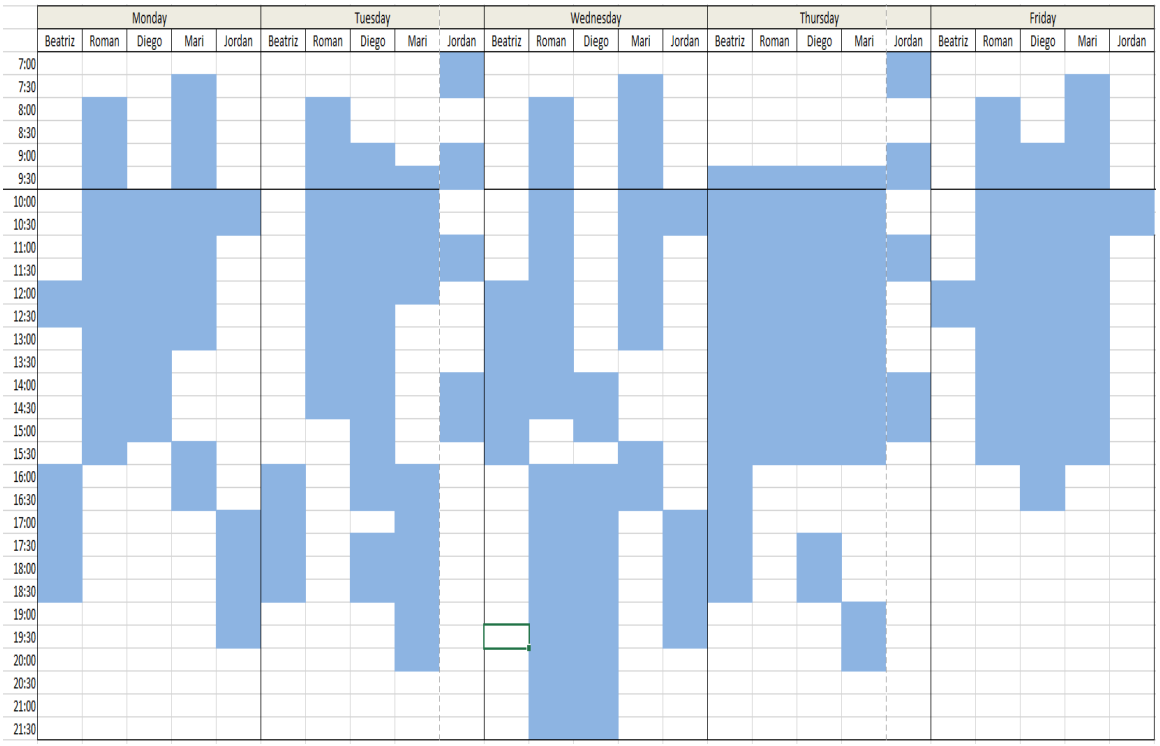
Maricruz Carrillo, Roman Huizar, Jordan Lenoir, Beatriz Moya Garcia, Diego Wright

Table of Contents

PROJECT MANAGEMENT

Organizing the team

Finding a meeting time when all team members were available was one of the most challenging tasks at the beginning of the semester. The spreadsheets seen below, showing work and school hours in blue, allowed us to visually identify a time that worked for everyone. The spreadsheet below is an example of how we organized it and the same format was used for Fall 2014.



Organizing the tasks: Task Manager in Excel.

The task manager includes a column for task description, person responsible, due date and status. If the status is 'In Progress' after the due date, it is marked late and the person responsible is contacted.

Item	Task	Person Responsible	Due Date	Status	Late
1	Talk to psychologists to introduce project	Team	11/6/2014	Complete	NO
2	Coordinate with Simpkins to meet the machine	Simpkins	11/20/2014	Complete	NO
3	Fill in Focus Meditation section of Research doc (Dr.Simpkins' book)	Diego	11/17/2014	Complete	NO
4	Fill in Focus Meditation section of Research doc (Dr.Simpkins' book)	Roman	11/17/2014	Complete	NO
5	Fill in EEG input & output section of Research doc	Jordan	11/17/2014	Complete	NO
6	Fill in EEG input & output section of Research doc	Bea	11/17/2014	Complete	NO
7	Fill in Brainwave section of Research doc	Mari	11/17/2014	Complete	NO
8	Have 5 different prototype ideas for the physical machine	Team	11/20/2014	Complete	NO
9	Analyze (or try at least) EEG data	Bea	12/16/2014	Complete	NO
10	Create small prototype with arduino to demonstrate what the will do	Diego	11/25/2014	Complete	NO
11	Collect all emails to compose the design notebook	Jordan	12/14/2014	Complete	NO
12	Reorganize and add details to Timeline	Mari	12/14/2014	Complete	NO
13	Come up with code to make Matlab communicate with Arduino	Diego	12/15/2014	Complete	NO
14	Finalize poster slides	Jordan	12/15/2014	Complete	NO
15	Print out poster	Roman	12/17/2014	Complete	NO
16	Discuss description of project for poster fair	Team	12/16/2014	Complete	NO
16	Put together the design notebook	Bea/Mari	12/18/2014	Complete	NO
17	Create finance spreadsheet to record our expenses	Mari	12/30/2014	Complete	NO

18	Find alternatives for EEG Machine	Team	1/31/2015	Complete	NO
19	Purchase NeuroSky mindwave EEG	Mari	1/31/2015	Complete	NO
20	Set up NeuroSky and figure out how to connect to Arduino	Diego	3/30/2015	Complete	NO
21	Order supplies needed to send to Puebla	Jordan	3/10/2015	Complete	NO
22	Create Solidworks model for petal	Bea	3/19/2015	Complete	NO
23	Create Solidworks model for lifting mechanism	Mari	3/19/2015	Complete	NO
24	Create Solidworks model for Base	Roman	3/19/2015	Complete	NO
25	Write Arduino sequence	Jordan	4/20/2015	Complete	NO
26	Test Arduino code	Jordan	4/20/2015	Complete	NO
27	Print parts	Mari/Bea	4/17/2015	Complete	NO
28	Finish poster draft	Team	4/12/2015	Complete	NO
29	Write draft design notebook	Team	4/19/2015	Complete	NO
30	Finish final poster	Roman/Jordan	4/20/2015	Complete	NO
31	Print final poster	Diego	4/22/2015	Complete	NO
32	Finalize compilation of Design notebook	Mari	5/10/2015	Complete	NO
33	Prepare final presentation draft	Team	4/19/2015	Complete	NO
34	Incorporate draft presentation comments to final presentation	Mari	4/27/2015	Complete	NO

High-level Timeline: The timeline was continuously changing throughout the length of the project. A Microsoft Word document was kept and revised periodically. All timeline revisions are seen below.

Timeline (Initial)

November 10th, 2014

Meditation device using EEG will help people meditate by providing them neurofeedback to attain a meditative brain state. This will help people with stress, ADHD, PTSD.

- November
  - Meet the machine
  - Talk to psychologists
  - Group/individual meditation
  - Understand output of EEG
  - Research meditation – How/why it helps?
  - Understand different brain waves
  - Research code
  - Plan "crude" prototype meditation device
  - Financial plan
- December
  - Build "crude" prototype meditation device
  - Build alpha code
  - Test prototype
- January
  - Plan final design
  - Beta version of code
- February
  - Build final meditation machine
- March
  - Synchronize code with machine
  - Extensive testing, refinement, debugging
- April
  - Write Report
- May
  - Present

Timeline (Rev A)

December 10th, 2014

Project: Using EEG signals to provide neural feedback during meditation for training purposes

Purpose: Help people meditate by providing them real-time neurofeedback to attain a meditative brain state. This will help people with stress, ADHD, PTSD.

- November
  - Talk to psychologists (completed)
  - Group/individual meditation (completed)
  - Understand output of EEG (completed)
  - Research meditation – How/why it helps? (completed)
  - Understand different brain waves
  - Research code needed for arduino (completed)
  - Plan "crude" prototype meditation device (completed)
  -
- December
  - Build "crude" prototype meditation device (completed)
  - Test prototype
  - Financial plan
- January
  - Meet the machine (delayed)
  - Plan final design
  - Build alpha code
- February
  - Build final meditation machine
  - Synchronize code with machine
- March
  - Extensive testing, refinement, debugging
- April
  - Write Report
- May
  - Prepare presentation
  - Present

Timeline (Rev B)

February 16th, 2015

Project: Using EEG signals to provide neural feedback during meditation for training purposes

Purpose: Help people meditate by providing them real-time neurofeedback to attain a meditative brain state. This will help people with stress, ADHD, PTSD.

- November
  - Talk to psychologists (completed)
  - Group/individual meditation (completed)
  - Understand output of EEG (completed)
  - Research meditation – How/why it helps? (completed)
  - Understand different brain waves
  - Research code needed for arduino (completed)
  - Plan "crude" prototype meditation device (completed)
  -
- December
  - Build "crude" prototype meditation device (completed)
  - Financial plan (completed)
- January
  - Order the machine (completed)
  - Plan final design (completed)
- February
  - Write Alpha code
  - Complete Solid Works models
- March
  - Synchronize code with machine
  - Print parts
  - Extensive testing, refinement, debugging
- April
  - Build final meditation machine
  - Write Report
- May
  - Prepare presentation
  - Present

Timeline (Rev C)

March 2nd, 2015

Project: Using EEG signals to provide neural feedback during meditation for training purposes

Purpose: Help people meditate by providing them real-time neurofeedback to attain a meditative brain state. This will help people with stress, ADHD, PTSD.

- November
  - Talk to psychologists (completed)
  - Group/individual meditation (completed)
  - Understand output of EEG (completed)
  - Research meditation – How/why it helps? (completed)
  - Understand different brain waves
  - Research code needed for arduino (completed)
  - Plan "crude" prototype meditation device (completed)
  -
- December
  - Build "crude" prototype meditation device (completed)
  - Financial plan (completed)
- January
  - Order the machine (completed)
  - Plan final design (completed)
- February
  - Write Alpha code (Still in progress)
  - Complete Solid Works models (Still in progress)
- March
  - Finalize code
  - Synchronize code with machine
  - Assemble Solid Works models and perform motion study
  - Print parts
- April
  - Build final meditation machine
  - Write Report
- May
  - Prepare presentation
  - Present

Timeline (Rev D)

April 6th, 2015

Project: Using EEG signals to provide neural feedback during meditation for training purposes

Purpose: Help people meditate by providing them real-time neurofeedback to attain a meditative brain state. This will help people with stress, ADHD, PTSD.

- November
  - Talk to psychologists (completed)
  - Group/individual meditation (completed)
  - Understand output of EEG (completed)
  - Research meditation – How/why it helps? (completed)
  - Understand different brain waves
  - Research code needed for arduino (completed)
  - Plan "crude" prototype meditation device (completed)
  -
- December
  - Build "crude" prototype meditation device (completed)
  - Financial plan (completed)
- January
  - Order the machine (completed)
  - Plan final design (completed)
- February
  - Write Alpha code (completed)
  - Complete Solid Works models (completed)
- March
  - Finalize code (Still in progress)
  - Assemble Solid Works models and perform motion study (Still in progress)
- April
  - Build final meditation machine
  - Synchronize code with machine
  - Print parts
  - Write Report
- May
  - Debug/test device
  - Prepare presentation
  - Present

IDEATION

Each team member went home after the first meeting to brainstorm. If you had an idea you had to develop it as shown in the outline below to quickly identify issues with the potential idea. The ideas were written on a google doc so the whole team was able to see each other's ideas. At the second meeting, the team reviewed each and every idea and decided whether the idea was feasible. If the idea seemed feasible, further research was conducted.

BRAINSTORMING IDEAS (GENERAL)

1. External artificial muscle (Big project to tackle… see idea 3)

a. External, could be worn

b. Simulate how an actual muscle works and use similar components (ex. Tendons)

i. http://www.edu.xunta.es/ftpserver/portal/S_EUROPEAS/ED_FISICA2/MUSCLES.htm

ii. First work with antagonistic muscle action

b. Control mechanism is still open to ideas (ex. Electrical stimuli from actual muscle)

c. Maybe used for rehabilitative purposes, place sensors to see how much load/work the artificial muscle is doing to calculate how much work the actual person's muscle is doing

d. Control the limits how much load the artificial muscle will take:

How it's made: https://www.youtube.com/watch?v=Tba8Nf02OSI

*Twist under high tension until it coils up. To maintain the shape is temperature treated. Twisting it enhances contraction effect. "By controlling the degree of twisting and the tightness of the resulting coil, it is possible to control the muscle properties".
https://www.polymersolutions.com/blog/artificial-muscles-from-cheap-polymer-fibers/
http://www.popularmechanics.com/science/health/breakthroughs/synthetic-muscle-made-of-fishing-line-is-100-times-stronger-than-the-real-thing-16514805

*Usual properties:
-can contract by 50%
-lift loads over 100 times heavier than muscle
-generate 7.1 horsepower/kilogram-5.3 kW/kilogram
http://spectrum.ieee.org/tech-talk/robotics/robotics-hardware/fishing-line-makes-superhuman-artificial-muscle

*How it contracts:
"Such artificial muscles are usually electrically powered by resistive heating, said Carter Haines, a doctoral student in materials science and engineering at UT Dallas and lead author on the new study. The resistive heating can come from the metal coating of commercial sewing thread or from metal wires twisted together within the coiled muscles." http://spectrum.ieee.org/tech-talk/robotics/robotics-hardware/fishing-line-makes-superhuman-artificial-muscle

f. Muscle material, lightweight and have the work limit similar to that of actual muscle [very important]

i. http://www.rsc.org/Publishing/ChemScience/Volume/2010/05/artificial_muscles.asp

ii. http://www.sciencedirect.com/science/article/pii/037967799403226V

iii. http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/aa-hp.htm

a. Could be used to work out muscles that no longer be used due to injury to maintain muscle mass

1. Something with Paraplegia

a. Wheelchair add-on to just stand

i. Have independence to reach things

ii. For manual wheelchairs, people with upper body strength
iii. Purely mechanical
iv. Universal to most wheelchairs
v. Design:
1. Crutches that lock on
2. Ankle injury therapy
a. Intensive therapy
b. Compute/program different exercises to strengthen different muscle ligaments
c. Design:
i. Brace with electrodes variably placed to stimulate certain muscles
ii. Could perhaps be worn at night or watching TV (passive)
2. Stability
3. Cheek muscle therapy: hypoglossal muscles
4. Non-Invasively Measuring Blood glucose
a. Currently none with blood sample
b. light spectra measuring device?
c. $$$: Potential to make millions of dollars

1. Space travel: Muscle atrophy
a. Problem: Muscles get weaker in space
b. Solution: Stimulate them??
1. Muscle electrical stimulation to help diabetics GLUT4 transport
a. Design
i. Chair with electrodes that can passively stimulate muscles while person is sitting (at work, in front of TV)
ii. Similar idea to ankle injury
1. muscle stimulation to lift toes of old folks so they don't trip

BRAINSTORMING IDEAS (<u>NARROWED DOWN</u>)

1. Fishing line artificial muscle [narrowed down idea of artificial muscle]
a. Highlights
i. Has high tensile strength
ii. Inexpensive
iii. Contracts with current (heat)
b. Would most likely be an external prototype (not attached to human)
c. Muscle contraction would be controlled with person's mind
2.

1. For non invasive blood glucose test project-
a. http://www.mendosa.com/The%20Pursuit%20of%20Noninvasive%20Glucose%203rd%20Edition.pdf
b. Big and complicated project
c. how will we be different?

BRAINSTORMING IDEAS v2

I. Designing Exoskeleton for Arm with Artificial Muscle out of Fishing Line that can be contracted with electric signals
A. Possibly controlled by motion sensor or brain signals
II. Machine that would allow wheel-chaired bound people to walk over stairs

A. e.g. legs (spider legs)

CHOSEN PROJECT

Project: Using EEG signals to provide positive neural feedback during meditation for training purposes.

Sponsors: Dr. Alex Simpkins (mentor) and Dr. Kee Moon (financial support)

Background: According to American Psychological Association, 77% of the US population experienced significant stress in 2014. Stress have been quoted as being the number one killer in America, and although this is not proven, the adverse effects of stress have been studied and have proven to be significant. Meditation has proven to be effective in treating stress.

Problem: Many people do not know how to meditate

Solution: Create a meditation training device to help new users get to a meditative state by using positive feedback using real time EEG signals.

Initial Goals:

- To create an intuitive device to train people into becoming better at meditating
- Give visual feedback based on brain wave activity
- Clear / Easy to use
- Advance meditation research
- More effective meditation
- Aid mental health through meditation

The topic of brain waves and meditation was a new topic for everyone in the team, therefore, extensive research was necessary to get a good insight on how the brain works and how meditation works, as well.

BACKGROUND RESEARCH

Google Doc- Background Research

Beatriz, Diego, Roman, Jordan, Maricruz

http://store.neurosky.com/products/developer-tools-2-5

http://sccn.ucsd.edu/~arno/fam2data/publicly_available_EEG_data.html

http://www.mathworks.com/company/newsletters/articles/eeg-data-processing-and-classification-with-gbsanalyze-under-matlab.html

Signal processing

https://www.youtube.com/watch?v=3tdumuwHgxc

https://www.youtube.com/watch?v=r3xup1GamDs

Focus Meditation (How/What/When/Why/Where)

Look at page 58

Notes from Meditation: from thought to action

Yoga

Philosophy of higher consciousness and a system of guidelines for living. Came from India, backdrop of Hinduism. It is a progressive sequence of methods of concentration that results in higher states of consciousness and healthier body. Originally yoga was written by Patanjali approx. 200 B.C.

It is divided by Eight Limbs of Yoga

Yama: Delineates actions prohibitions against immoral actions (e.x. killing, stealing, lying)

Niyamas: Instructs people to be modest, tolerant, sincere, clean, and healthy

Asana: Encourages to perform yogic postures and exercises

Pranayama: Breathing techniques

Pratyahara: Accomplished by focusing disciplined attention and attaining self-control

Dharana: Intense concentration

Samadhi: Spiritual enlightenment

Many forms of yoga have then erected from back then

E.x.- Hatha Yoga: mostly focuses on body postures, healthy diet, and cleanliness [most familiar to westerners]

Buddhism

Philosophy that originated in India around the 6th century

Sees that evil and suffering derive from the ignorance we carry in our minds

Founder Siddhartha Gautuama discovered enlightenment [nirvana] through meditation

Buddha's answer to suffering

Four noble truths: Illness, pain, failure, and eventual death are ever present

Life is not hopeless because the cause of suffering derives from our own thinking
Craving for possessions, power, position, or other pleasures are bonded to suffering
True happiness comes from being free from desires and from Wisdom
Path to wisdom: Eightfold path
Right views, right aspirations, right speech, right behavior, right livelihood, right effort, right thoughts, and right contemplation
Early adopters [elders] took strict discipline and took themselves out of society
Mahayana Buddhism: similar to early Buddhism but viewed that helping out other, especially in achieving nirvana, was very important
No-self
Self-identity is an illusion
Source of suffering
Contradictory to western views
Solution is to base society on no-self {bit confusing, need to look more into tha}
Self cannot be categorized and in doing so we limit ourselves by our illusion of who we are
"no-self" is achieved through meditation
Emptiness: Synonymous to no-self
The world is in constant change, nothing ever is, but nothing is not, either
Emptiness is in the middle, between two extremes
Moderation: Emptiness should not be conveyed as emptiness but in nonduality [not being two separate things]
Suchness: reality of our world without superimposing our own interpretations

There are slightly different ways in which object focused meditation can be done, but it is easier to do it as follows:

- do breath counting meditation to stabilize the mind as a prelude to moving the attention outward to the external object
- once the mind is calm and present, open your eyes and study the object
- observe every detail in a non-discursive way
- notice how light falls on the object - does it induce any changes in its texture or colour
- how sharp are the lines of its edges
- is the object's surface rough or smooth
- simply observe and refrain from putting labels on what you see

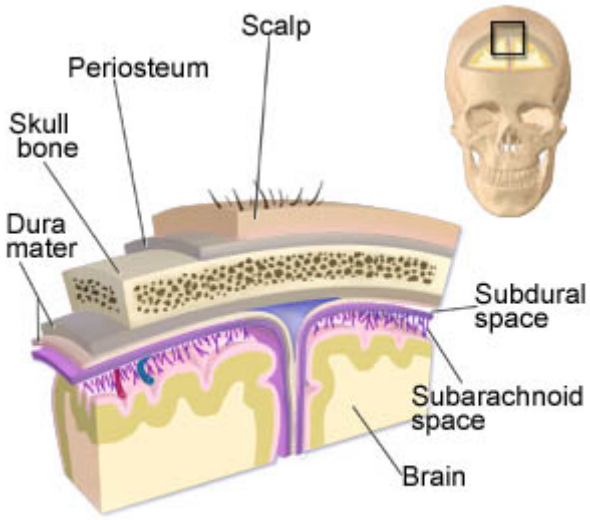
- See more at: http://www.do-meditation.com/object-focused-meditation.html#sthash.OWVMizBS.dpuf

EEG input

It is a non-invasive way to observe brain activity. EEG is based on measuring postsynaptic potentials of neurons with electrodes.

Those electrodes can be attached to the subject's scalp, subdurally (beneath the dura matter; the outermost, toughest and most fibrous of three membranes covering and protecting the brain and the spinal cord), or even on the cortex itself (these later two cases are relatively rare).

EEG potentials are measured as the difference between two points, one on the scalp where EEG effects are strong and one (the reference electrode) hopefully isolated from these effects.

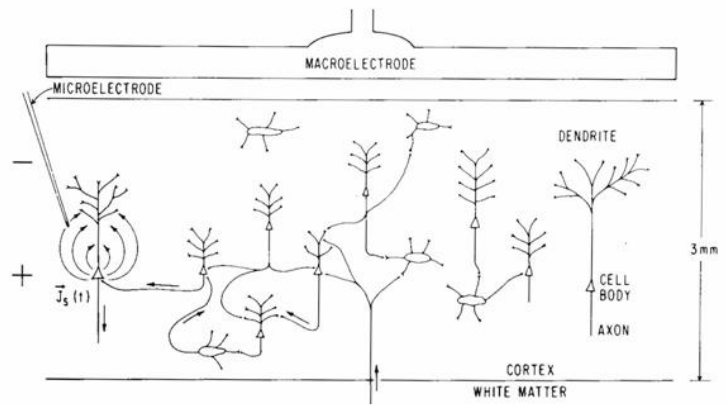


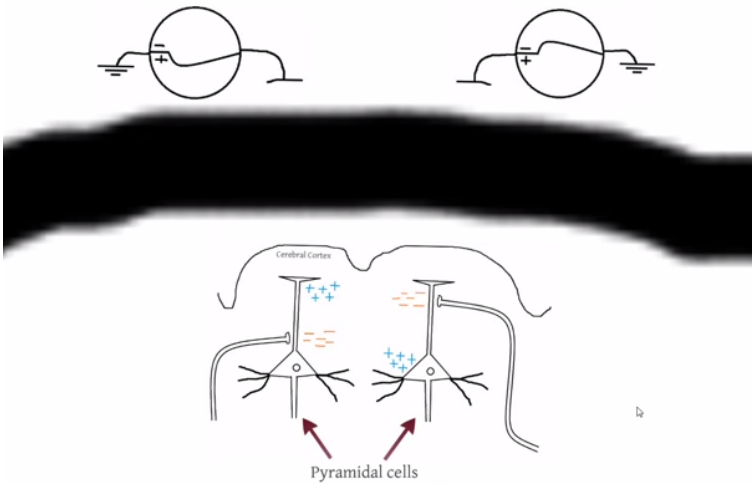
Layers covering the Brain

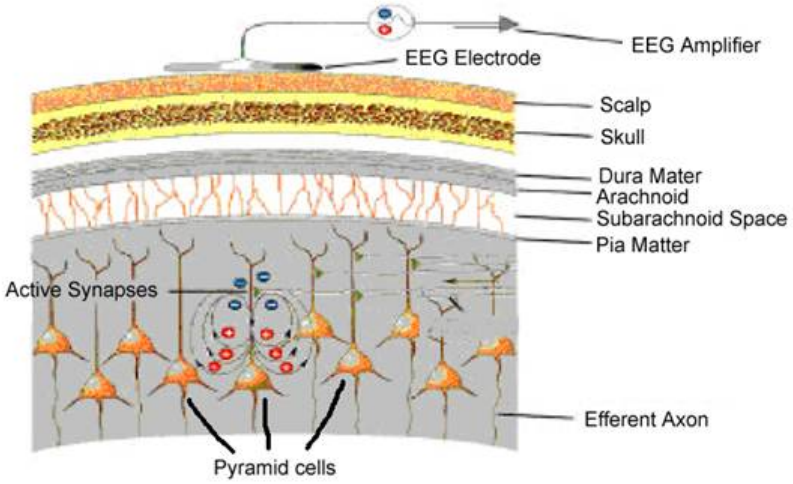
PHYSIC PRINCIPLE: This method is based on the theory of volume conduction of ionic current through non-empty extracellular space.

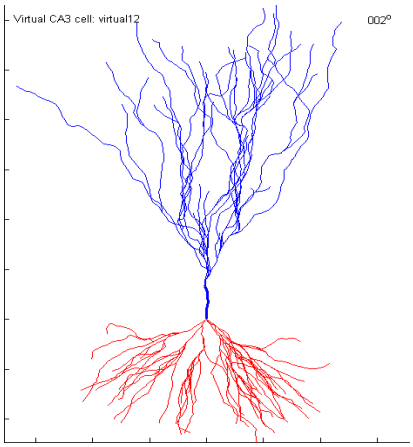
Electrodes measure the sum of the activity of all the neurons in the surface below them. Usually, a conductive gel is used to create a better contact.

EEG records voltage differences across low resistance extracellular space. Generally, it measures potentials of pyramidal cells because: They have strong enough potentials to be detectable (ex: neurons are asynchronous and too fast-moving to generate measurable signals), they are oriented in parallel and their dendrites run perpendicular to the cortical surface. Dipoles are created when a pyramidal cell in the cortex receives stimulation from surrounding neurons; the dipole results in a recordable electrical field or potential. Depending on the orientation of the combined dipoles, the potential recorded at the scalp is either positive or negative


MACROELECTRODE
MICROELECTRODE
DENDRITE
3mm
CELL BODY
AXON
CORTEX
WHITE MATTER

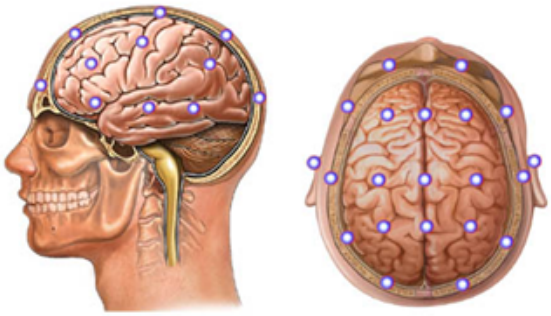

Cerebral Cortex
Pyramidal cells


EEG Amplifier
EEG Electrode
Scalp
Skull
Dura Mater
Arachnoid
Subarachnoid Space
Pia Matter
Active Synapses
Efferent Axon
Pyramid cells



Pyramidal cell

The machine records the signals and works as both an amplifier and as a galvanometer, and signals are amplified 10,000 times (the rapid drop in potential combined with the large resistance of the scalp, skull and cerebrospinal fluid surrounding the brain results in a measured scalp potential that is very small).



Points where electrodes are placed.

ADVANTAGES OF EEG:

- continuous recording with split second accuracy
- It indicates the general conscious state of a person, useful for measuring answer under a stimuli, assess brain damage or sleep research.

DISADVANTAGES OF EEG:

EEGs is limited in that they do not reveal brain structures or anatomy, nor can they indicate the functioning of specific brain structures.

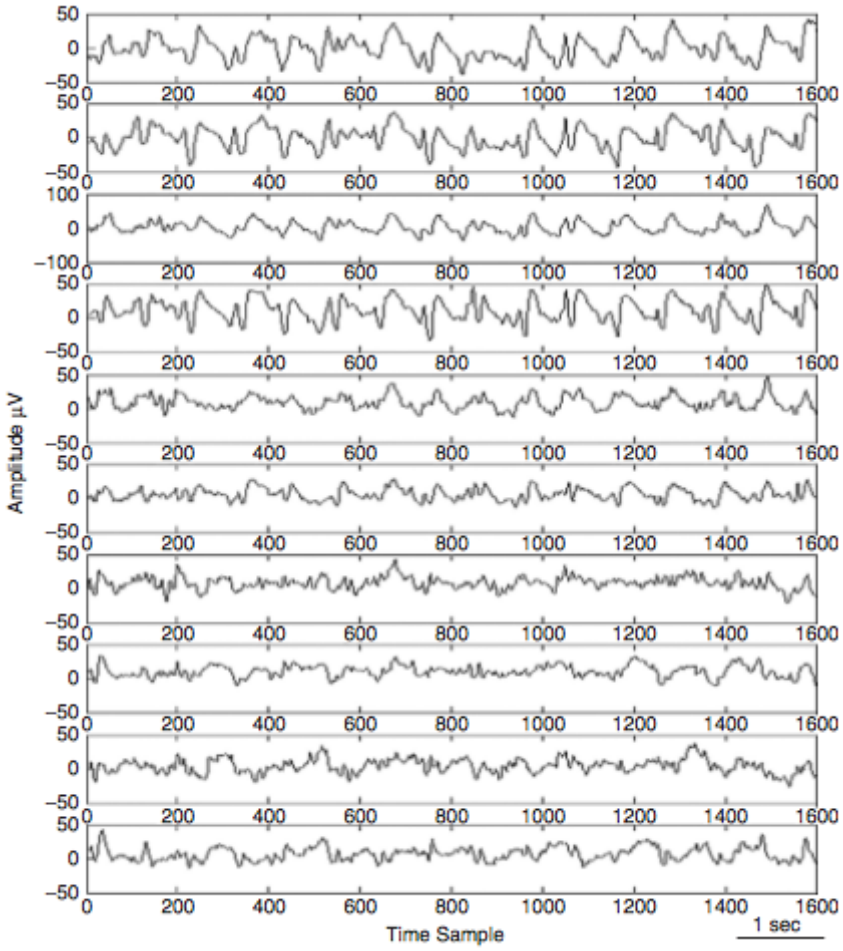
http://www.csulb.edu/~cwallis/482/eeg/eeg.html
https://www.youtube.com/watch?v=86zIa3pGM50
https://www.youtube.com/watch?v=YtbP8kITBZ0
http://www.psych.nmsu.edu/~jkroger/lab/EEG_Introduction.html

Other explanations just in case:

Galvanometers are instruments that detect and measure small electric currents by means of a copper hoop or coil of wire that deflects a needle proportionate to the current flowing through the coil. The galvanometers are in turn hooked up to pens, which trace the electrical signals on graph paper moving continuously underneath them.

EEG output

- **there is general info of brain waves in this link:**
  http://www.csulb.edu/~cwallis/482/eeg/eeg.html
- I've uploaded the textbook "EEG Signal Processing (Sanie, Chambers) to the Google Drive folder "Reference Material." It is a lengthy and thorough text. Below are the chapters to give you an idea of what is covered. I will skim it tomorrow and after we talk to Simpkins about his EEG code, we can focus on the relevant section(s).
  - Ch 1 - Introduction to EEG (p1)
  - Ch 2 - Fundamentals of EEG Signal Processing (p35)
  - Ch 3 - Event-Related Potentials (p127)
  - Ch 4 - Seizure Signal Analysis (p161)
  - Ch 5 - EEG Source Localization (p197)
  - Ch 6 - Sleep EEG (p219)
  - Ch 7 - Brain-Computer Interfacing (p239)
- Typical EEG signal in adult (EEG signal Processing, Sanei, p18)

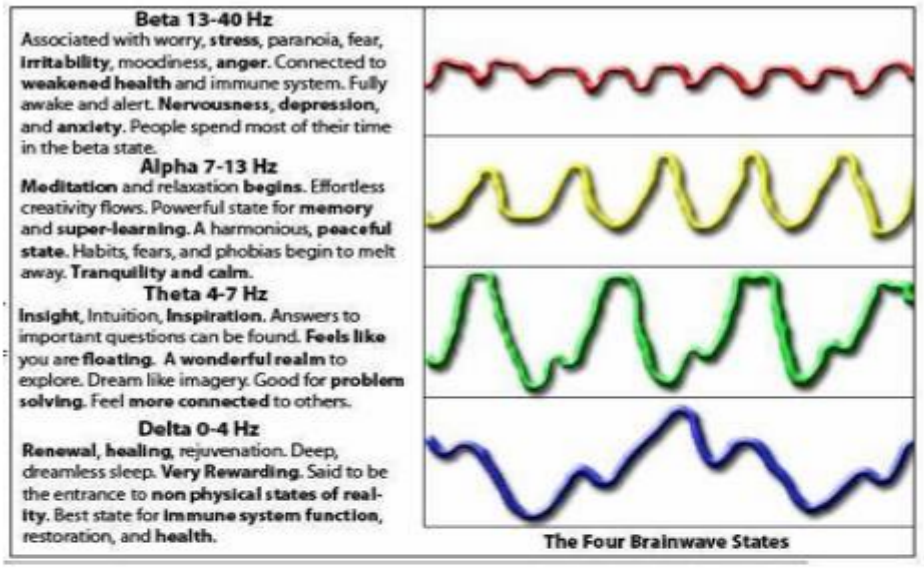


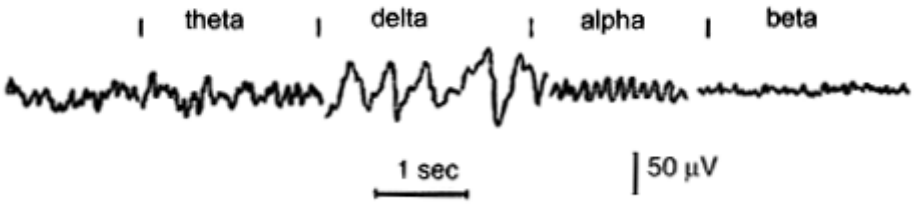
  -
- From skimming over textbook and graphs (and talking with Prof May-Newman) it seems we will be able to extract signal amplitude and frequency

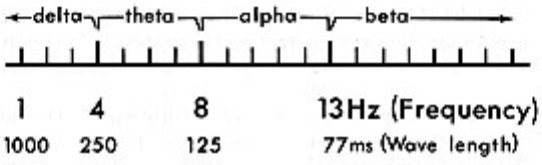
Brain waves (during meditation)

Alpha Brain Waves (I believe these are the ones we will focus on)

- 8-12 Hz
- This brain wave indicates a relaxed state of mind.. State of relaxed alertness, good for inspiration and learning facts fast. A meditative mind. In this state tap into internal "antenna" like qualities. Visions, powerful ideas, mindless creation of the incredible. Internal feeling & sensations.







Theta Brain Waves (We might be interested in these... It looks like these waves land in the unconscious/subconscious realm so maybe they don't apply to what we want.)

- 4 to 8 cycles per second Deep meditation. Deep inward thought. This is associated with life-like imagination. High state of mental concentration. A magical mind. Internal pictures / visualisation. Intuition, inner guidance. Access to unconscious material. Dreaming.

4.5 Hz - Brings about Shamanic/Tibetan state of consciousness, Tibetan chants.
4.9 Hz - Induce relaxation and deeper sleep
4.9 Hz - Introspection. Relaxation, meditation
5 Hz - Reduces sleep required. Theta replaces need for extensive dreaming
5.35 Hz - Allows relaxing breathing, free and efficient

5.5 Hz - Inner guidance, intuition
6.5 Hz - Centre of Theta frequency. Activates creative frontal lobe
7.5 Hz - Activates creative thought for art, invention, music. Problem solving
7.5 Hz - Ease of overcoming troublesome issues
7.83 Hz - Schumann earth resonance. Grounding, **meditative, Leaves you revitalized**
3 - 8 Hz - Deep relaxation, **meditation**. Lucid dreaming
3 - 8 Hz - Increased memory, focus, creativity
4 - 7 Hz - Profound inner peace, emotional healing. Lowers mental fatigue
4 - 7 Hz - Deep meditation, near-sleep brainwaves

Prototype (concepts)

I came across this. It's a 3d printed led ball. We could program the ball to stay still and have the lights do cool stuff. http://imgur.com/a/xwP0I

Choosing a visual object as your object of meditation.
For the purpose of taming the mind, it is best to pick a neutral object – one that you don't have strong opinions about and one that does not arouse strong emotion. (We'll talk below on different kinds of visible objects.) A rock, a flower or a candle would be fine – not a picture of a loved one or an enemy. Take your meditation posture with the object in front of you. It will be most comfortable for you if the object is slightly below the horizontal plane of your eyes. (If the object is above the horizontal plane, you may find yourself tipping your head back to see the object, and developing a neck tension as a result.)
https://badlamaguide.wordpress.com/2012/09/10/meditating-on-visual-objects/

Colors for Relaxation
Blue: calming, sedative effect, and can actually cause the body to become cooler.
Green: said to lessen depression, anxiety, and nervousness by soothing and refreshing.
Purple: can be very relaxing depending on tone; lighter is better.
Avoid reds, oranges and yellow.
http://stress.lovetoknow.com/Colors_for_Relaxation

Attention

Definition

http://www-psych.stanford.edu/~ashas/Cognition%20Textbook/chapter3.pdf

Throughout life, we are bombarded by an overwhelming amount of perceptual information; the party is simply a highly dramatic example of what's going on all the time. Our information-processing capacity cannot make sense of the constant input from many sources all at once
In the context of human information processing, attention is the process that, at a given moment, enhances some information and inhibits other information. The enhancement enables us to select some information for further processing, and the inhibition enables us to set some information aside
Although we have an intuitive idea of what attention is, this term is not fully defined, and it causes difficulties to design and carry out studies.

Many factors have an influence attention.

Diseases

Chronic Stress Disrupts the Brain's Ability to Shift Attention
http://www.dana.org/News/Details.aspx?id=42911

Effects of Attention and Emotion on Face Processing in the Human Brain
http://www.cell.com/neuron/abstract/S0896-6273(01)00328-2?cc=y

Meditation and attention

In a meditation sense, attention is taking possession by the mind in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. We can accomplish many things in life through better use of attention
Concentration means being interested and involved in something. Through meditation exercises we learn to control concentration, applicable in other tasks.
There are two types of meditation; outer meditation, focusing and something external not only through visualization but with all ours senses, and inner meditation, which requires a higher control of thoughts.

Role of color meditation

http://www.exploremeditation.com/favorite-color/

Jordan Lenoir
12/13/2014

EEG and Meditation Research

SOURCE: Travis, F., & Shear, J. Focused attention, open monitoring and automatic self-transcending: Categories to organize meditations from Vedic, Buddhist and Chinese traditions. Consciousness and Cognition (2010), doi:10.1016/j.concog.2010.01.007.

Cognitive processing and EEG frequency bands

- Gamma bands (30-50 Hz)
  - object recognition
  - construction of content of experience
  - can be confused with EMG
- Beta2 (20-30 Hz)
  - focused executive processing
- Beta1 (13-20 Hz)
  - integration of visual and auditory information
  - unity of meditation experience
- Alpha (8-12 Hz)
  - cortical idling for simple *sensorimotor* tasks
  - alpha activity in *association* cortices (frontal alpha) for internally directed attention (imagining tune v. hearing it)
- Alpha1 (8-10 Hz)
  - index level of internalized attention, alertness and expectancy
  - frontal alpha1 meditation that transcends its own activity
- Alpha2 (10-12 Hz)
  - posterior alpha2 meditation that involve sitting with eyes-closed (classical cortical idling)
- Theta (4-8 Hz)
  - frontal midline theta originates in medial prefrontal and anterior cingulate cortices
  - neural index of monitoring inner processes
  - tasks with self control, internal timing, assessment of reward, working memory tasks
  - expected in meditation that involves monitoring of ongoing experience without high levels of control or manipulation
- Delta (1-4 Hz)
  - 1 Hz is slow wave sleep

EEG patterns during different meditation processes

- Focused attention
    - voluntary sustained attention is focused on a given object, and attention is brought back to the object of attention when the mind has wandered
    - EEG Band
        - Gamma (30-50 Hz)
        - Beta2 (20-30 Hz)
- Open monitoring
    - non-reactive monitoring of the content of ongoing experience, primarily as a means to become reflectively aware of the nature of emotional and cognitive patterns
    - dispassionate, non evaluative awareness of ongoing experience
    - EEG Band
        - Theta (5-8 Hz)
- Automatic self-transcending
    - Automatic transcending of the procedures of the meditation practice
    - Minimal cognitive control
    - Transcendal Meditation (TM) can be superficially described as as thinking or repeating a mantra—a word without meaning—and going back to it when it is forgotten… however, the matra is appreciated at “finer” levels and becomes increasingly secondary until it disappears and self awareness becomes primary
    - EEG Band
        - Alpha1 (8-10 Hz)

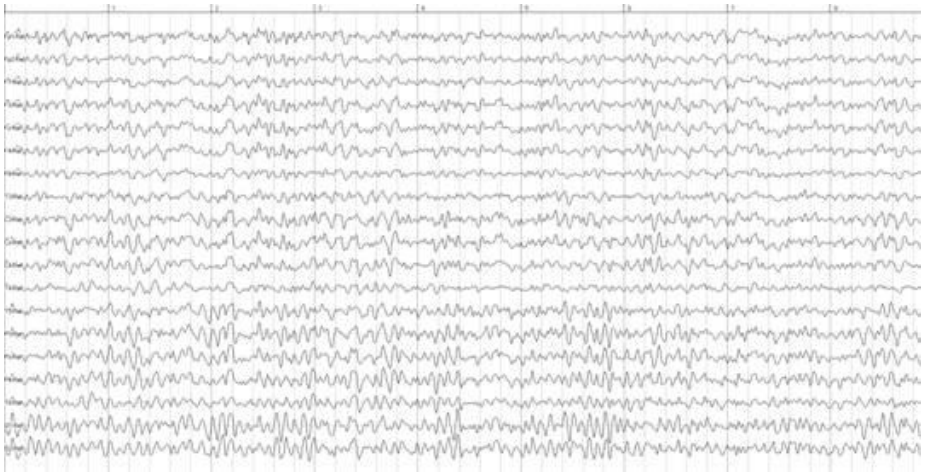
Conclusion

(Copied directly from article).
Each of the three meditation-categories—focused attention, open monitoring and automatic self-transcending— included different meditation practices with different degrees of attention control, different degree of subject/object relations, and different procedures. Each category appears orthogonal to the others, and together they appear to reflect the wide range of possible meditation practices. These explicit differences between meditation techniques need to be respected when researching physiological patterns or clinical outcomes of meditation practices. If they are averaged together, then the resulting phenomenological, physiological, and clinical profiles cannot be meaningfully interpreted. Attention to these differences in meditation practices will clarify the results gained from researching the power of meditation practices to enhance development of mind and body.

ELECTROENCEPHALOGRAPHY (EEG)

Electrocardiogram: Background

An ECG is a Non-invasive method to record electrical activity from billions of excited neurons in the brain along the scalp. An electrode/s is attached to the forehead which picks up electrical potential from the brain and is referenced to a grounded electrode attached away from the brain. At this point analog data of voltage potential vs time is attainable. An example of this kind of data is given here:



In order to be able to use EEG data to figure out whether or not the user is meditating, one must filter the data in order to interpret the state of mind of that person. This is done by the following steps:

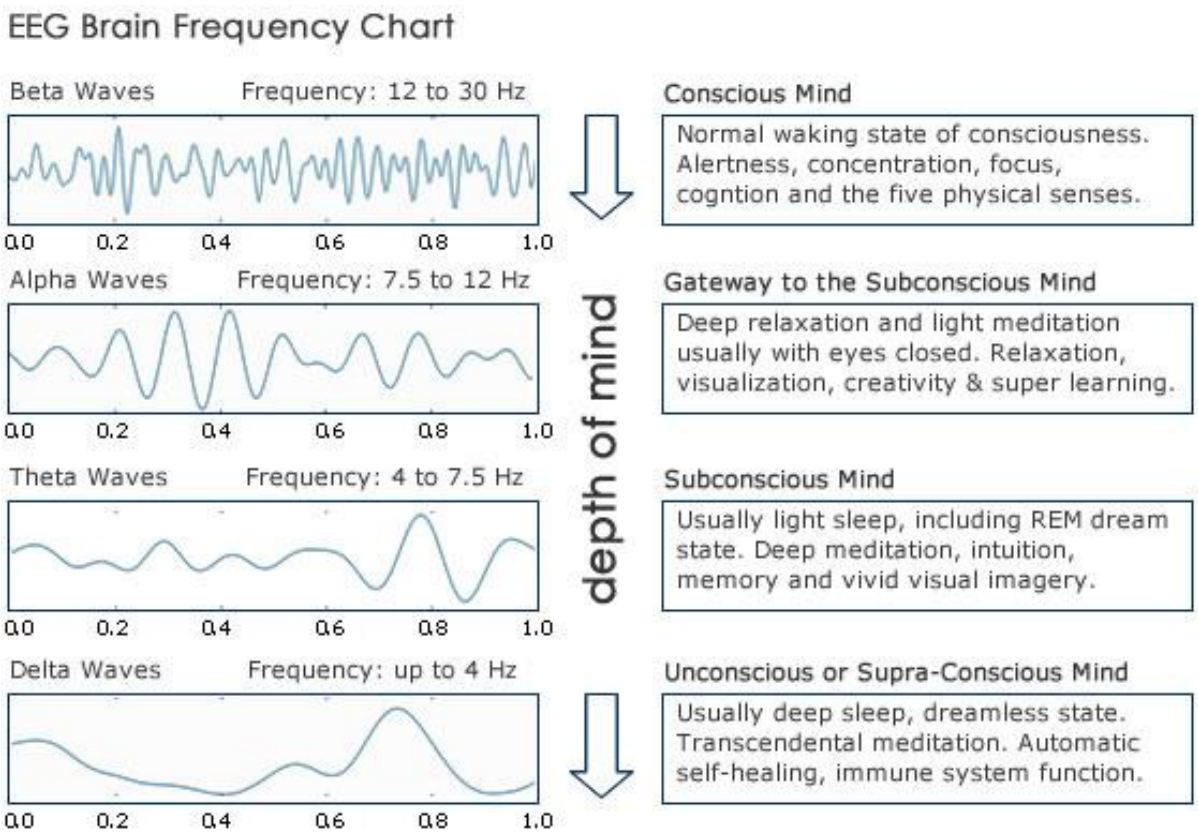
1. Epoching: cutting the data into sets
2. Filtering: highpass, lowpass, bandpass
3. Artifact Detection/Rejection: eliminates signals picked up from blinking, muscle activity, etc.
4. Averaging: calculating mean value for each time point across all sets

All these levels of processing require the understanding of high level math and programming. The outcome of this is to attain the different values of brain waves. Not all of us had a lot of hands on EEG data processing but read about it for background knowledge. A lot information that we attained was from:

http://classes.engineering.wustl.edu/ese497/images/2/20/EEG_Book.pdf

We were able to use that if we ever stuck on some EEG process that we needed to understand. From that, having brain wave information makes it possible to diagnose what is happening in the brain. As mentioned before, for example by knowing if beta brain waves are prominent gives a clear indication that that person is in the meditative state.

An example of brain wave data is given here:

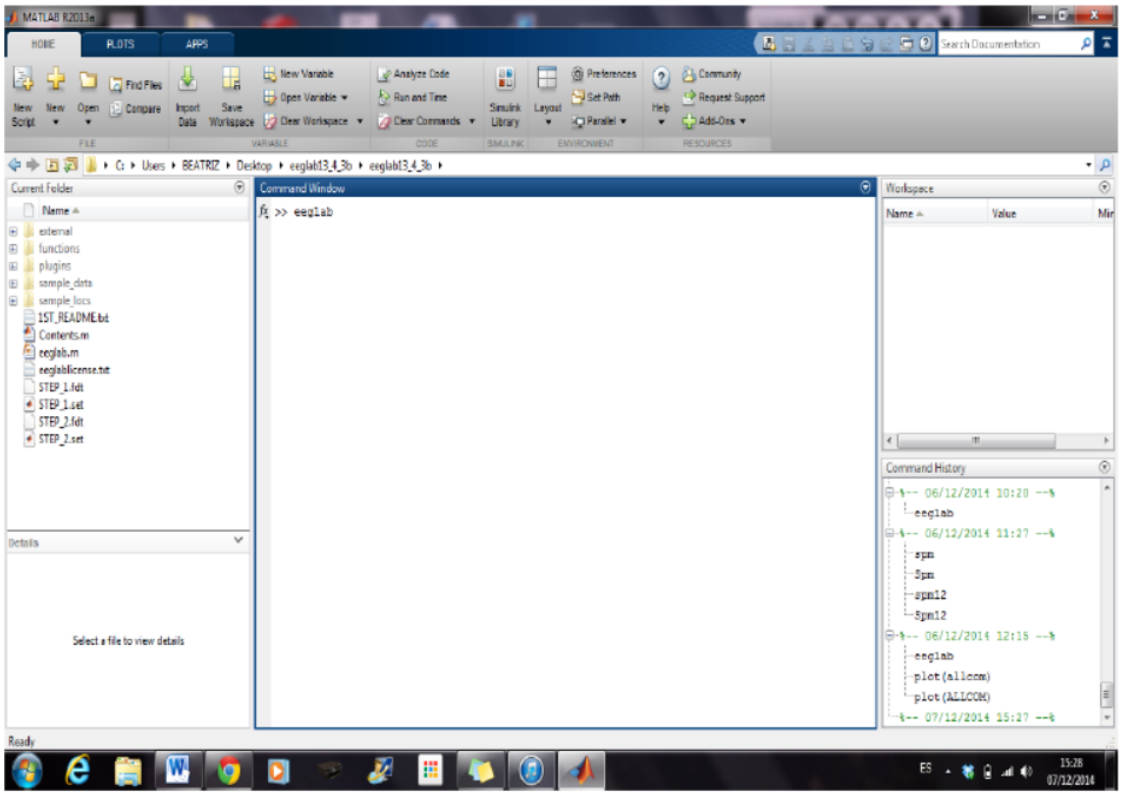


SIGNAL PROCESSING

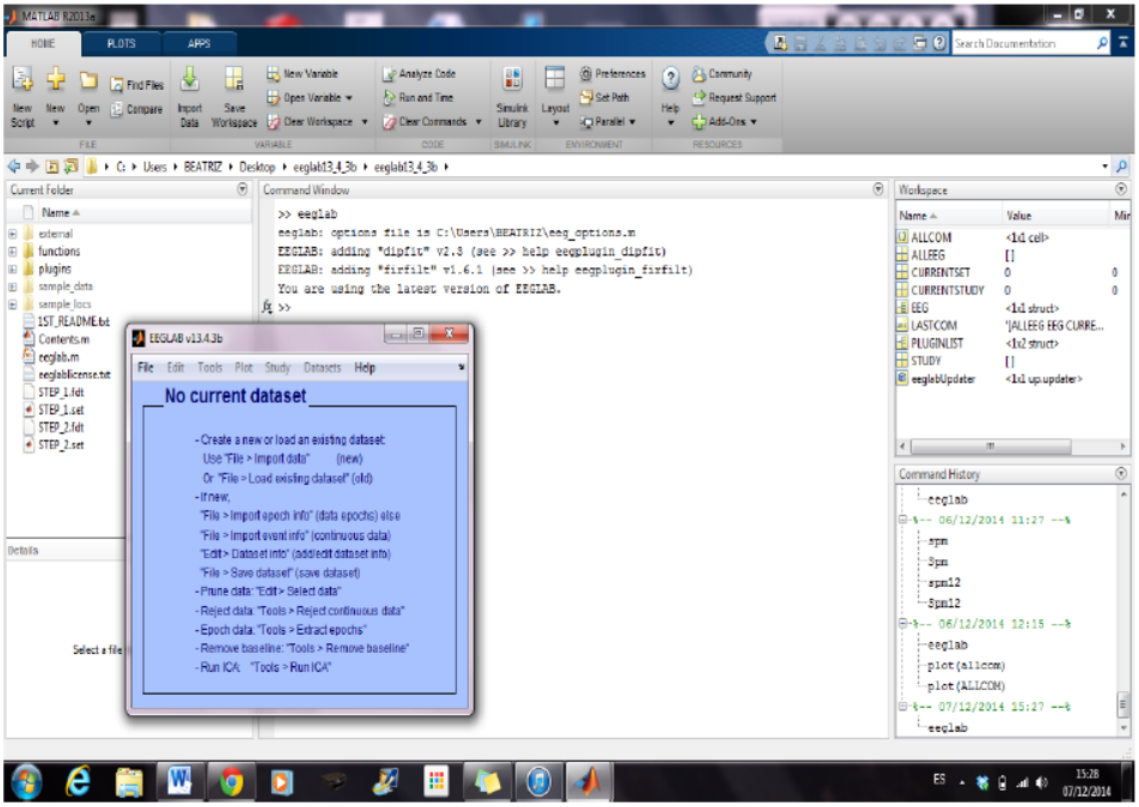
Potential signal processing procedure per the following guide: Pre-processing for EEG and MEG by Przemek Tomalski & Kathrin Cohen Kadosh.

Some experimental runs where performed to get familiar with the processing process, depicted below.

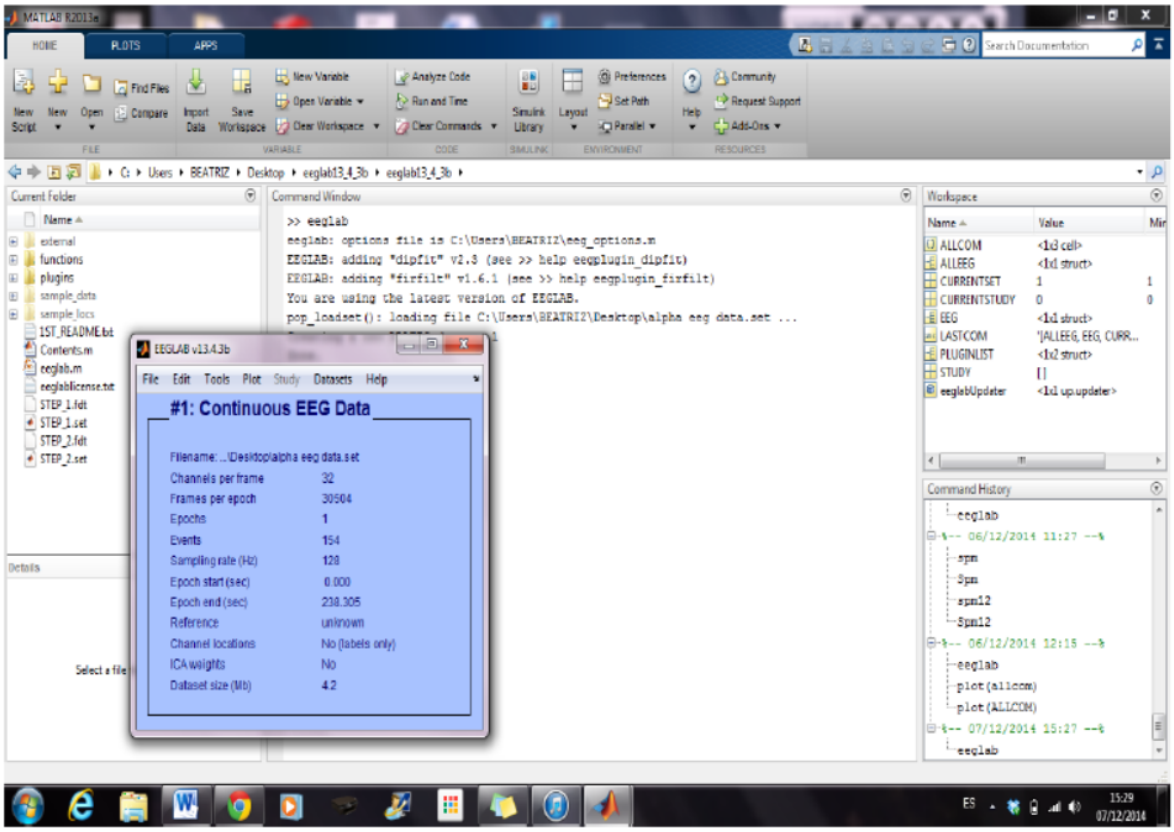
eeglab(matlab) images on how to process raw EEG data through Epoching



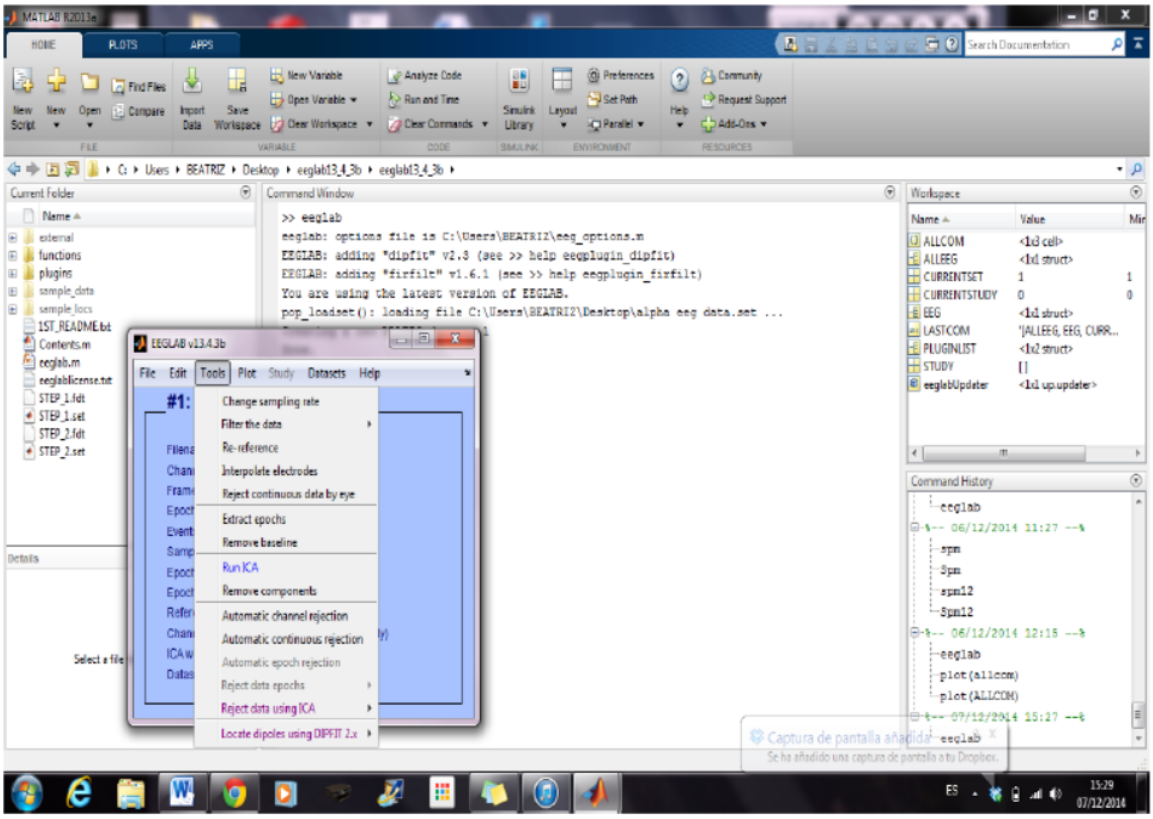
eeglab(matlab) images on how to process raw EEG data through Epoching



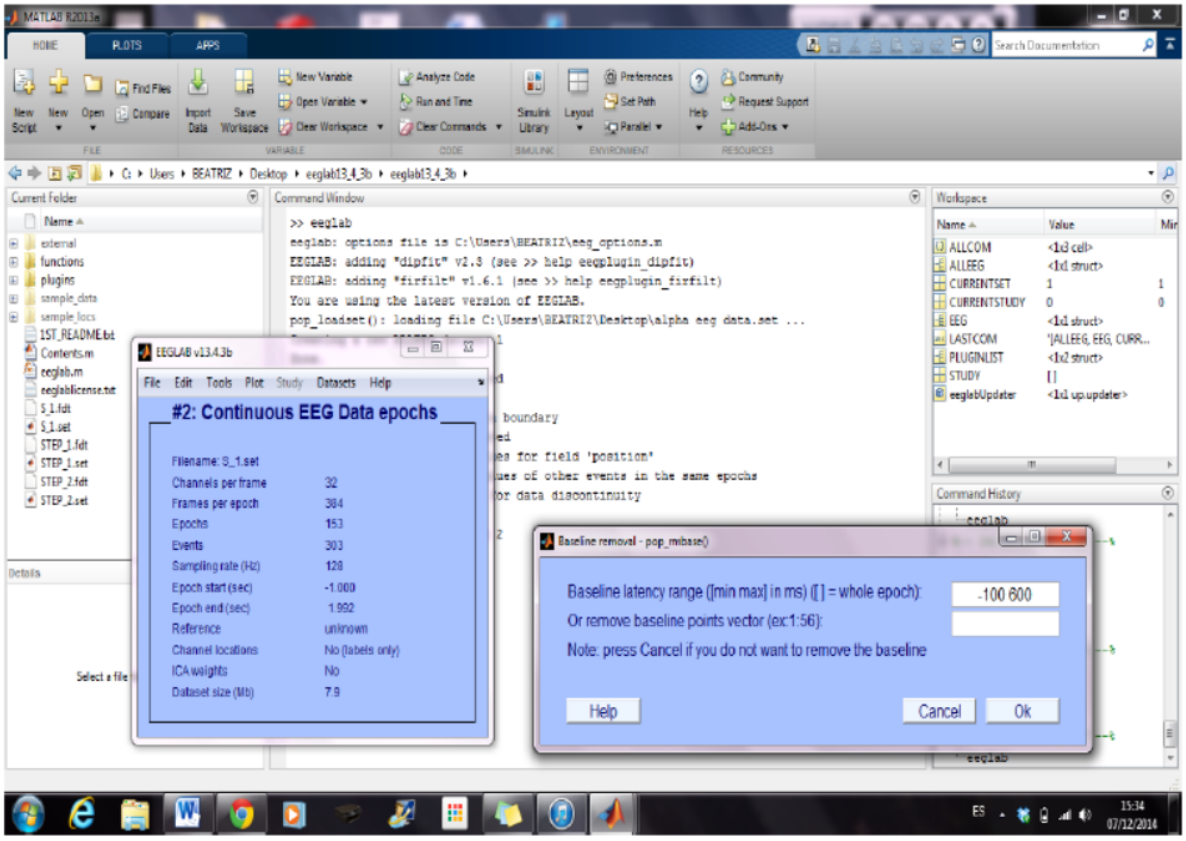
eeglab(matlab) images on how to process raw EEG data through Epoching



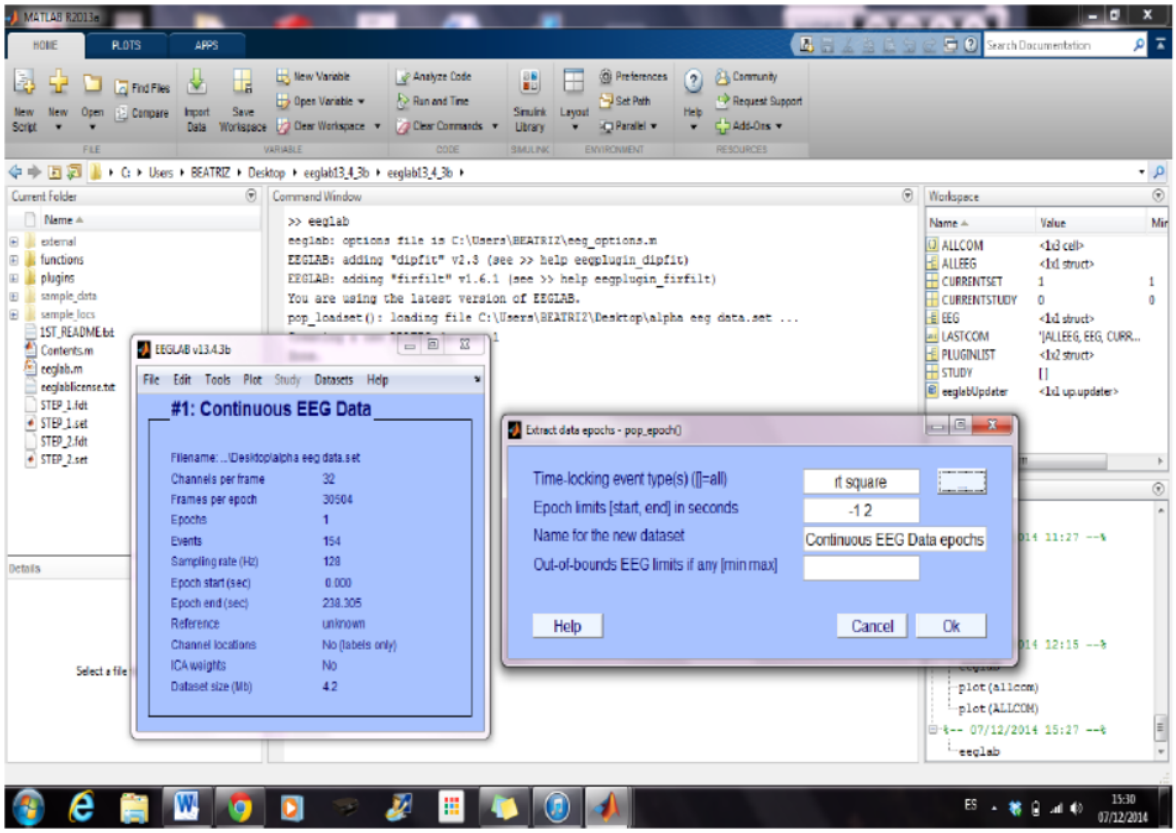
eeglab(matlab) images on how to process raw EEG data through Epoching



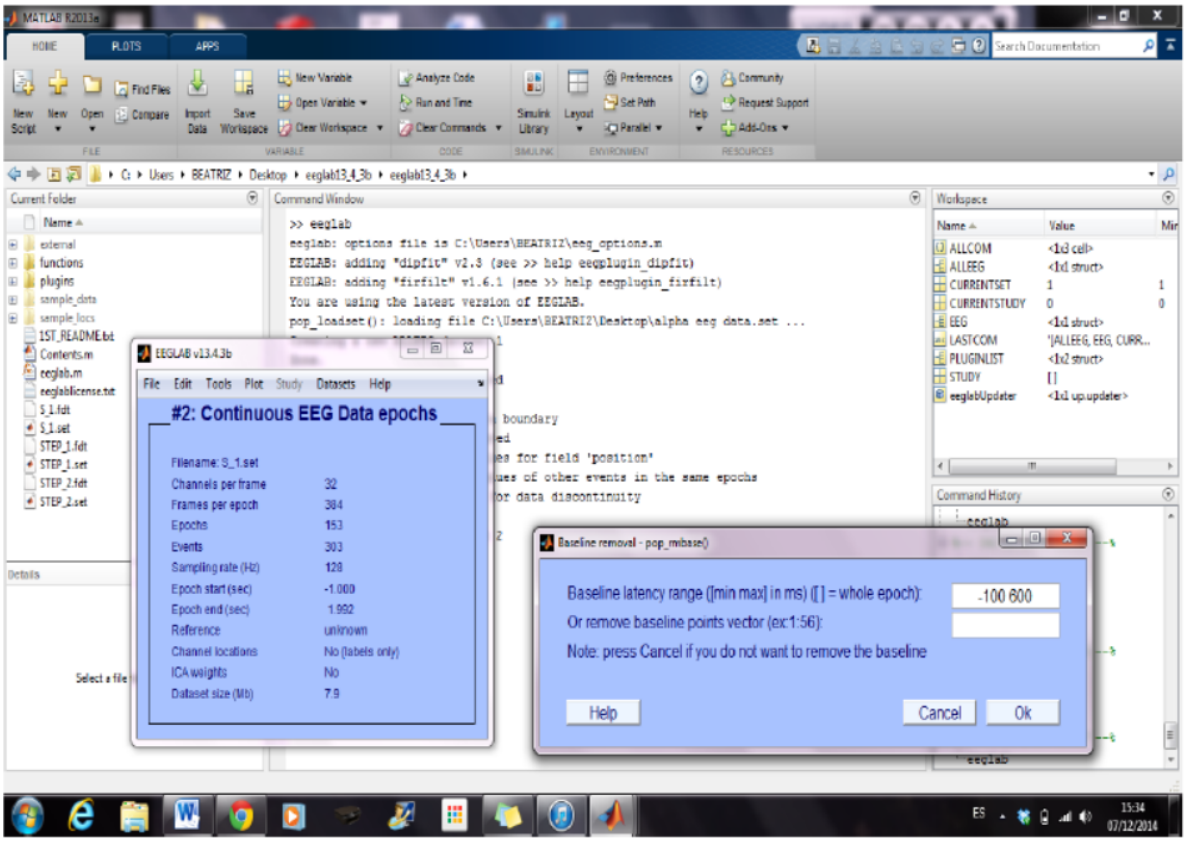
eeglab(matlab) images on how to process raw EEG data through Epoching



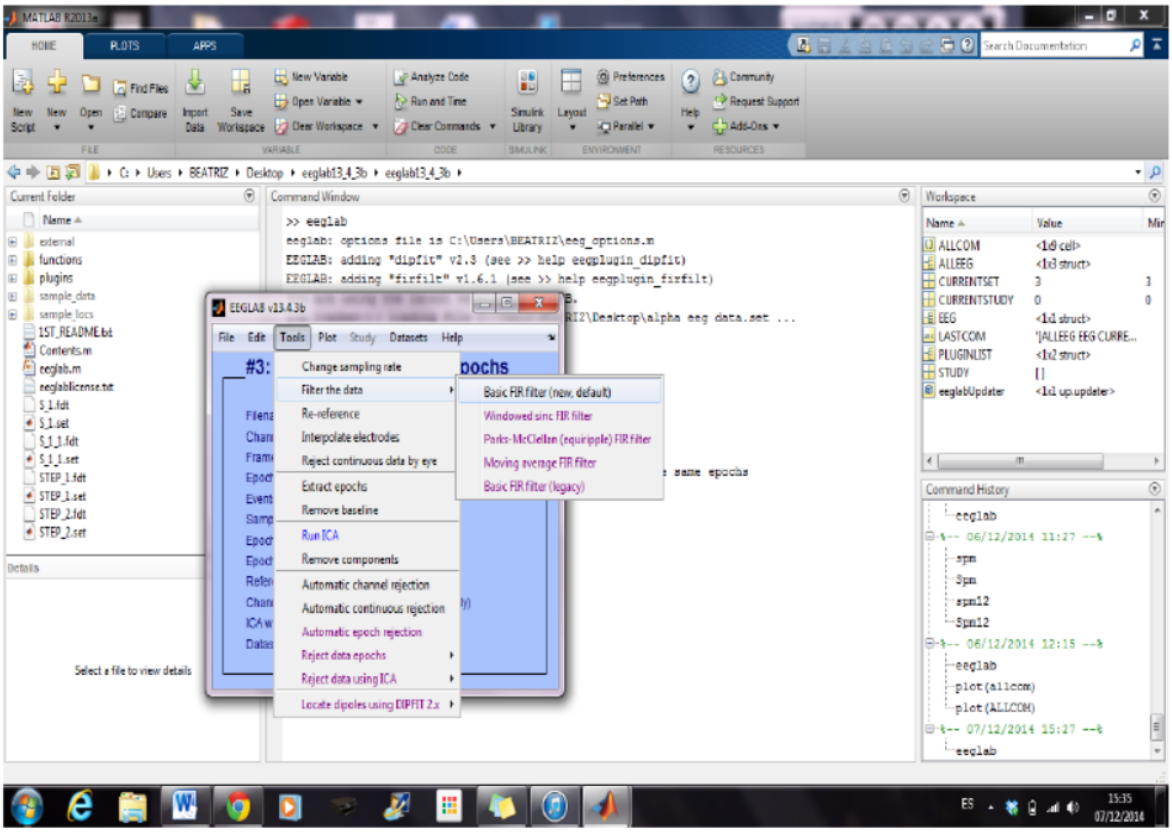
eeglab(matlab) images on how to process raw EEG data through Epoching



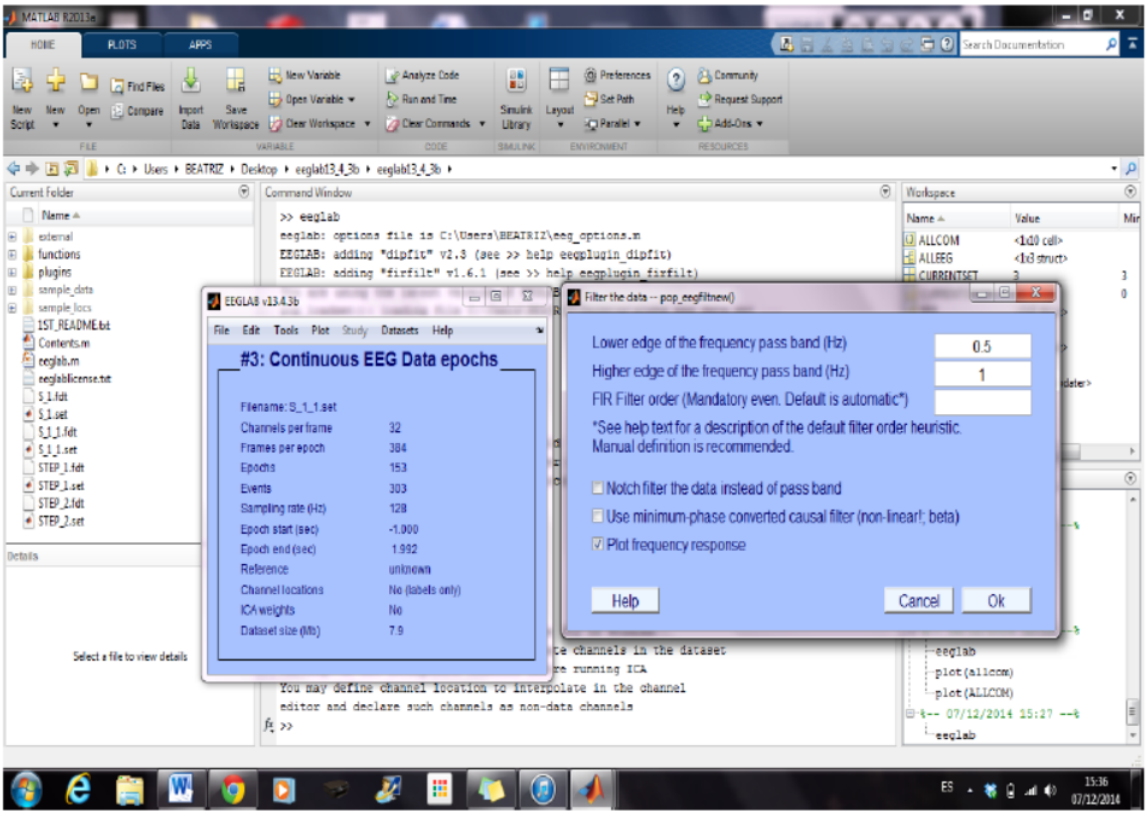
eeglab(matlab) images on how to process raw EEG data through Epoching



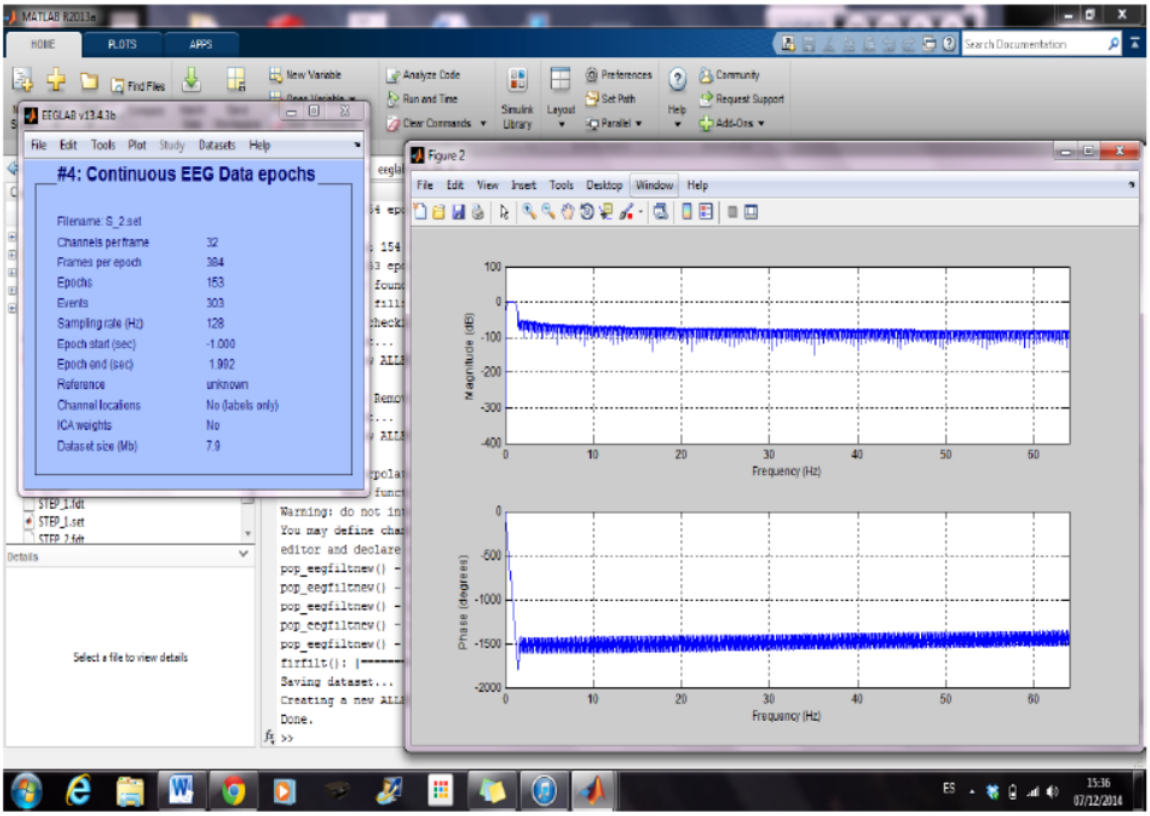
eeglab(matlab) images on how to process raw EEG data through Epoching



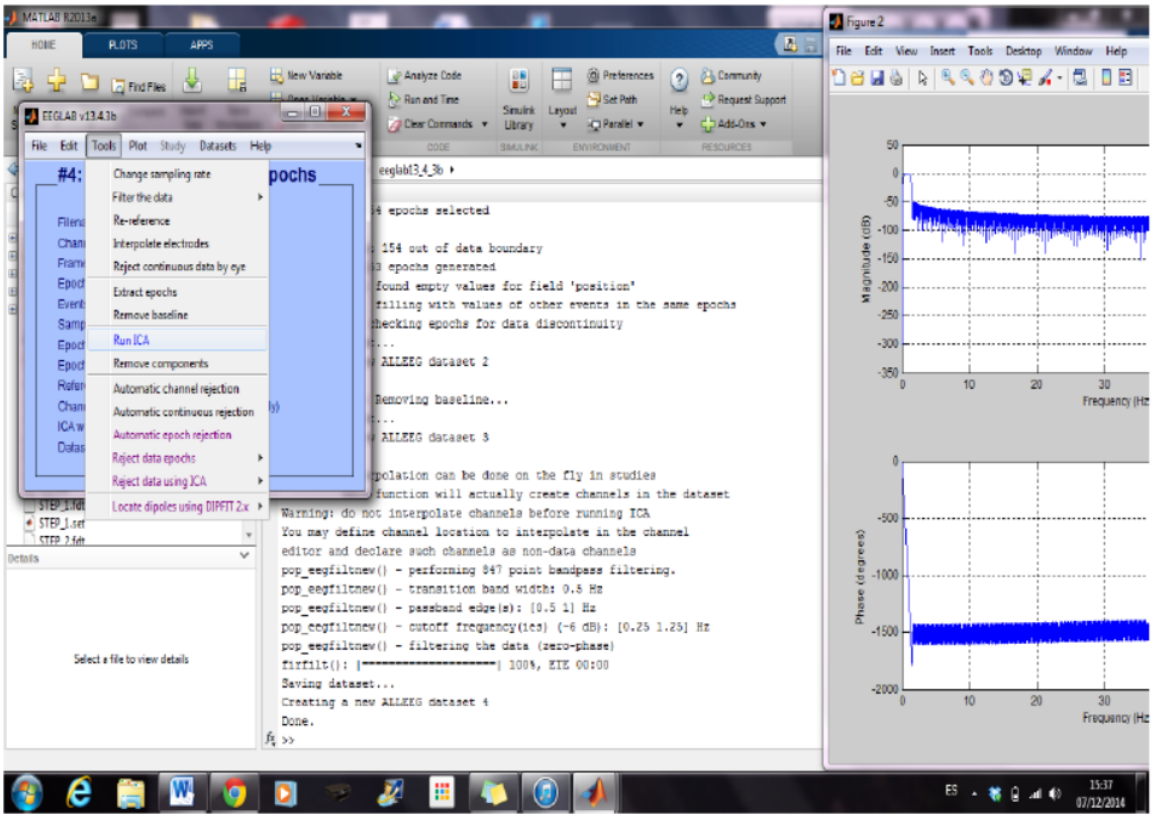
eeglab(matlab) images on how to process raw EEG data through Epoching



eeglab(matlab) images on how to process raw EEG data through Epoching



eeglab(matlab) images on how to process raw EEG data through Epoching



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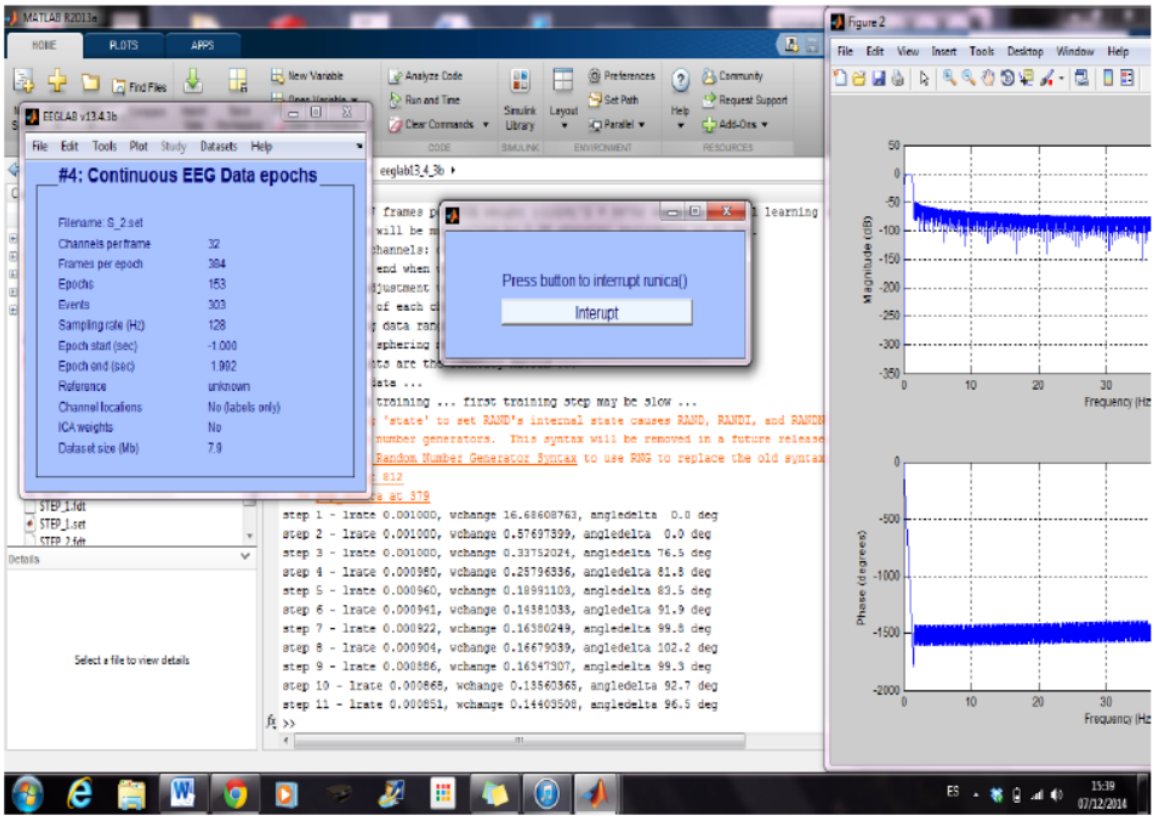
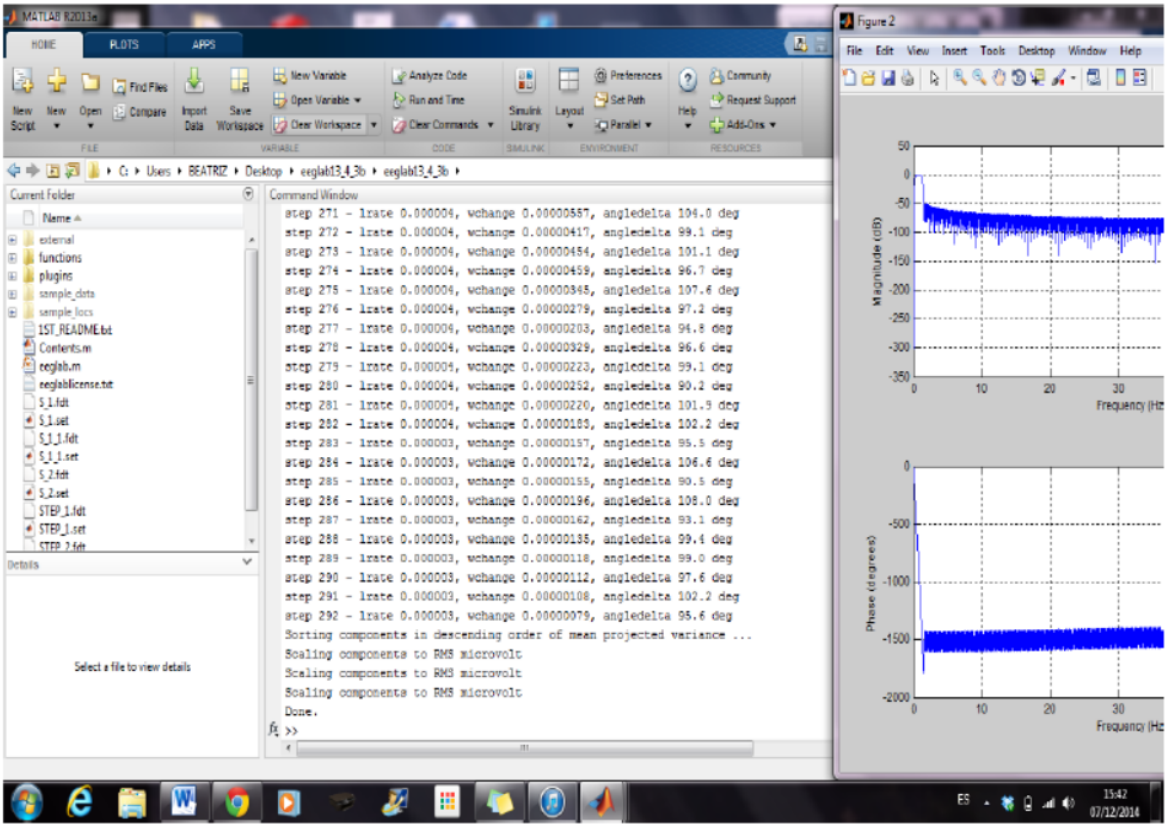


eeglab(matlab) images on how to process raw EEG data through Epoching



EEG MACHINE SELECTION

EEG headset: Neurosky Mindwave Mobile

The headset used for this project is the Mindwave Mobile from Neurosky. It is a one channel Bluetooth headset. The image and specifications of the headset are given here:

Dimensions

- Size: 2.79cm x 1.52cm x 0.25cm
- Weight (Max) 130mg

Specifications

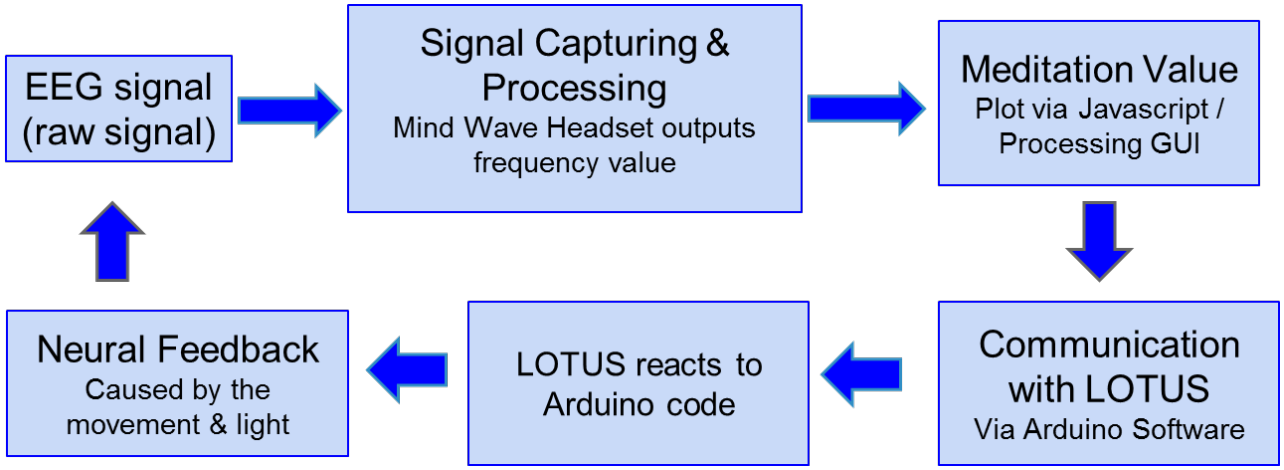
- 512Hz sampling rate
- 3-100Hz frequency range
- ESD Protection: 4kV Contact Discharge; 8kV Air
- Max Power Consumption: 15mA @ 3.3V • Operating voltage 2.97 ~3.63V
- UART (Serial):
- – 1200, 9600, 57600 baud
- – 8-bits
- – No parity
- 1 stop bit

The reason because we went with this headset was because it was reliable and the headset itself helped with a lot of the needed data processing. This headset has an integrated chip, called the thinkgear chip, where it is able to process all of the needed filtering. From there it is able to send data one of two ways. One way is by getting the value of all the different brain waves. You can set when every so often the headset will send you digital data of brainwaves. Another way is by getting an eSense value. An eSense value is a digital value from 1 to 100 that determines whether or not you are in the meditative state or attention state. The way the value works is that from 40-60 is the baseline value, anything below that means decreased activity in that state and anything above that means increased activity from that state. The headset does this by running the brain wave data through an algorithm Neurosky developed

that is within the thinkgear chipset. In terms of what that algorithm is exactly is somewhat unknown. We have tried to contact Neurosky in order to get the specifications of that algorithm but had no luck. Overall the headset has been working fine and it is robust enough to perform all functions needed for the project.

PROGRAMMING

The data analysis process and programming is illustrated in the following flow chart:



Meditation Value

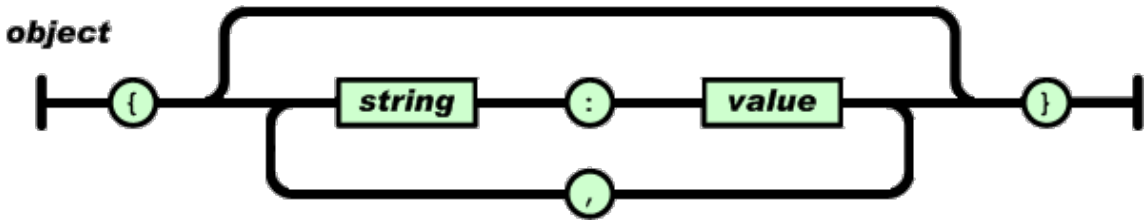
The communication between the EEG headset and computer was done via socket communication. The ThinkGear Communication driver was given by the headset manufacture to aid in the development of applications for the headset. The ThinkGear communication took care of the bluetooth communication and rerouted all the output from the headset in a JSON object via IP socket protocols. All of the code was done in Processing, a program that allows for easy GUI creation as well as easy access to Arduino. Processing uses a form of javascript language as its code.

In order to connect to the headset, a socket had to be opened at the IP address : 127.0.0.1

```
// Connect to ThinkGear socket (default = 127.0.0.1:13854)
        String thinkgearHost = "127.0.0.1";
        int thinkgearPort = 13854;

        String envHost = System.getenv("THINKGEAR_HOST");
        if (envHost != null) {
        thinkgearHost = envHost;
        }
        String envPort = System.getenv("THINKGEAR_PORT");
        if (envPort != null) {
        thinkgearPort = Integer.parseInt(envPort);
        }
        println("Connecting to host = " + thinkgearHost + ", port = " + thinkgearPort);
        myClient = new Client(this, thinkgearHost, thinkgearPort);
        String command = "{\"enableRawOutput\": false, \"format\": \"Json\"}\n";
        print("Sending command");
        println (command);
        myClient.write(command);
```

Once the connection had been established, the EEG would send the data in a JSON object. JSON stand for javascript object notation. It is a simple way to send an array of information.



This is an example of how the data is received:

```
// Sample JSON data:

//{"eSense":{"attention":91,"meditation":41},"eegPower":{"delta":1105014,"theta":211310,"lowAlpha
":7730,"highAlpha":68568,"lowBeta":12949,"highBeta":47455,"lowGamma":55770,"highGamma":282
47},"poorSignalLevel":0}
```

The data then had to be split between each of the different channels. This is done by parsing the JSON object.

```
String data = myClient.readString();
        try {
        JSONObject json = new JSONObject(data); //<>//

        channels[0].addDataPoint(Integer.parseInt(json.getString("poorSignalLevel")));

        JSONObject esense = json.getJSONObject("eSense");
        if (esense != null) {
        channels[1].addDataPoint(Integer.parseInt(esense.getString("attention")));
        channels[2].addDataPoint(Integer.parseInt(esense.getString("meditation")))
        }

        JSONObject eegPower = json.getJSONObject("eegPower");
        if (eegPower != null) {
        channels[3].addDataPoint(Integer.parseInt(eegPower.getString("delta")));
        channels[4].addDataPoint(Integer.parseInt(eegPower.getString("theta")));
        channels[5].addDataPoint(Integer.parseInt(eegPower.getString("lowAlpha")));
        channels[6].addDataPoint(Integer.parseInt(eegPower.getString("highAlpha")));
        channels[7].addDataPoint(Integer.parseInt(eegPower.getString("lowBeta")));
        channels[8].addDataPoint(Integer.parseInt(eegPower.getString("highBeta")));
        channels[9].addDataPoint(Integer.parseInt(eegPower.getString("lowGamma")));
        channels[10].addDataPoint(Integer.parseInt(eegPower.getString("highGamma")));
```

The data we were interested was in
:channels[2].addDataPoint(Integer.parseInt(esense.getString("meditation")))

This channel gave us the Mediation score given off by the Mindwave.

That meditation score was then added to an array so that the average can be calculated.

```
    ● //Set up the average
    ●           storedValues = new float[500];
void AddNewValue(float val)

{

 if(count < storedValues.length)

 {

        //array is not full yet

        storedValues[count++] = val;


        sum += val;

 } else

 {      sum += val;

        sum -= storedValues[0];


        //shift all of the values, drop the first one (oldest)

        for(int i = 0; i < storedValues.length-1; i++)

        {

        storedValues[i] = storedValues[i+1] ;

        }

        //the add the new one

        storedValues[storedValues.length-1] = val;

 }
```

That score was then converted from a float to an integer and sent to the Arduino via serial.

```
        int med = int(ave);

        myPort.write(med);
```

The Arduino then reads this score and executes programmed sequences dependent on value.

In conclusion, the software worked for the purposes of this project. It took some time to learn the basics of javascript but once the overall concept of how it worked was understood it was easy to make the software work.

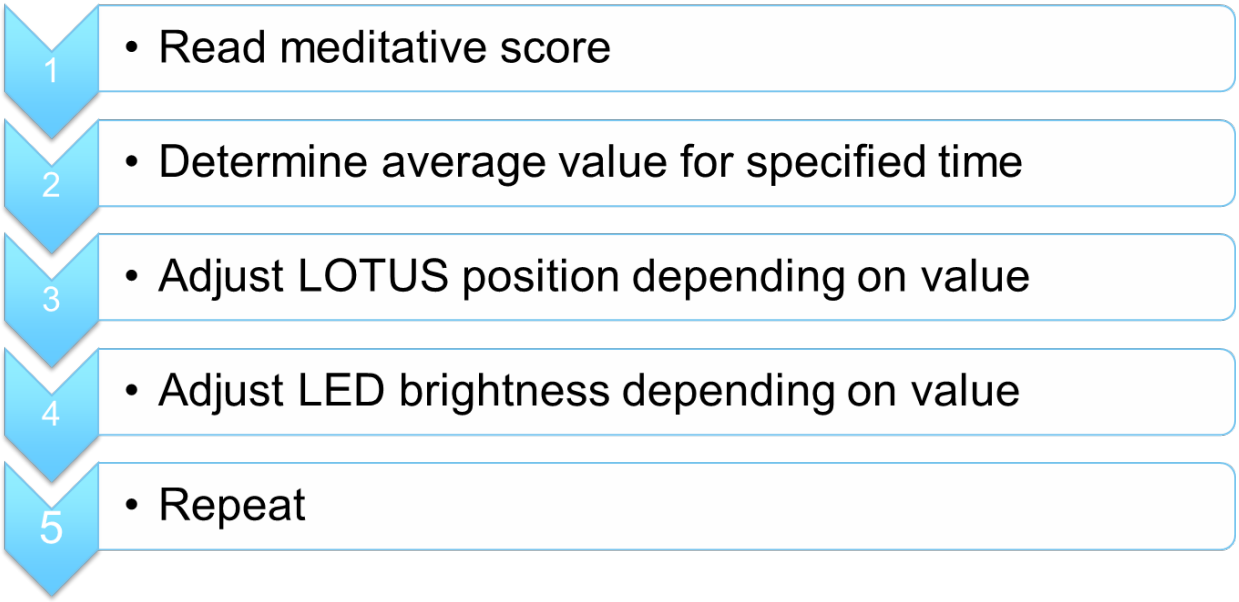
Communication with Lotus

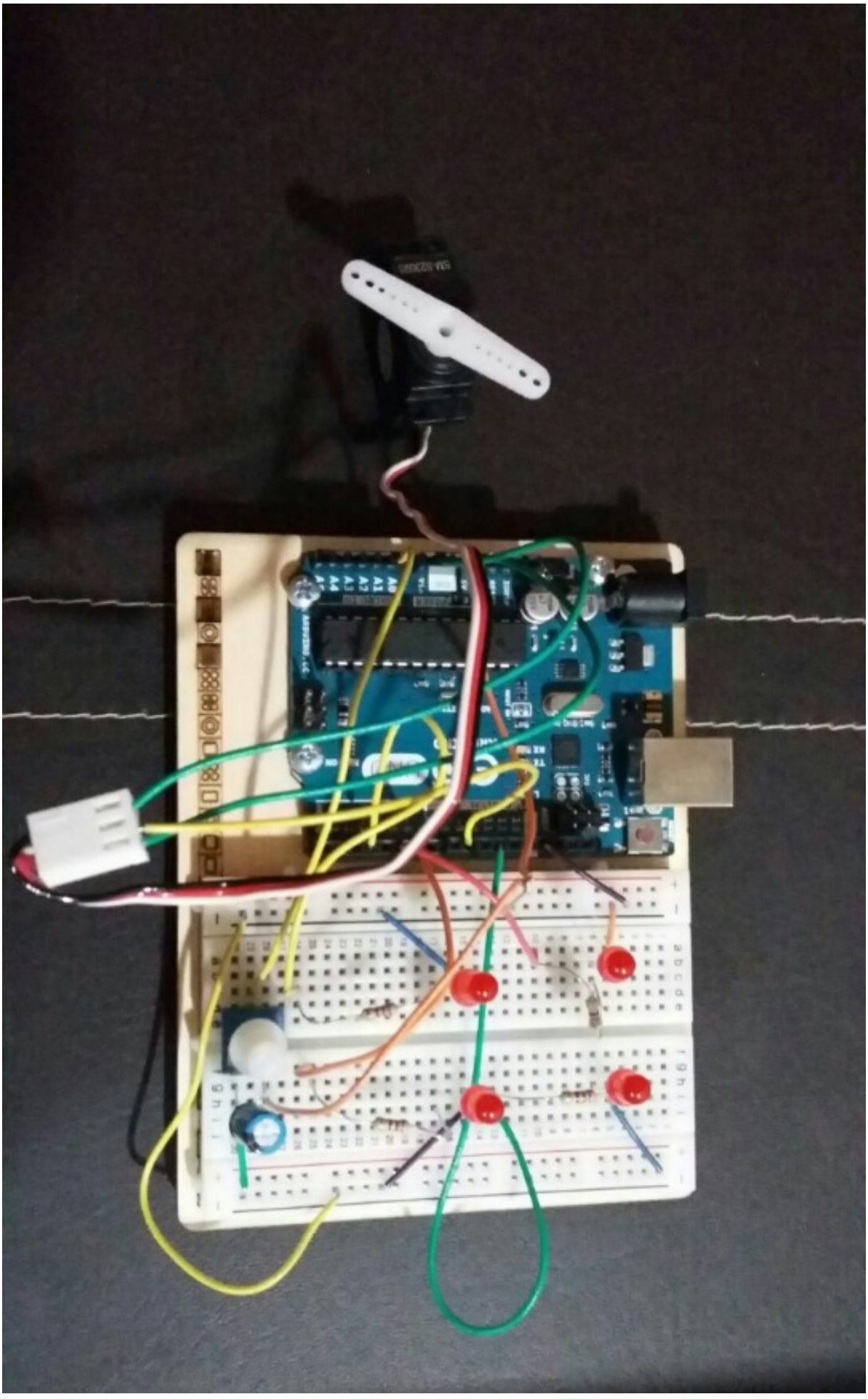
The Arduino software was used to program the flower's movement and lighting. The following logic was used:

IF: user remains in meditative state for specified time

THEN: servo rotates specified degrees (opening lotus) and brightness of LEDs increases using PWM

ELSE: servo (hence the LOTUS) remains in current position





```
// Title: led_1_brightness
//SERVO STUFF
#include <Servo.h>
Servo   myservo;// create servo object to control a servo
                // a maximum of eight servo objects can be created
//LED fade

int ledPin = 3;//the Arduino pin that is connected to the LEDint ledPin2 =
5;//the Arduino pin that is connected to the LED #2 int ledPin3 = 6;//the
Arduino pin that is connected to the LED #2 int ledPin4 = 11;//the Arduino
pin that is connected to the LED #2 int MinValue = 0;int MaxValue = 0;int
DelayTime = 3000;int pos = 0;// variable to store the servo positionint
MinServo = 0;int MaxServo = 0;int IntervalServo = 0;int DelayBetween =
5000;int IntervalLED = 0;

void setup()                    {
  pinMode(ledPin, OUTPUT);// initialize the pin as an output
  pinMode(ledPin2, OUTPUT);// initialize the pin as an output
  pinMode(ledPin3, OUTPUT);// initialize the pin as an output
  pinMode(ledPin4, OUTPUT);// initialize the pin as an output
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}
void loop() {
  //SERVO TRIAL
 myservo.write(pos);
  //SETTING 1
// tell servo to go to position in variable 'pos'
MinValue = 1;
MaxValue = 4;
IntervalLED = (MaxValue-MinValue)/3;
IntervalServo = 20/(MaxValue-MinValue);
for (pos = 0; pos < 21; pos +=IntervalTimer){
            myservo.write(pos);              // move servo
MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
```

```
  delay(DelayBetween);// wait one second
//SETTING 2

  MinValue = 4;
  MaxValue = 9;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 21; pos < 41; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 3

  MinValue = 9;
  MaxValue = 15;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 41; pos < 61; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

  analogWrite(ledPin,brightness);
  analogWrite(ledPin2,brightness);
  analogWrite(ledPin3,brightness);
  analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 4

  MinValue = 15;
  MaxValue = 22;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 61; pos < 81; pos ++){
            myservo.write(pos);
```

```
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 5

  MinValue = 22;
  MaxValue = 30;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 81; pos < 101; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

  analogWrite(ledPin,brightness);
  analogWrite(ledPin2,brightness);
  analogWrite(ledPin3,brightness);
  analogWrite(ledPin4,brightness);
    }
  delay(DelayTime/20);
}
delay(DelayBetween);// wait one second
//SETTING 6

  MinValue = 30;
  MaxValue = 42;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 101; pos < 121; pos ++){
            myservo.write(pos);           // move servo
MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
```

```
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 7

  MinValue = 42;
  MaxValue = 70;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 121; pos < 141; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 8

  MinValue = 71;
  MaxValue = 140;
  IntervalLED = (MaxValue-MinValue)/20;
for (pos = 141; pos < 161; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
  }
  delay(DelayBetween);// wait one second
//SETTING 9

  MinValue = 140;
  MaxValue = 255;
  IntervalLED = (MaxValue-MinValue)/20;
```

```
for (pos = 161; pos < 1811; pos ++){
            myservo.write(pos);
// move servo

MaxValue =round(MinValue + IntervalLED);for (int
brightness=MinValue;brightness<MaxValue;brightness++){

    analogWrite(ledPin,brightness);
    analogWrite(ledPin2,brightness);
    analogWrite(ledPin3,brightness);
    analogWrite(ledPin4,brightness);
      }
    delay(DelayTime/20);
}

  delay(DelayBetween);// wait one second
}
```

```
// Title: move_motor_n_degs
// MOVE HOW MANY DEGREES
int deg = 1;// CHANGE TO ANY NUMBER int pos = 0;// Initial position

#include <Servo.h>
Servo   myservo;// create servo object to control a servo
                // a maximum of eight servo objects can be created
//LED fade

int ledPin = 3;//OLD CODEint ledPin2 = 5;//OLD CODEint ledPin3 = 6;//OLD
CODEint ledPin4 = 11;//OLD CODEint MinValue = 0;//OLD CODEint MaxValue =
0;//OLD CODEint DelayTime = 3000;//OLD CODE int MinServo = 0;//OLD CODEint
MaxServo = 0;//OLD CODEint IntervalServo = 0;//OLD CODE int DelayBetween =
5000;//OLD CODE int IntervalLED = 0;//OLD CODE

void setup()                    {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
  pinMode(ledPin, OUTPUT); // OLD CODE
  pinMode(ledPin2, OUTPUT); // OLD CODE
  pinMode(ledPin3, OUTPUT); // OLD CODE
  pinMode(ledPin4, OUTPUT); // OLD CODE
}
void loop() {
 myservo.write(pos);              // tell servo to go to position in
variable 'pos'
for (pos = 0; pos < 180; pos +=deg){
            myservo.write(pos);           // move servo
}

myservo.detach();
}
delay(300000/180*deg);
```

```
// Title: Lotus_Mind_Arduino_code
#include <Servo.h>
Servo   myservo;// create servo object to control a servo
char val;// Data received from the serial portint ledPin1 = 3;//the Arduino
pin that is connected to the LED #1 int ledPin2 = 5;//the Arduino pin that
is connected to the LED #2 int ledPin3 = 6;//the Arduino pin that is
connected to the LED #3 int ledPin4 = 11;//the Arduino pin that is
connected to the LED #4

int pwm = 0;// PWM signal for LEDint deg = 0;// degress to turn motorint
pwm_old = 0;// previous brightness int deg_old = 0;// previous servo
position

int time_180 = 5000;//time (in ms) to open LOTUS completelyint time_LED =
5000;//time (in ms) for LED to reach maximum bightness int time_loop =
1000;//time (in ms) in between loops

int val_old = 80;// value to beat for LOTUS to move (initially 80)

int val_histeresis = 1;// difference from old value to move LOTUS

 void setup() {
  pinMode(ledPin1, OUTPUT);// initialize the pin as an output
  pinMode(ledPin2, OUTPUT);// initialize the pin as an output
  pinMode(ledPin3, OUTPUT);// initialize the pin as an output
  pinMode(ledPin4, OUTPUT);// initialize the pin as an output
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
 }
 void loop() {
   pwm_old = pwm;
   deg_old = deg;
   val_old = val + val_histeresis;
   if (Serial.available())
    {// If data is available to read,
val =Serial.read(); // read it and store it in val }

if(val >= val_old)
{
   pwm_old = pwm;
   deg_old = deg;
pwm =map(val,79,100,0,255);

deg =map(val,79,100,0,180); analogWrite(pwm,3);for (int pos = deg_old; pos
< deg; pos++){

Serial.begin(9600)
} }
```

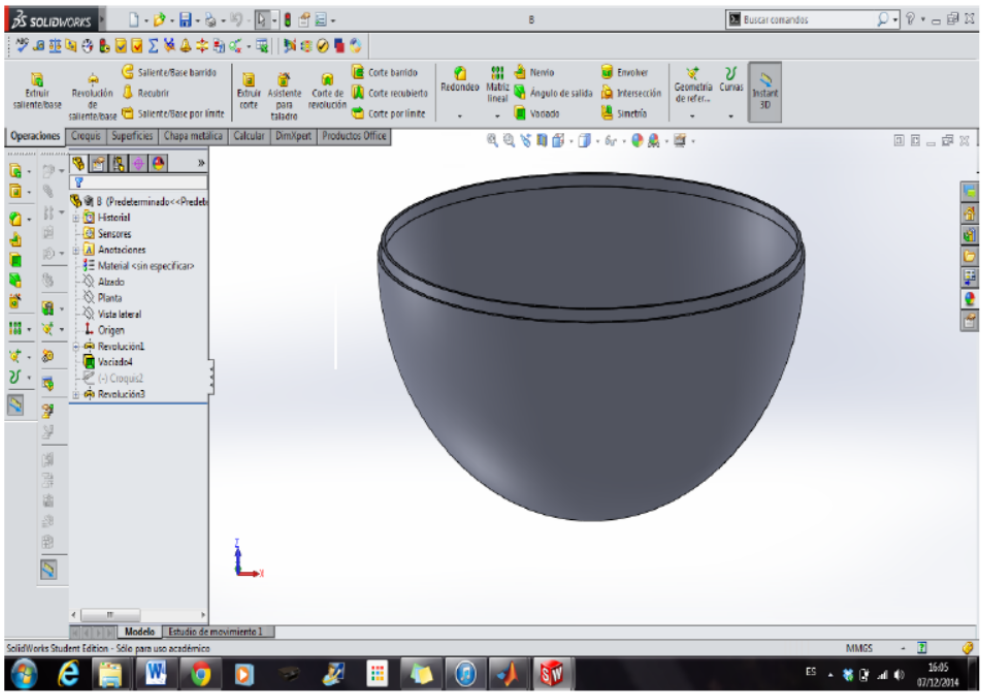
```
          myservo.write(pos);           // move servo
          delay(10000/180);
}
 for (int brightness = pwm_old; brightness < pwm; brightness++){
delay(time_loop);
}
analogWrite(ledPin1,
analogWrite(ledPin2,
analogWrite(ledPin3,
analogWrite(ledPin4,
delay(10000/255);
brightness);// increase brightness LED #1
brightness);// increase brightness LED #2
brightness);// increase brightness LED #3
brightness);// increase brightness LED #4
```

DESIGN

INITIAL DESIGN IDEA

At the end of the Fall 2014 semester, the design was an orb. The orb would have LEDs protruding from it that would light up with different intensities and colors depending on the user's state of mind. A solidworks model was started for that design but, as seen in a later section, the design was later changed completely. Below is half of what the orb would have looked like.

SOLIDWORKS Images of a meditation orb



ACTUAL DESIGN OF THE PARTS

The design of the Lotus was decided in two steps. First, we tried different possible mechanisms and configurations for our flower. Once we decided the best system for the Lotus, we adapted the size to the power limitations of the servo and the assumptions that were made for the movement of the mechanism.

Two options were explored for the mechanism connected to the servo that was to move the flower; the rack & pinion and the piston. In addition, two possible designs to move the petals were tested; the "pull-push" system and the linkage mechanism.

For the "pull-push" mechanism entails six sticks with curved ends that link the petals to the central pole. When the central pole raises vertically, the sticks push the petals up and they close. When it goes down, it pulls the petals and opens them.

On the other hand, the linkage mechanism is a simple system of links that opens the flower when the central pole lifts.

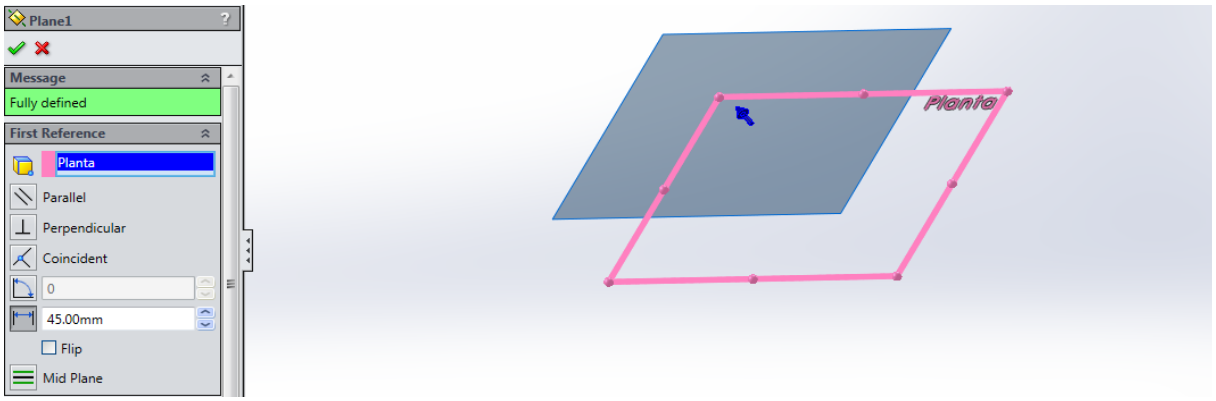
Initial configurations

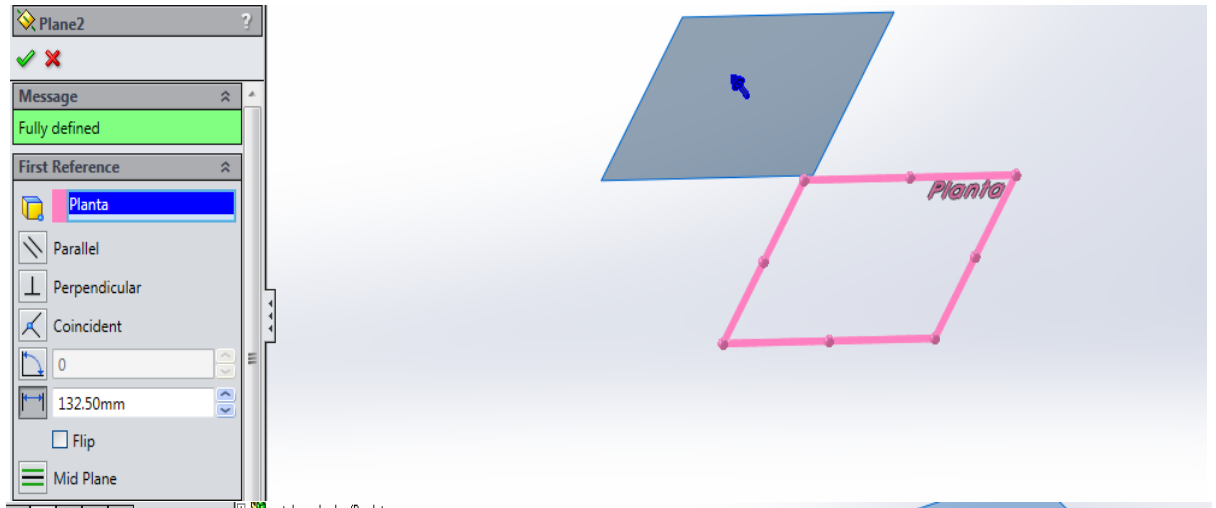
PETAL

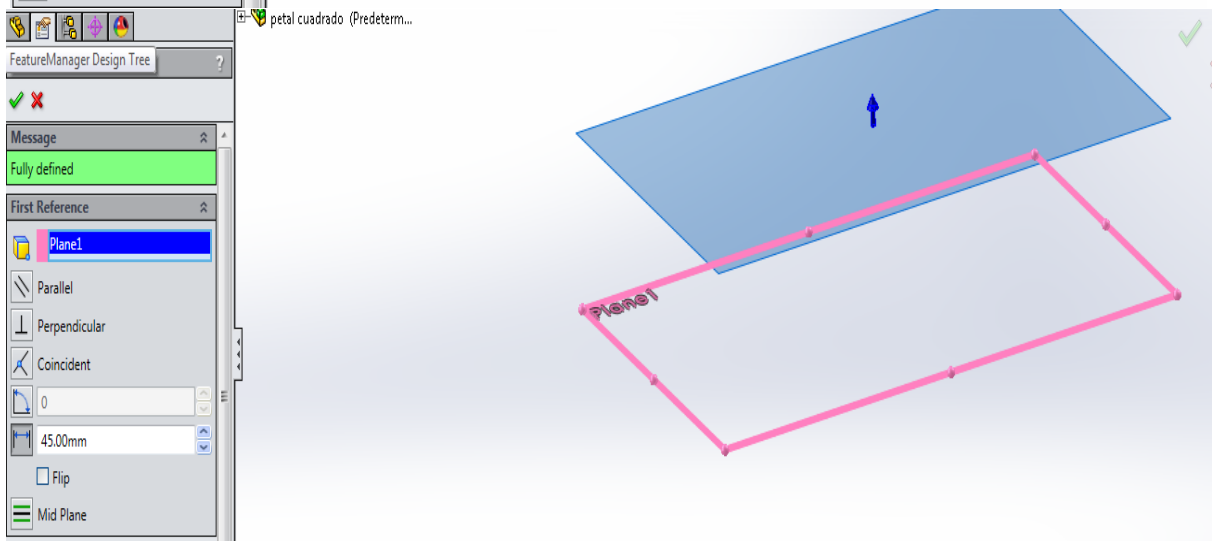
Prototype petal

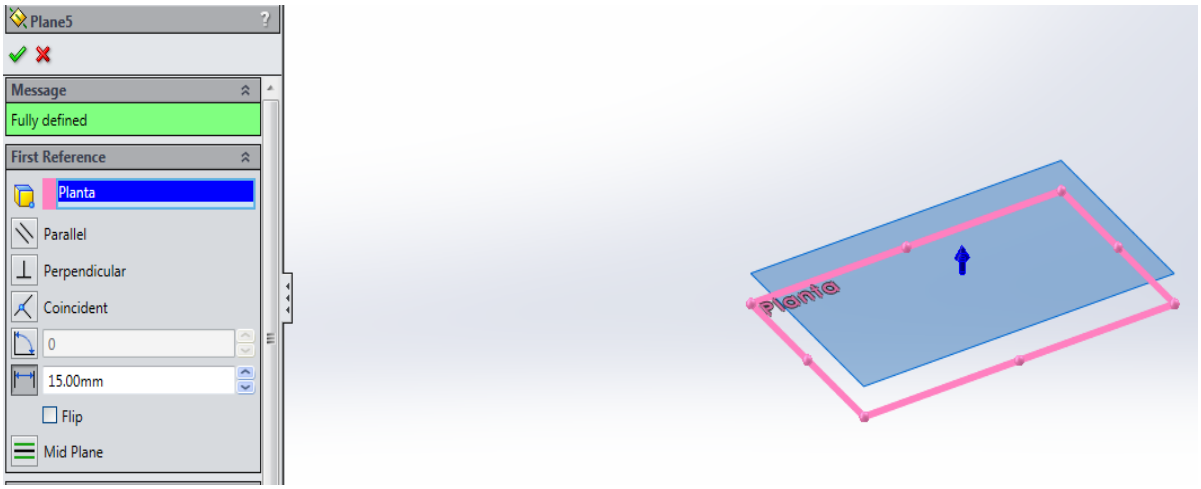
The dimensions of the petal were defined based on the dimensions of the base, so the flower has a proportional size within we can include the mechanism chosen. We decided to make the flower with 6 petal, so each one covers an angle of 60º.
It was created following the next steps:

1. Creating four planes, parallel to the top plane, so we can draw the section of the petal at each height to use the *Loft* tool, which creates a feature by making transitions between profiles, creating organic shapes. Plane 1 is located 45 mm over the top plane (height of maximum distance between flowers), and Plane 2 is located 132.5 mm over the top plane (maximum height of the flower). Plane 4 and 5 are located respectively 45 and 15 mm over the top plane. They are simply used to model the shape of the flower.


Plane1
Message
Fully defined
First Reference
Planta
Parallel
Perpendicular
Coincident
0
45.00mm
Flip
Mid Plane
Planta

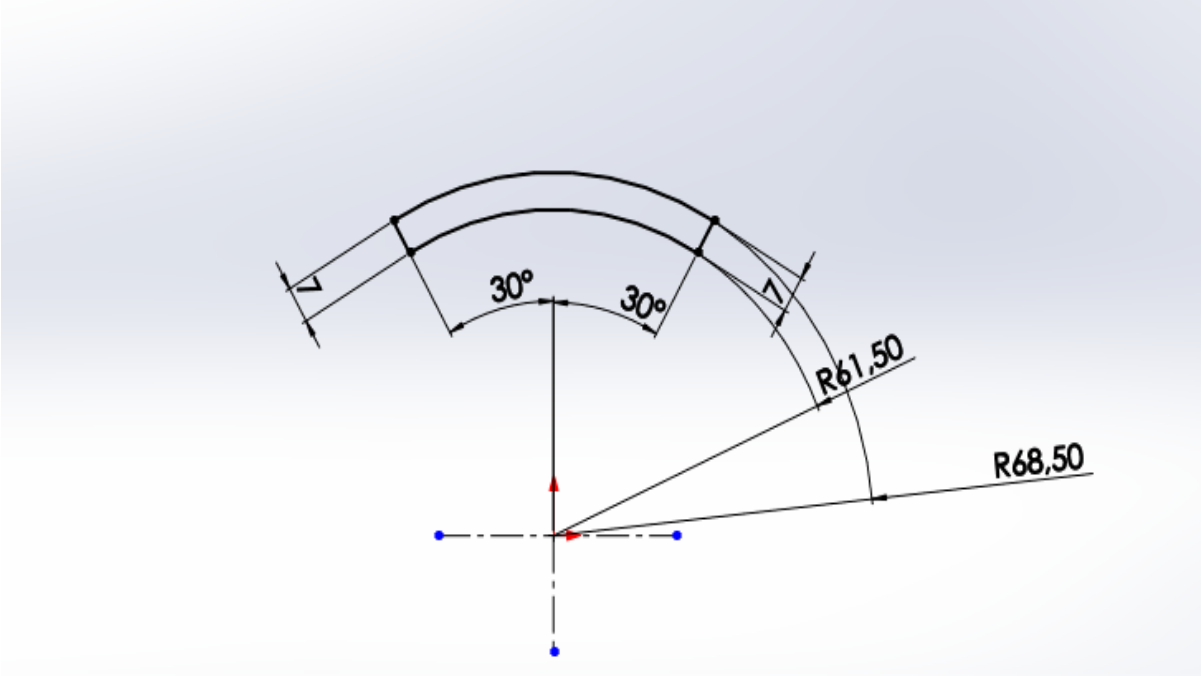

Plane2
Message
Fully defined
First Reference
Planta
Parallel
Perpendicular
Coincident
0
132.50mm
Flip
Mid Plane
Planta


petal cuadrado (Predeterm...
FeatureManager Design Tree
Message
Fully defined
First Reference
Plane1
Parallel
Perpendicular
Coincident
0
45.00mm
Flip
Mid Plane
Plane1

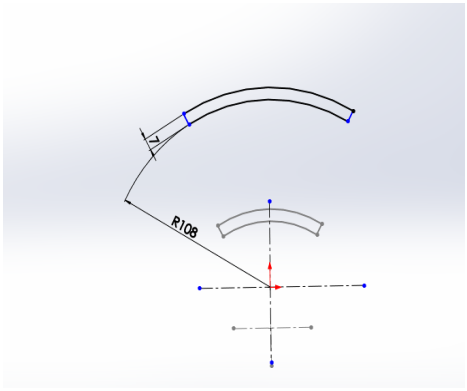


2. Draw in each plane the section of the flower that the tool Loft is going to follow.

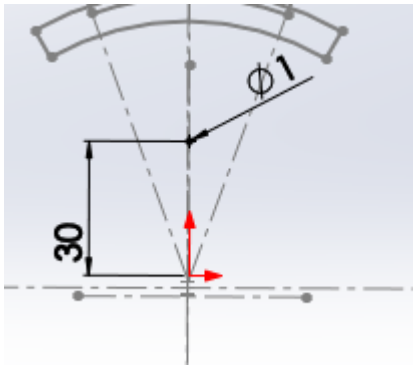
The shape of the petal is not relevant in the design, but it is important to define the height and sections of the petal in the planes that we have already defined in order to have enough space within the flower to assemble the mechanism that is going to make the petal move.
According to the initial scale freehand designs, these are the sections required for our model:



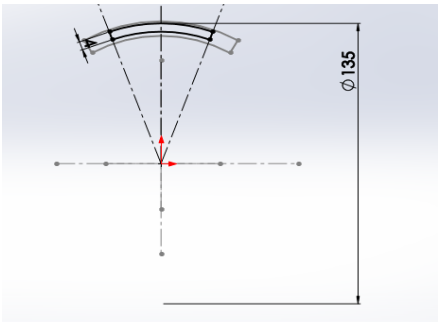
Section at plane #1



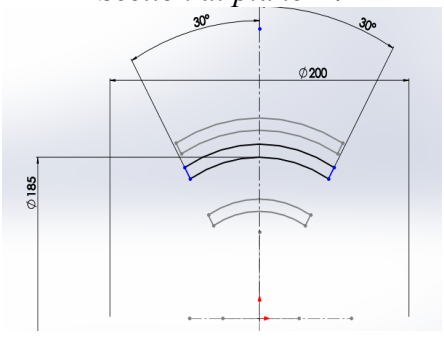
Section at plane #2



Section at plane #3

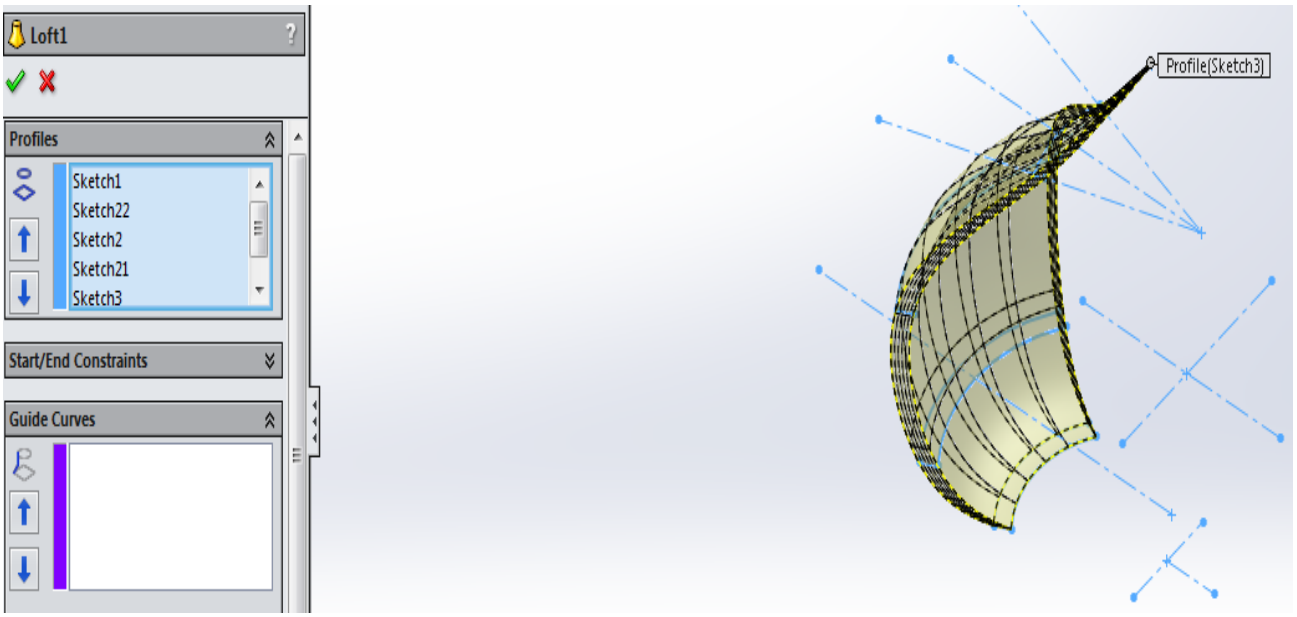


Section at plane #4

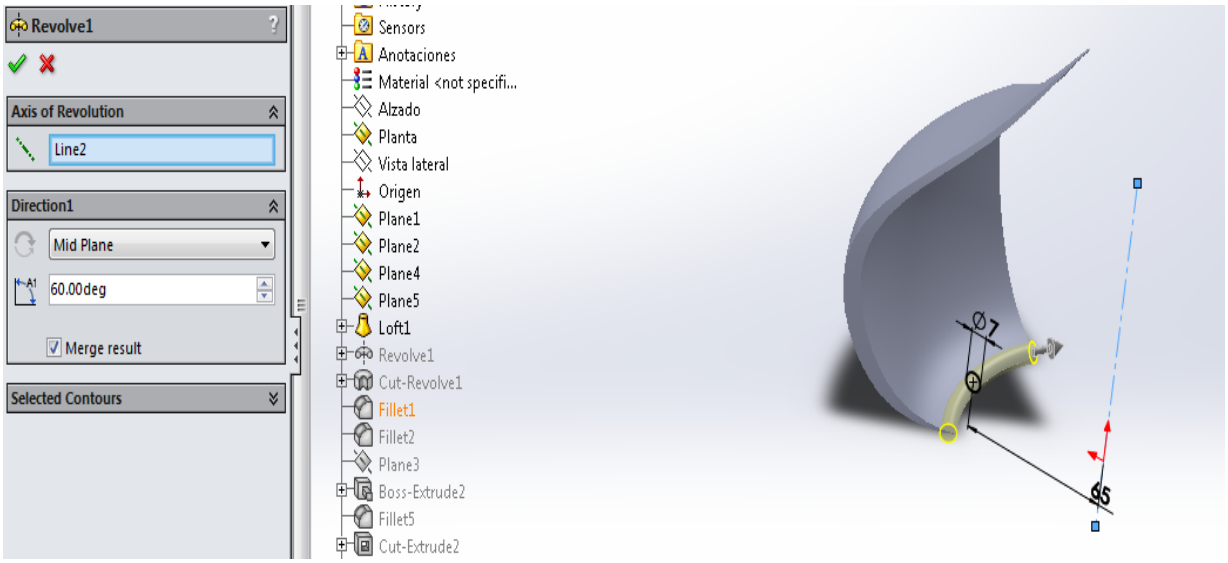


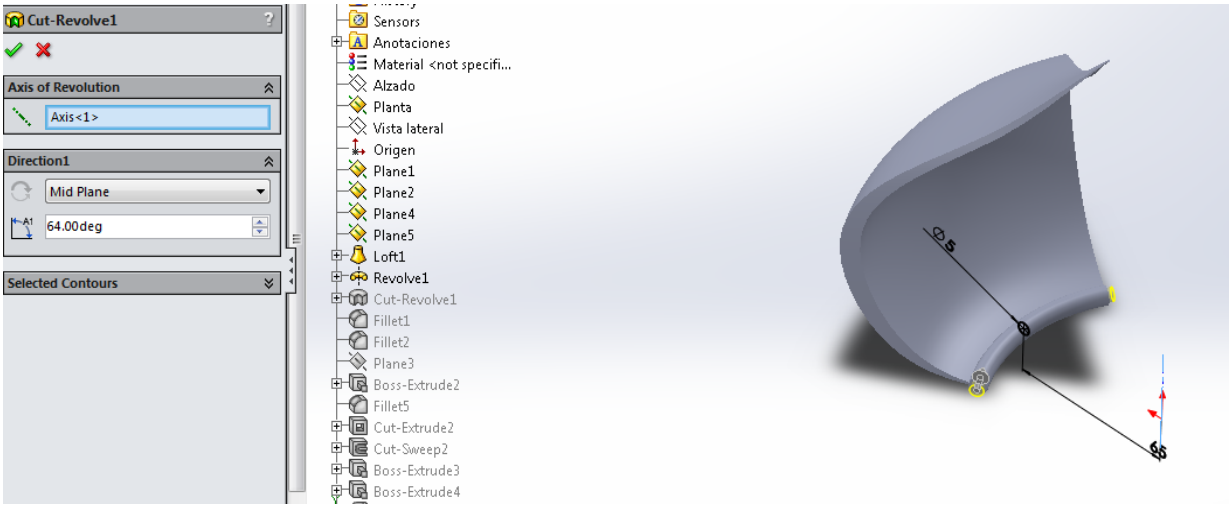
Section at plane #5

3. Use the tool loft to build the petal

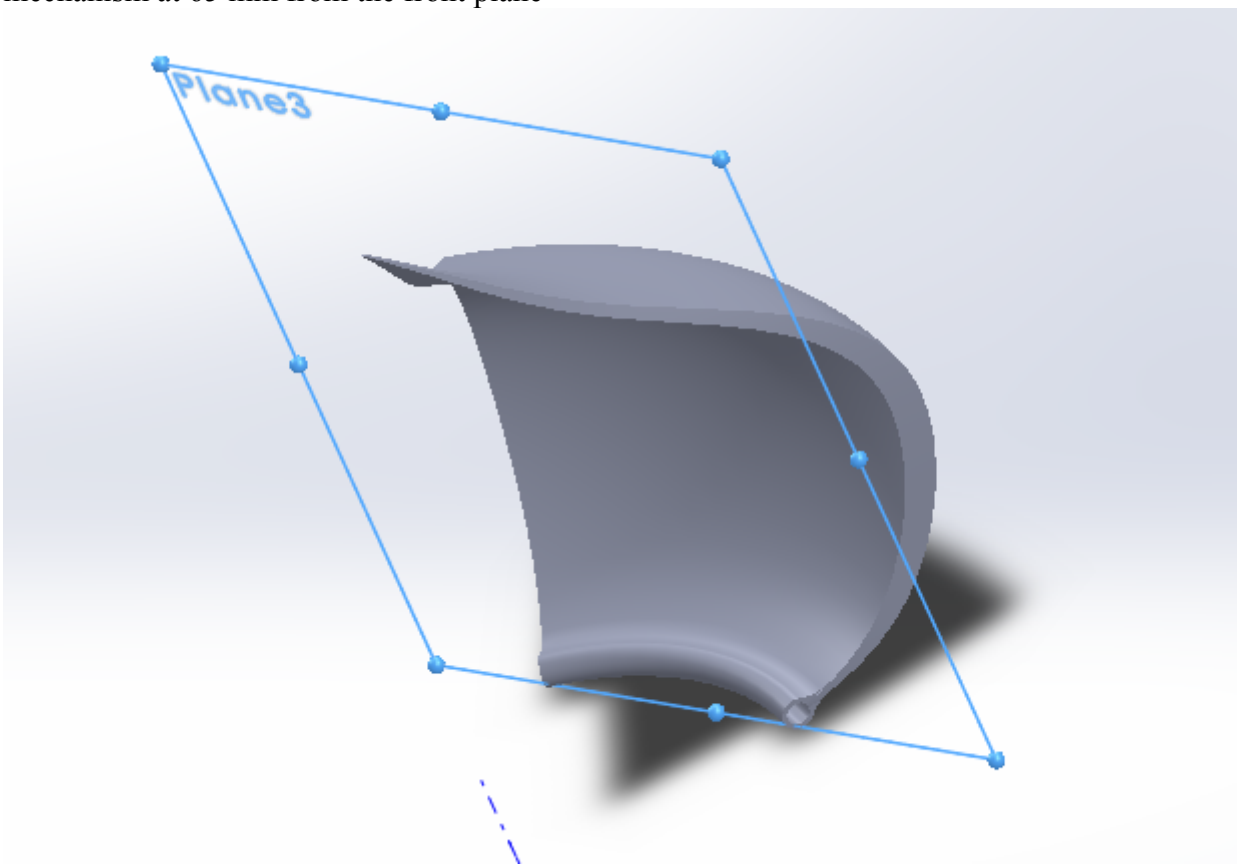


4. Add and extrude a cylinder in the petal to assemble the petals with a ring, which will be introduced in the extruded cylinder, with the tool *Revolve* and *Cut Revolve*. In addition add fillets with the *Fillet* tool.



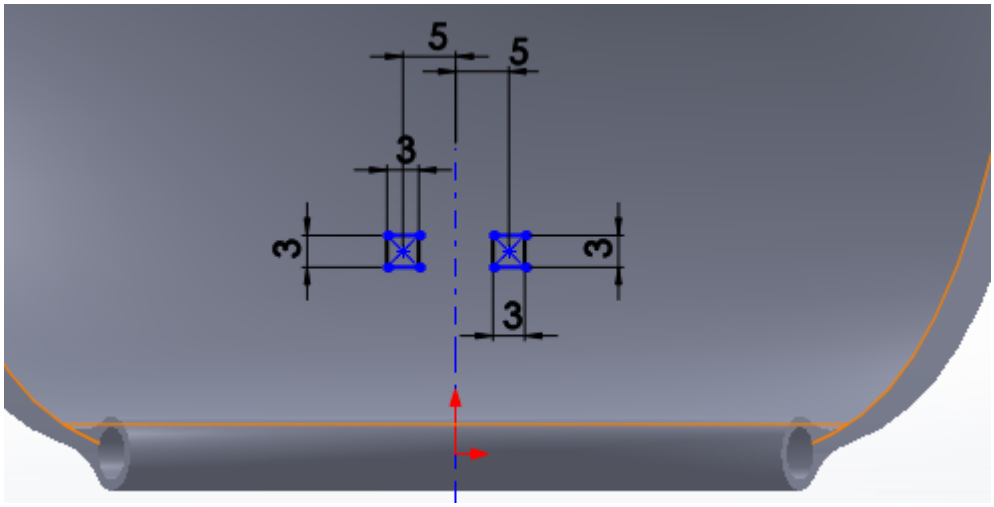


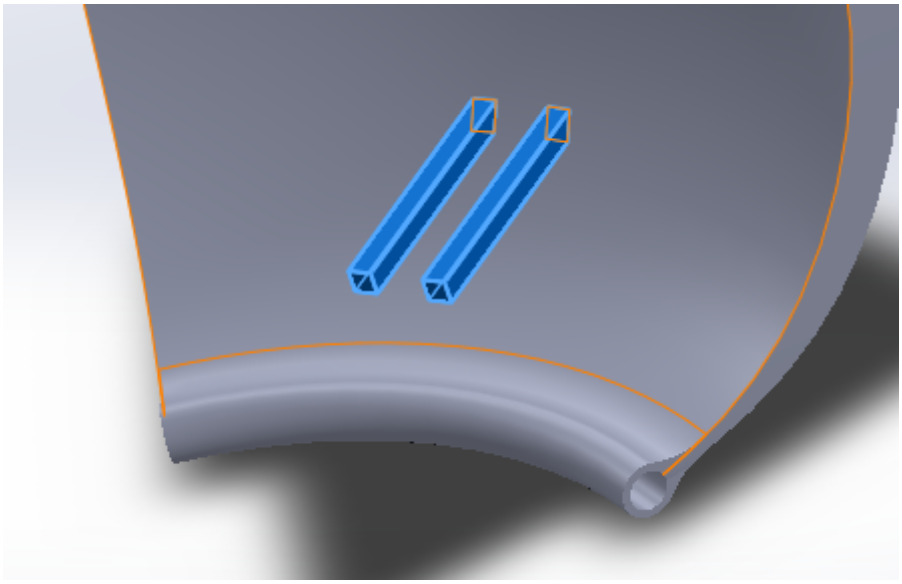
5 Create plane #6 as a reference for the extruded element to connect the petal with the mechanism at 65 mm from the front plane

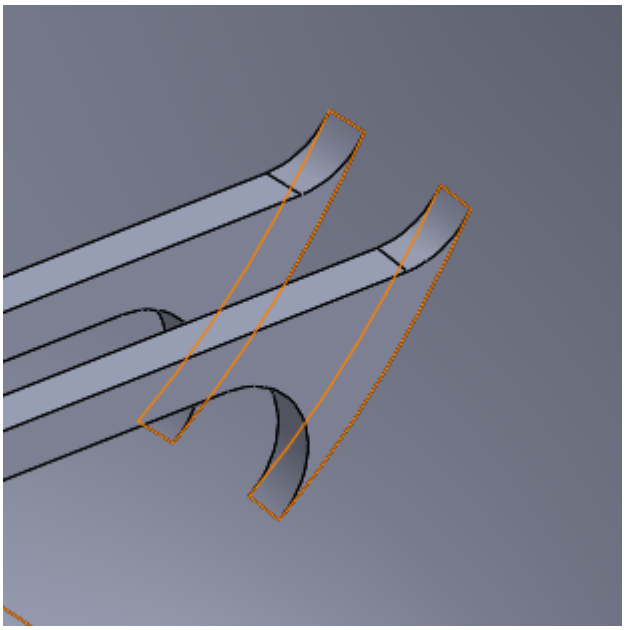


6 Create element with the required dimensions to fit with the mechanism “pull-push”

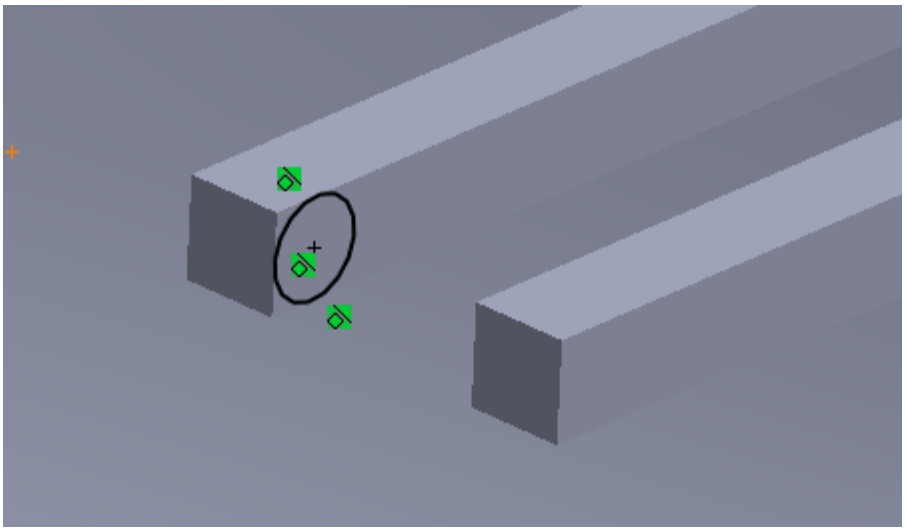
6.1 Extrude two rectangles, in which we will create the attachment, from the sixth plane. *Add Fillets* of 5 mm of diameter with the *Fillet* tool to the connection edges of the rectangle to reinforce them.

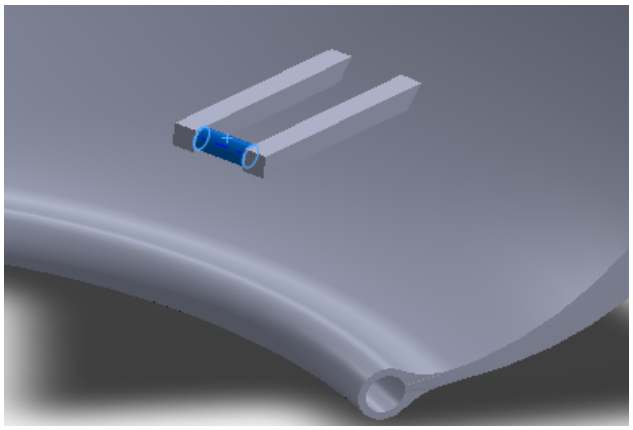




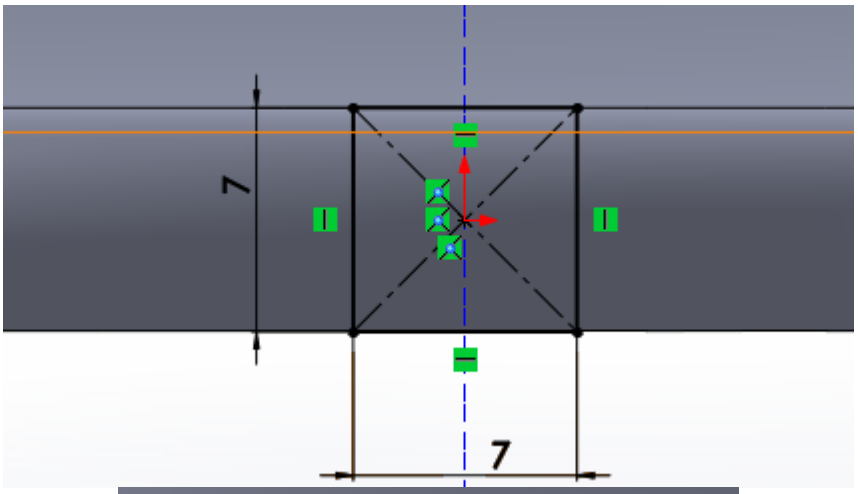


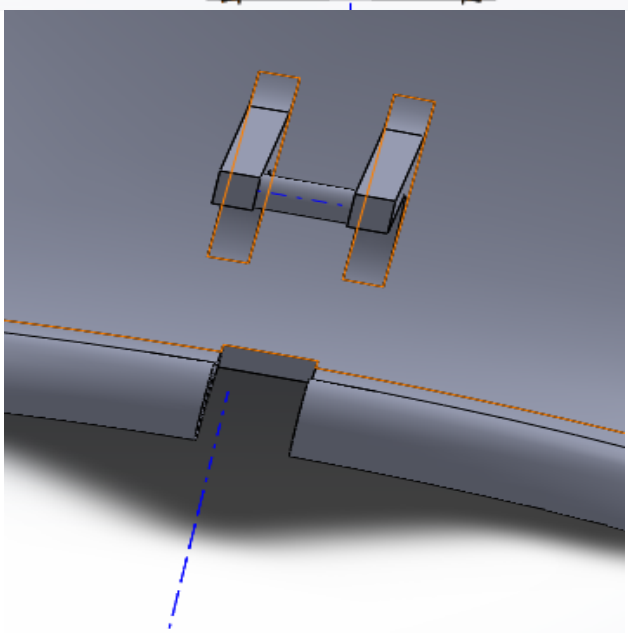
6.2 Extrude a cylinder of surfaces tangent to the extruded rectangles.



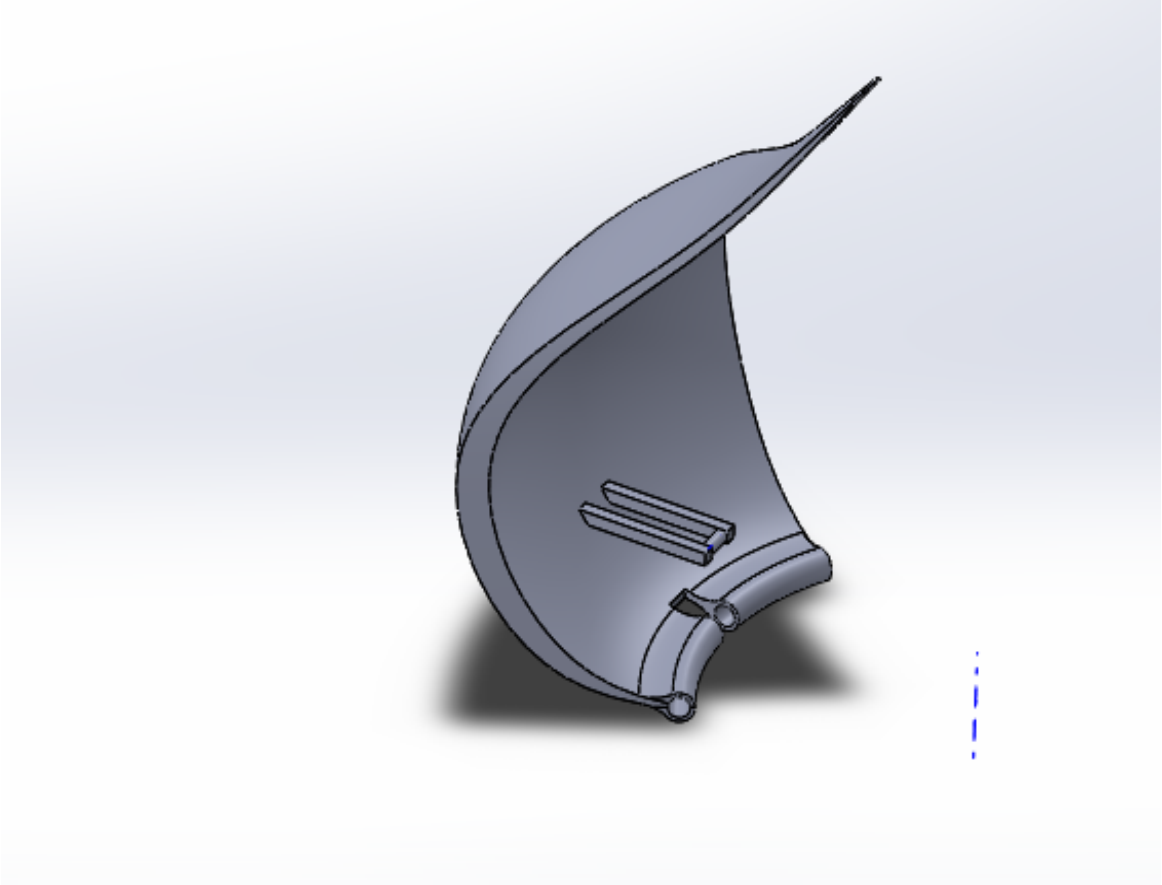


6.3 Extrude a hole, drawn in the front plane, for the hanger of the ring





7. Final result



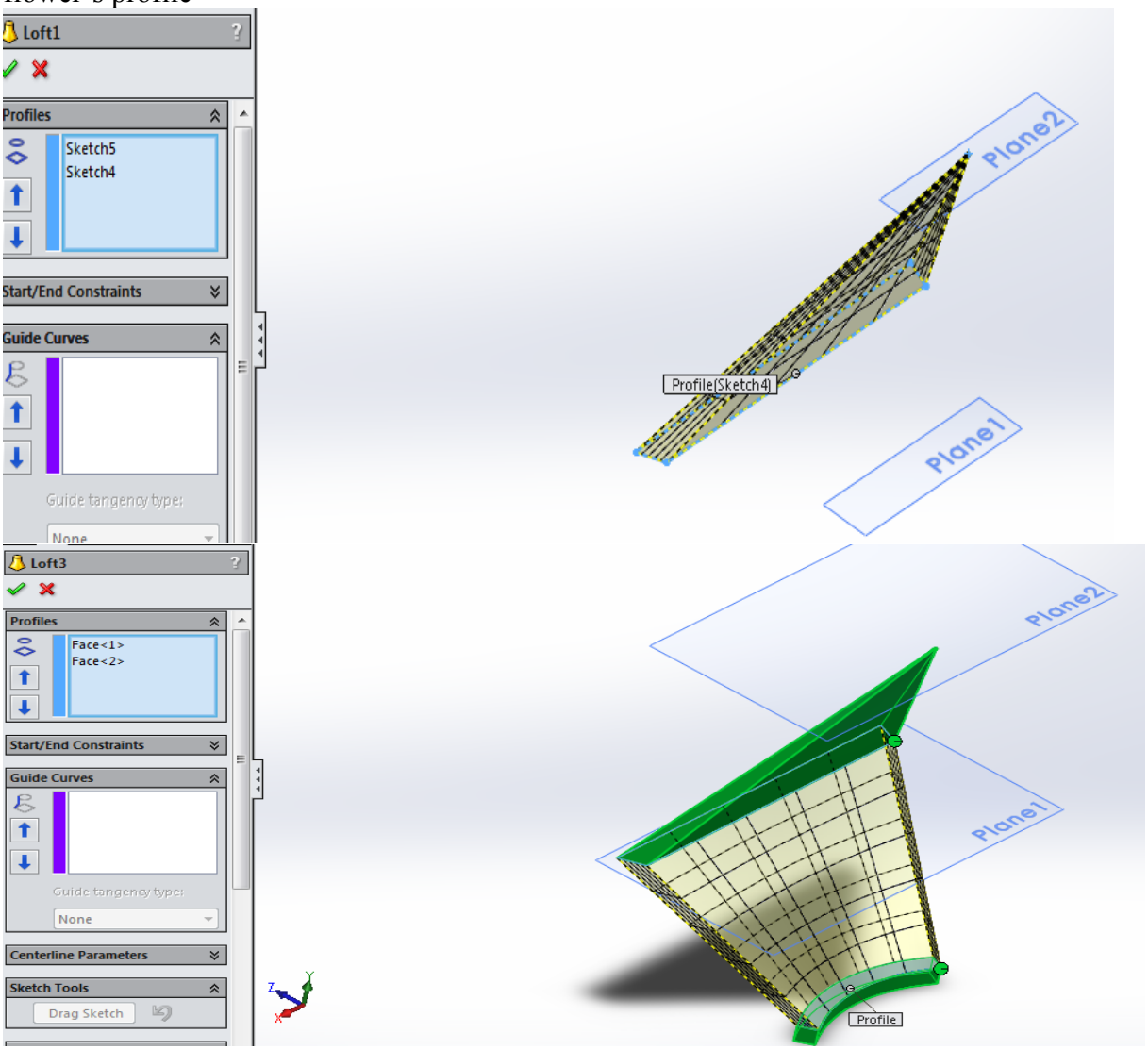
Test petal

In order to test the mechanism, we designed a test petal which is easier to print. It has two main differences:

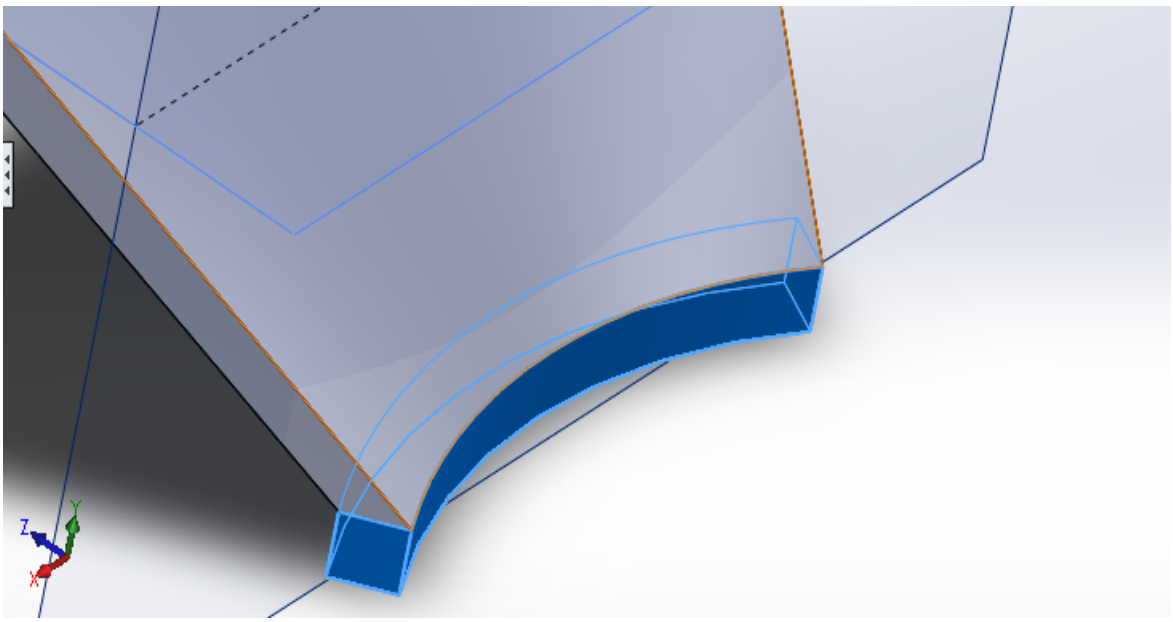
- The shape is simple and linear
- Instead of having a curved cylinder at the end of the petal, this element has square surface

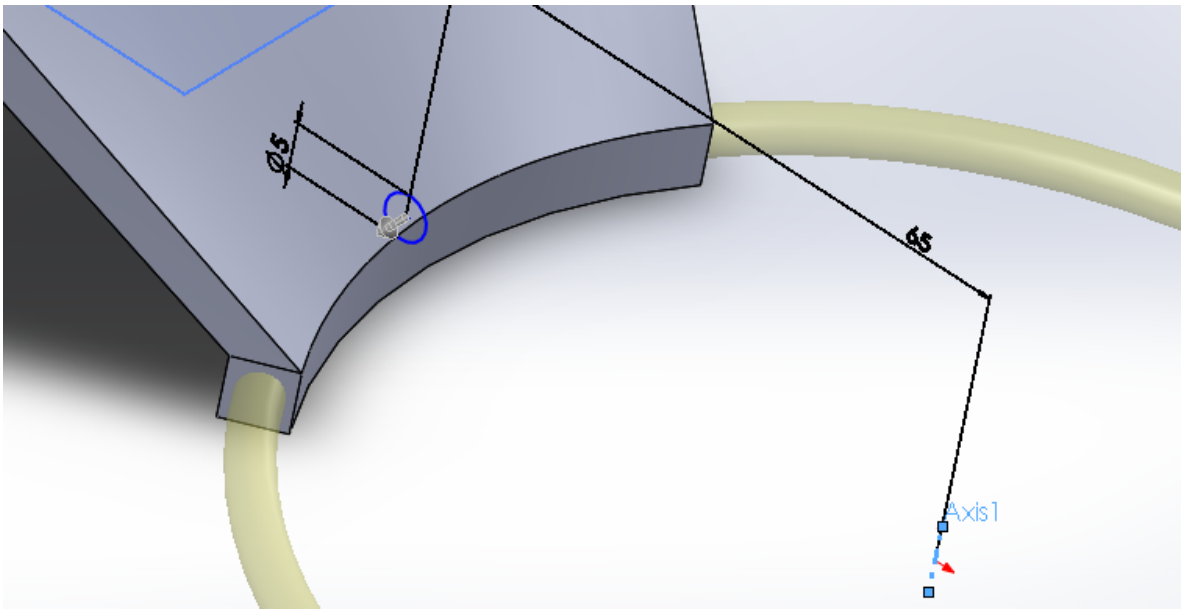
To build the petal shape, we only need the top, #1 and #2 planes.

1.1 Create the different sections that the tool *Sweep* will follow. Use Sweep tool to build the flower's profile



1.2 Add the cylinder of squared surface. Use Extrude Cut to add the internal cylinder for the connection ring.



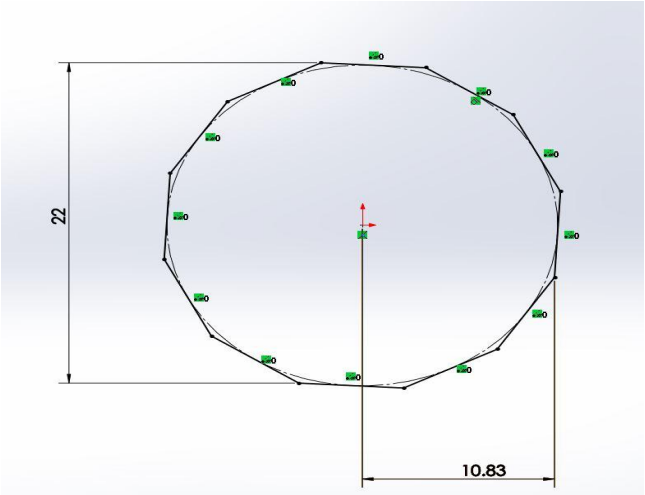


The element to link the petals with the “pull-push” stick is the same as for the initial petal.

BASE

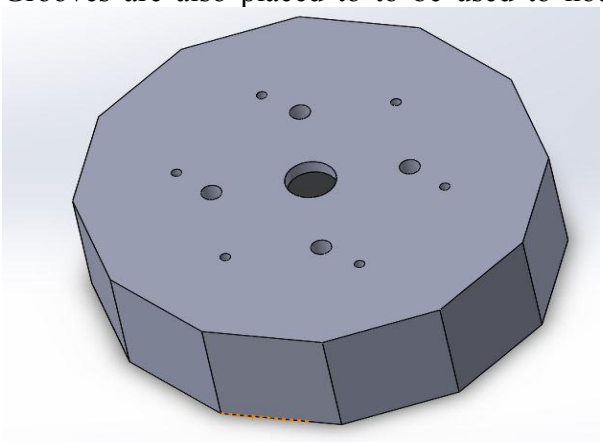
The base is retrofitted to do the following:

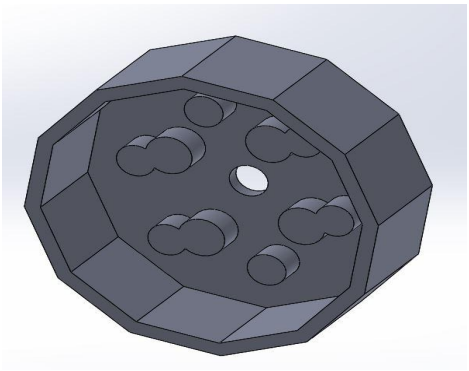
- support the petals and moving mechanism
- house the arduino



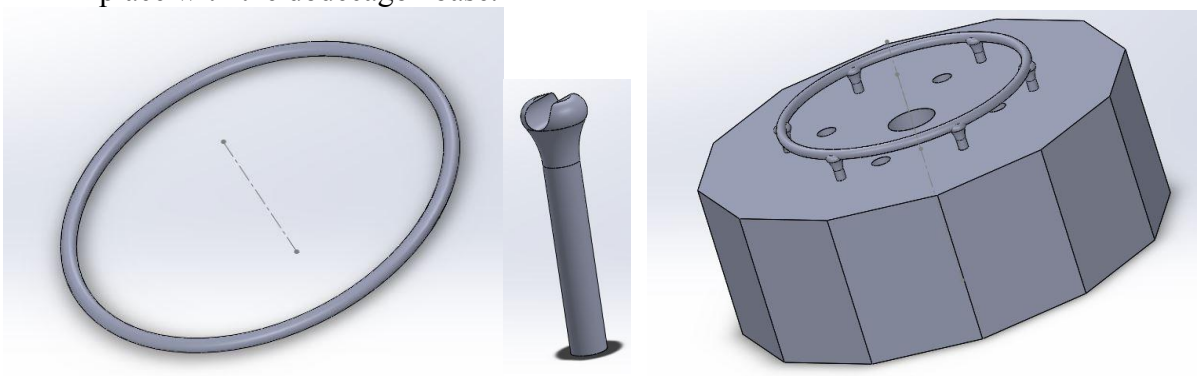
The above dimensions are used in order to be able to fit the arduino

1. The above image was extruded by 8 cm in then shelled in order to create space to place the arduino and any other necessary parts for the flower. A hole is placed in the middle of the base in order to accommodate the moving mechanism of the flowers. Grooves are also placed to to be used to house the ring that will attach the petals.





2. The other part that entails the base is a ring and some holder that keep that ring in place with the dodecagon base.



2.1 The ring was created with the tool …. from a circular section with a smaller diameter than the cylinder of the petals so it allows its movement but, at the same time, restricts their movement. The ring was finally designed in two parts to introduce the petals in.

2.2 The ring holders were made with the same outside diameter of the ring to fix it.

RACK AND PINION MECHANISM

A rack and pinion mechanism is a linear actuator which converts the rotation of the pinion into the linear movement of the rack. Consequently, the mechanism goes up and down, pulling and pushing the petals with the sticks to make them move.

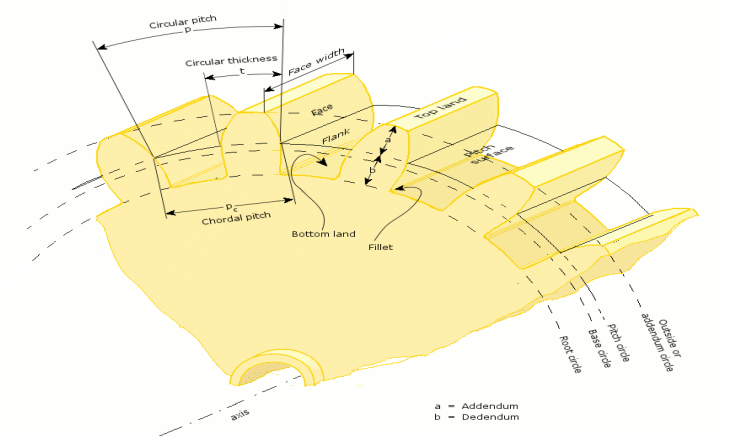
The elements of this system are two; rack and pinion.

Pinion

This element is connected to the servo, so it rotates as the servo does. Servo and rack through pression.

We specified in the design that the rack has to move 45 mm vertically. Therefore, the half of the pitch circle perimeter of the rack has to the that distance. We impose Z (number of teeth) = 10

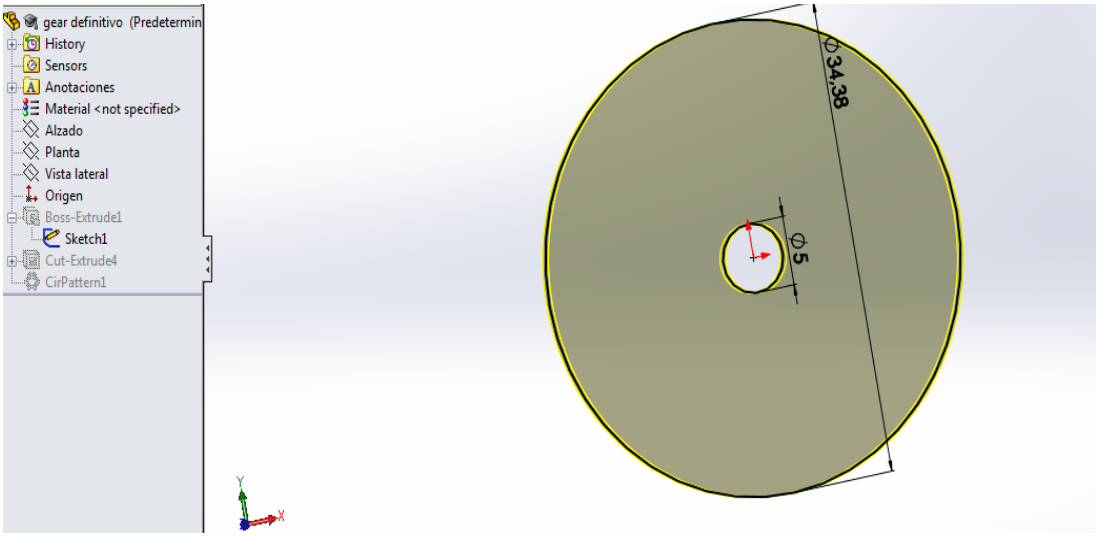
Perimeter=Dp=45*2=90 mm
Dp= 28.65 mm Dp= Pitch circle diameter
M=DpZ=2.87 mm M= Module
Dint=Dp-2.5M=21.49 mm Dint=Root circle diameter
Dext=Dp+2M=32.38 mm Dext = Outside circle diameter
Pe=1.25M=3.6 mm Pe= "pie de diente"
P=M=9 mm P="paso circular"



The rack was built following the next steps:

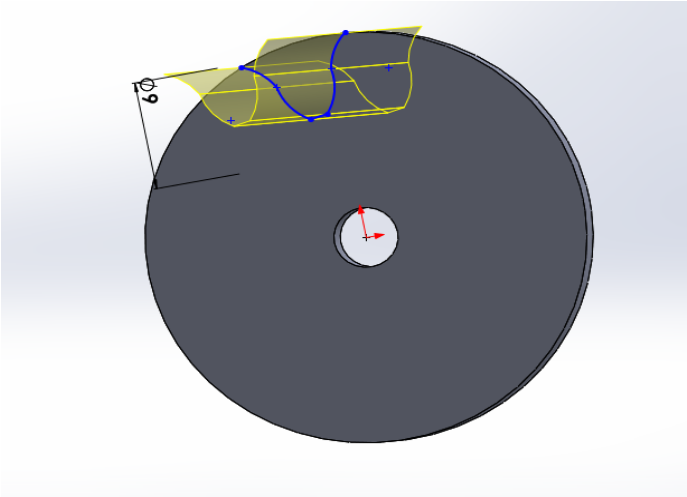
3.1.1) Draw and extrude a cylinder

In the center of that circle, draw another circle, which is going to be the connection between the rack and the servo.

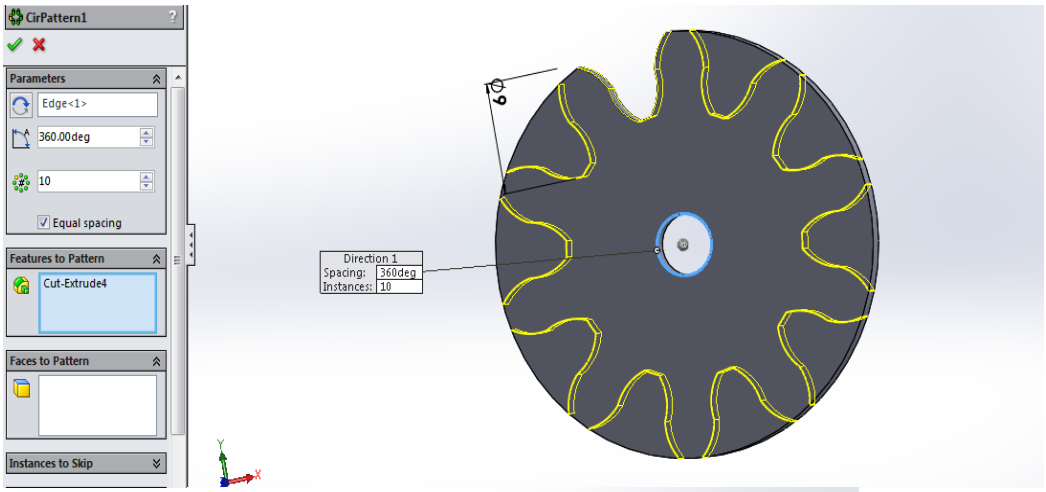


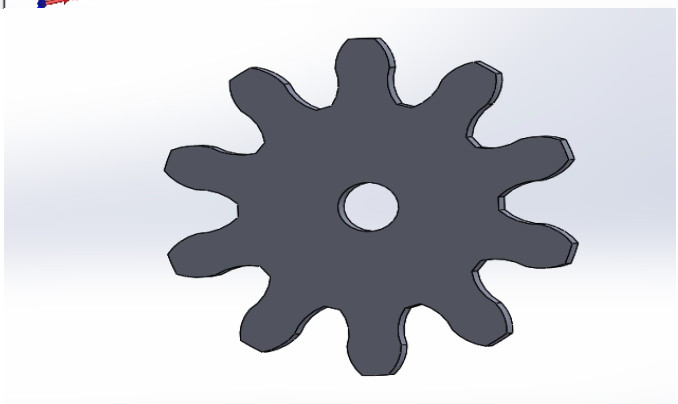
3.1.2) Draw in the surface of the the extruded cylinder 3 circles (outside circle, pitch circle, inside circle). Then, draw 4 circles, with diameter equal to the “paso circular”, with center coincident with the pitch circle and the intersection between the the circle drawn before and the pitch circle.

3.1.3) After that, use the tool “” to eliminate lines we do not need to define the space between the teeth. Once we have that section, use “Extruded cut” to get the desire hole.



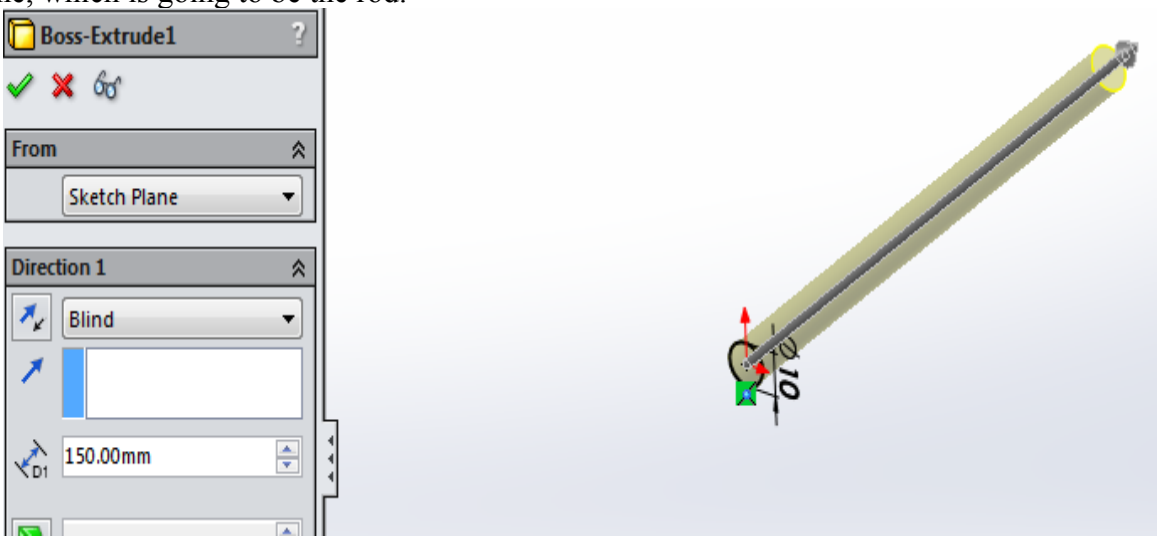
3.1.4) Use the tool “Circular pattern” with n= 10 elements, equally spaced, to obtain the final shape of the gear.



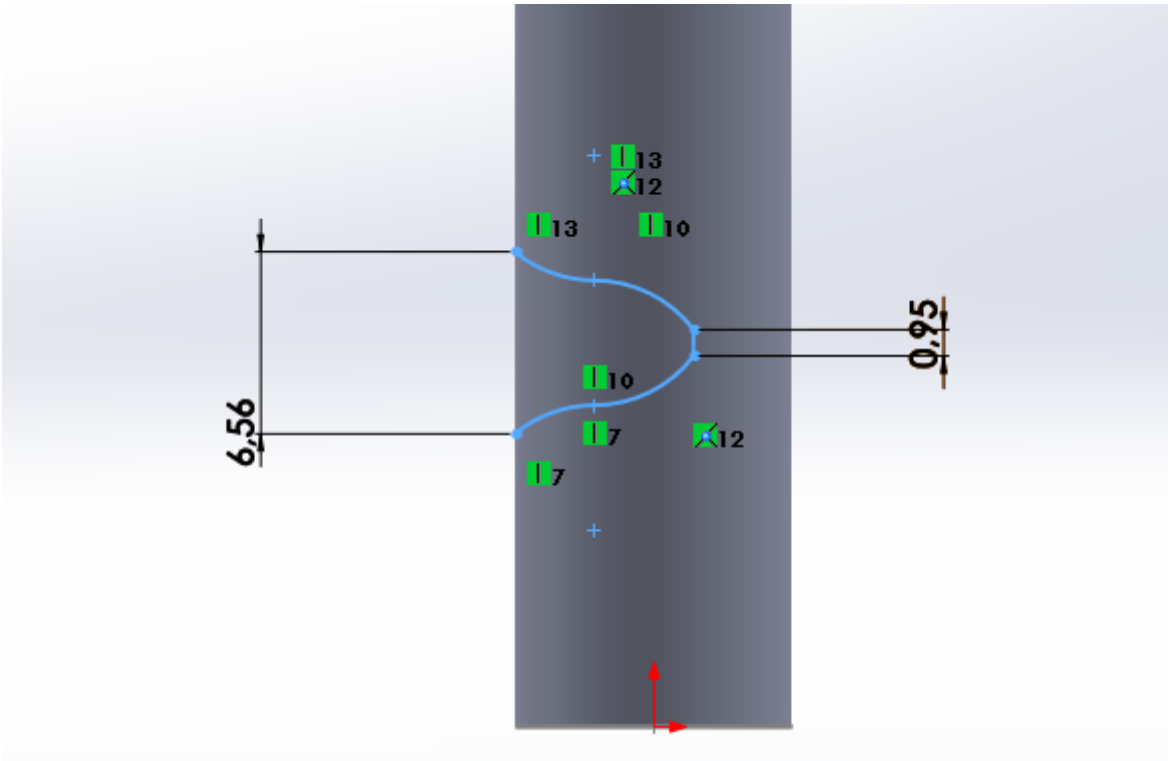


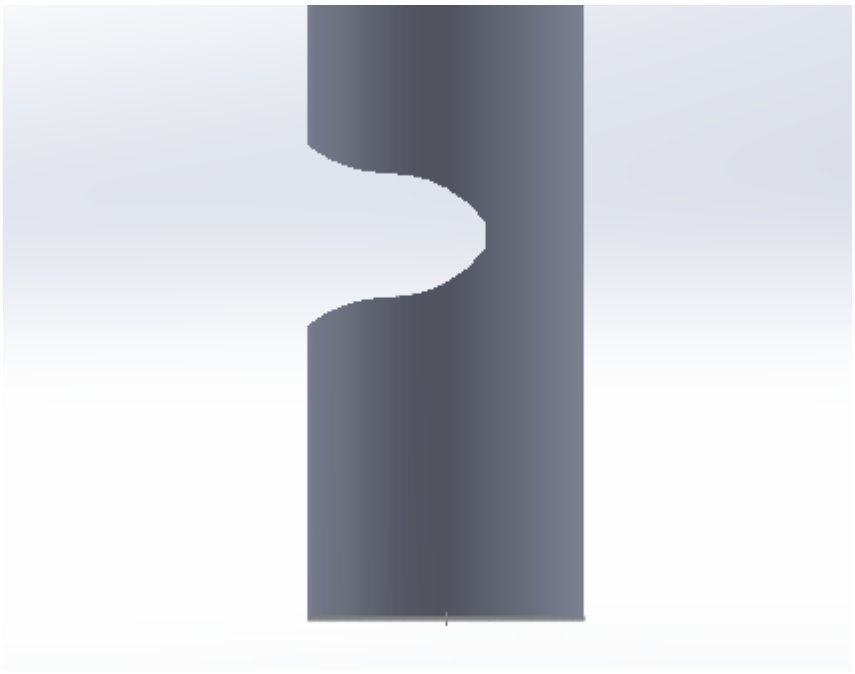
The size of the rod used to move the petals through the sticks has been designed according with the dimensions of the petal.

3.2.1) Create a extruded cylinder with the tool *Extrude*, from a circle drawn in the top plane, which is going to be the rod.

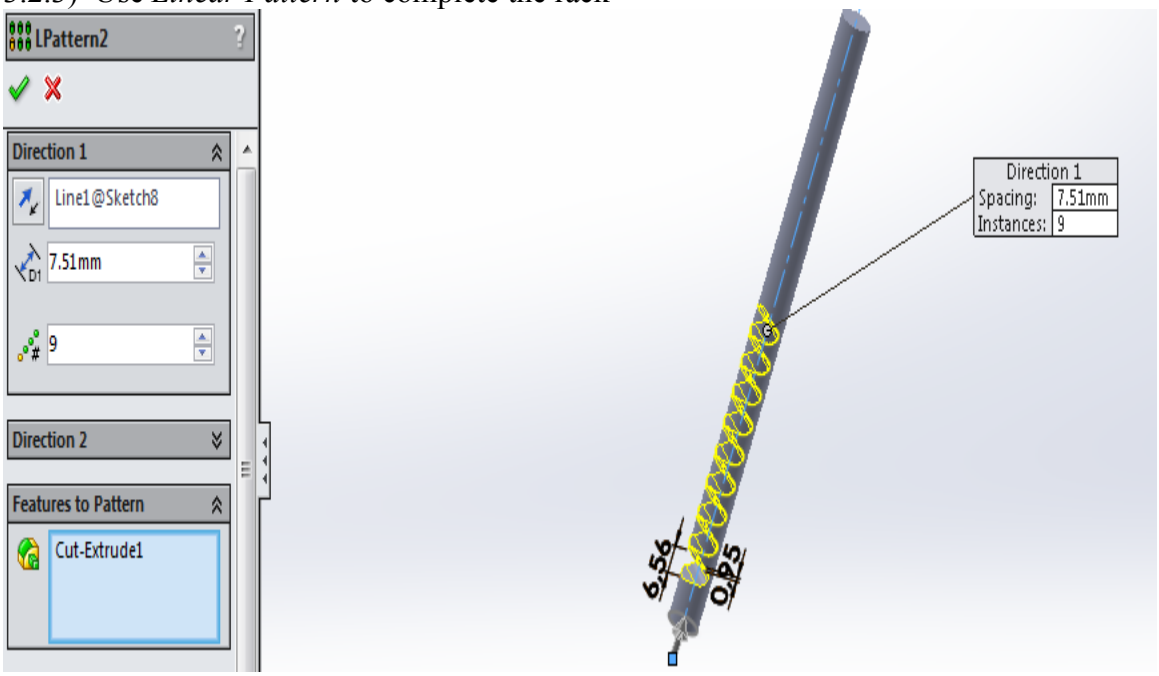


3.2.2) Develop the rack shape following the same dimensions of the pinion to extrude it.



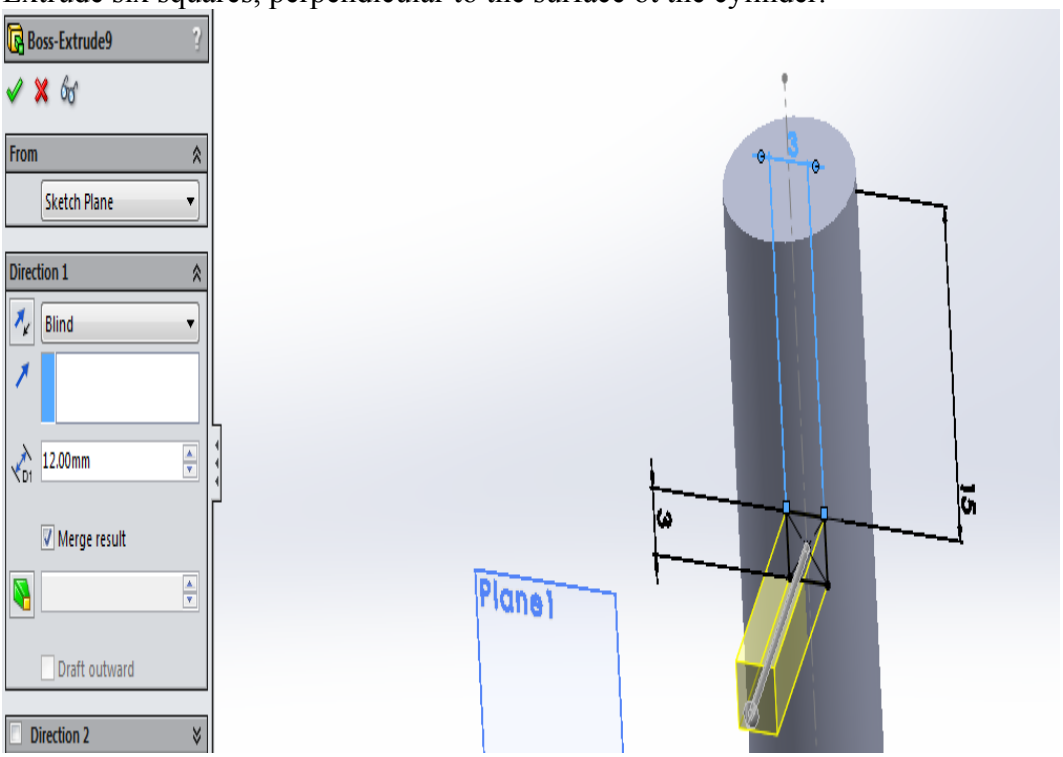


3.2.3) Use *Linear Pattern* to complete the rack

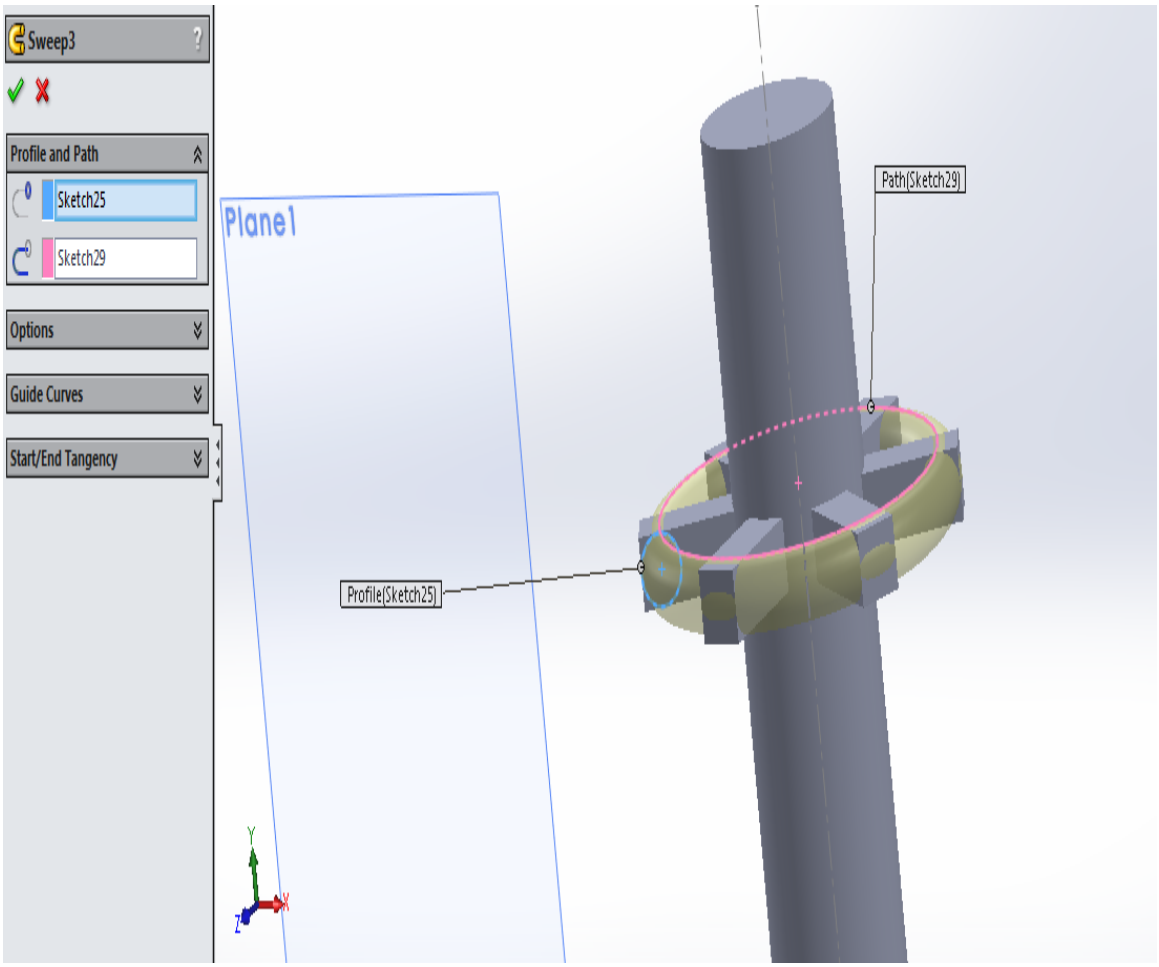


3.2.4) Build the connection element between the pole and the stick.

Extrude six squares, perpendicular to the surface ot the cylinder.



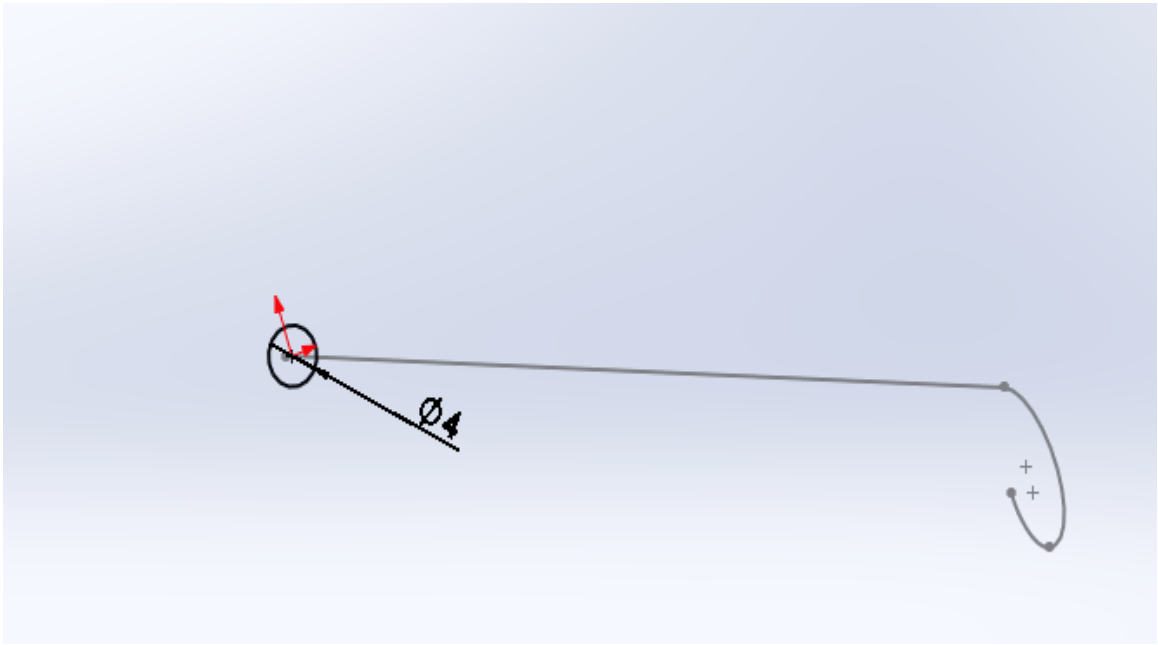
Extrude circular cylinder at the end of the six extruded squares.



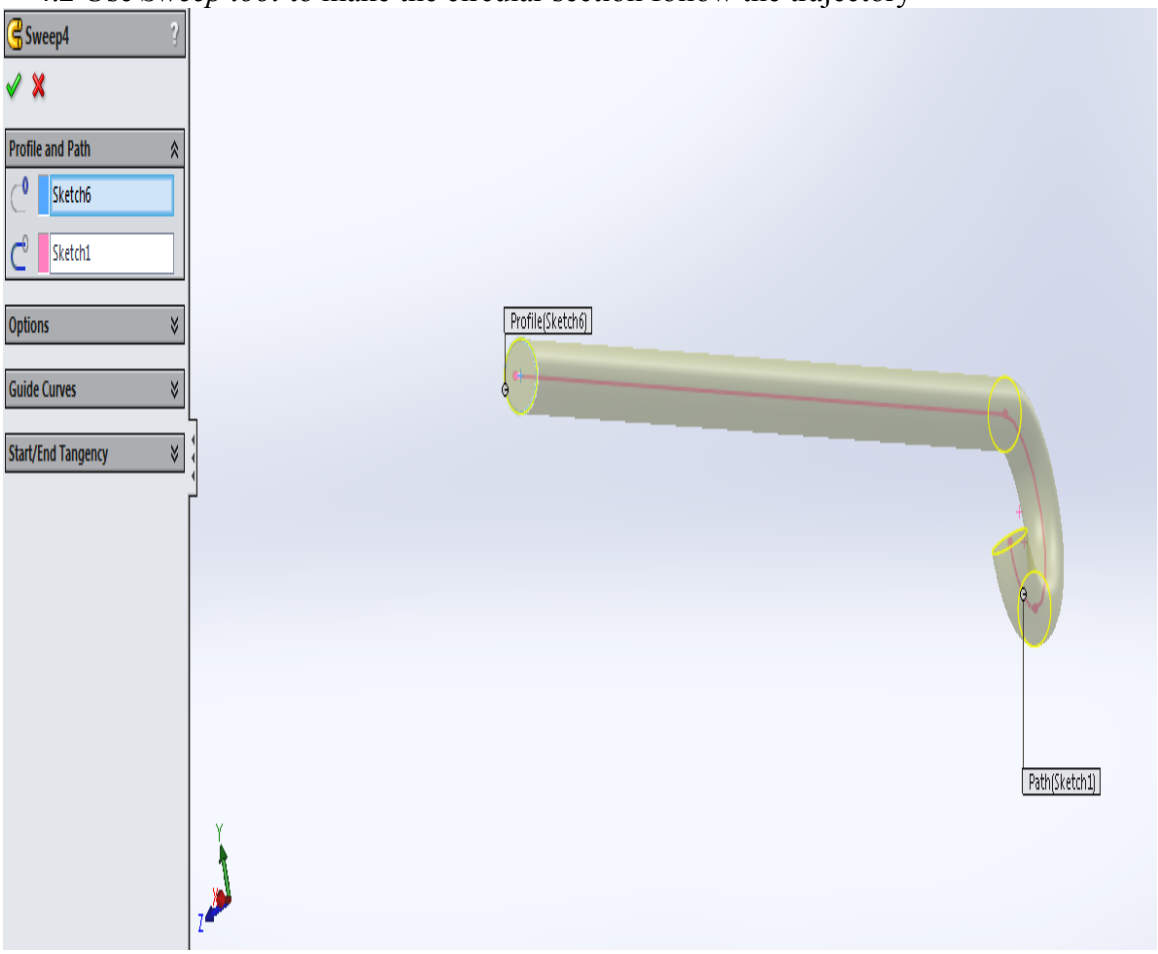
PULL-PUSH MECHANISM

Once we add to the petal and the central pole the connection elements to attach both parts to the stick, we only have to build it.

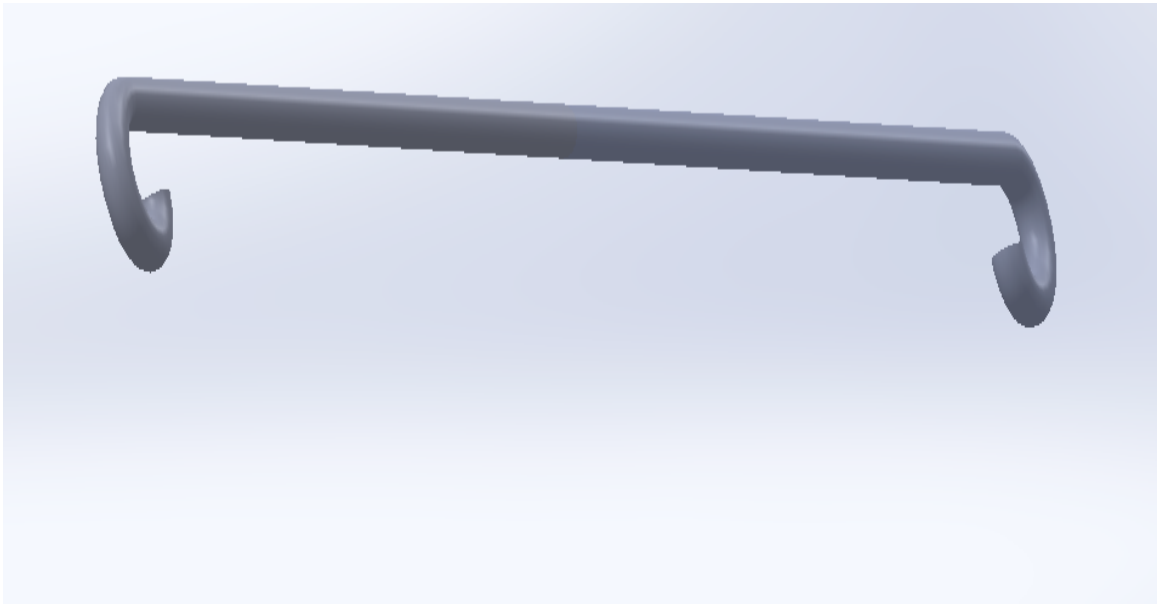
4.1 Create circular section on the front plane. Draw trajectory equivalent to the shape that the stick has.



4.2 Use *Sweep tool* to make the circular section follow the trajectory



4.3 Use Mirror tool to end the stick



ASSEMBLIES

Design chosen

After assembling the parts described before and trying them, we realized that those designs did not function as planned. The petals did not opened as much as expected since their movement were much restrictive than we thought due to the holding system that we chose the petals did not open the amount required to successfully communicate to the user the progress. Also, the "pull-push" mechanism attachment elements and the central pole were difficult to print. Consequently, we had to print more parts, which were fragile, small to print properly, and difficult to glue to the pole again.

With the linkage system, we overcame both problems. This system consists of two links which transform the vertical movement of the central pole to horizontal movement, opening the petals when it lifts. The reason we chose the linkage system is because it consists of simple parts, which are easy to print and easy to change dimensions if necessary. Moreover, the flower is held only by a small hinge restricting the movement side to side but not limiting the opening. As a result of these changes, we have easy printable parts, less material and a more efficient system.

The system chosen to move the flower was the piston mechanism. The rack and pinion mechanism was discarded because it had a higher probability of failure since the elements were too small and the 3D printer did not have the resolution required to get the accuracy needed for those parts. In addition, the rack and pinion system, due to friction, loses more energy.

The last design change was to make the flower with four petals instead of six. This variation simplifies the flower and makes it easier to print all parts in a timely matter.

1. Piston mechanism

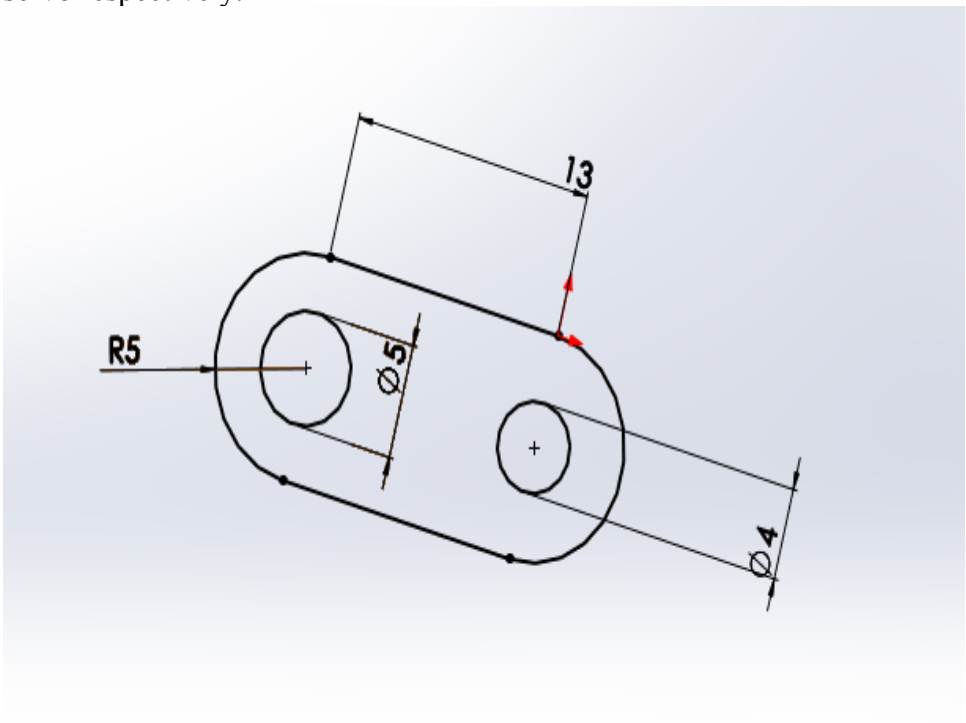
a. Crank

i. Define size

We assumed that the flower was going to open when the piston raised 30mm (1.18 in).

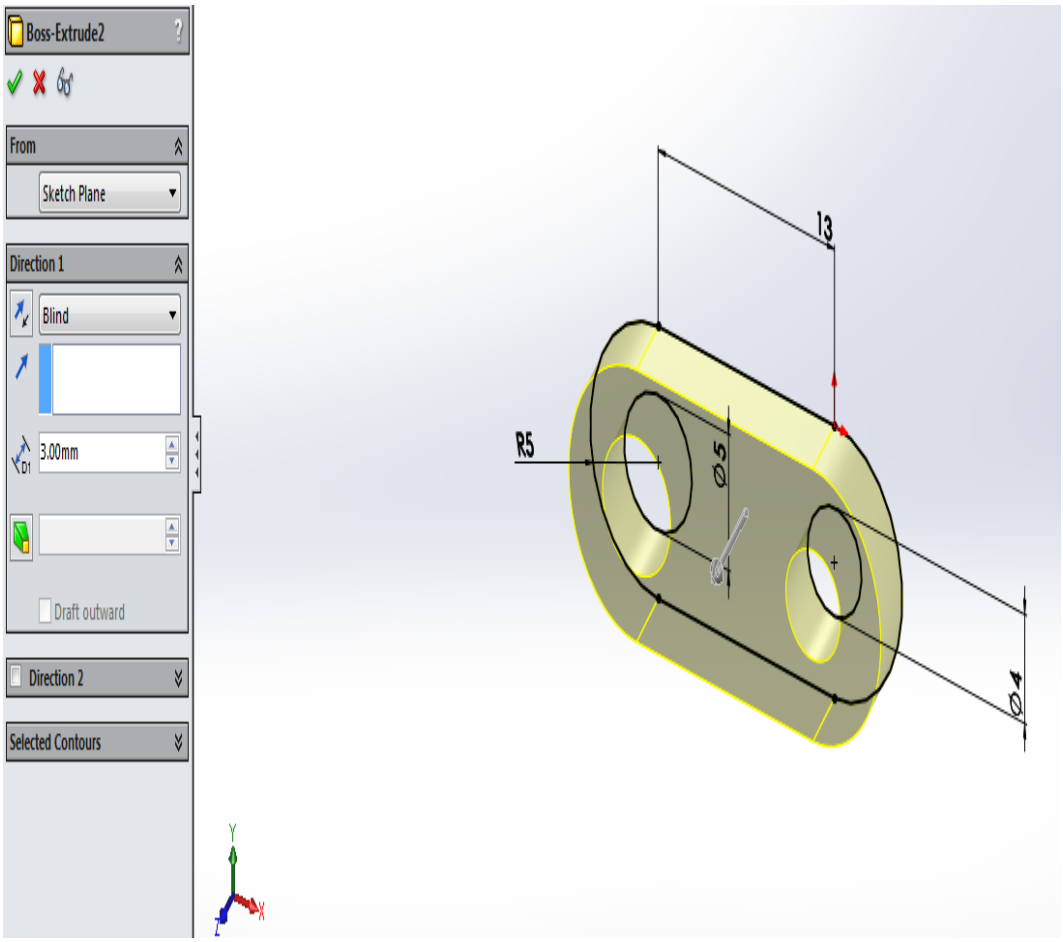
ii. Draw profile in the front plane

To keep that condition, the center of the holes for the bolts must be separated 13 mm. The diameters of the holes must be 4mm and 5mm for the bolt and servo respectively.



iii. Extrude it using the *Extrude* tool.

To make it strong and, at the same time, thin enough, the crank will be 3 mm thick



b. Piston

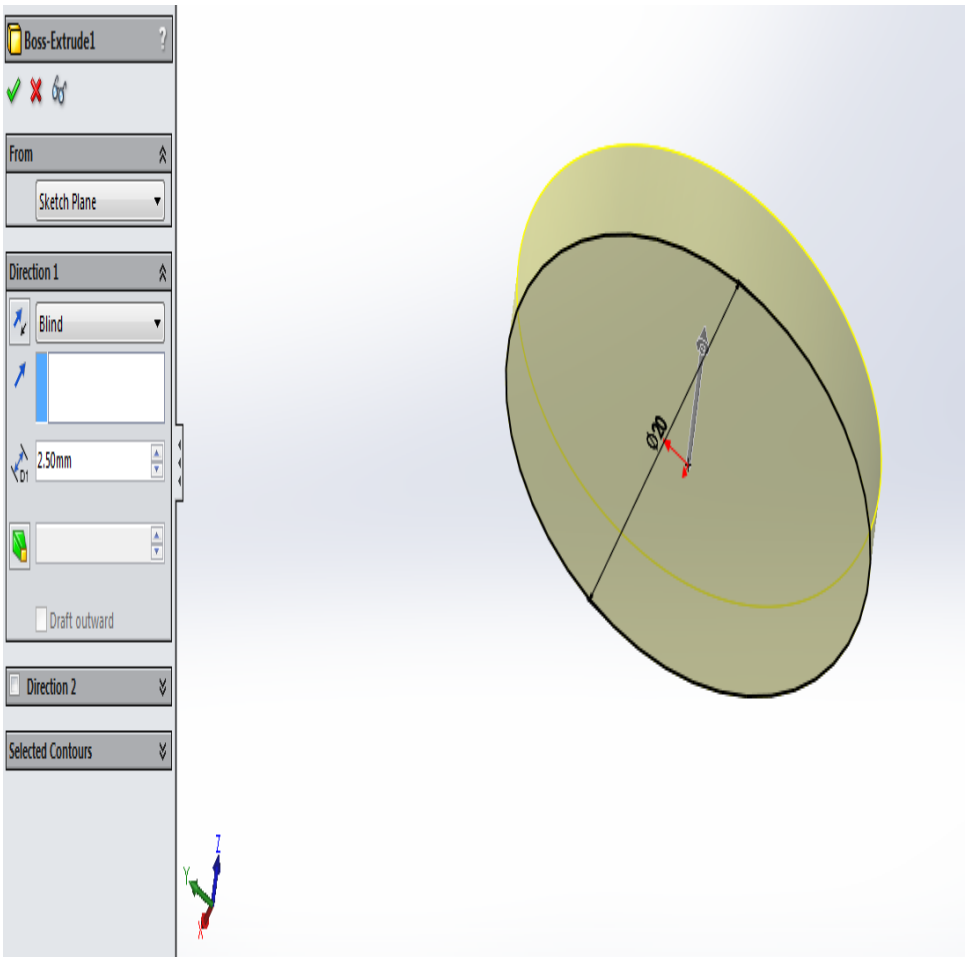
i. Define size.

The second assumption for the design is that the cylinder will have diameter 10 mm since we consider it thick enough but not too big to meet the power specifications of the servo.

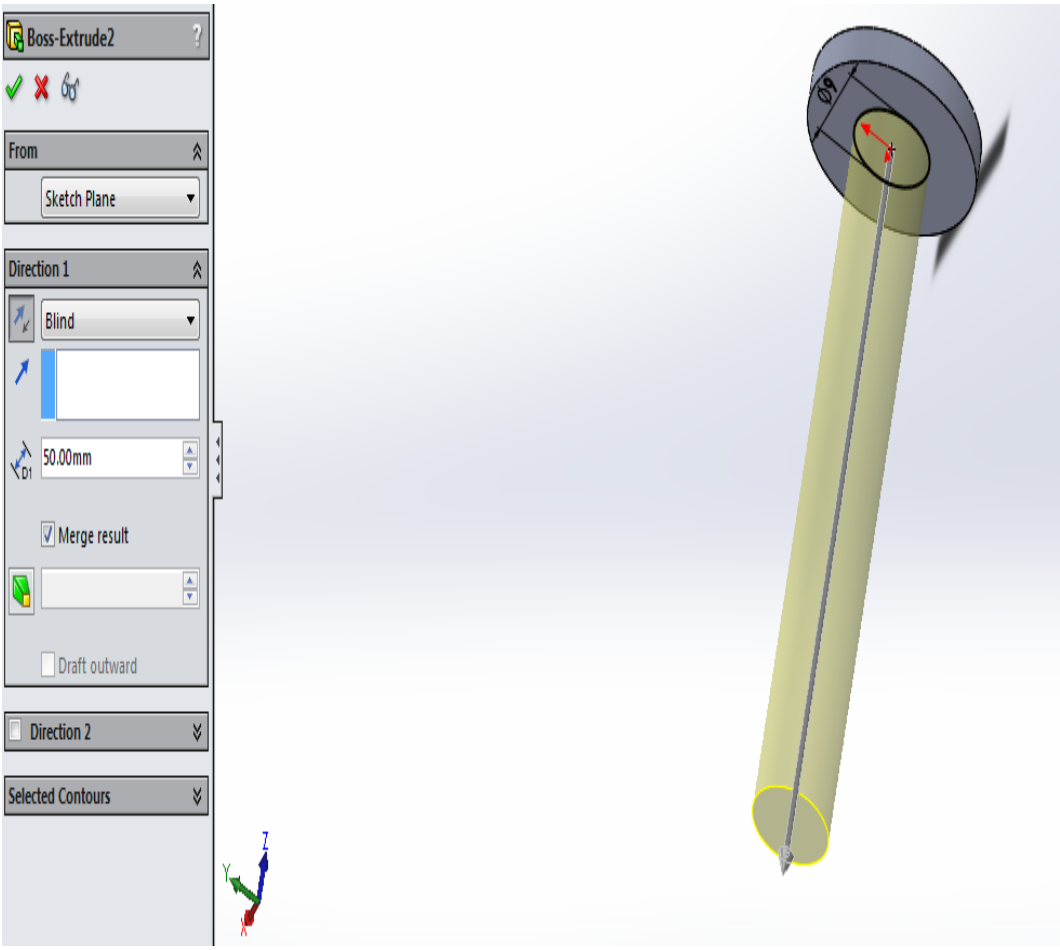
The piston must have length twice the height of the piston support of the base so neither the piston nor the rod hit any other element of the mechanism. So that, the final length must be 50 mm

ii. Create thin cylinder to restrict the movement of the piston when it goes down, acts like a bumping post.

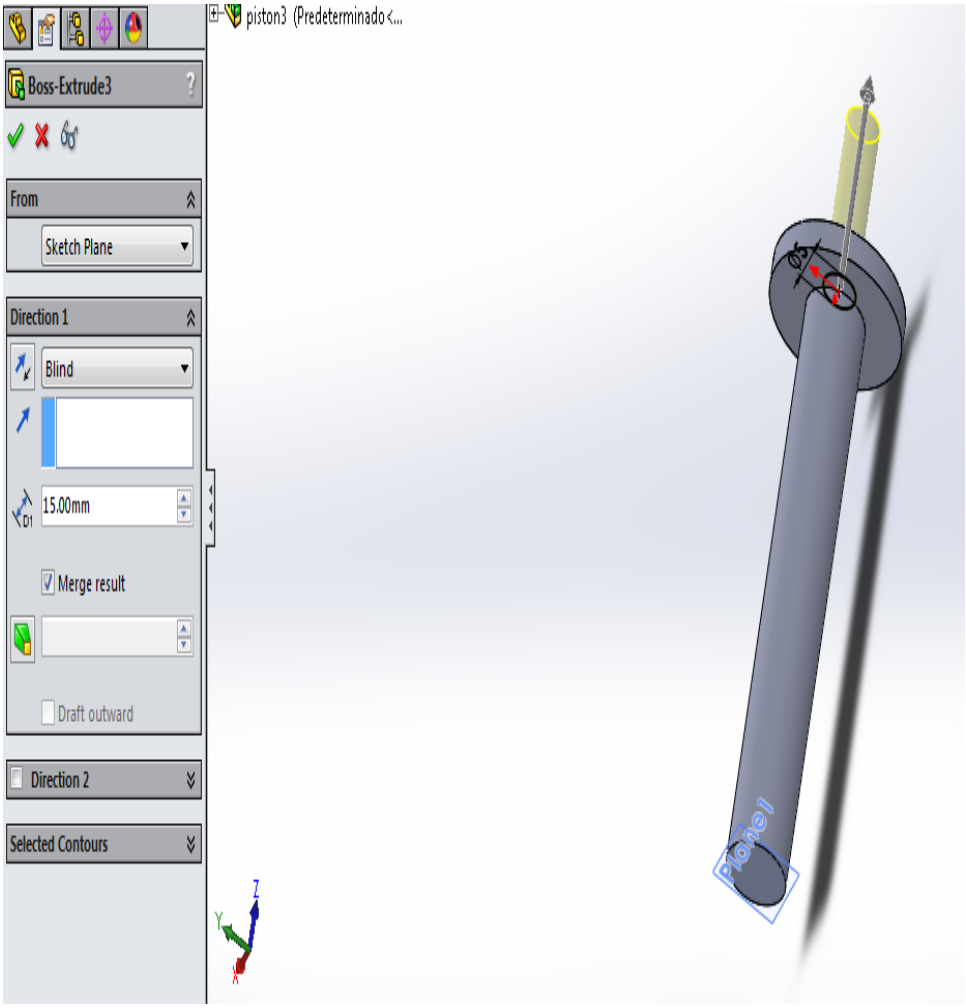
Extrude a cylinder of diameter 20 mm, drawn in the front plane, 2.5 mm.



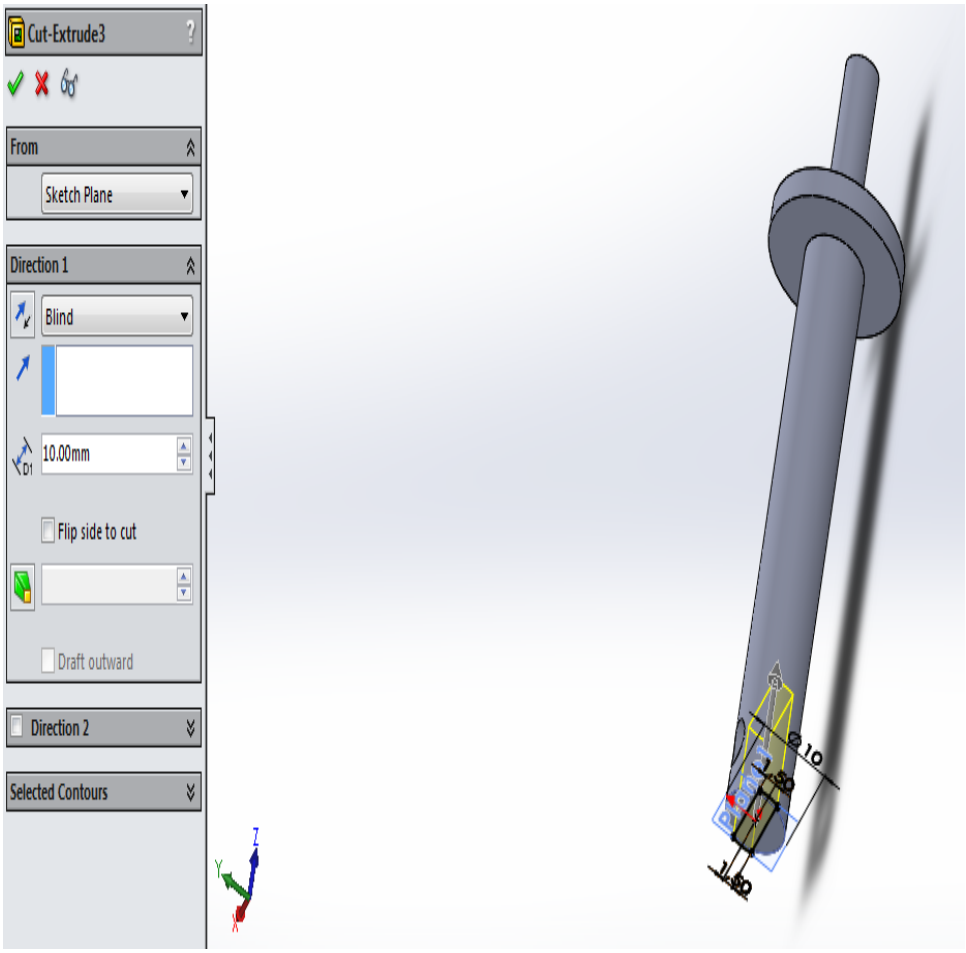
iii. Extrude circular section of 9 mm diameter (tolerance of 1 mm so the movement within the base is correct) to create the piston in the front plane, and extrude it in the opposite direction to the cylinder created before.Extrude it with the *Extrude* tool 50 mm



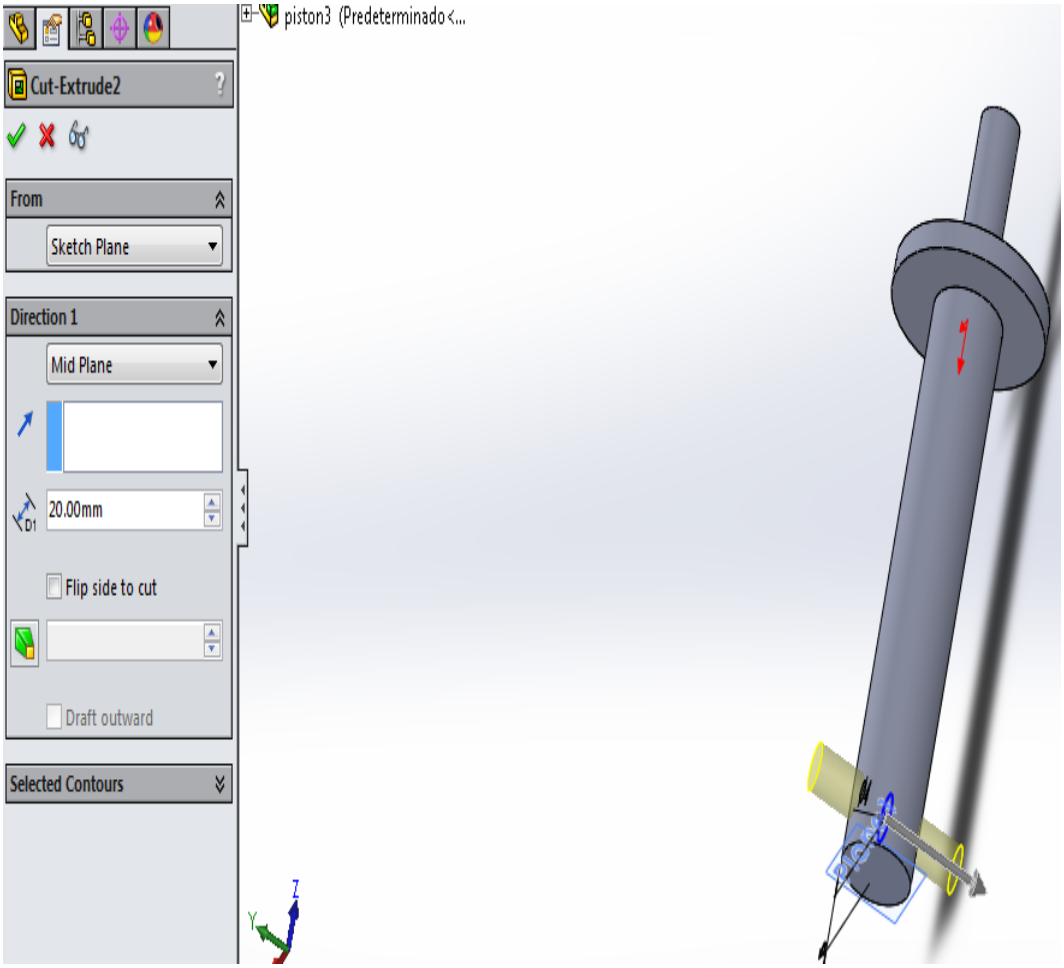
iv. Extrude small cylinder as a support for the crown element of the linkage system. Regarding the size of the crown, The new cylinder, extruded from the upper surface of the first cylinder, has diameter 5 mm and length 15 mm.



v. *Extrude Cut* to create the connection space between the rod and the piston. The space is 3 mm thick and 10 mm long.



vi. Extrude holes of diameter 4 mm from the top plane for the bolt which joins rod and rod.

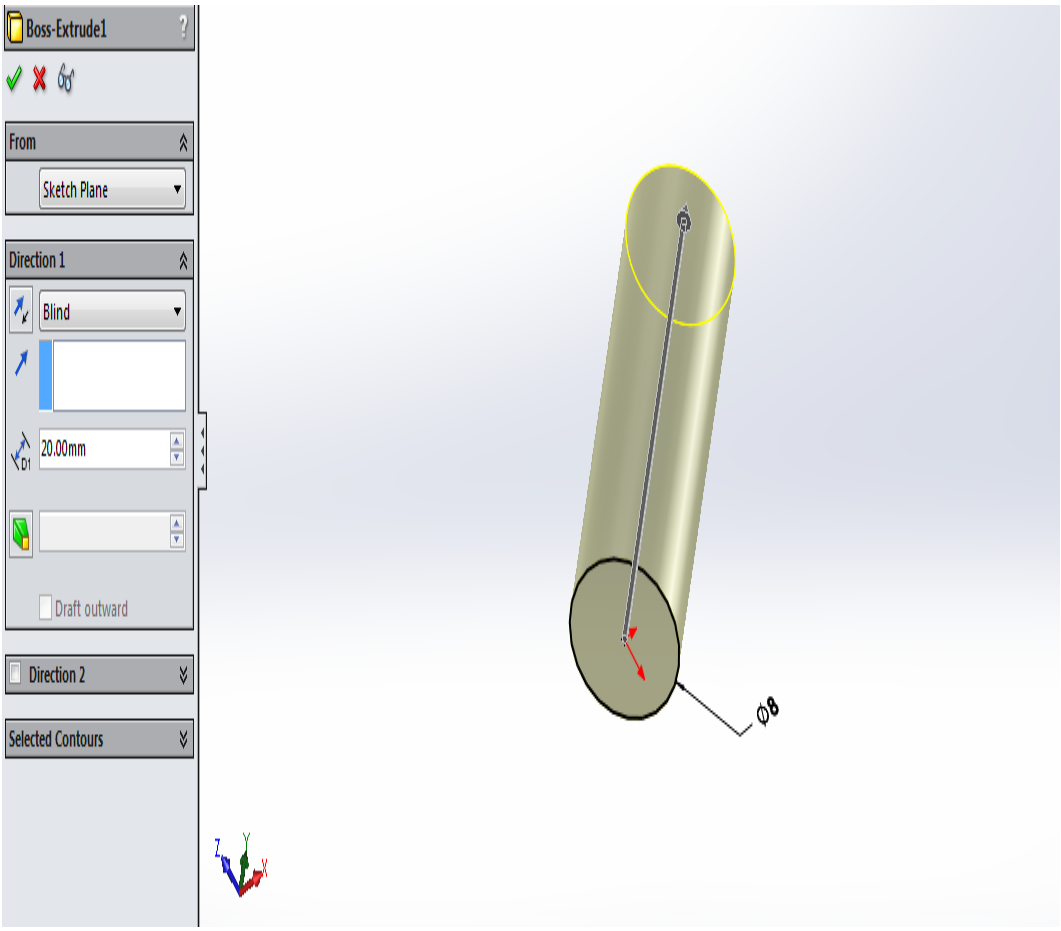


c. Rod

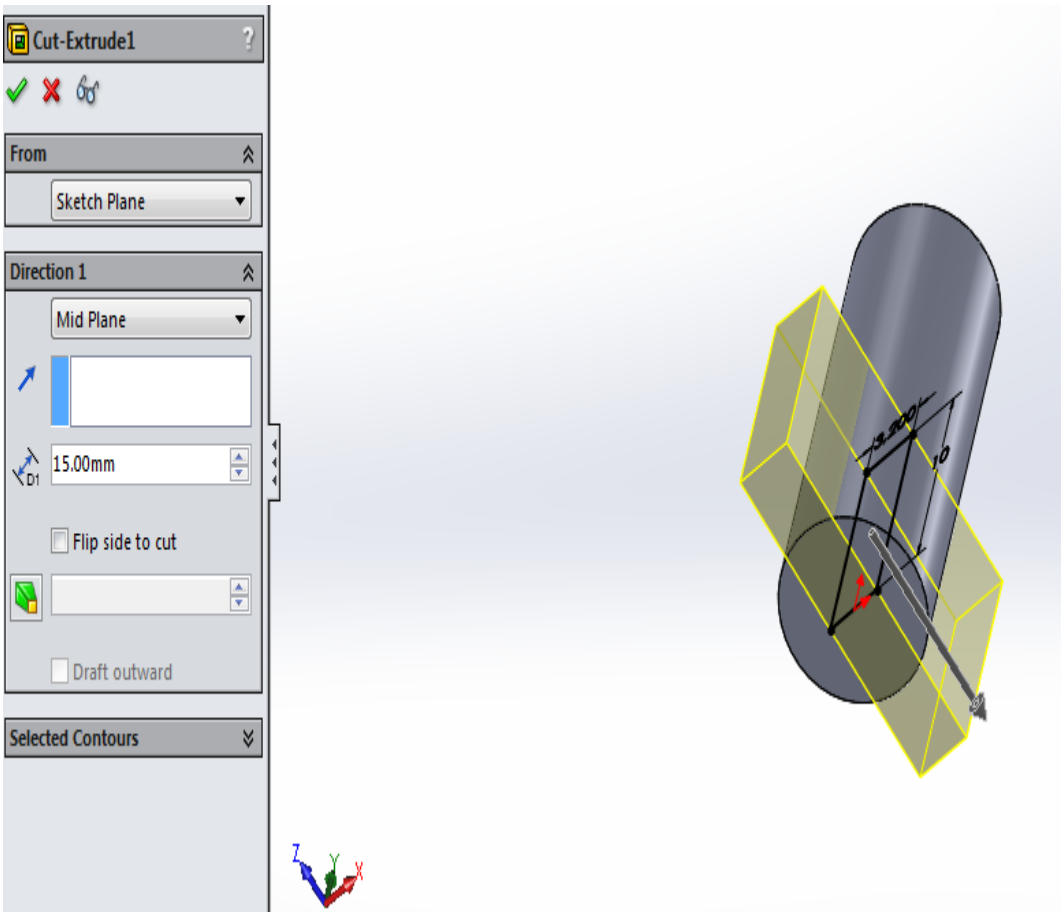
i. Define size

The size of the rod depends on the position of the crank and the piston. Thought the assembly, we measure the relative position. The servo, the piston and the rod will located parallel in line since this is the configurations with smaller resultant forces and, consequently, it creates smaller moments. Therefore,it is the most efficient configuration.
In that assembly we measure the distance between the servo and the piston.This will be the value of the distance between the center of the holes for the bolts.

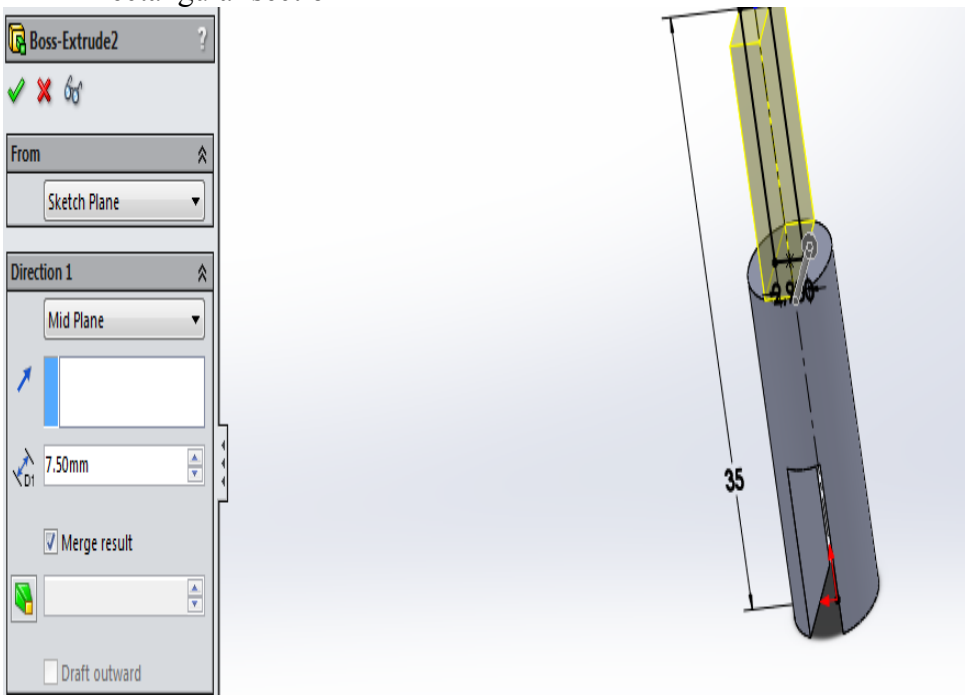
ii. Draw a circle and extrude it to build the thicker half where the crank will be introduced.



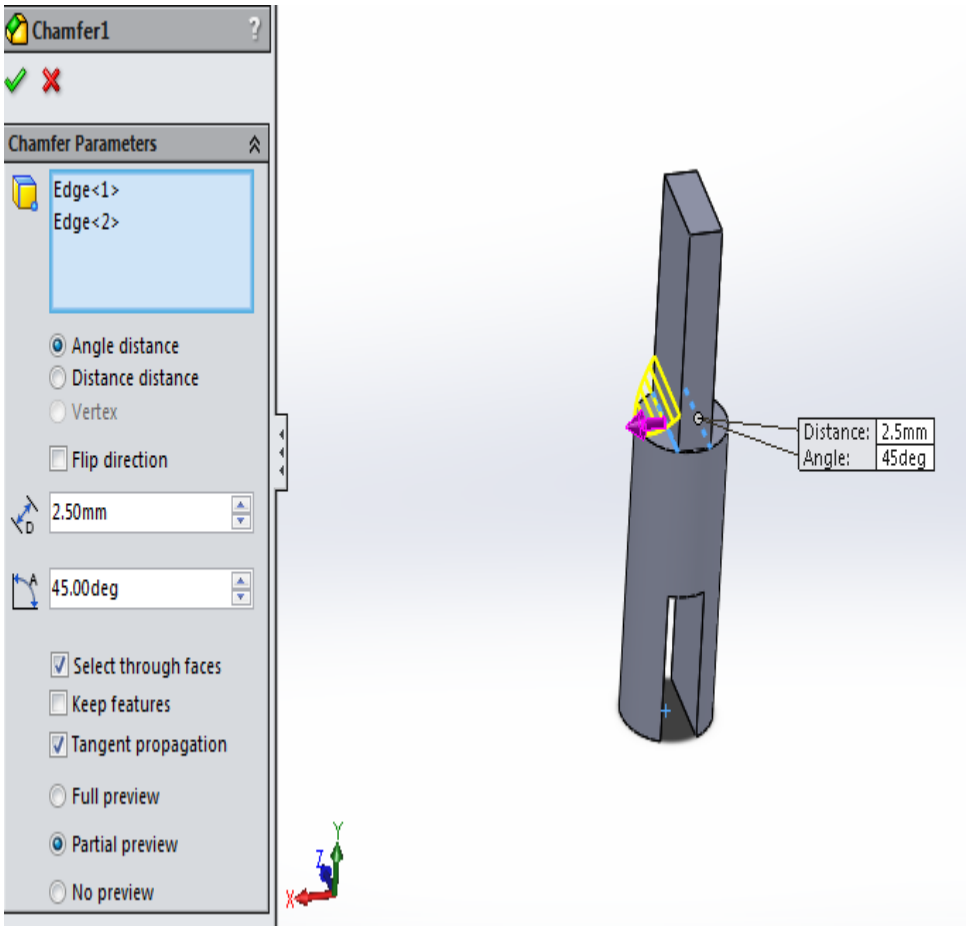
Use *Extrude Cut* to create the attachment space for the crank



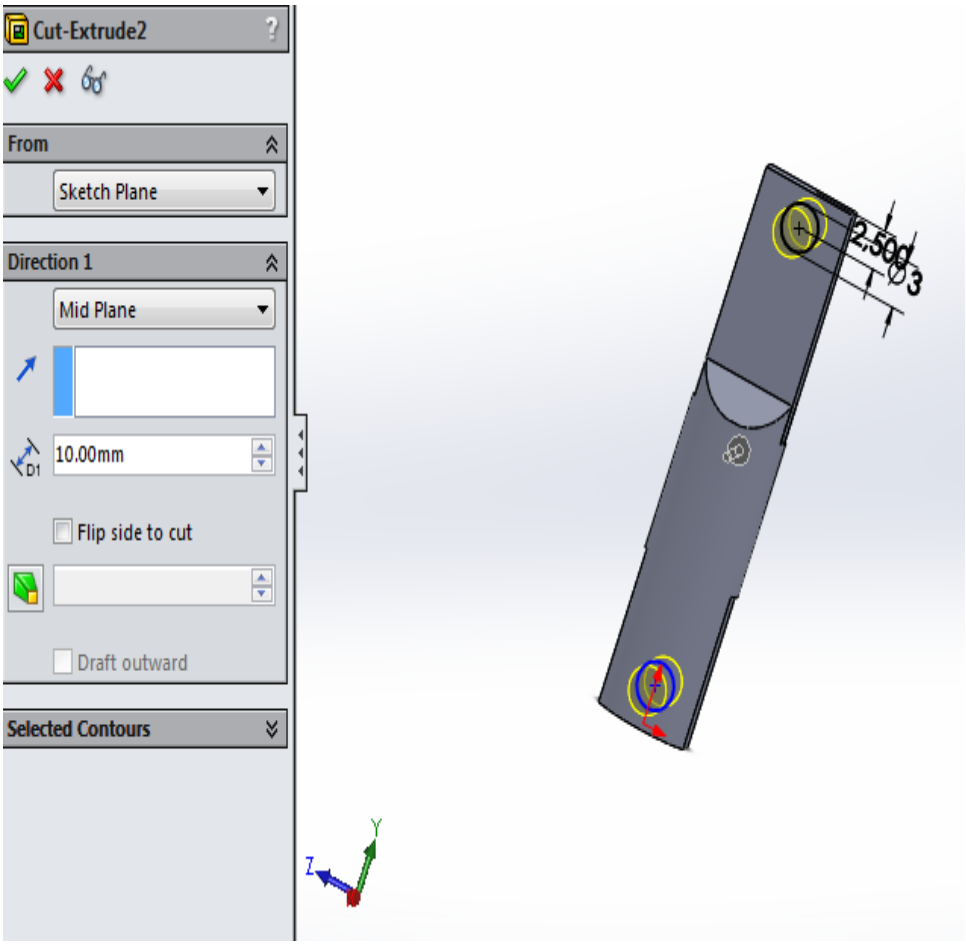
iii. Build thinner half for the connection with the piston. Extrude a rectangular section



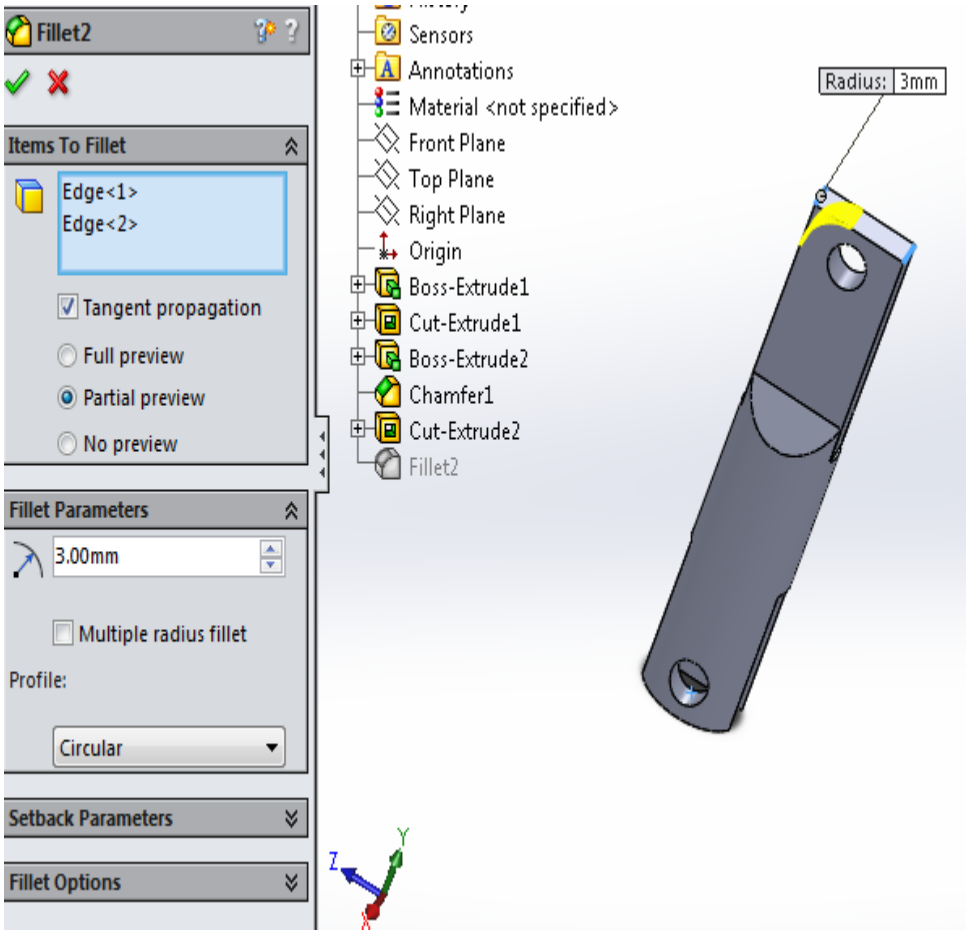
Add Chamfer at the boundary between the two halves to make it more robust.



Use *Extrude Cut* to create in the part the holes for the bolts.



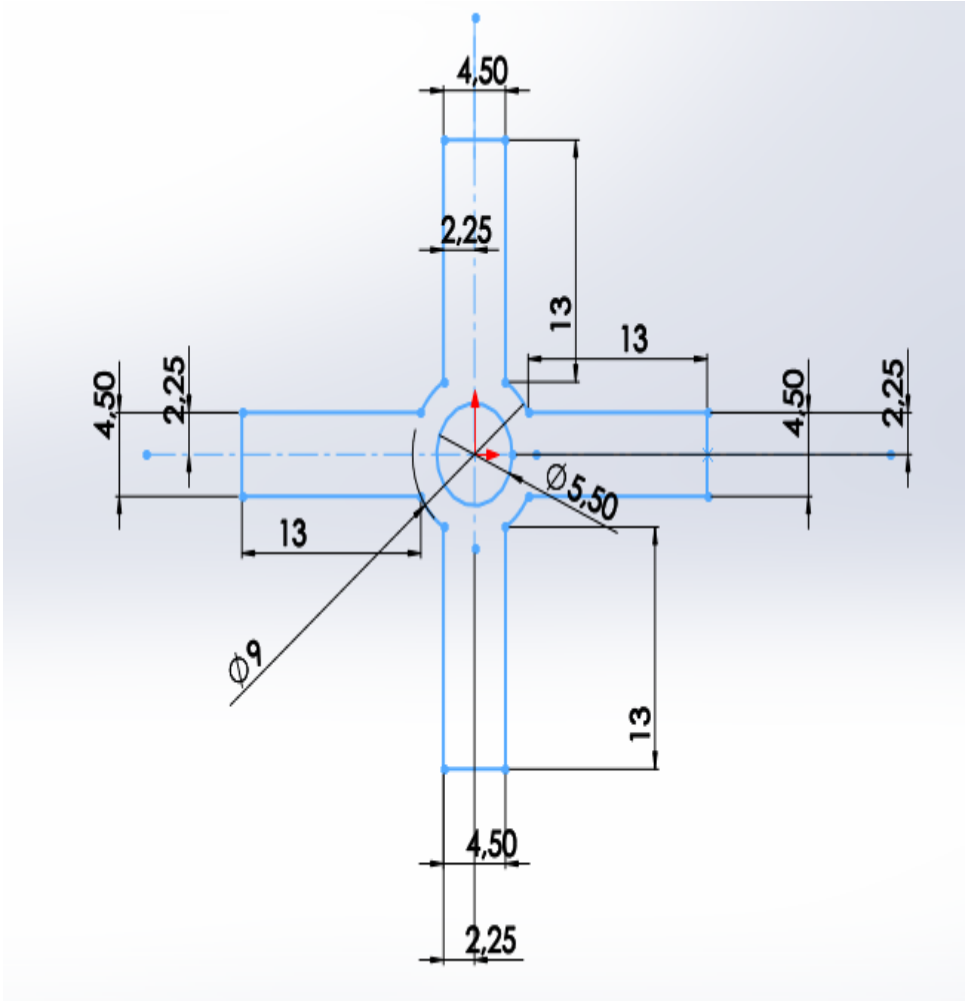
Use *Add Fillet* to curve the edge of the thinner half



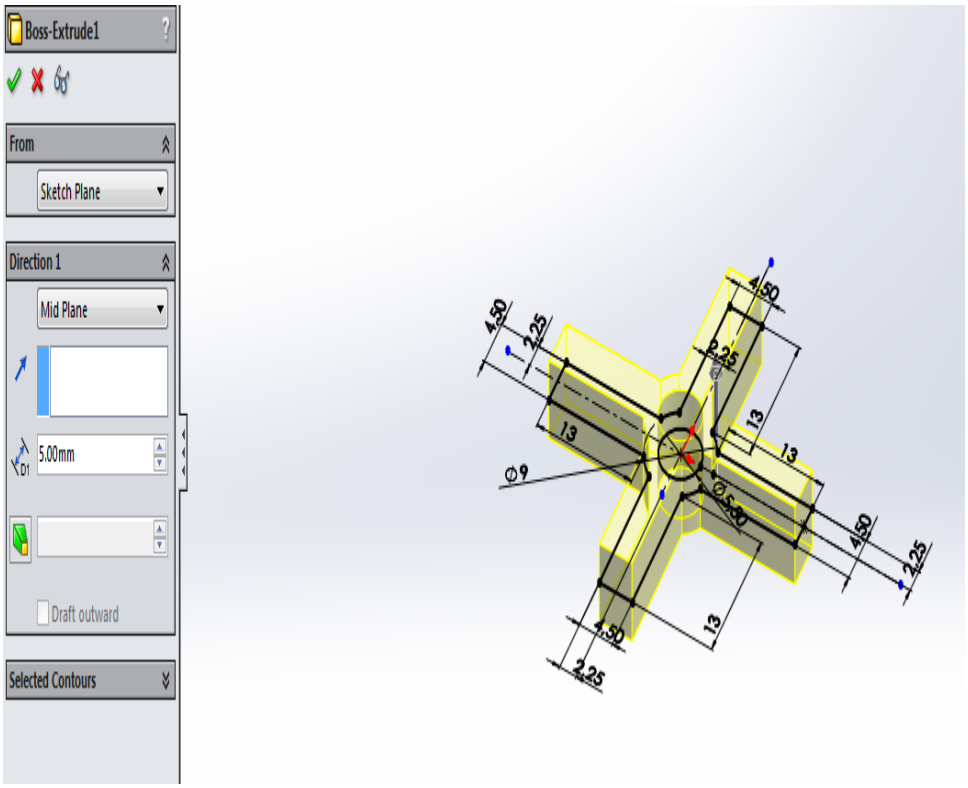
1. Linkage system

a. Crown

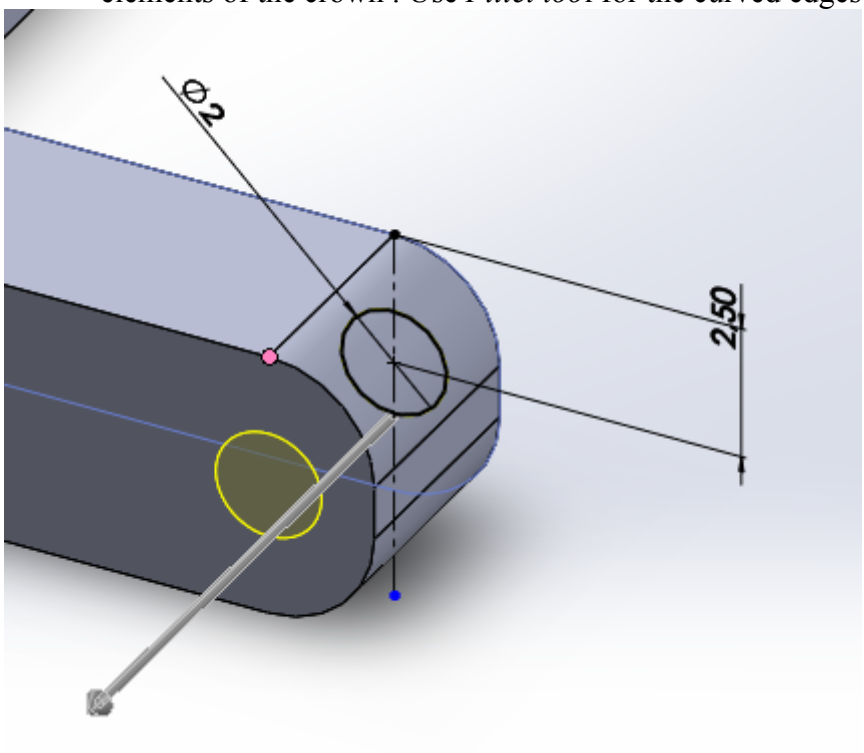
i. Draw profile in the top plane



ii. Extrude it

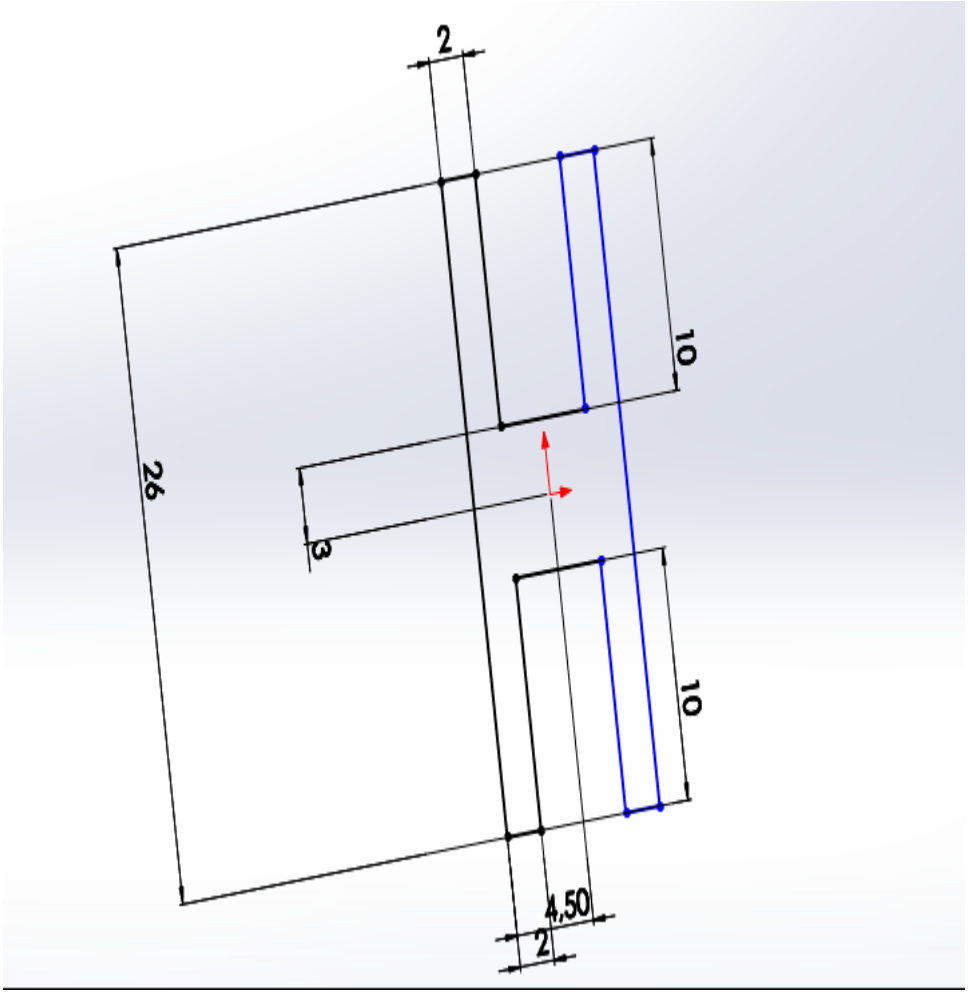


iii. Extrude cut of circles of diameter 2 for the hinge connection at outside elements of the crown . Use *Fillet too*l for the curved edges

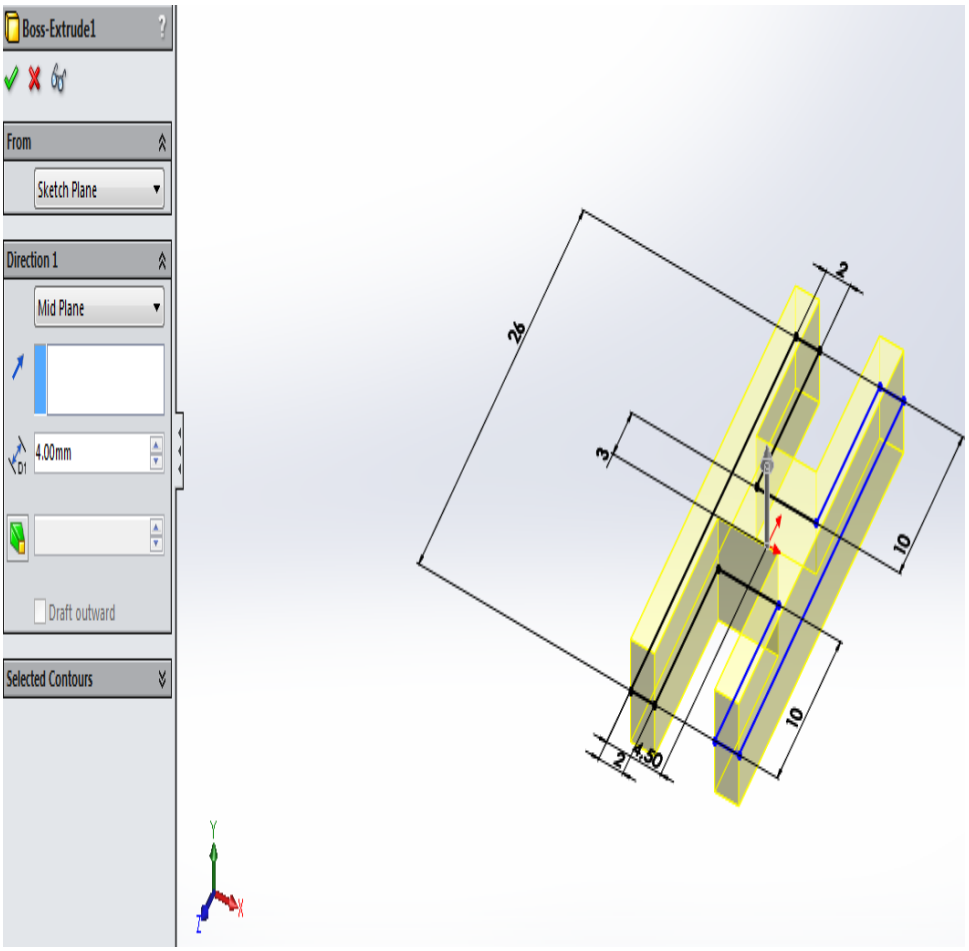


b. Internal link

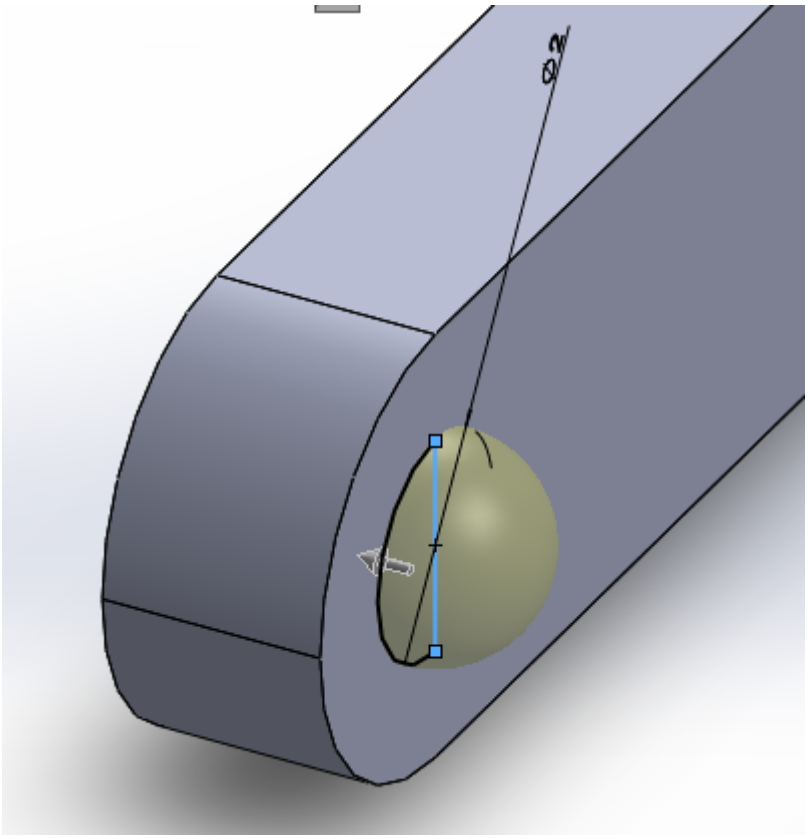
i. Draw profile in the top plane



ii. Extrude it

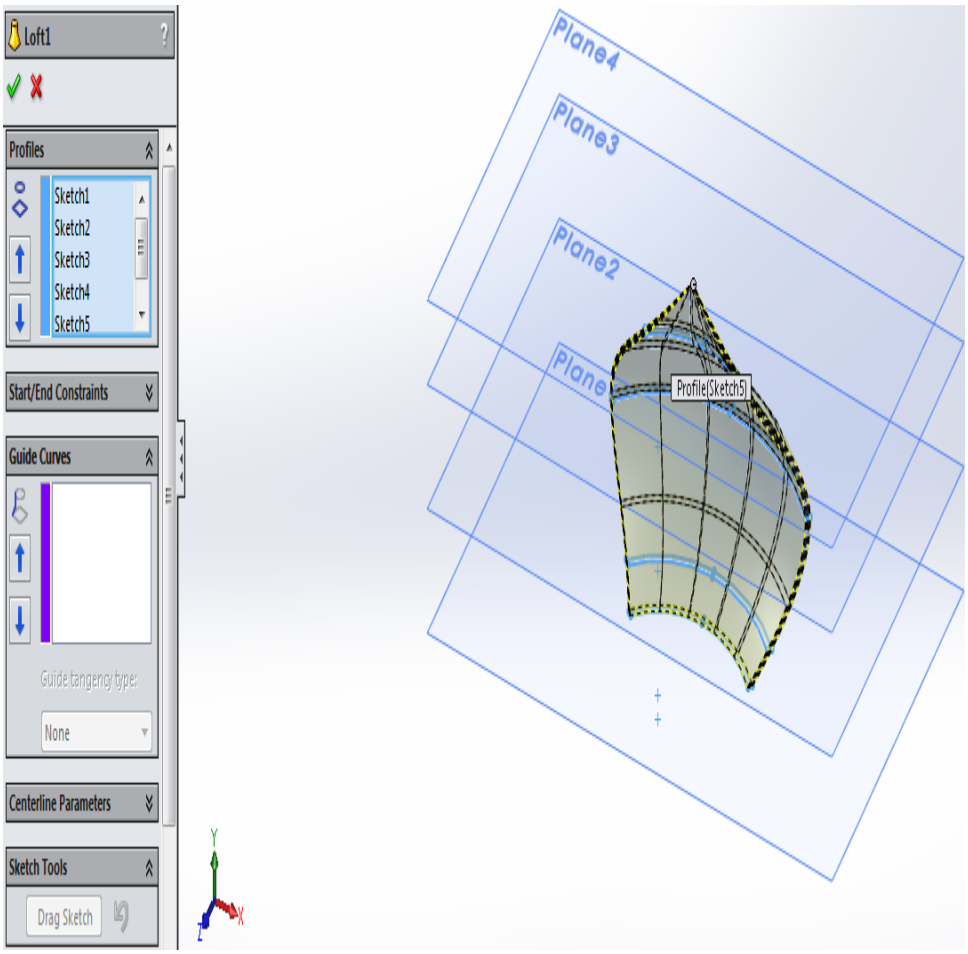


iii. Revolve half spheres for the hinge connection at outside elements.Use *Fillet too*l for the curved edges

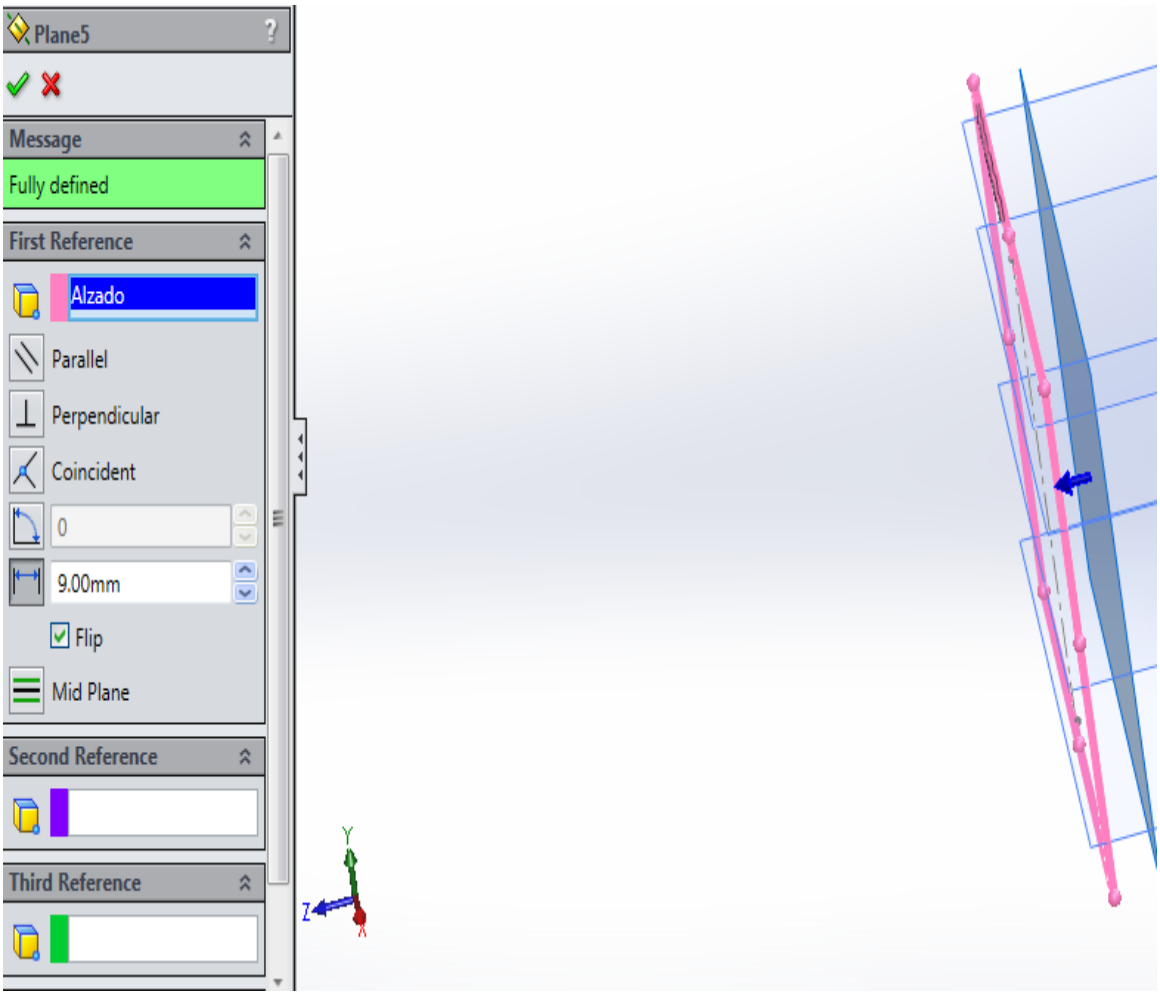


1. Petal

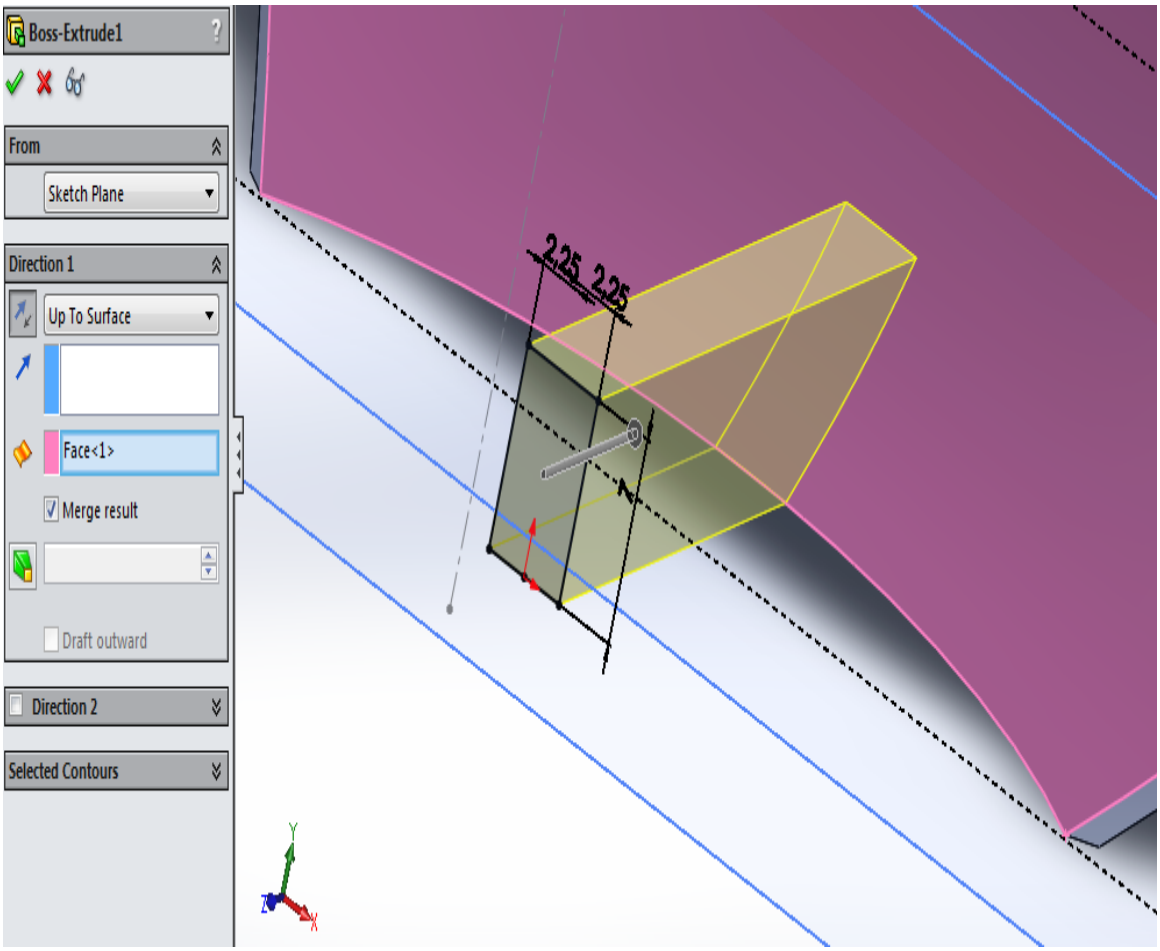
i. Use the same the 5 initial planes to draw the different section. Use *Loft* tool to create the petal



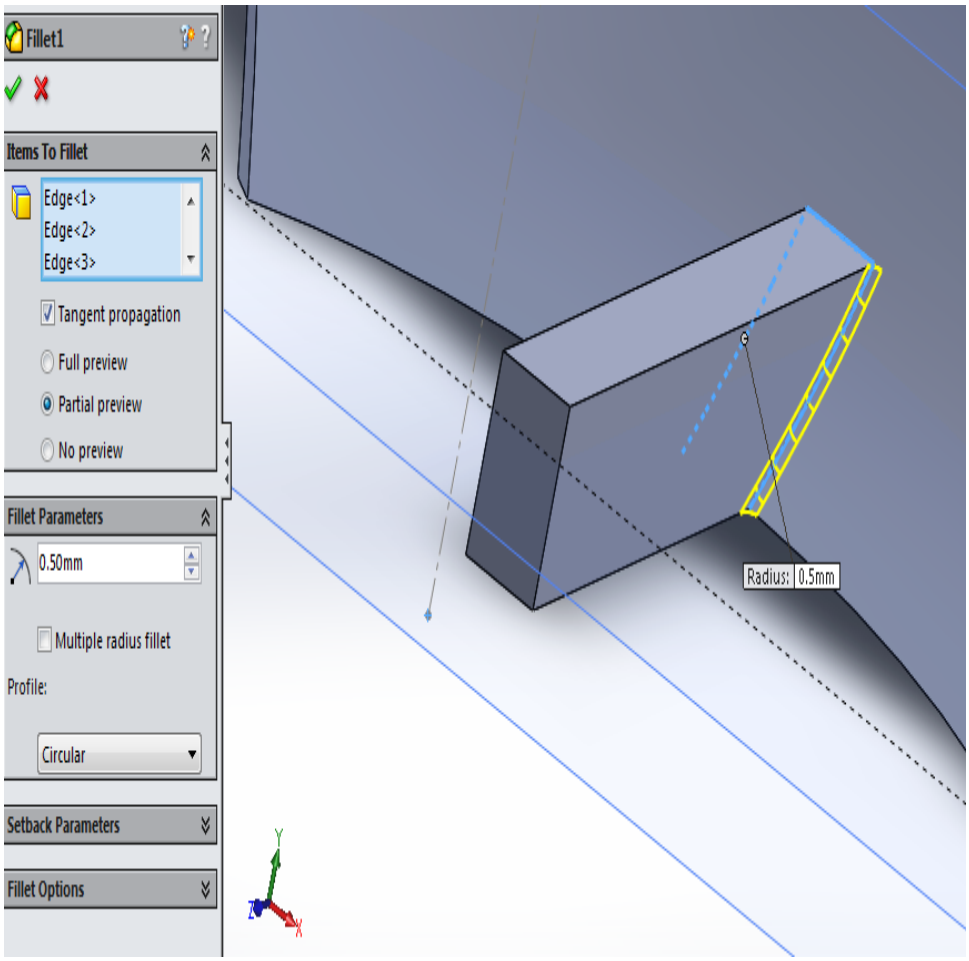
ii. Create a plane, parallel to the front plane.



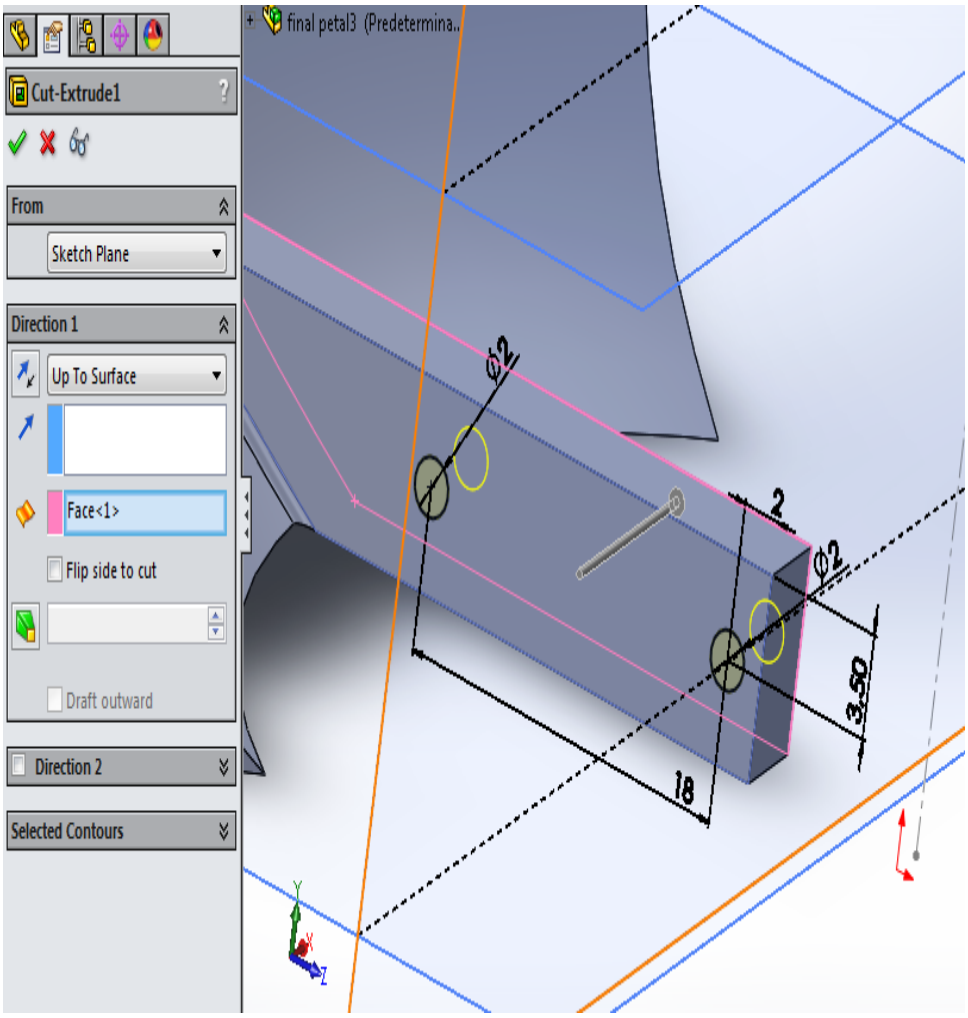
iii. Draw a rectangle at the plane just created. *Extrude* rectangle.



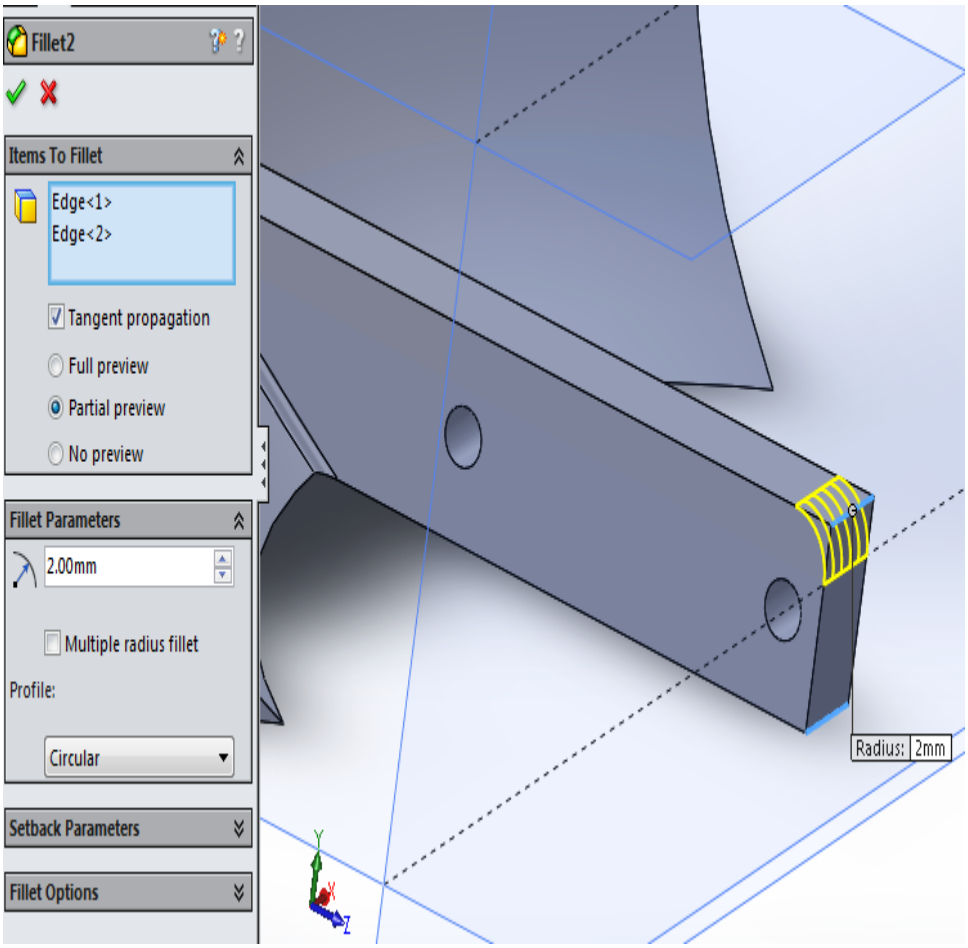
iv. *Add Fillet* to make the element stronger



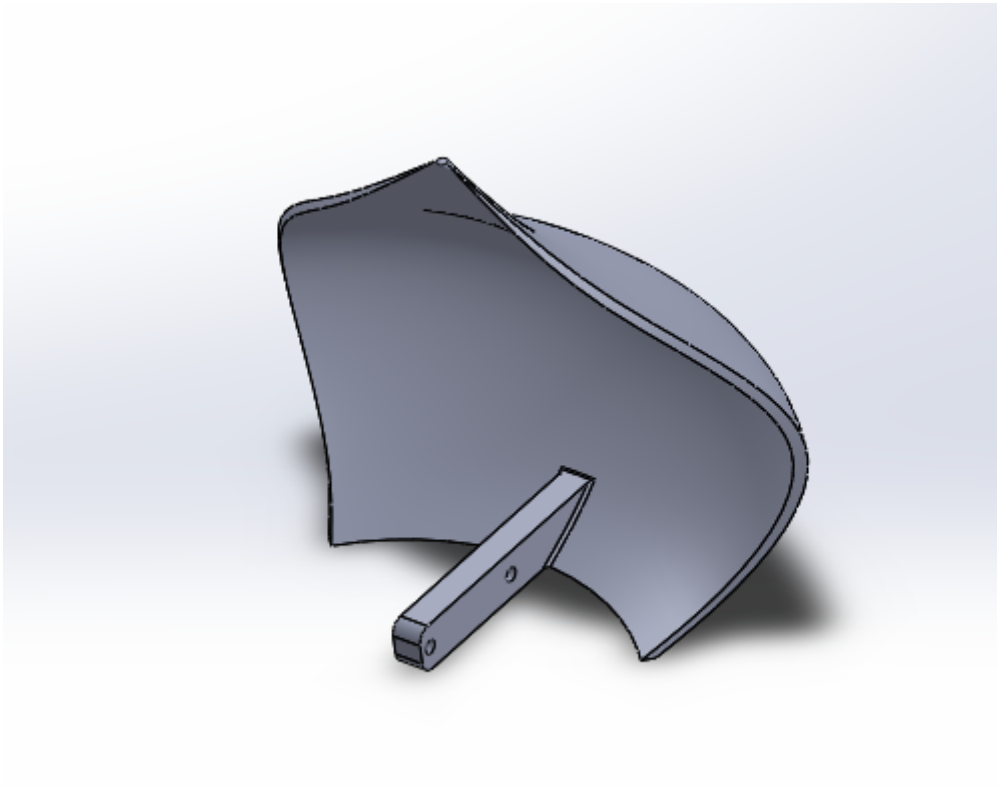
Extrude Cut of circles of diameter 2 for the hinge connection at outside elements of the crown



Use *Fillet too*l for the curved edges



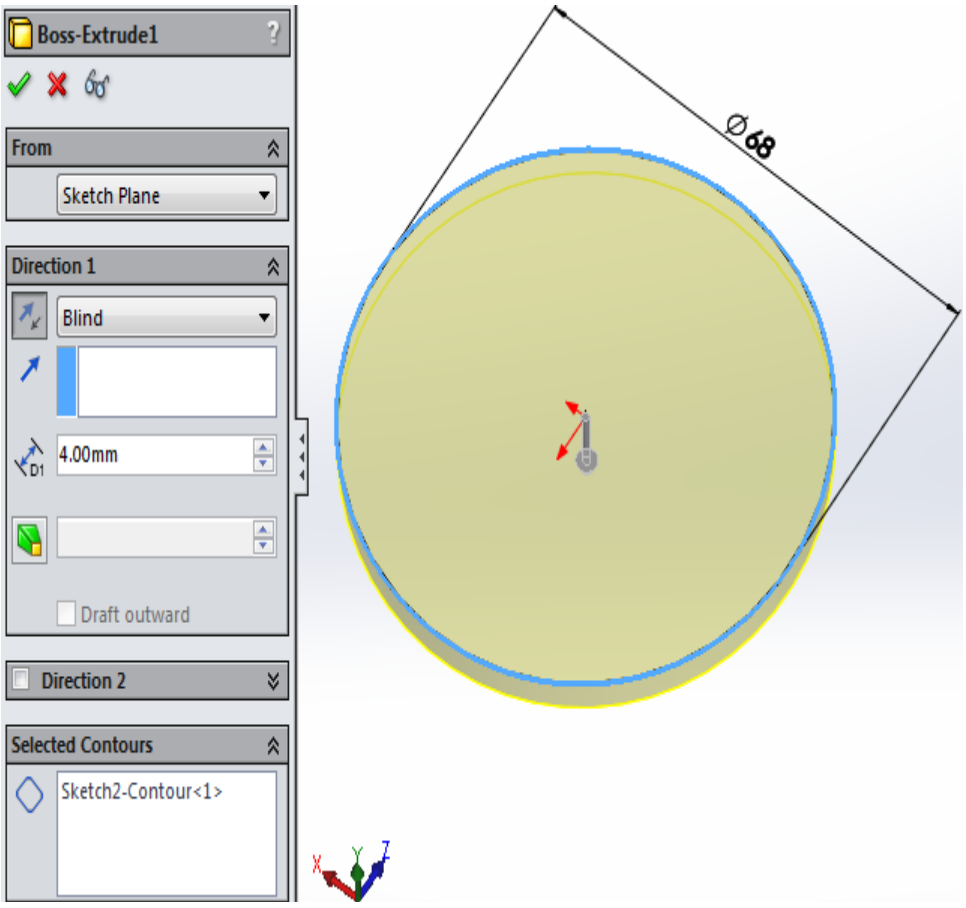
v. Final result



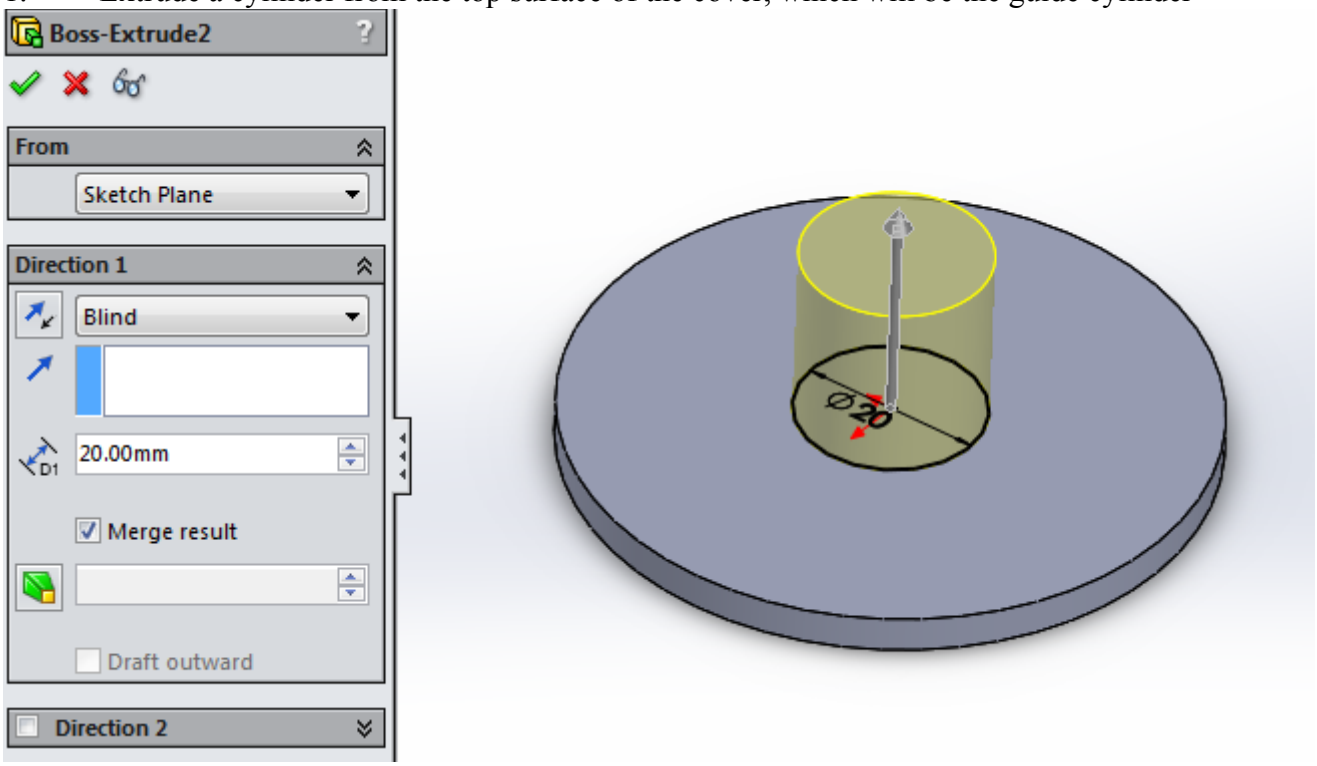
1. Base

i. Create the initial shape shape of the base

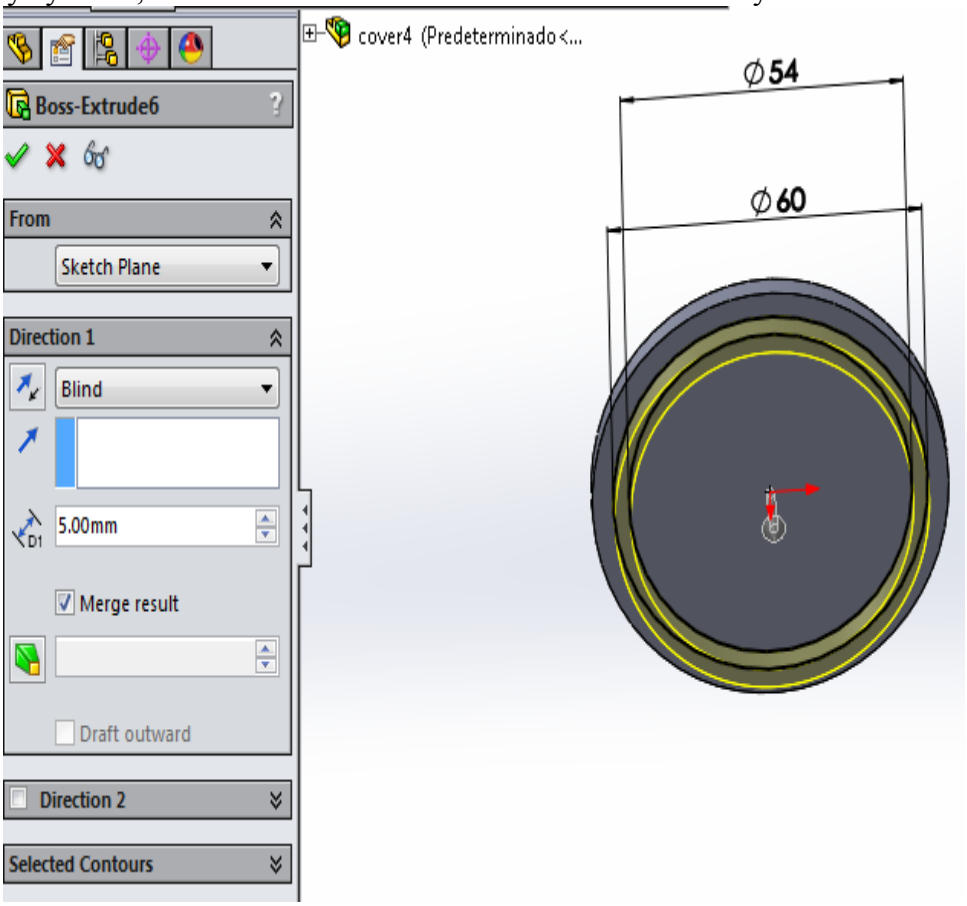
1. Extrude cylinder, which is going to be the cover of the mechanism



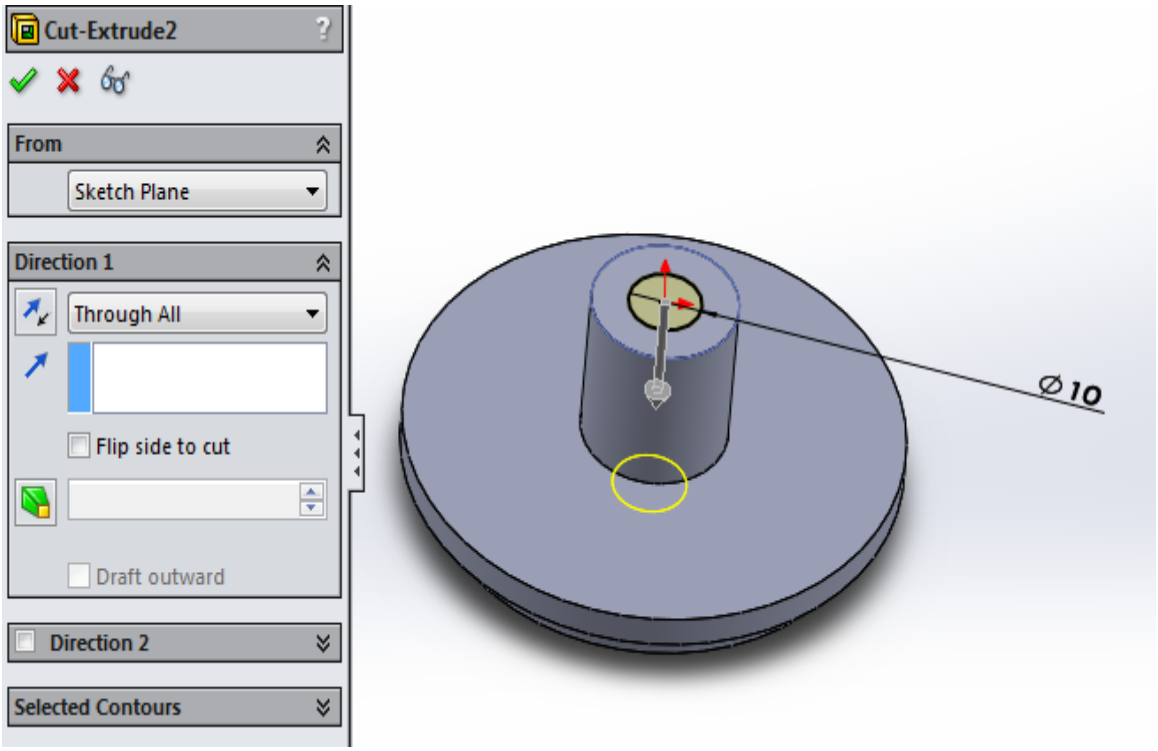
1. Extrude a cylinder from the top surface of the cover, which will be the guide cylinder



1. Extrude a empty cylinder, which will be the connection with the Holder cylinder



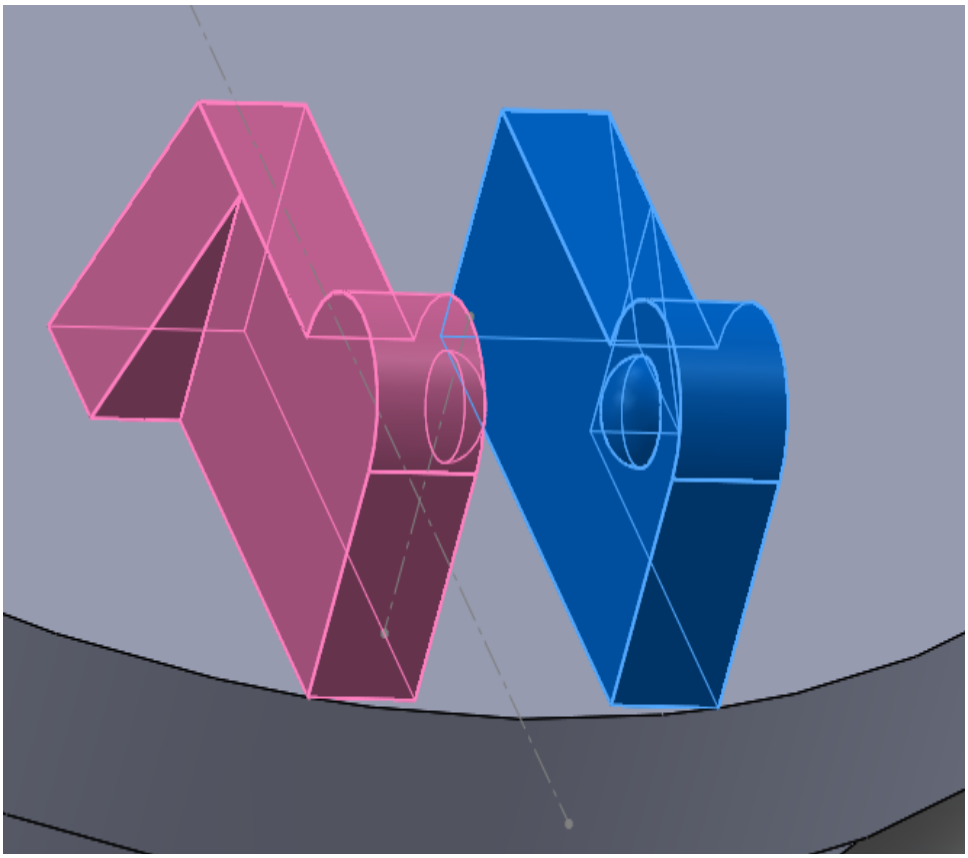
ii. Use Extrude Cut for the piston at the guide cylinder



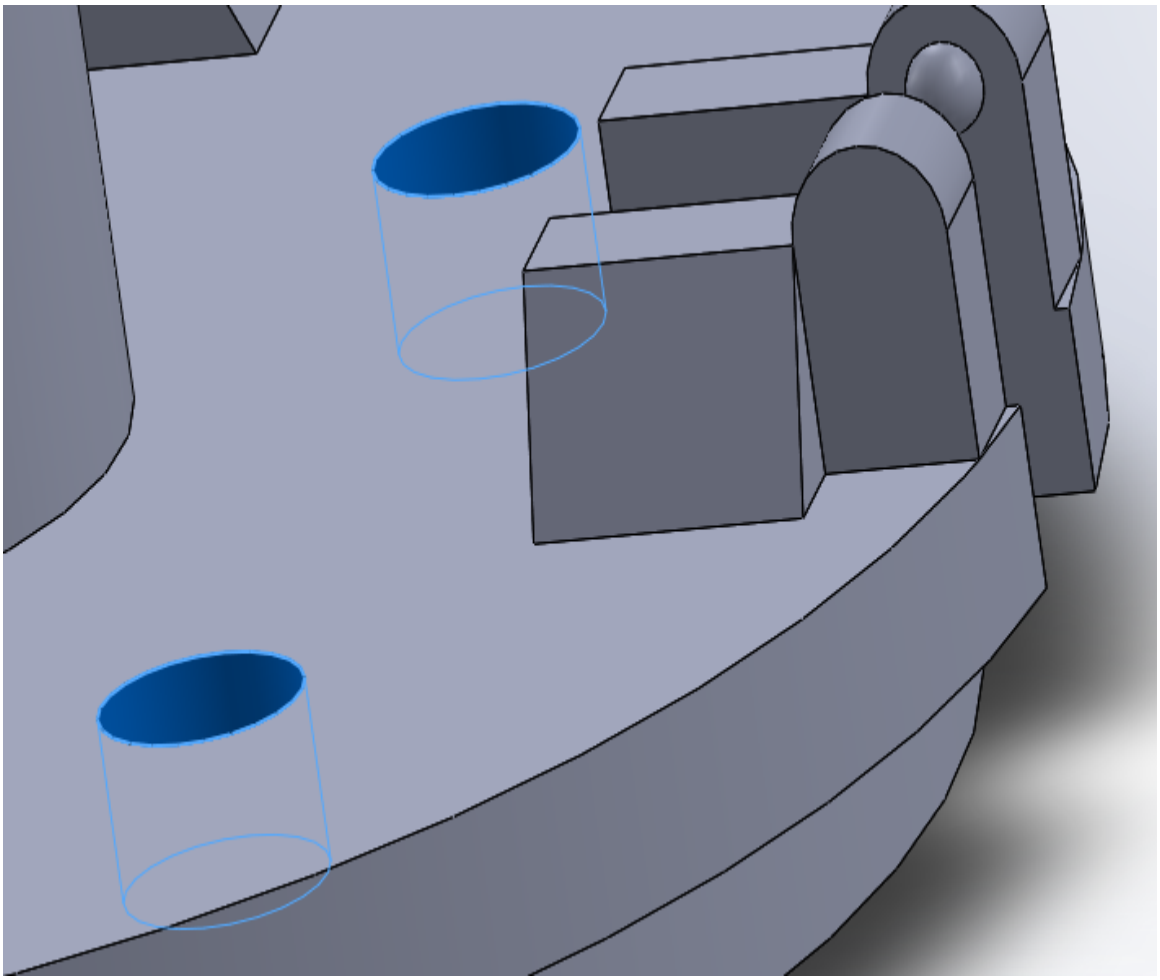
iii. Add hinge to attach the petal with the base

First we create only one side of the hinge to copy it with the tool Mirror and obtain the hinge complete. For the hinge connection, a half sphere of diameter 2 mm is revolved.

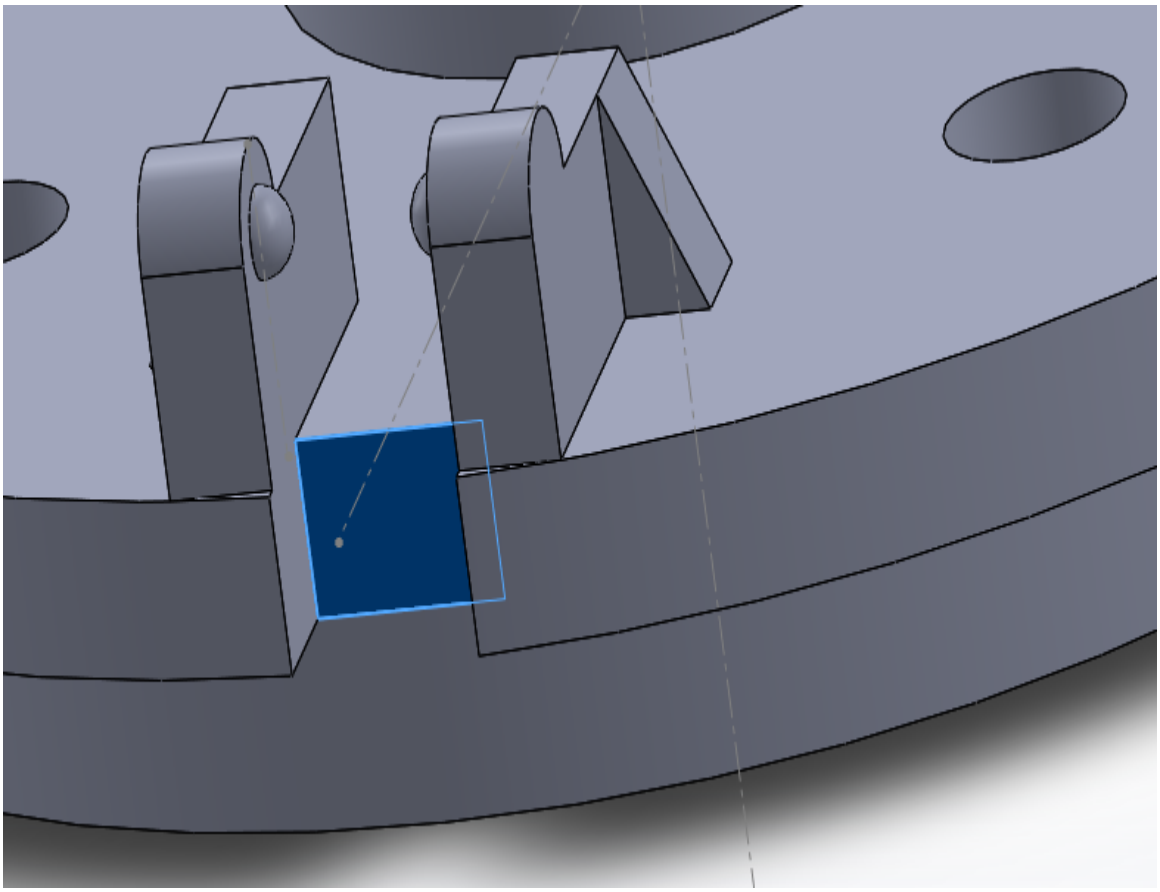
Then, the tool circular pattern is used to get the 4 hinges for the 4 petals.



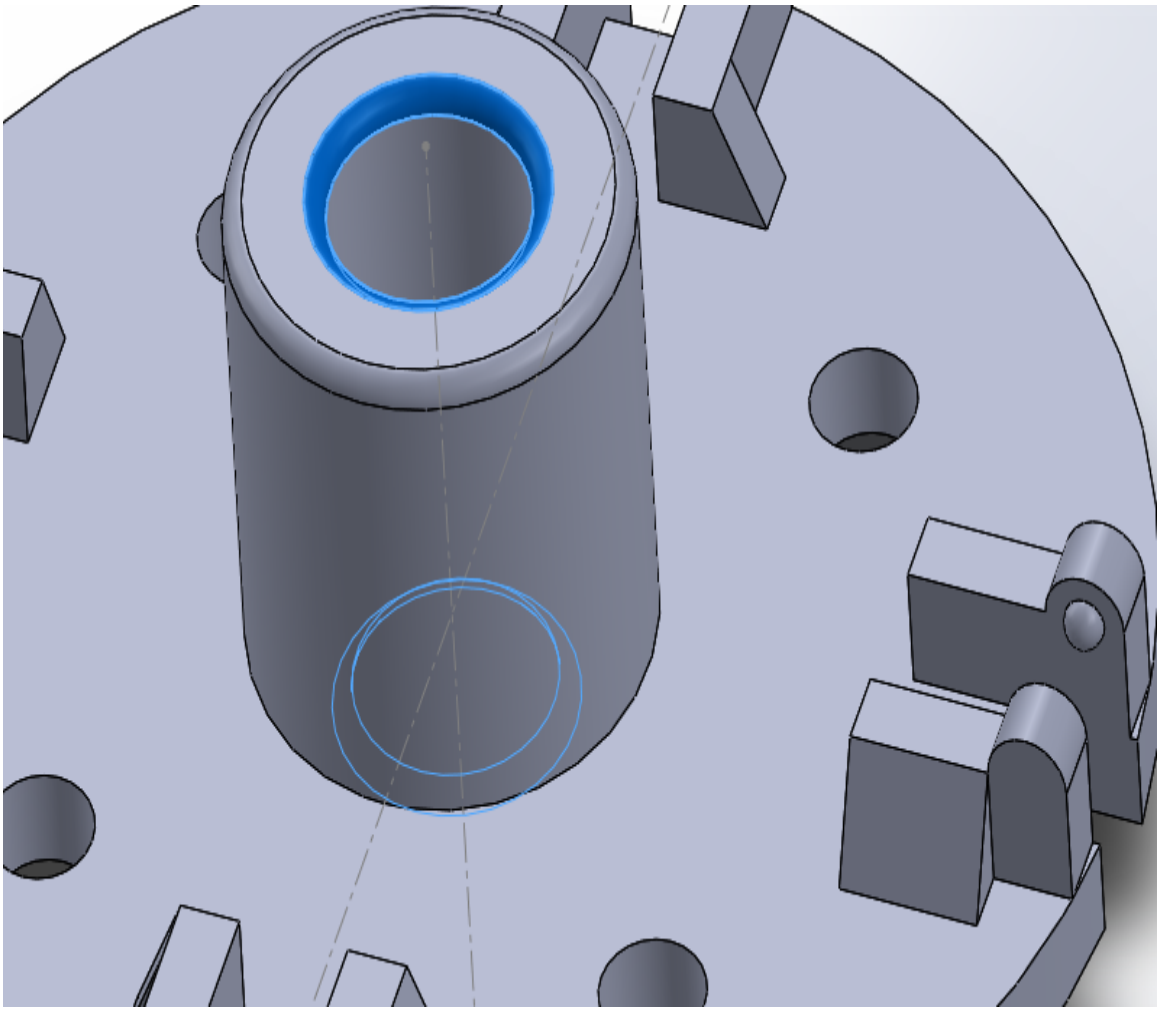
iv. Add hole for the LEDs



v. Make a cut at the end of the space between the hinge so the petal does not hit the cover



vi. Add Fillet at the guide cylinder

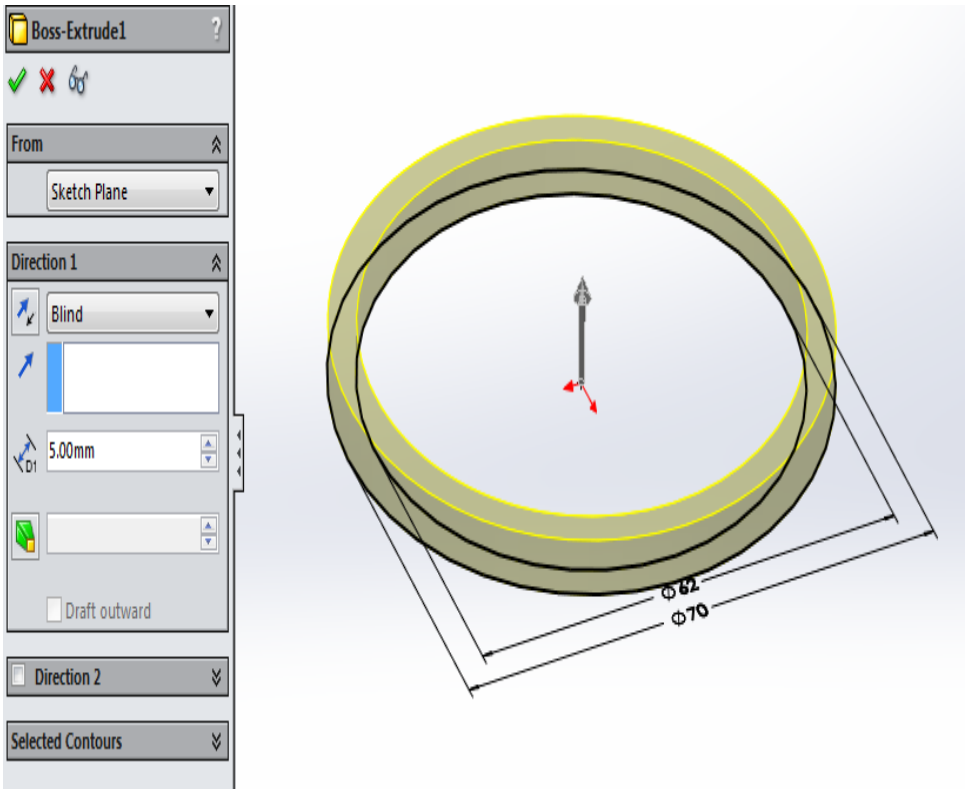


1. Holder

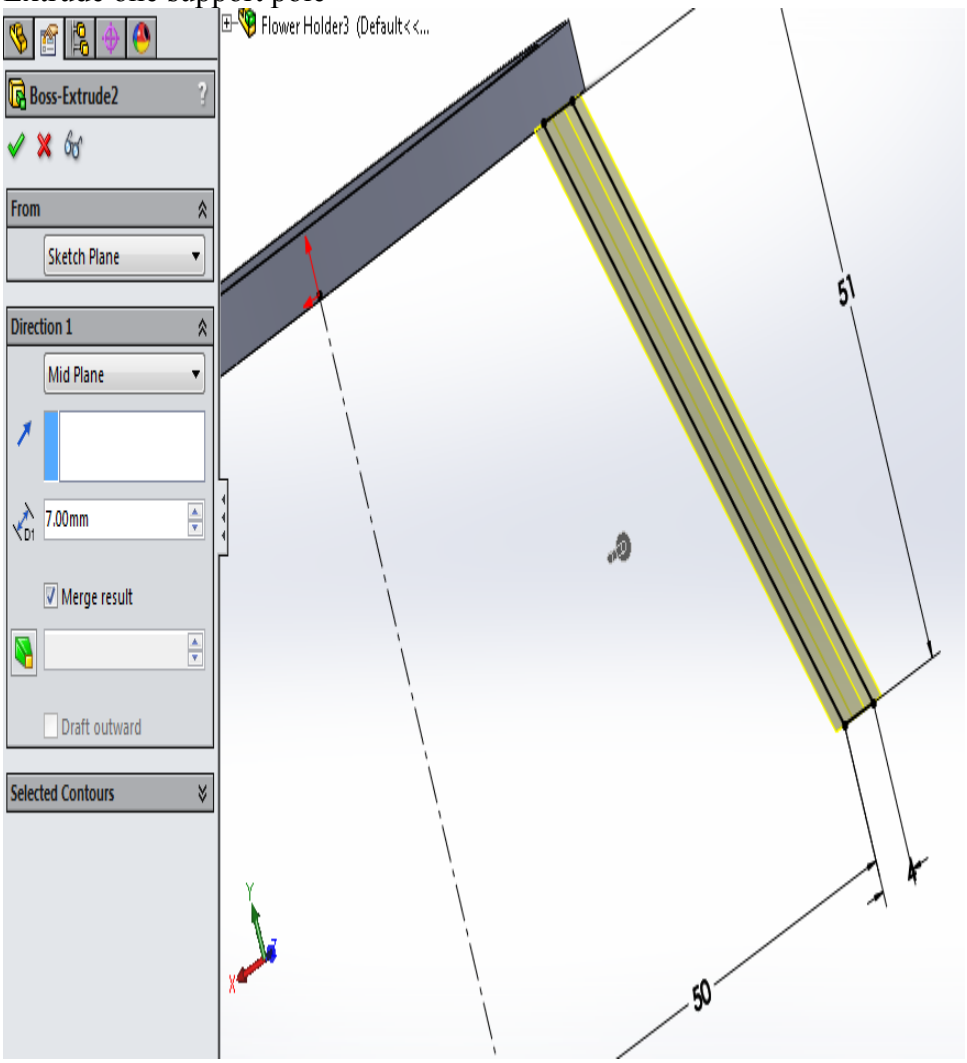
It was designed to

- Make the model more robust and safe material
-Built the servo holder in the bottom of the holder cylinder

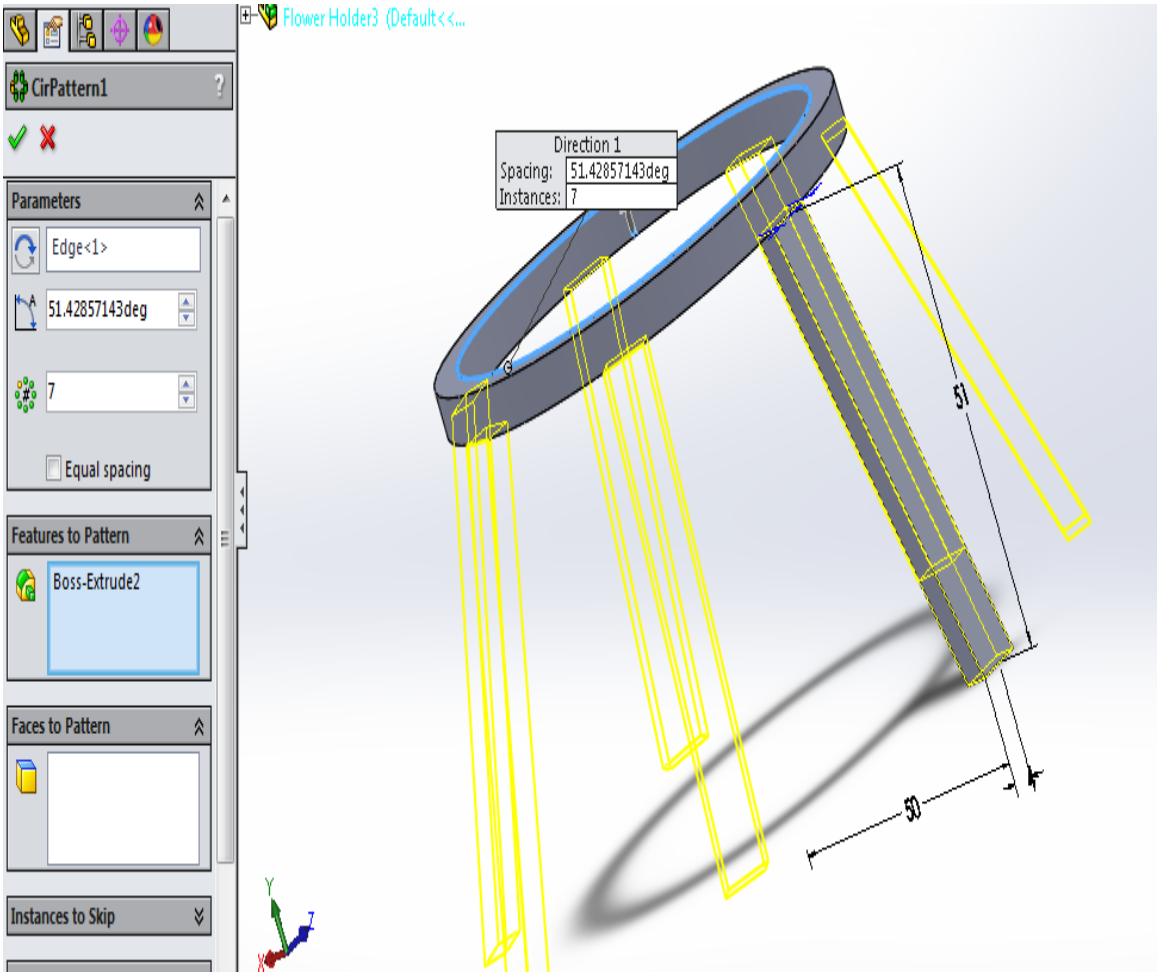
i. *Extrude* an empty cylinder for the connection between the base and the Holder


Boss-Extrude1
From
Sketch Plane
Direction 1
Blind
5.00mm
Draft outward
Direction 2
Selected Contours
Φ62
Φ70

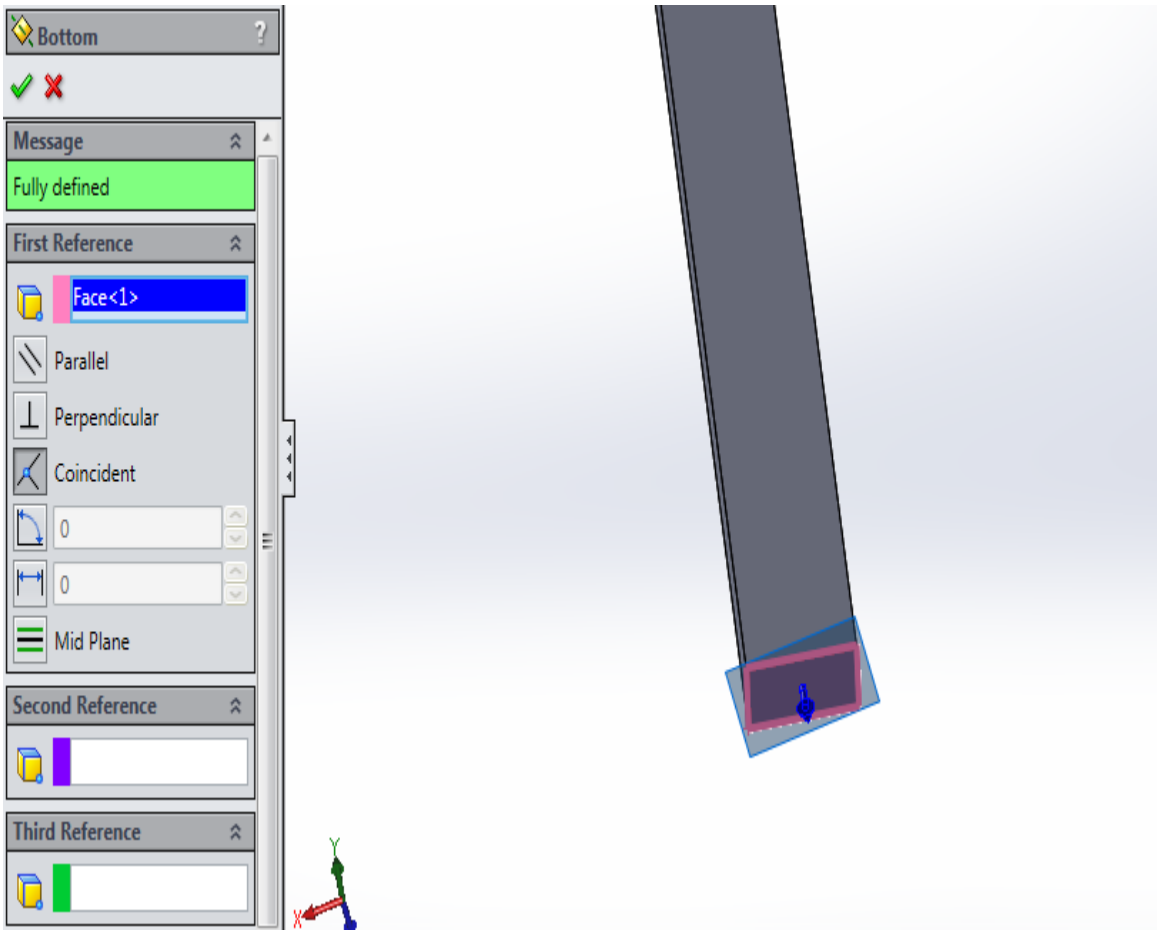
ii. Extrude one support pole



Use Circular Pattern to build the final structure

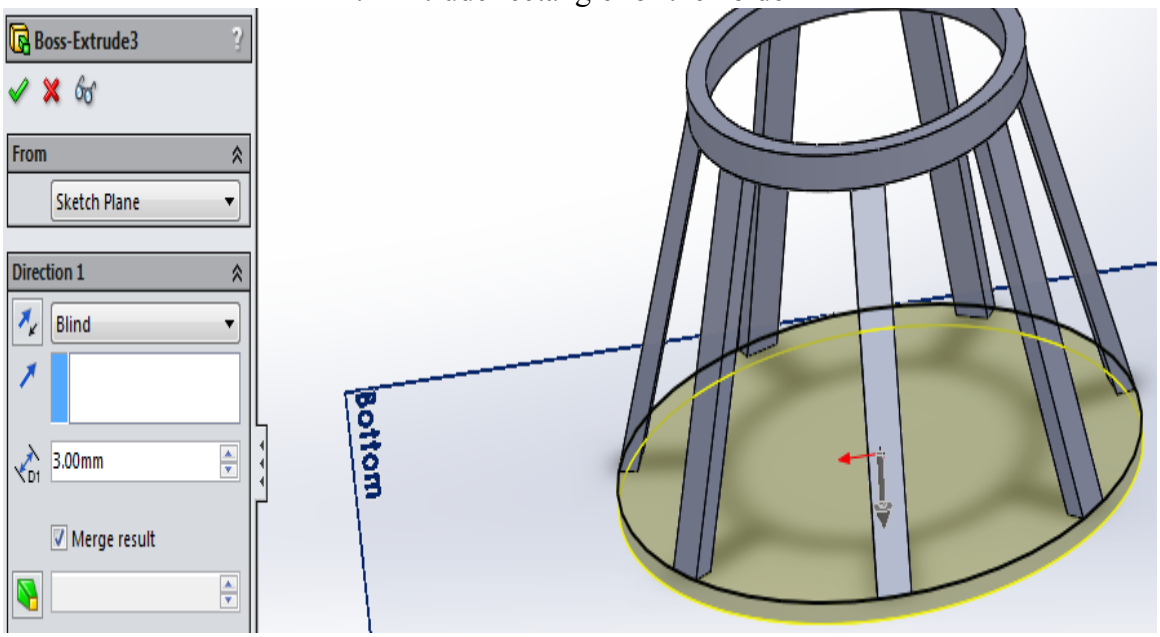


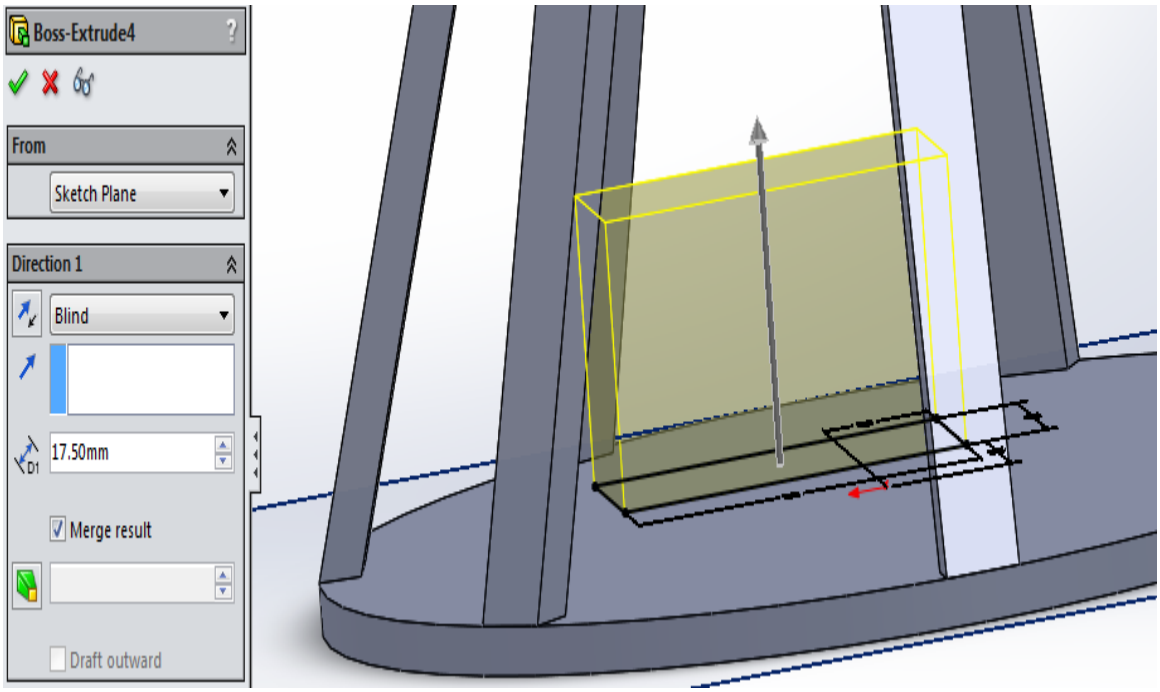
iii. Create a reference plane at the bottom of the support poles



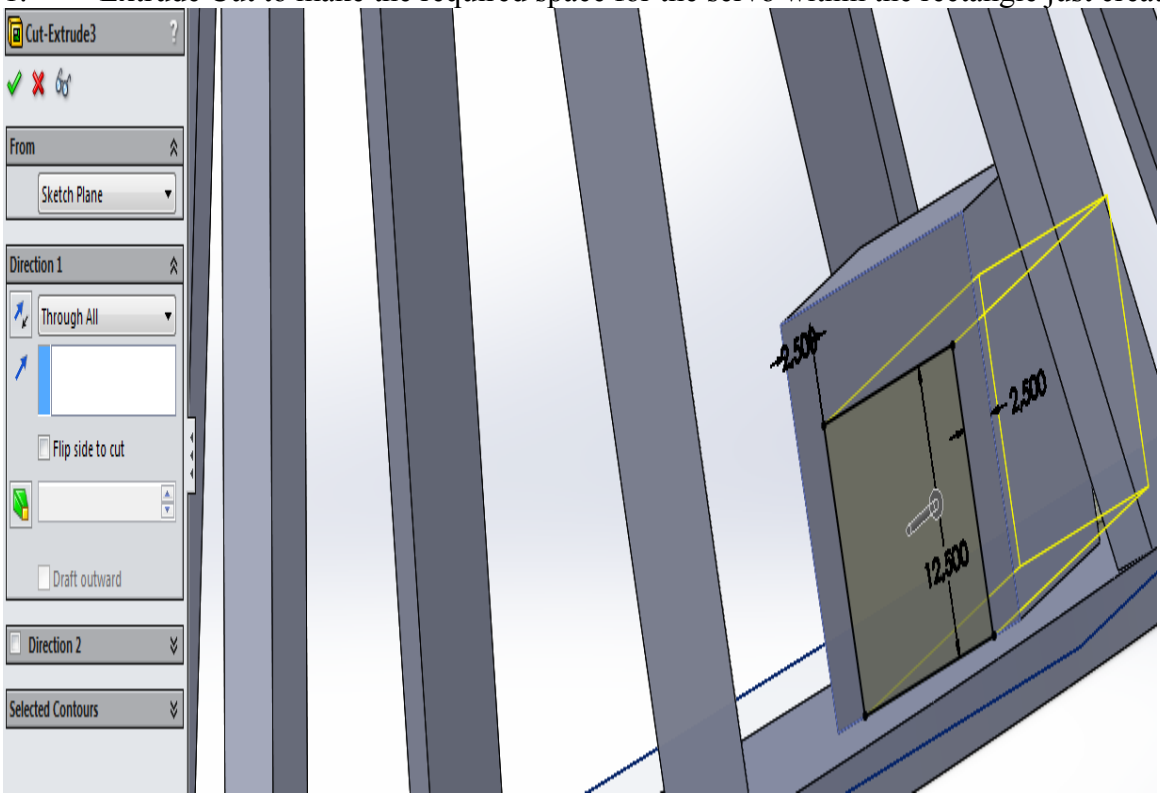
iv. Create servo holder

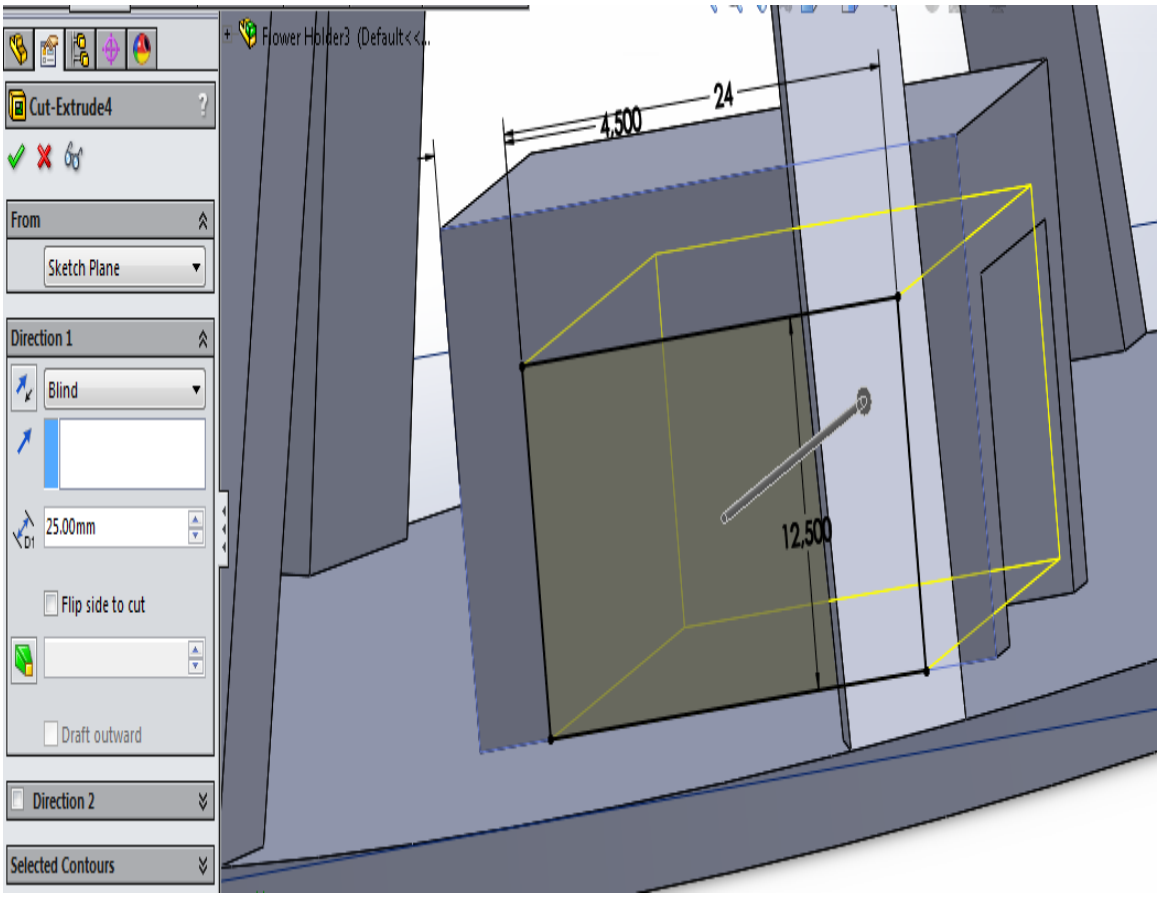
1. Extrude rectangle for the holder



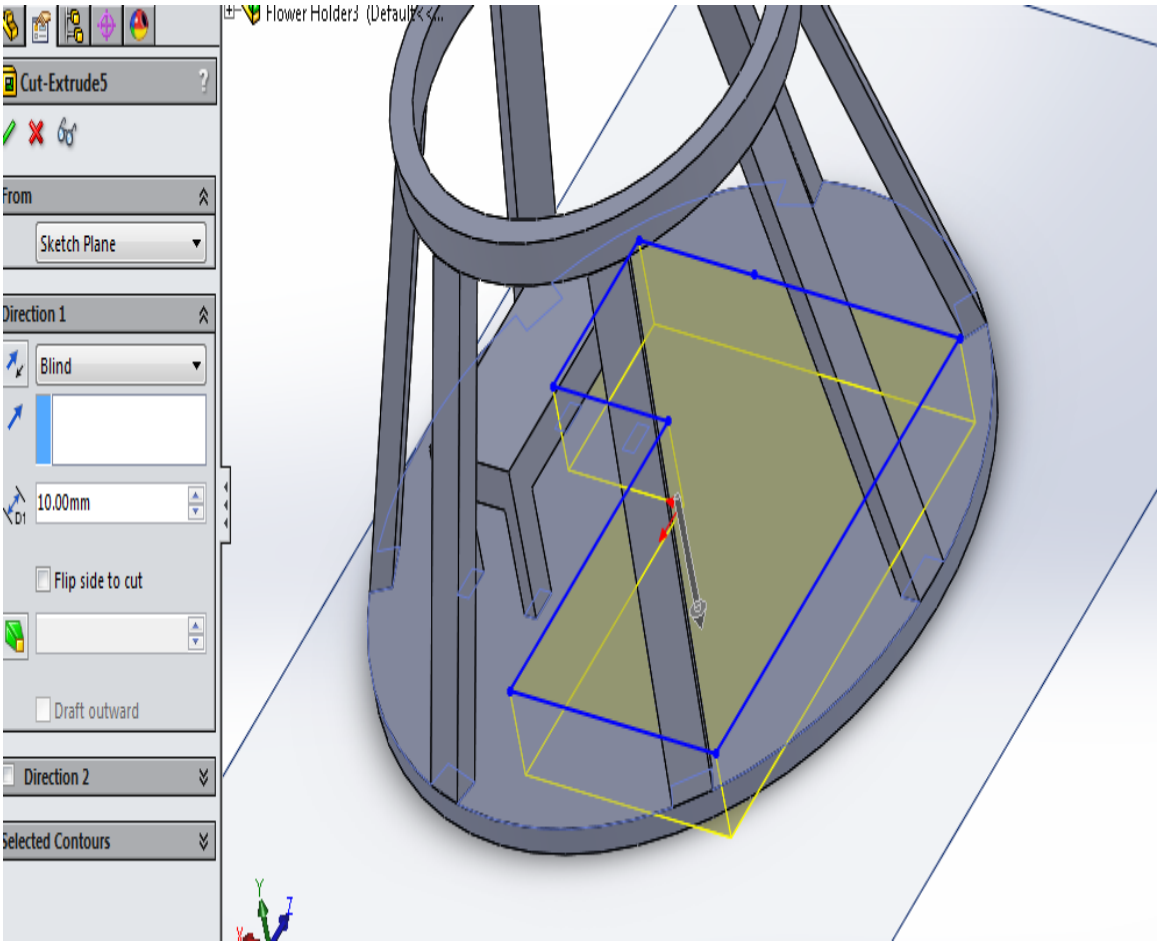


1. Extrude Cut to make the required space for the servo within the rectangle just created

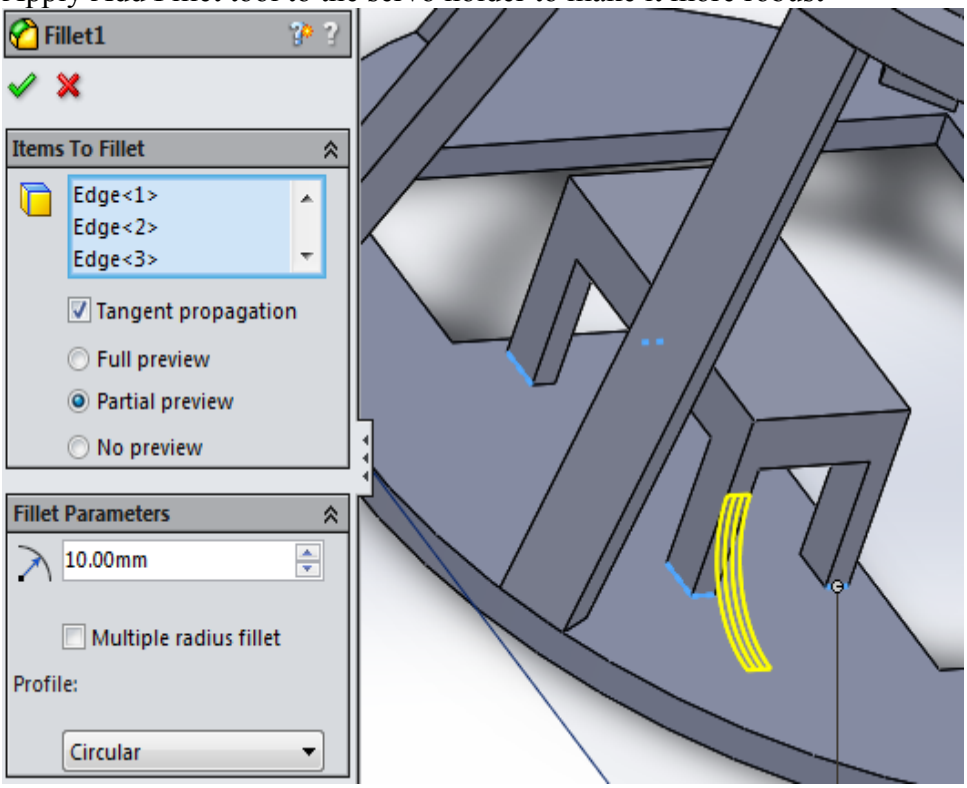




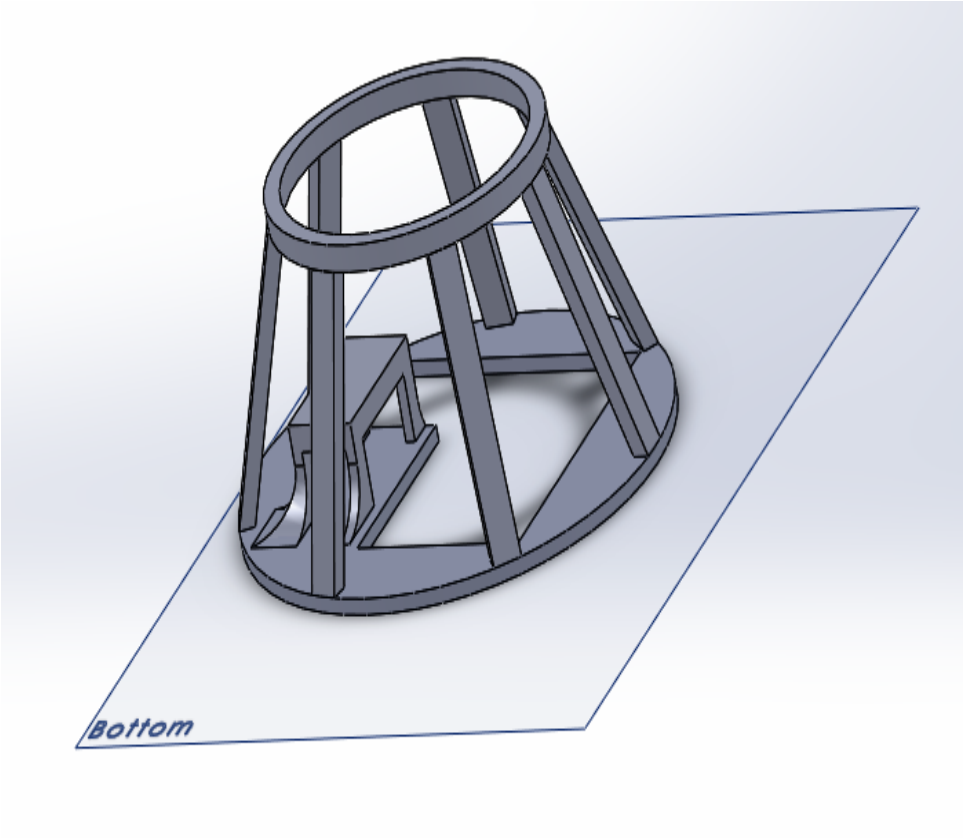
v. Extrude Cut to extrude regular section at the bottom of the holder to introduce and assemble the parts for the mechanism and the servo and save material


Flower Holder3 (Default
Cut-Extrude5
From
Sketch Plane
Direction 1
Blind
10.00mm
Flip side to cut
Draft outward
Direction 2
Selected Contours

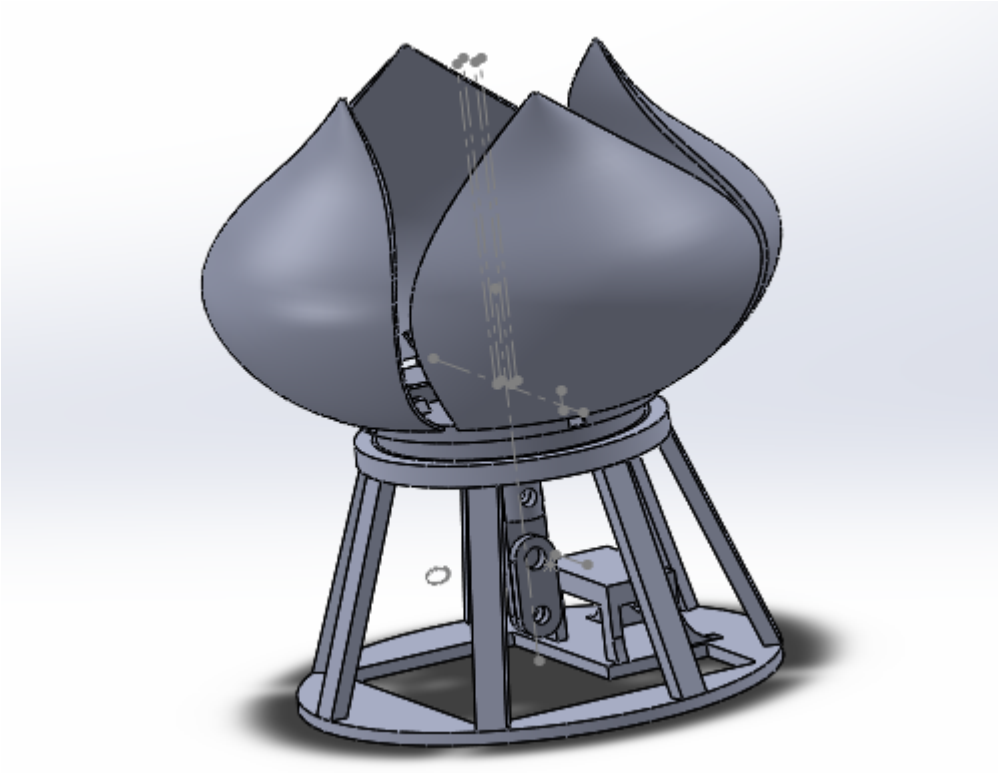
vi. Apply Add Fillet tool to the servo holder to make it more robust

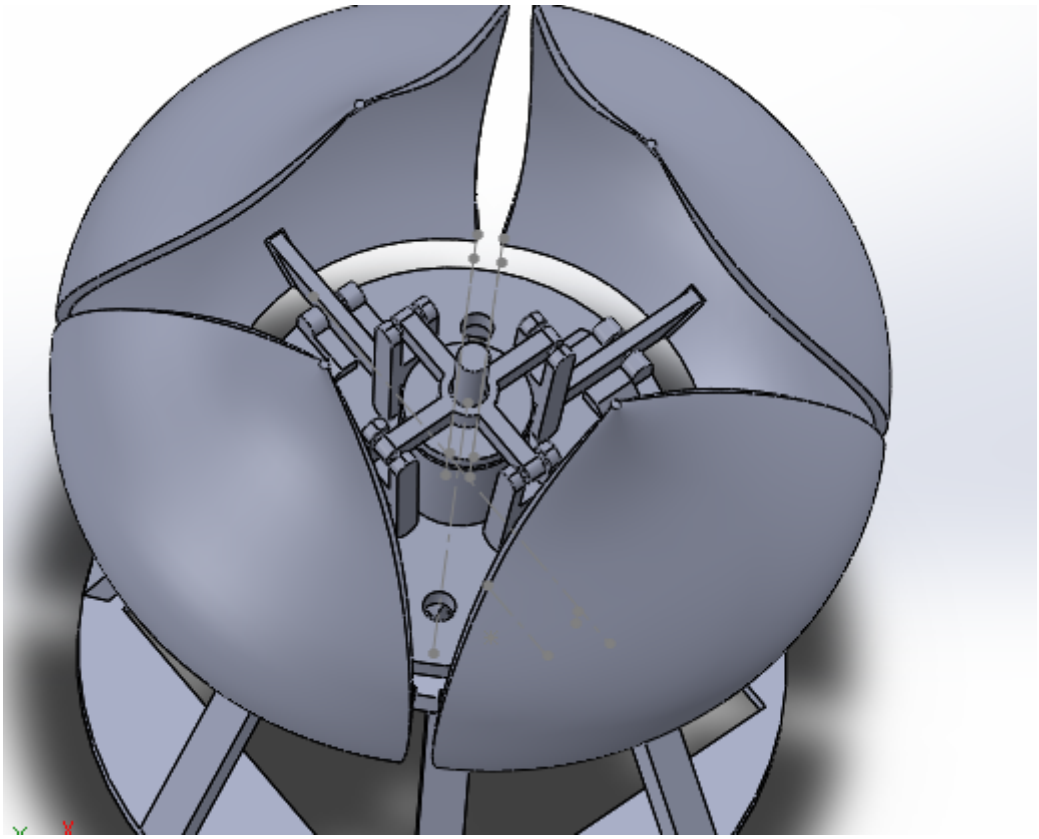


i. Final result



ASSEMBLY





Finances

The project received it funding from the Engineering Research Center (ERC) for Sensimotor Neural Engineering, a grant given by the National Science Foundation and managed by Professor Dr.Kee Moon. The team was given a budget of one thousand dollars at the beginning of the year. The team kept a record of all expenses in an excel spreadsheet to make sure the expenses did not exceed the allowed budget. Extra precaution was needed given that one of the team members was studying abroad in Mexico for the second semester of the project which led to unexpected expenses such as importation fees and extra shipping costs. Also, the main expense, which was the EEG Headset, was bought twice for the team here because the first one failed to operate after working with it for a while. The total spent was $669.22, which is well below the budget given. All expenses are tabulated below and receipts for all transactions are attached in the appendix.

Item	Purchaser	Supplier	Total
NeuroSky EEG Headset	Mari	Amazon	89,36
Sparkfun Logic controlller	Diego	Sparkfun	6,96
Acetone	Mari	SDSU Pharmacy	2,00
Nuts and Bolts	Mari	Home Depot	2,25
Neurosky EEG Headset (bluetooth)	Diego	Amazon	108,76
MindWave Dongle	Diego	Amazon	21,59
Supplies/Fees for member abroad	Jordan	Multiple	438,3
		Total	669,22

The costs due to having a member studying abroad are tabulated below:

Product	Price	Currency	Final Price (USD)
Mindwave EEG	90,70	USD	90,70
Shipping for Mindwave EEG	336,54	MXN	23,21
Import Taxes (16%) for Mindwave EEG	14,51	USD	14,51
Newark (Arduino Kit, LEDs, PWN chip)	237,77	USD	237,77
Import Fees for Newark	333,20	MXN	22,98
Adafruiti 24 Channel PWM LED Driver	39,16	USD	39,16
Import Fees Adafruit LED Driver	144,53	MXN	9,97
		TOTAL COST	438,30

Conversion (Buy Rate)
14,50

CONCLUSION

The goals set at the beginning of the project were met. The team created a device, the LOTUS, which provides visual feedback to the user while meditating. The team was able to make the EEG signals reach a computer, communicate with Arduino and, in turn, communicate with the flower.

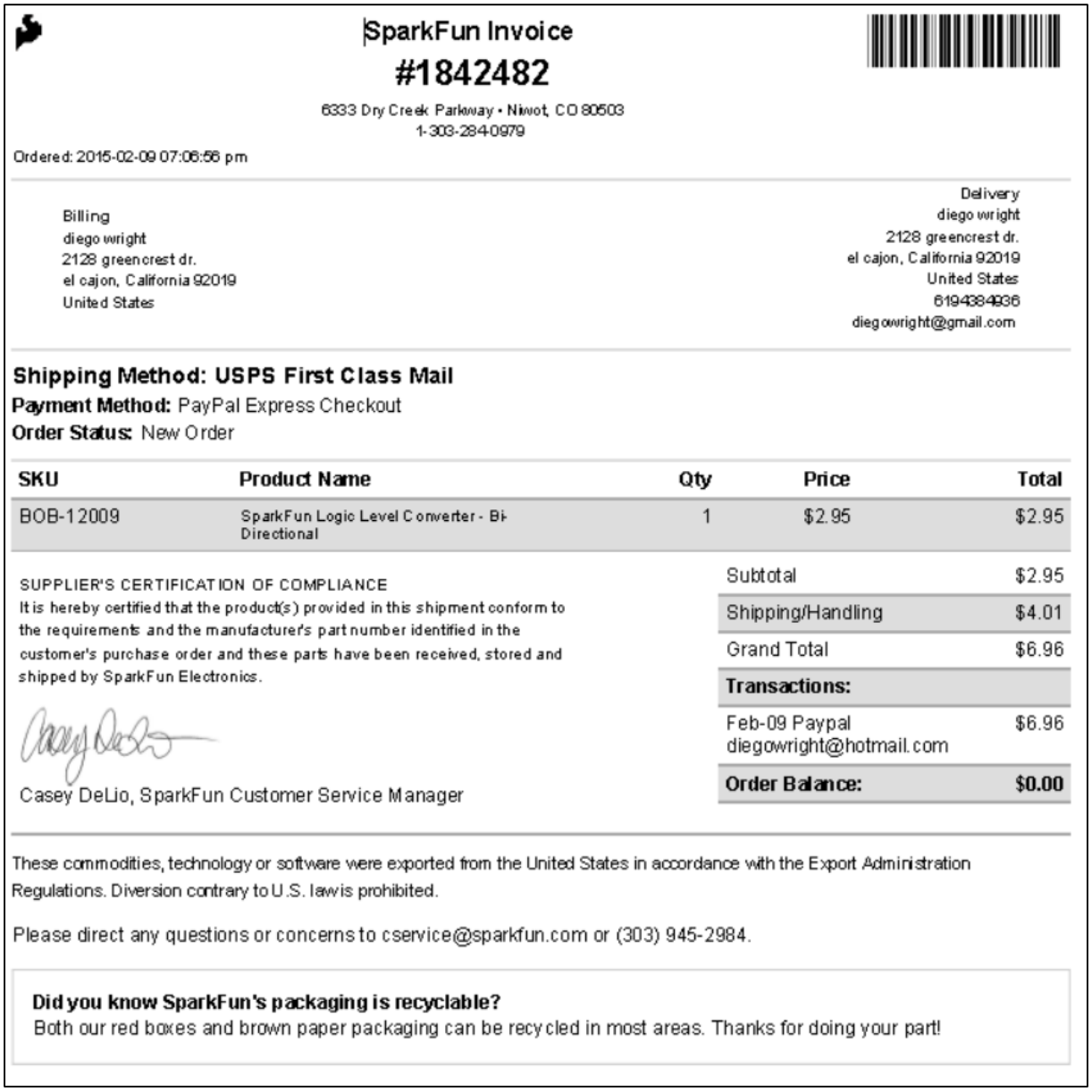
Unexpected issues encountered:

- All 3D printers available malfunctioning
- Original EEG Headset failure
- EEG Headset used required software that was unfamiliar to team
- Lack of documentation online on ThinkGear program
- Proprietary information

Recommendations for the future:

- Add ability to record data to log meditation sessions
- Include health metrics (e.g. heart rate) to illustrate improvement
- Improve aesthetics of lotus
- Make design more compact for easy transportation
- Connect to mobile device rather than laptop

Appendix



SparkFun Invoice

#1842482

6333 Dry Creek Parkway • Niwot, CO 80503
1-303-284-0979

Ordered: 2015-02-09 07:06:56 pm

Billing
diego wright
2128 greencrest dr.
el cajon, California 92019
United States

Delivery
diego wright
2128 greencrest dr.
el cajon, California 92019
United States
6194384936
diegowright@gmail.com

Shipping Method: USPS First Class Mail
Payment Method: PayPal Express Checkout
Order Status: New Order

SKU	Product Name	Qty	Price	Total
BOB-12009	SparkFun Logic Level Converter - Bi-Directional	1	$2.95	$2.95

SUPPLIER'S CERTIFICATION OF COMPLIANCE
It is hereby certified that the product(s) provided in this shipment conform to the requirements and the manufacturer's part number identified in the customer's purchase order and these parts have been received, stored and shipped by SparkFun Electronics.

Casey DeLio, SparkFun Customer Service Manager

Subtotal	$2.95
Shipping/Handling	$4.01
Grand Total	$6.96
Transactions:	
Feb-09 Paypal diegowright@hotmail.com	$6.96
Order Balance:	**$0.00**

These commodities, technology or software were exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to U.S. law is prohibited.

Please direct any questions or concerns to cservice@sparkfun.com or (303) 945-2984.

Did you know SparkFun's packaging is recyclable?
Both our red boxes and brown paper packaging can be recycled in most areas. Thanks for doing your part!

Invoice Details:
Invoice Number: AA26278461
Invoice Date: 03/09/2015

Company:
Name: Valued Customer-US
Account Number: 395462
Order will be billed to your credit card

Shipping to:
Name: Valued Customer-US
Account Number: 395462 / 001
For Attn Of:
UNIVERSIDAD DE LAS AMÉRICAS
EX HACIENDA
STA CATARINA MÁRTIR S/N
SAN ANDRÉS CHOLULA PU, FF, 72810, Mexico

Invoice:

	Stock No:	Manufacturer Part No:	UOM:	Quantity:	Price:	Extended Price:
Line No: 1	03P5011	TLC5947DAP	Each 1	1	$5.58	$5.58
	Customer Part Number:					
	Description: 12 BIT, LED DRIVER, TSSOP-32; Device Topology:Constant Current; No. of Outputs:24; Output Current:30mA; Output Voltage:30V; Driver Case Style:HTSSOP; Input Voltage Min:3V; Input Voltage Max:5.5V; Switching Frequency:30MHz					

	Stock No:	Manufacturer Part No:	UOM:	Quantity:	Price:	Extended Price:
Line No: 2	83T3705	CLVBA-FKA-CAEDH8BBB7A363	Tape and Reel Cut 1	50	$0.502	$25.10
	Customer Part Number:					
	Description: LED, HB, RGB, SMD, 130mW; Bulb Size:-; LED Colour:Red, Green, Blue; Luminous Intensity / Colour:R 320mcd, G 500mcd, B 160mcd; Viewing Angle:110ø; Forward Voltage / Colour:R 2.4V, G 3.6V, B 3.6V; LED Mounting:SMD; Lens Shape:Round					

	Stock No:	Manufacturer Part No:	UOM:	Quantity:	Price:	Extended Price:
Line No: 3	47W2965	K000007	Each 1	1	$104.18	$104.18
	Customer Part Number:					
	Description: STARTER KIT, ARDUINO, WITH UNO BOARD; Silicon Manufacturer:Atmel; Core Architecture:AVR; Core Sub-Architecture:megaAVR; Silicon Core Number:ATmega328; Silicon Family Name:ATmega; No. of Bits:8bit					

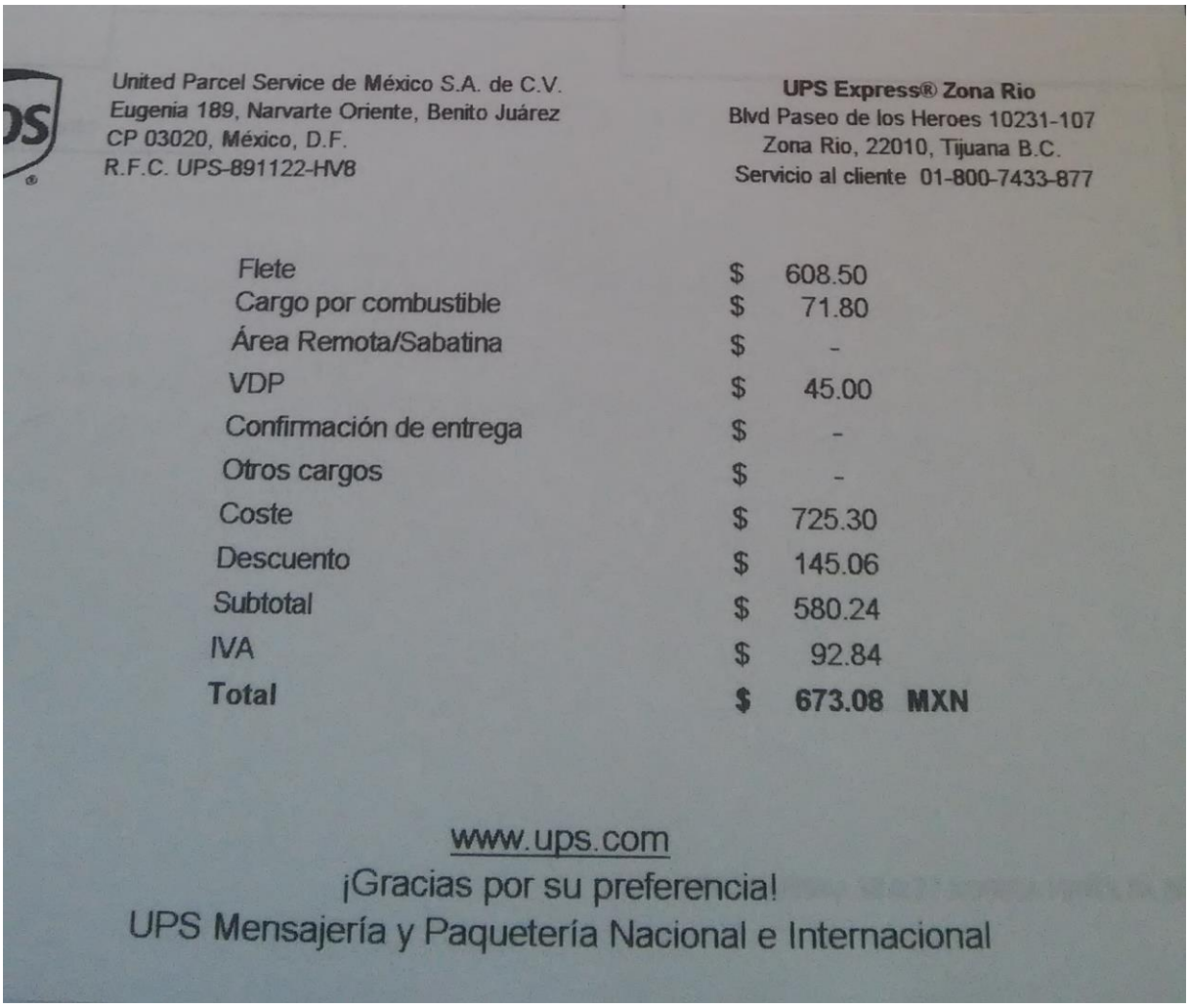
Your Merchandise Total $134.86

Your Freight Total $102.91

Your Tax Total $0.00

Your Invoice Total $237.77

Shipping fees



United Parcel Service de México S.A. de C.V.
Eugenia 189, Narvarte Oriente, Benito Juárez
CP 03020, México, D.F.
R.F.C. UPS-891122-HV8

UPS Express® Zona Rio
Blvd Paseo de los Heroes 10231-107
Zona Rio, 22010, Tijuana B.C.
Servicio al cliente 01-800-7433-877

Flete	$ 608.50	
Cargo por combustible	$ 71.80	
Área Remota/Sabatina	$ -	
VDP	$ 45.00	
Confirmación de entrega	$ -	
Otros cargos	$ -	
Coste	$ 725.30	
Descuento	$ 145.06	
Subtotal	$ 580.24	
IVA	$ 92.84	
Total	**$ 673.08**	**MXN**

www.ups.com
¡Gracias por su preferencia!
UPS Mensajería y Paquetería Nacional e Internacional

amazon.com

Final Details for Order #106-9847623-2510615

Print this page for your records.

Order Placed: March 11, 2015
Amazon.com order number: 106-9847623-2510615
Order Total: $90.70

Shipped on March 12, 2015

Items Ordered	**Price**
1 of: *NeuroSky MindWave Headset* Sold by: Amazon.com LLC Condition: New	$79.99

Shipping Address:
Jordan Lenoir
4110 TEXAS ST APT # 10
SAN DIEGO, CA 92104-1670
United States

Shipping Speed:
One-Day Shipping

Item(s) Subtotal:	$79.99
Shipping & Handling:	$3.99
Total before tax:	$83.98
Sales Tax:	$6.72
Total for This Shipment:	**$90.70**

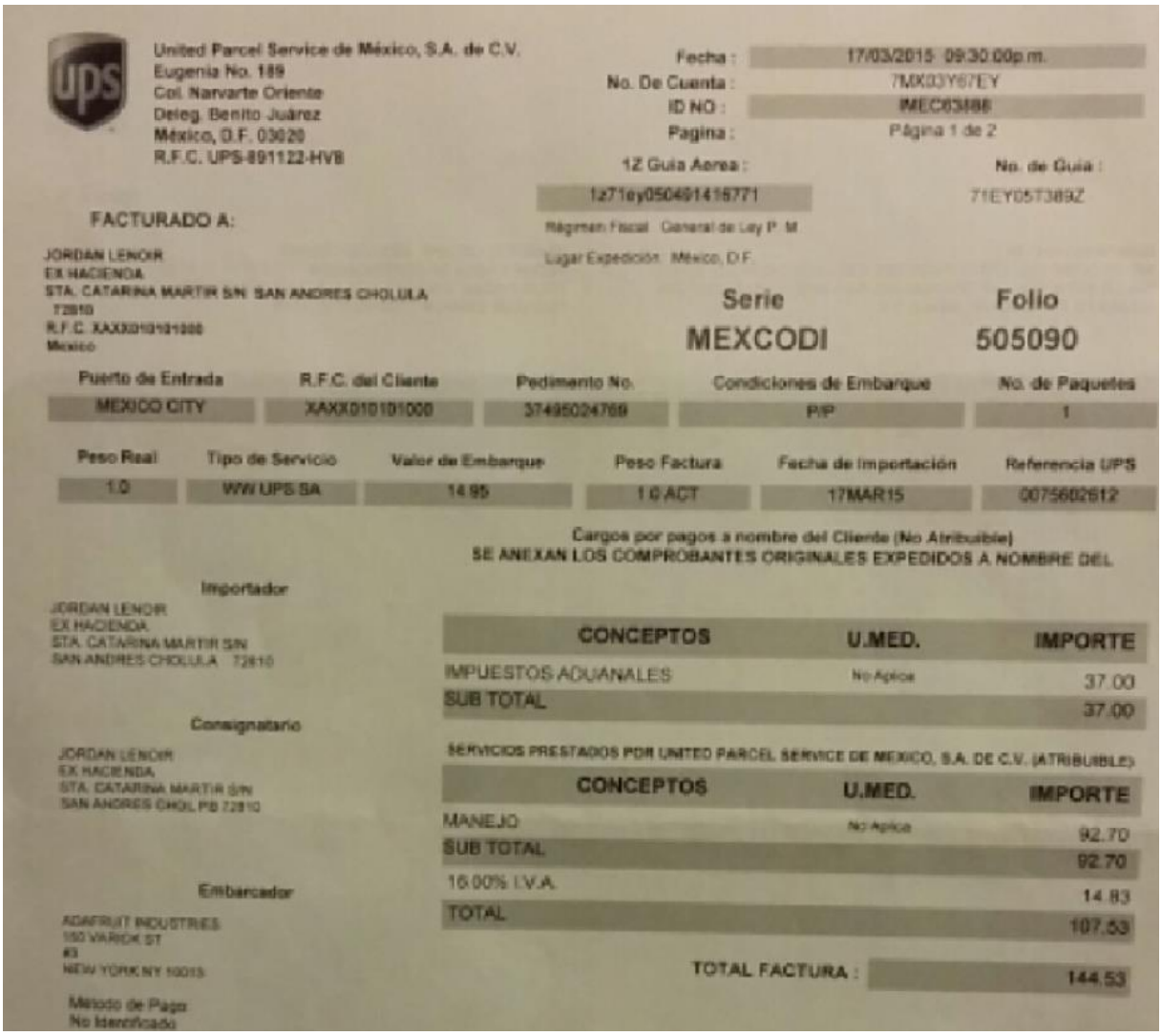
Payment information

Payment Method:
Visa | Last digits: 1536

Billing address
Jordan Lenoir
4110 TEXAS ST APT # 10
SAN DIEGO, CA 92104-1670
United States

Item(s) Subtotal:	$79.99
Shipping & Handling:	$3.99
Total before tax:	$83.98
Estimated tax to be collected:	$6.72
Grand Total:	**$90.70**

Import fees



United Parcel Service de México, S.A. de C.V.
Eugenia No. 189
Col. Narvarte Oriente
Deleg. Benito Juárez
México, D.F. 03020
R.F.C. UPS-891122-HV8

Fecha : 17/03/2015 09:30:00p.m.
No. De Cuenta : 7MX03Y67EY
ID NO : IMEC63888
Pagina : Página 1 de 2

1Z Guía Aerea : 1z71ey050491416771
No. de Guía : 71EY05T389Z

Régimen Fiscal: General de Ley P. M.
Lugar Expedición: México, D.F.

FACTURADO A:

JORDAN LENOIR
EX HACIENDA
STA. CATARINA MARTIR S/N SAN ANDRES CHOLULA
72810
R.F.C. XAXX010101000
Mexico

Serie: MEXCODI
Folio: 505090

Puerto de Entrada	R.F.C. del Cliente	Pedimento No.	Condiciones de Embarque	No. de Paquetes
MEXICO CITY	XAXX010101000	37495024769	P/P	1

Peso Real	Tipo de Servicio	Valor de Embarque	Peso Factura	Fecha de Importación	Referencia UPS
1.0	WW UPS SA	14.95	1.0 ACT	17MAR15	0075602612

Cargos por pagos a nombre del Cliente (No Atribuible)
SE ANEXAN LOS COMPROBANTES ORIGINALES EXPEDIDOS A NOMBRE DEL

Importador
JORDAN LENOIR
EX HACIENDA
STA. CATARINA MARTIR S/N
SAN ANDRES CHOLULA 72810

CONCEPTOS	U.MED.	IMPORTE
IMPUESTOS ADUANALES	No Aplica	37.00
SUB TOTAL		37.00

Consignatario
JORDAN LENOIR
EX HACIENDA
STA. CATARINA MARTIR S/N
SAN ANDRES CHOL PB 72810

SERVICIOS PRESTADOS POR UNITED PARCEL SERVICE DE MEXICO, S.A. DE C.V. (ATRIBUIBLE)

CONCEPTOS	U.MED.	IMPORTE
MANEJO	No Aplica	92.70
SUB TOTAL		92.70
16.00% I.V.A.		14.83
TOTAL		107.53

Embarcador
ADAFRUIT INDUSTRIES
150 VARICK ST
#3
NEW YORK NY 10013

TOTAL FACTURA : 144.53

Método de Pago
No Identificado

amazon.com

Final Details for Order #108-8633513-4169041

Print this page for your records.

Order Placed: April 18, 2015
Amazon.com order number: 108-8633513-4169041
Order Total: $225.44

Shipped on April 20, 2015

Items Ordered	**Price**
1 of: *Skagen Men's SKW6082 Ancher Quartz 3 Hand Date Stainless Steel Dark Brown Watch* Sold by: Amazon.com LLC Condition: New	$108.75
1 of: *NeuroSky MindWave Mobile BrainWave Starter Kit* Sold by: Amazon.com LLC Condition: New	$99.99

Shipping Address:
diego wright
2128 GREENCREST DR
EL CAJON, CA 92019-4105
United States

Shipping Speed:
Two-Day Shipping

Item(s) Subtotal:	$208.74
Shipping & Handling:	$0.00
Total before tax:	$208.74
Sales Tax:	$16.70
Total for This Shipment:	**$225.44**

Payment information

Payment Method:
Visa | Last digits: 1497

Billing address

Item(s) Subtotal:	$208.74
Shipping & Handling:	$0.00
Total before tax:	$208.74
Estimated tax to be collected:	$16.70
Grand Total:	**$225.44**

amazon.com

Final Details for Order #115-7059932-5976230

Print this page for your records.

Order Placed: February 17, 2015
Amazon.com order number: 115-7059932-5976230
Order Total: $21.59

Shipped on February 18, 2015

Items Ordered	Price
1 of: *MindWave RF Dongle* Sold by: NeuroSky (seller profile) Condition: New	$19.99

Shipping Address:
diego wright
2128 GREENCREST DR
EL CAJON, CA 92019-4105
United States

Shipping Speed:
Two-Day Shipping

Item(s) Subtotal:	$19.99
Shipping & Handling:	$0.00
Total before tax:	$19.99
Sales Tax:	$1.60
Total for This Shipment:	**$21.59**

Payment information

Payment Method:
Visa | Last digits: 1497

Billing address
diego wright
2128 GREENCREST DR
EL CAJON, CA 92019-4105
United States

Item(s) Subtotal:	$19.99
Shipping & Handling:	$0.00
Total before tax:	$19.99
Estimated tax to be collected:	$1.60
Grand Total:	**$21.59**