IIT Madras
Centre For Innovation

CODE : PDC02 Radiscent-(Smart Switch)

PRODUCT DESIGN CLUB

Akash Anand, Gaurav Vaidya

Team Members

EE18B035	Nithin Uppalapati

Work done: Electronics module: Proposed couple of designs for implementation of the module.

1) By using Solenoids
2) By using relays as a two way switch.
3) By using Motors*

*Alternate design using motors proved out to be more efficient.

Tasks in Progress/Planned to do:

1. Currently working on schematic which maximises the no. of switches to be controlled per PCB.
2. Design a custom PCB for as per our requirement.
3. Basic prototype of controlling leds, using HC05-Arduino.

Email : ee18b035@smail.iitm.ac.in
&
nithineem@gmail.com

CH19B082	Rajdeep Thakur

Work done:
Team Head (Project Manager): Participated in CFI Open House and Industry Conclave
Made thorough analysis of the market segments, analysed competitors and projected our USP.
MVP in progress.
Designed and analysed various ideas and implementations of the mechanical add on. Made CAD models of parts and assembly for manufacturing of MVP (3D printing).

Tasks in progress: Assembling of parts to make the first MVP

Email : ch19b082@smail.iitm.ac.in & rajdeep.thakur@yahoo.com

<table>
<tr><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">  </td><td>EE19B003</td><td>Adityan CG</td></tr>
<tr><td colspan="2">Electronics module : Checked the feasibility of the models proposed. Helping Nithin to modify the designs/models proposed.

Tasks in progress : Working on PCB for specific application and commands. And it's work nature in backup stages.

Email : cgadityan@gmail.com + ee19b003@smail.iitm.ac.in</td></tr>
<tr><td rowspan="2">  </td><td>NA19B014</td><td>Vaidehi Garodia</td></tr>
<tr><td colspan="2">Work done:
Product Design: Market Segmentation, Conducted user interviews and a thorough customer survey.

Email : na19b014@smail.iitm.ac.in & vaidehigarodia@gmail.com</td></tr>
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ME17B123	Utkarsh Kumar

Work did:

- As a part of the Product Design module I have worked on feasibility check of the multiple prototypes developed.
- Market research: Worked on designing interactive assessment forms for data collection for backing up our product and making changes to accustom according to the users benefit.

Plans Ahead:

- Product customization according to the market segmentation
- Product pricing and further research on existing similar products along with other verticals of the team.

Email : utkarshk99@gmail.com / me17b123@smail.iitm.ac.in

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1) Title of Invention-

Radiscent- Smart Switch

2) Field of invention - Electronics and Smart products

3) Background on invention -

In this day and age of constant modernisation and automation, the need for electricity is more than it was ever before and it keeps increasing everyday. With that, unfortunately, has risen the daily wastage of electricity due to human negligence. We are all aware of what wastage of electricity means to the grand scheme of things, higher pollution, higher drain of resources etc.

A piece of technology which is seemingly restricted to just high-end hotels as of now, that is a smart switch, can be a vital tool to aid the elderly, specially-abled and serve as a luxury for everyone else while playing a vital role of saving energy.

The vision we have with our project is to bring the future a little closer to our fingertips. As one might know, a smart ecosystem is definitely the future we are heading towards very rapidly.

A smart ecosystem is the concept that everything around us will be interconnected and act automatically as per our actions.
Today, it is limited to only smart-phones, laptops, tablets and TVs. This product will act as the perfect intermediate to this humongous market of automated household appliances. We intend this product to be a disruption toward a much smarter and integrated ecosystem of appliances around us.

4) Objective of Invention

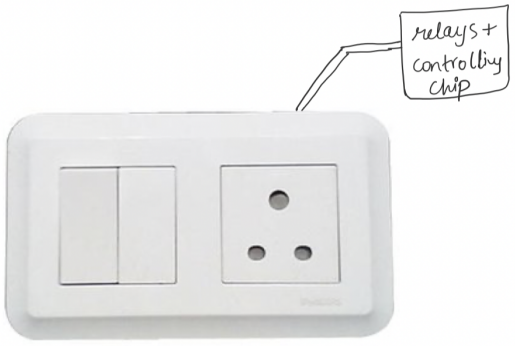
With a vision in mind, we have set our goal to provide a piece of technology which will not empty the pockets of its buyers, and yet provide a much better, convenient and incredibly easy to implement solution to this annoying problem of getting up to just shift a switch.

We want to make it more common to find smart switches in typical Indian households as well. That is why, we set our goal to making a smart switch which is as user friendly as possible, with almost no drawbacks of using it and very easily implementable.

5) Design History and Overview:

A) Hard-Wired Model

Hard - wiring the connections inside/near the switch board with the help of relays and a microcontroller.



A Hard-wired Model.

In this model there are no plug-ins on top of the switches, and the conventionality is gone. Each switch now acts as a 2-way switch.

B) Mechanical Add on Model /Plug-In Model

Plug-in Model/ Mechanical Add-on: A device will be attached on the switchboard on top of the switches to control them. The setup will be a quick DIY by the customer.

Analysing the Mechanical add-on Model:

Advantages:

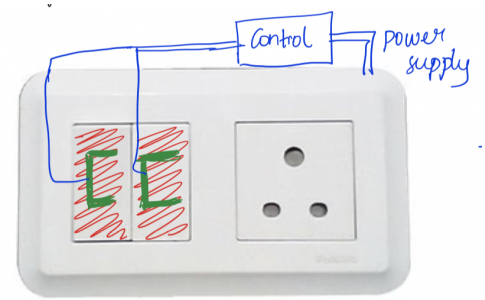
1. Does not depend on current layout of the switchboard
2. No hassle to implement; no electrician needed; as easy to install as sticking a double sided tape.
3. Very easily reversible; can be removed easily if and when needed, for upgradation, for returning or for changing to some other switch
4. Very modular; can be bought as one main piece plus x (less than 8) number of individual switches. Can be bought/ returned individually
5. Retains 100% manual functionality of a switch

Disadvantages:

1. Protrusion may cause accidental removals
2. Bulky, may protrude a little from the switchboard

In this plug-in model, first we have to come up with a design which is easily adaptable to the design of the buyer's switchboard. The solution we thought was shown below. There are 2 degrees of freedom for aligning the position of the plug-in on top of the switch to be controlled.

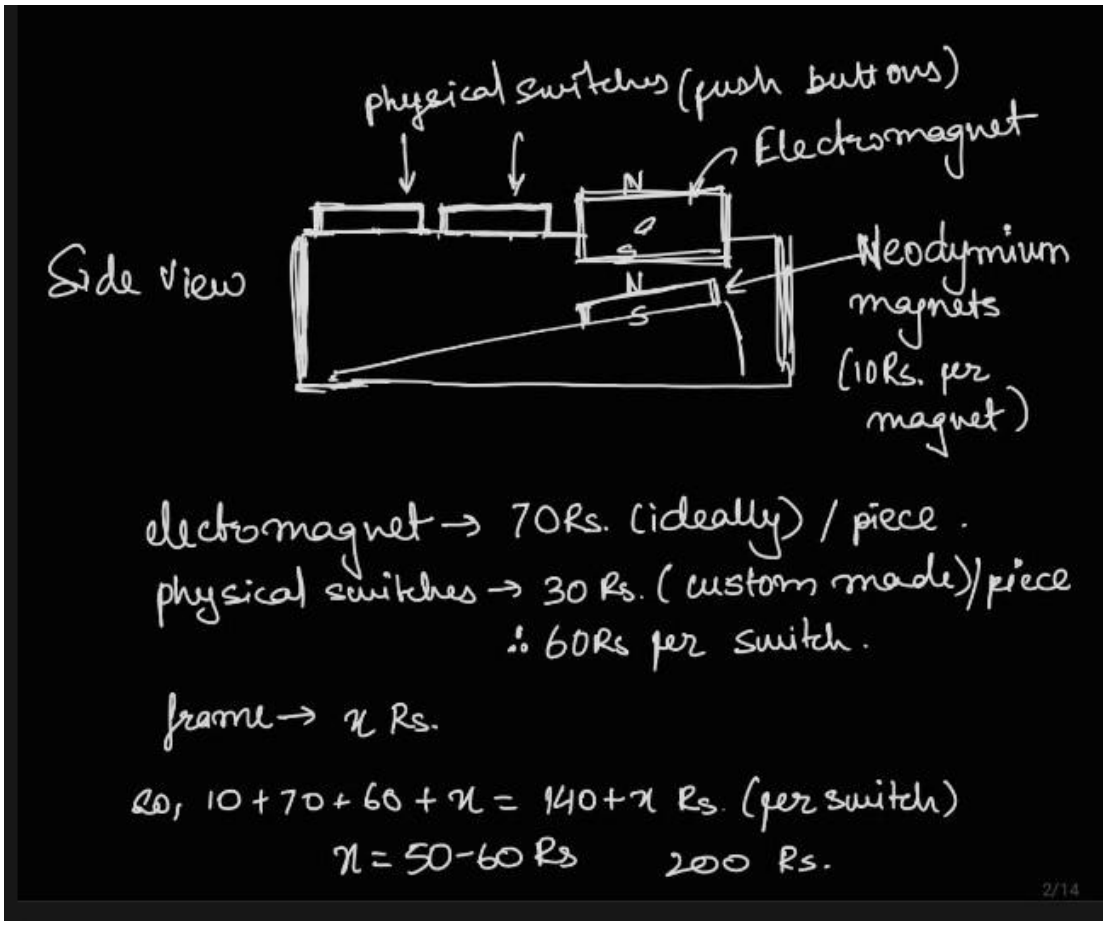
1) Controlling the switches by Electromagnets:
    a) In this design we control the switches with help of electromagnet, where the electromagnet pulls/pushes the magnetic adhesive which is attached to the switches.



[— electromagnet

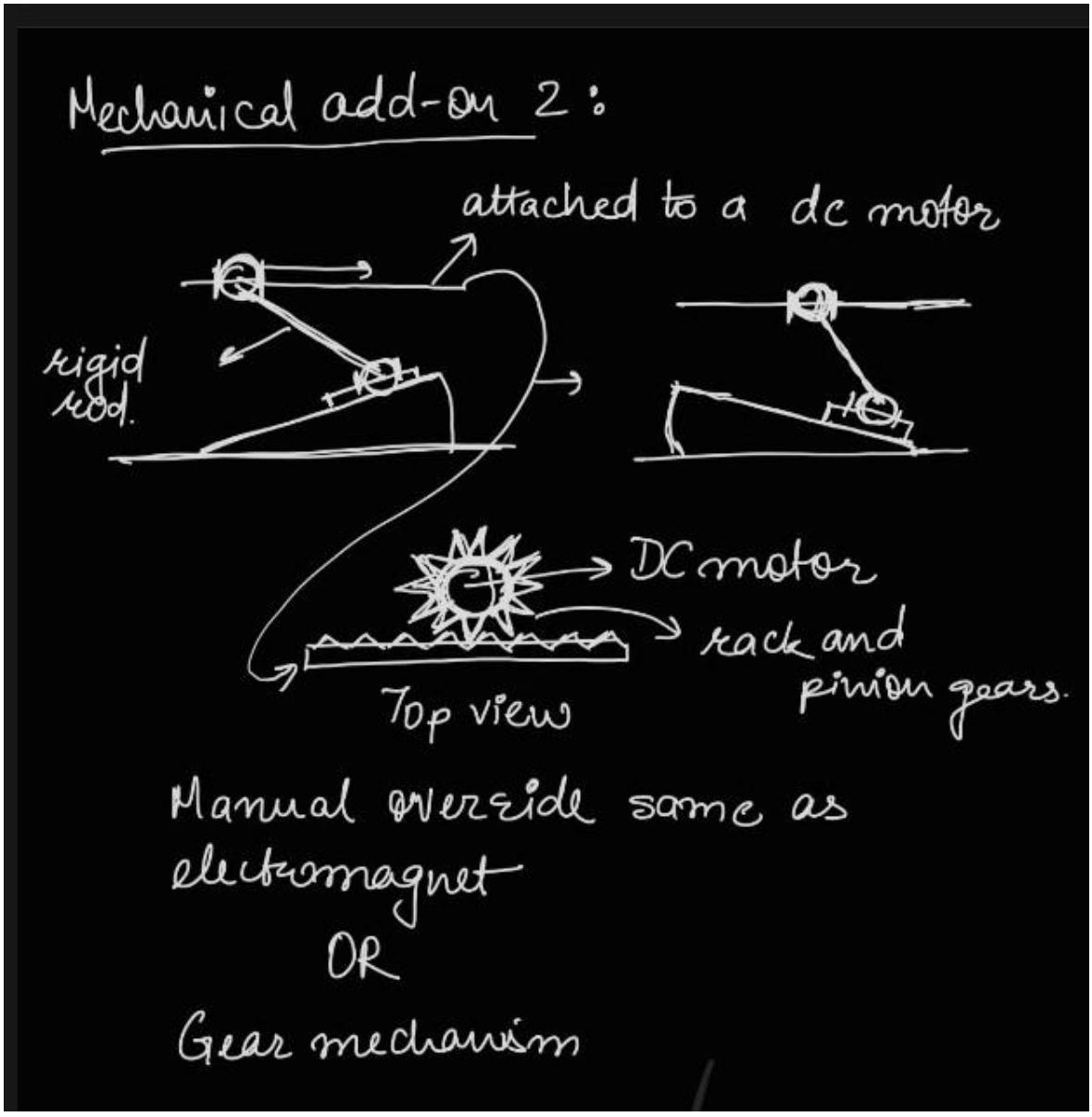
~ — wire

— magnetic adhesive

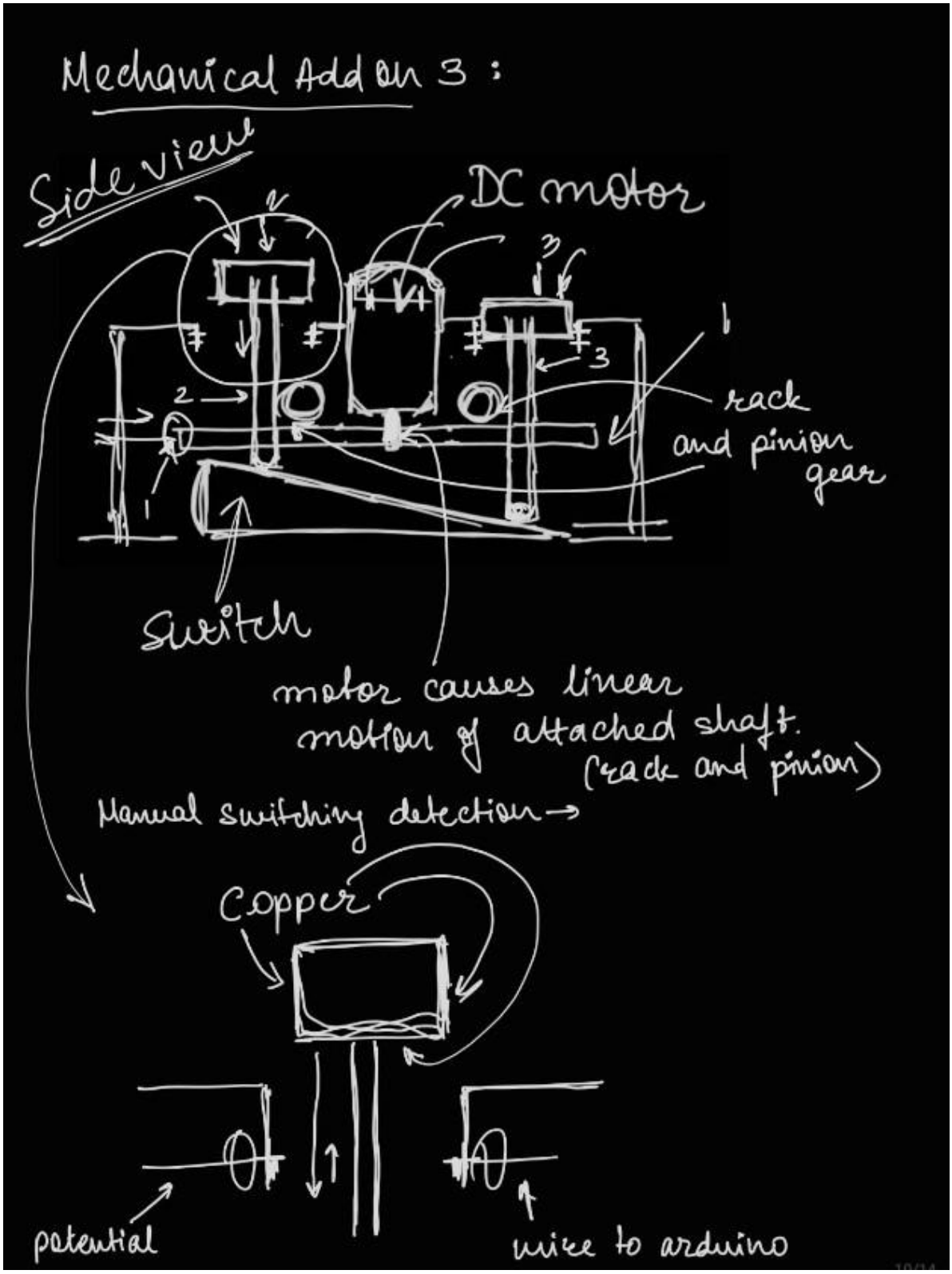


b) Difficulty with this design was that the magnetic forces are weaker in a smaller package of electromagnets. And costs/size go up if we plan to use larger electromagnets.

2)



3) Rack and Pinion Mechanism :



When the switch goes down, contacts on the opposite side are connected (or same side if designed another way.)

rest same as the previous one.

Instead electromagnets use of dc motors.

(3N) → force required to flip a switch.

easy to find a suitable motor.

Advantage:

The button is a simple push button with no connection or intervention required from motor for manual override

Tactile and firm buttons.

This is easy to implement for different sizes of switches

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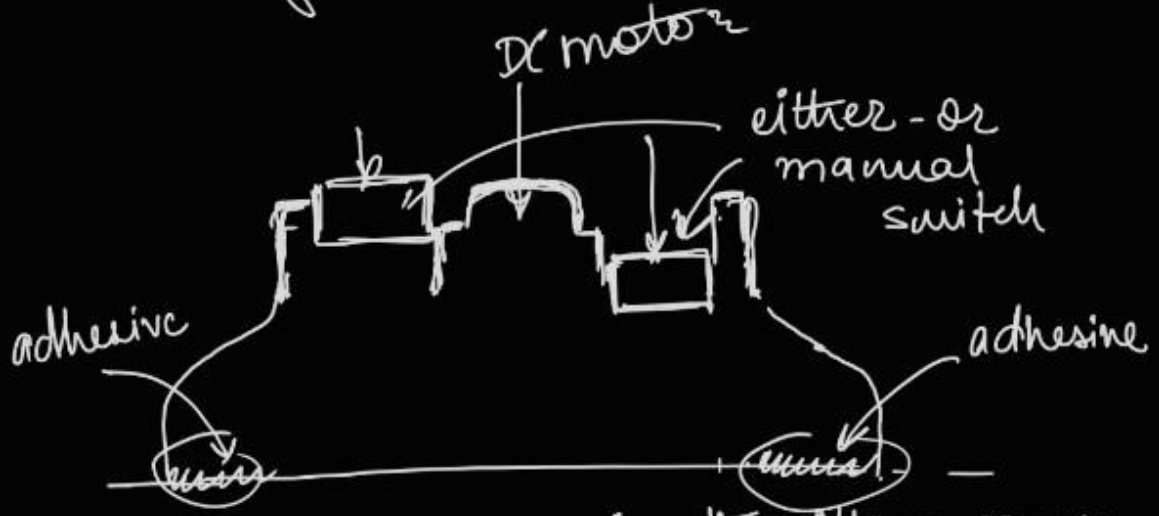
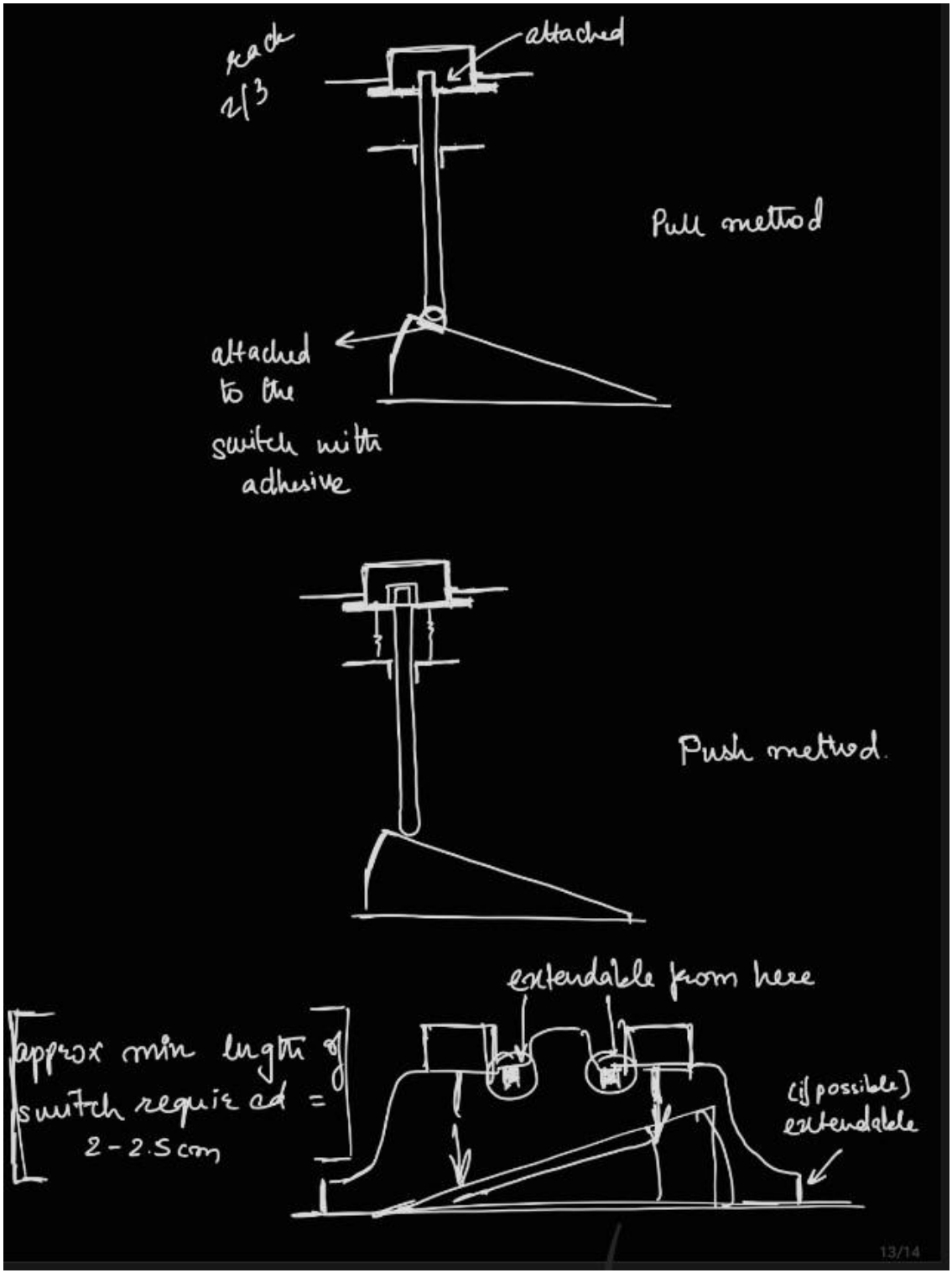
- Manufacturing this is possible. have to look for 3d printing/precision cutting vendors.



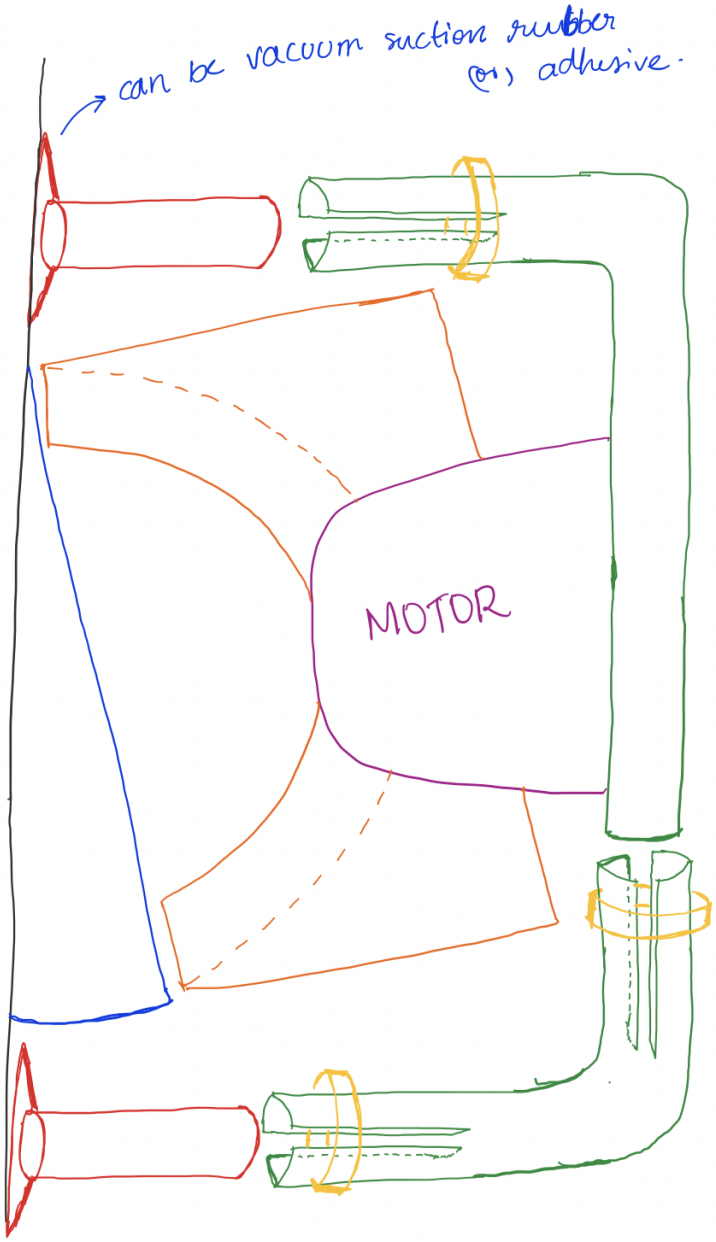
When one goes in, the other comes out.

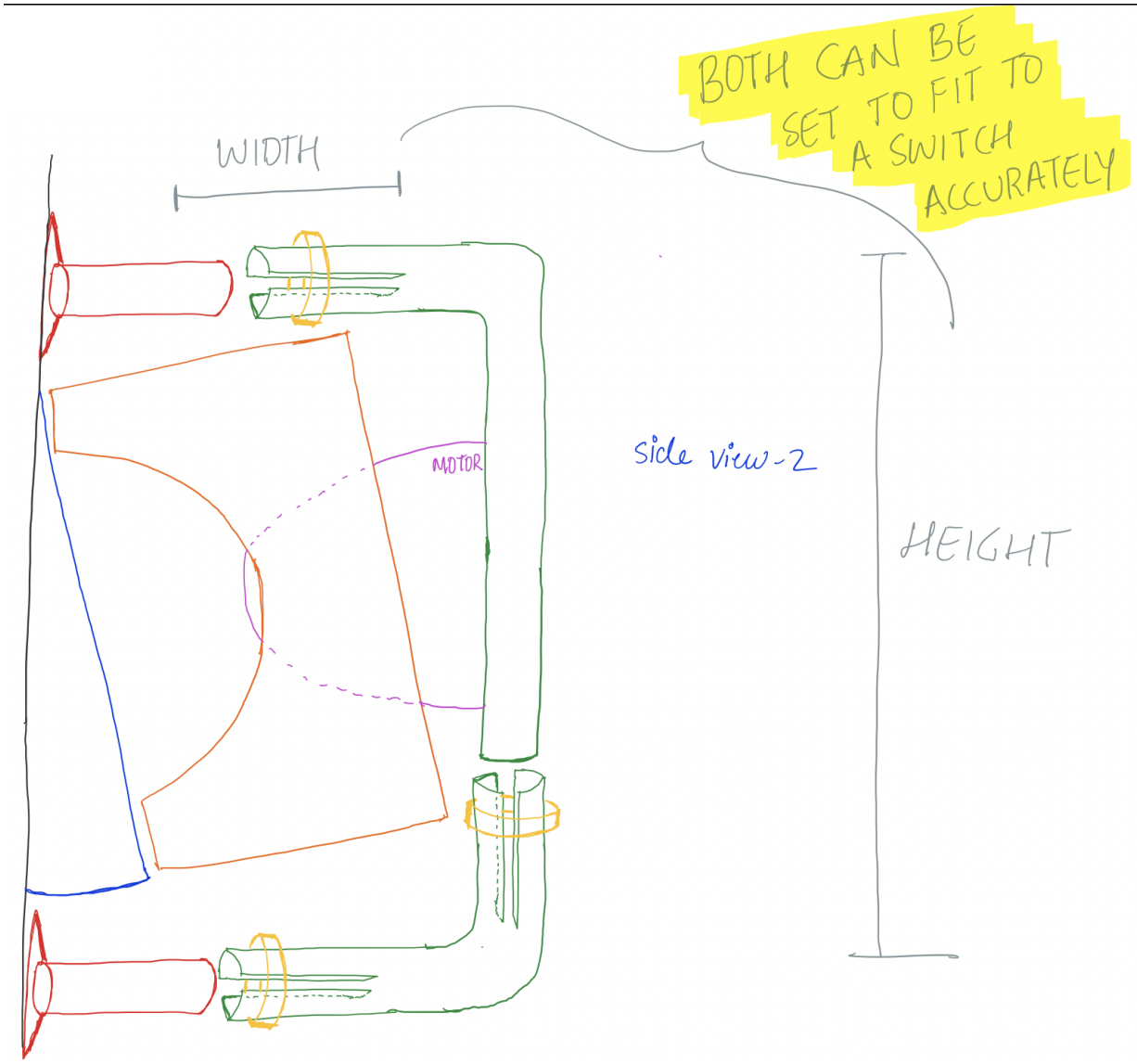
If push force is used, nothing will be attached on the switch itself.

If pull force is used (due to adhesive constraint maybe), then a mech. needs to be attached to the switch itself.

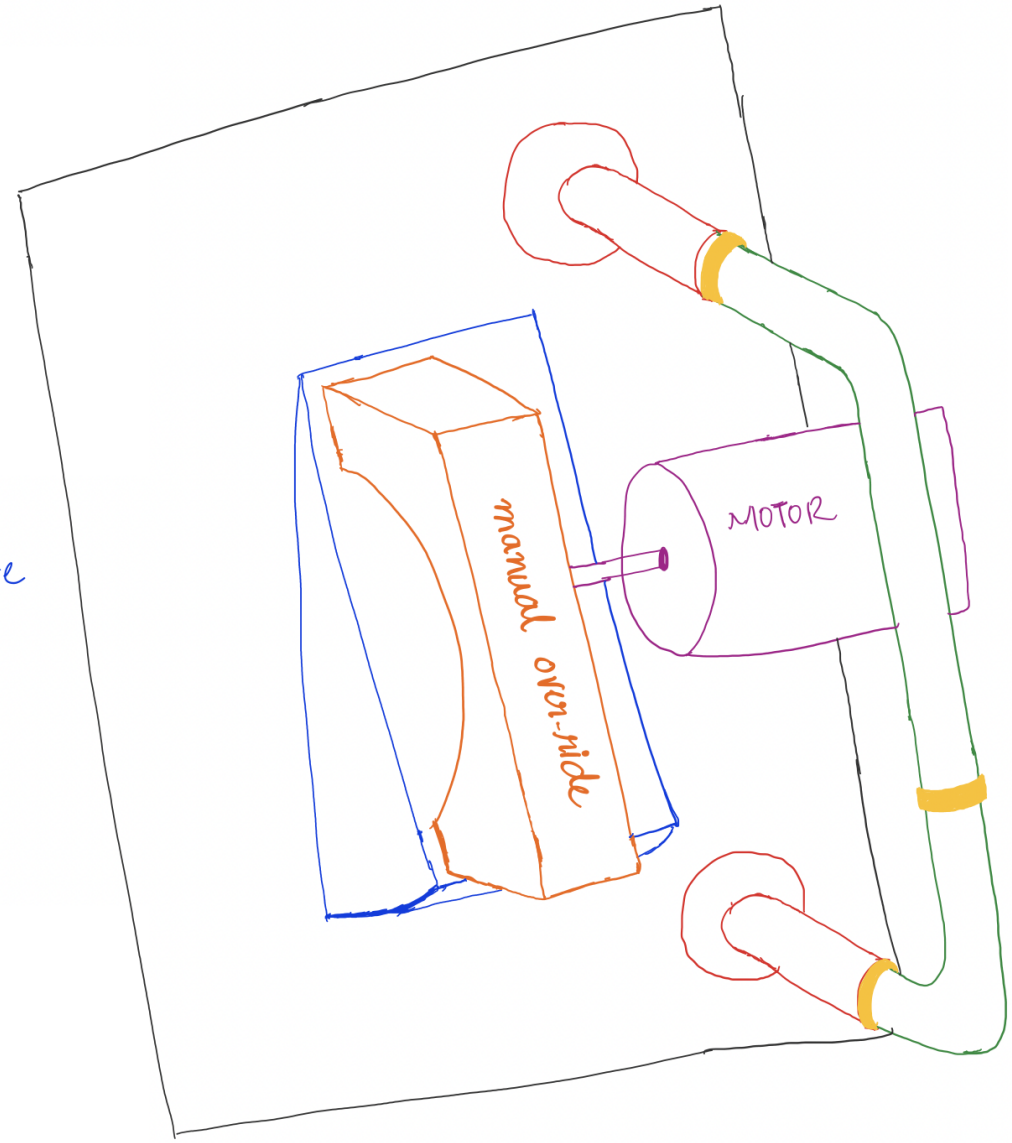

grade 2/3
attached
Pull method
attached to the switch with adhesive
Push method.
extendable from here
approx min length of switch required = 2-2.5 cm
(if possible) extendable
13/14

4) Rotating disk and motor
    a) In this design we try to control the switches with help of a motor. We move the switch with angular actuation of the motor. This is unlike the rack and pinion mechanism, which also uses a motor, but it is a linear actuation.

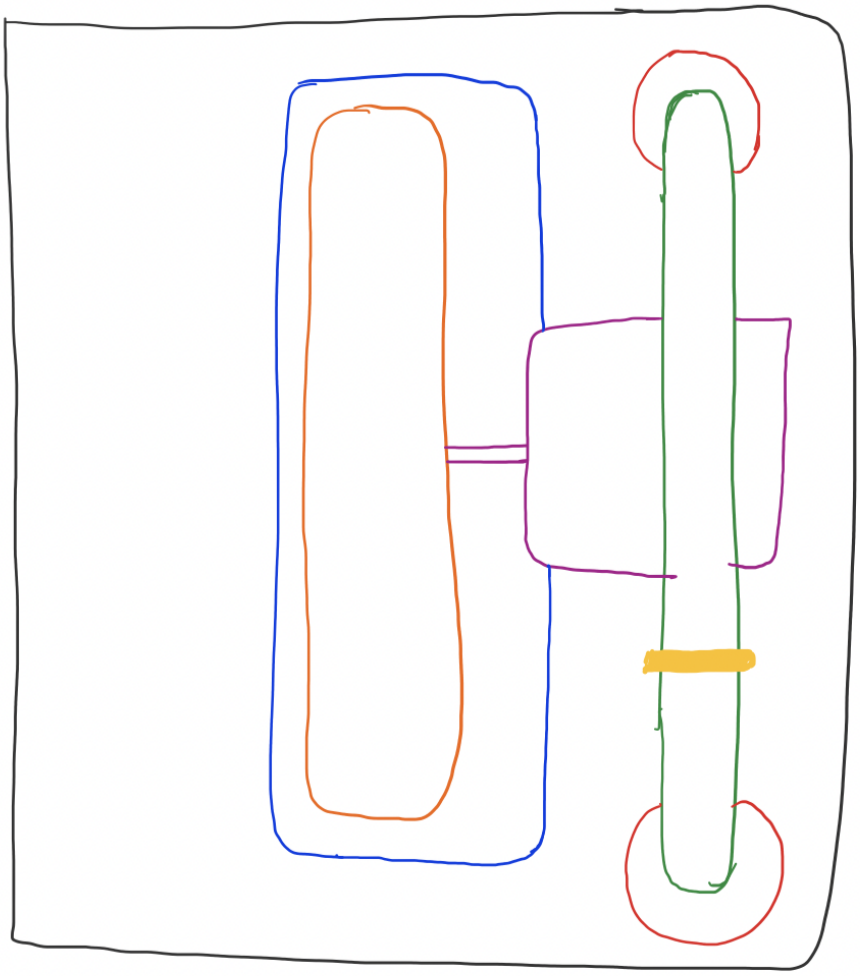



BOTH CAN BE SET TO FIT TO A SWITCH ACCURATELY
WIDTH
MOTOR
Side view - 2
HEIGHT

3-D perspective



Front - view

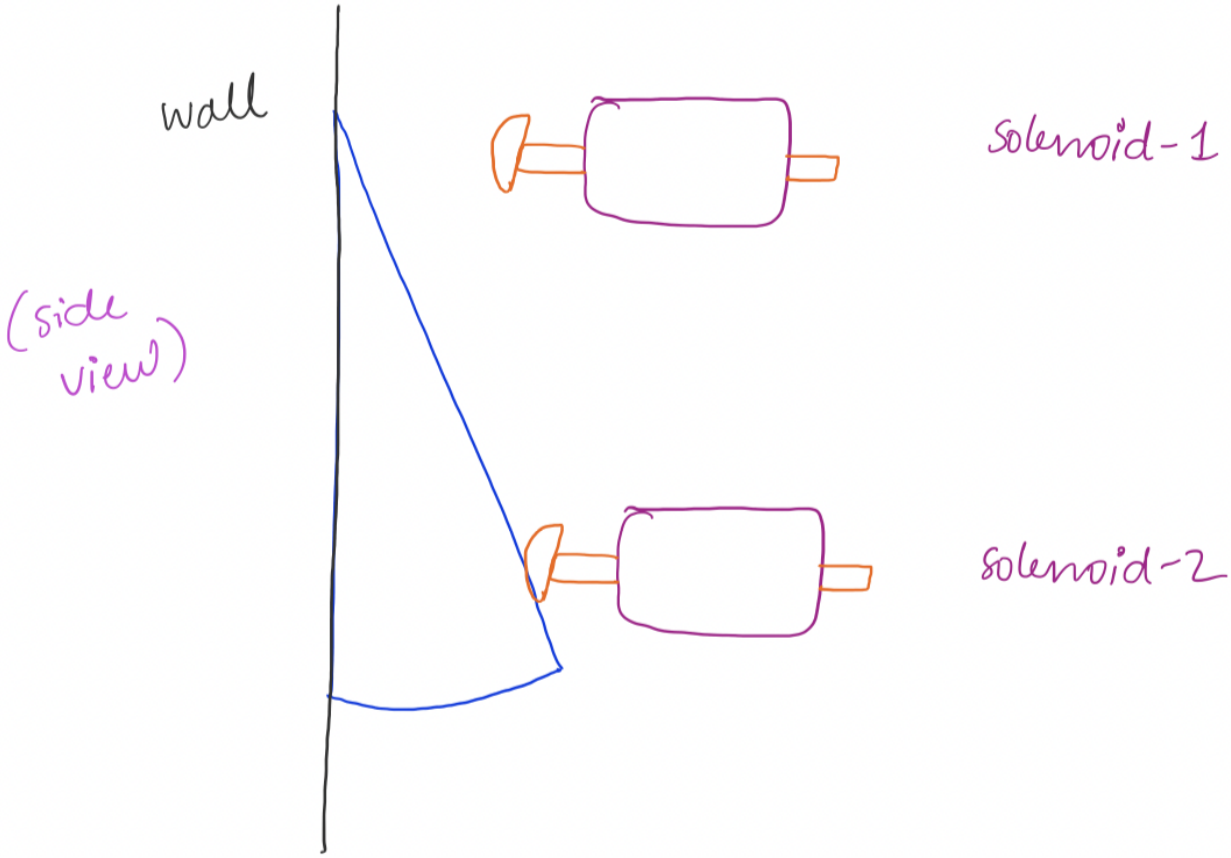


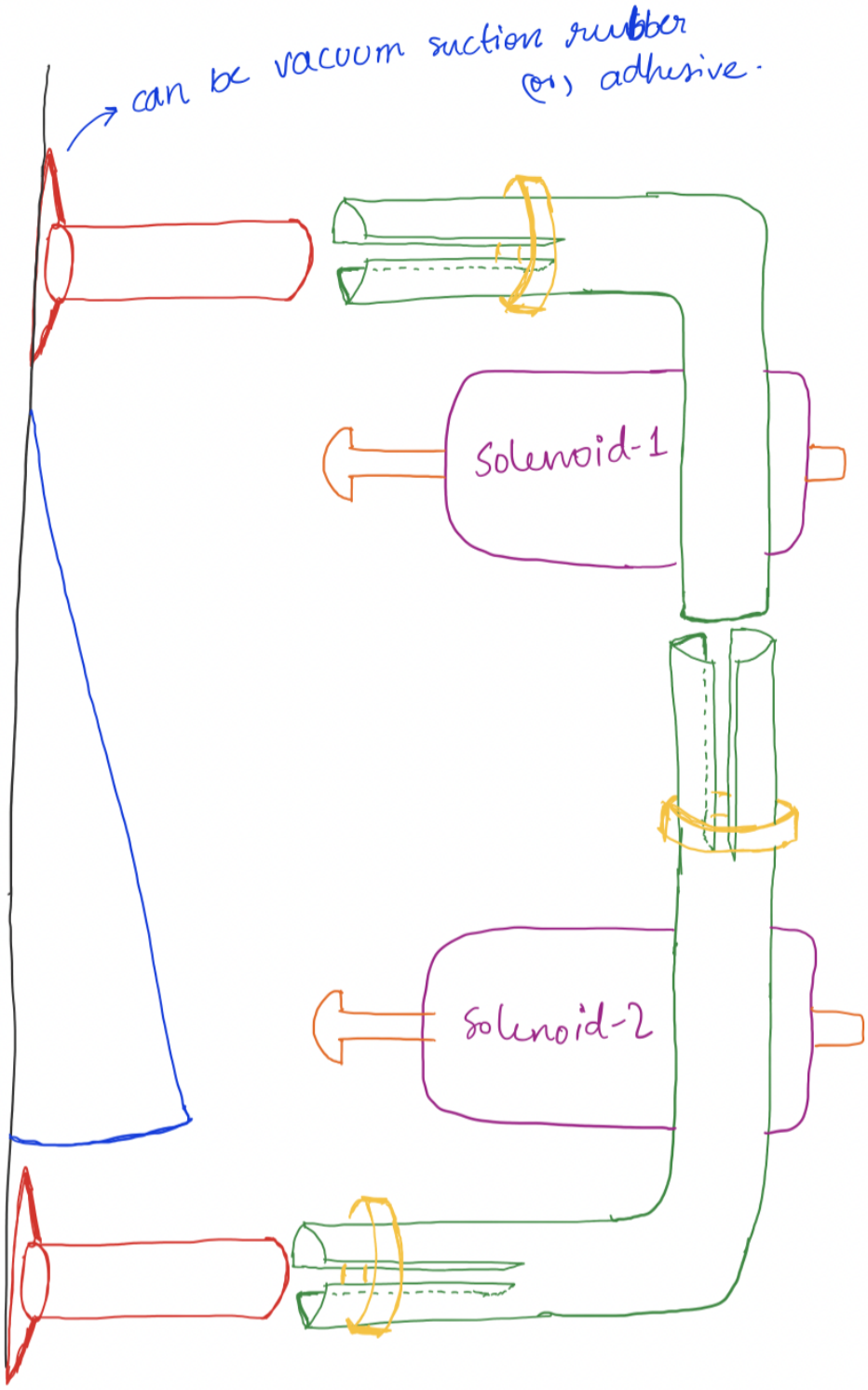
b) Potential difficulties: The motor not being able to provide sufficient torque to flip the switch. Solution is we can use a desirable gear ratio, as in our application the angle of rotation is lesser (typically <90°) so we can produce much higher torques...

5) Controlling the switch using Solenoid:
   a) In this design we try to control the switches with help of impulses from a solenoid. Solenoids when excited with a large current, outputs a good amount of force which can be suitable for pushing

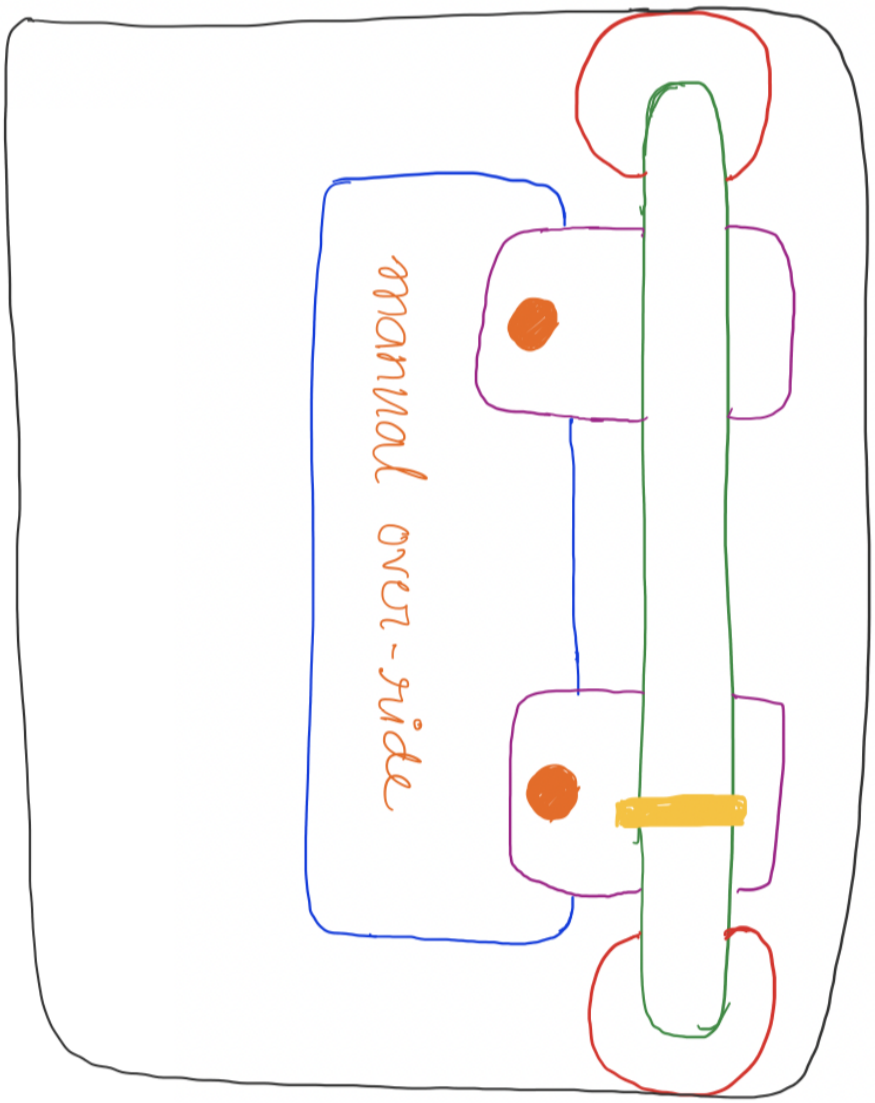
the switches. We need a pair of solenoids for every switch as pulling is difficult with a solenoid.

b) Need a current driver to source large amounts of currents. The overall power consumption can be made less, as the solenoids only consume the current when they are in a state of pushing.




can be vacuum suction rubber
(or) adhesive.
Solenoid-1
Solenoid-2

SIDE VIEW



FRONT VIEW

Pros and Cons of Plug-In Model over the hard-wired Model:

S.No	Mechanical Control (Plug-in model)	Electronic Control (Hard-wired model)
1	DIY Installation	Requires an electrician to install / uninstall the product
2	Easy returns, if the product is not	Returns are a bit difficult as the product is

	satisfactory to the consumer	hard-wired inside/near the switchboard.
3	Not-much resilient to external damages	Durable when compared to Plug-in models, as there are no moving parts.
4	No scope of controlling fan speed - mechanically.	Can also take it to the next level, by electronically controlling the speed of Fans through the App.

Features of App:

1. Can group multiple switches and assign tasks for them at a particular time.
2. Can turn on/off a switch at a particular - preset time.
3. Can turn on/off a switch even when we are outdoors.

6) Market Analysis

Many companies have realised the potential of this idea and the future which this type of technology envisions, thus there are quite a few alternatives available, albeit very inconvenient to implement.

Many companies have tried to replace the current switchboard to implement a smart switch in place of it like Phillips and TP-link. A major drawback is that they are applicable for just a single switch and cannot be implemented on an unisolated switch. This is a major inconvenience for implementation.

One more solution is completely rewiring the entire electrical system of the place. This takes a tiring amount of time to get things going and it is

extremely inefficient to revert back in case of any problems. Also this costs an extortionate amount of money.

Another potential solution companies have come up with is individual smart electrical appliances like Phillips, Syska, TP-link, Mi etc. This is a much more expensive solution to implement and also sacrifices on the versatility of smart switches.

Some companies like Oakter, Mi, Realme, Tp-link make only the plug points smart. That is, only the devices which can be plugged into the socket externally like table lamps can be controlled wirelessly. We are ‘extending’ it to the normal switches too, which control the lights and fans and are internally wired.

Standing out vividly from the competition courtesy to novelty in ideation and technological implementation, the product is easy to implement with a quick DIY guide and supposedly cheaper than most of the alternatives in the market today. No rewiring, no electrician required to install, nothing of that sort.

We conducted some surveys too, which let us know some important information regarding the stance of consumers towards such products.

7) What did we learn?

When we first started out as a team, we had very little understanding of the problem statement itself in the true sense. We thought that a smart switch with all the features packed into it will be very well received by the consumers as long as the technology behind it is solid and works well.

But as we went deeper into the topic, went through the market segmentation process, made the survey form, analysed it and tried to comprehend the results, we found out that the technology is not the only

thing that is impeding the usage of smart switches.

It is rather the user friendliness, the price, and the inability to revert easily. The barrier that is stopping people from entering the smart ecosystem is still very high and one of the main reasons for it is that the implementation process is very tedious and the ones with easy implementation are not very functional.

Therefore, we set our main aim to lower this initial barrier and make the implementation as easy as sticking a double sided tape.

We brainstormed on many potential solutions, around 5-6 of which were genuinely implementable. These designs had to be simple to use by any lay person since we were aiming at users from all age groups and classes to be able to use the product easily.

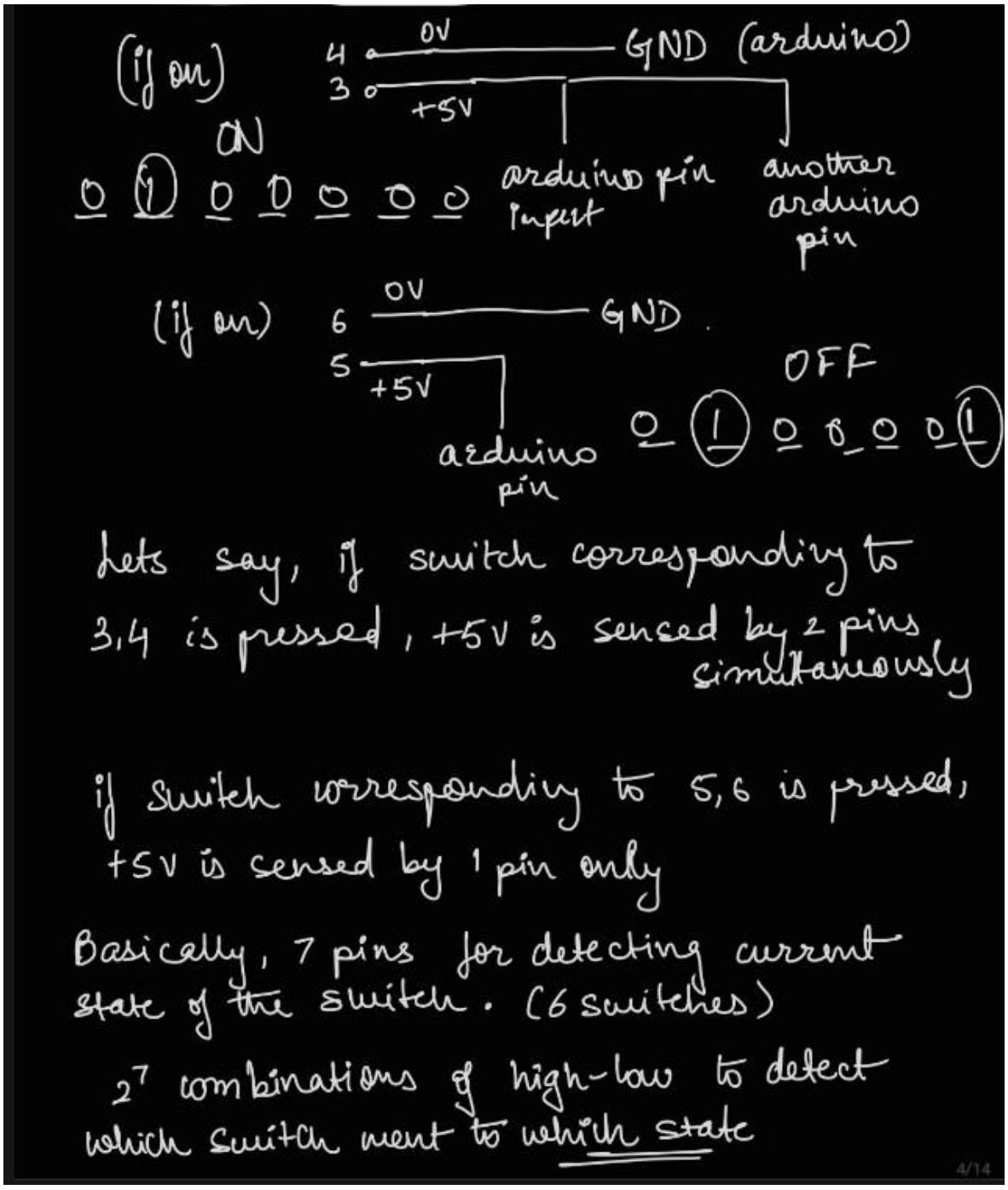
Our market research had backed our understanding of the necessity of such a device in the market. We also learnt that the industry is getting geared up for massive changes to IoT as the internet is accessible to most in the indian subcontinent and thus will enable us to make a ‘switch’ from the current mechanical to automated electronics.

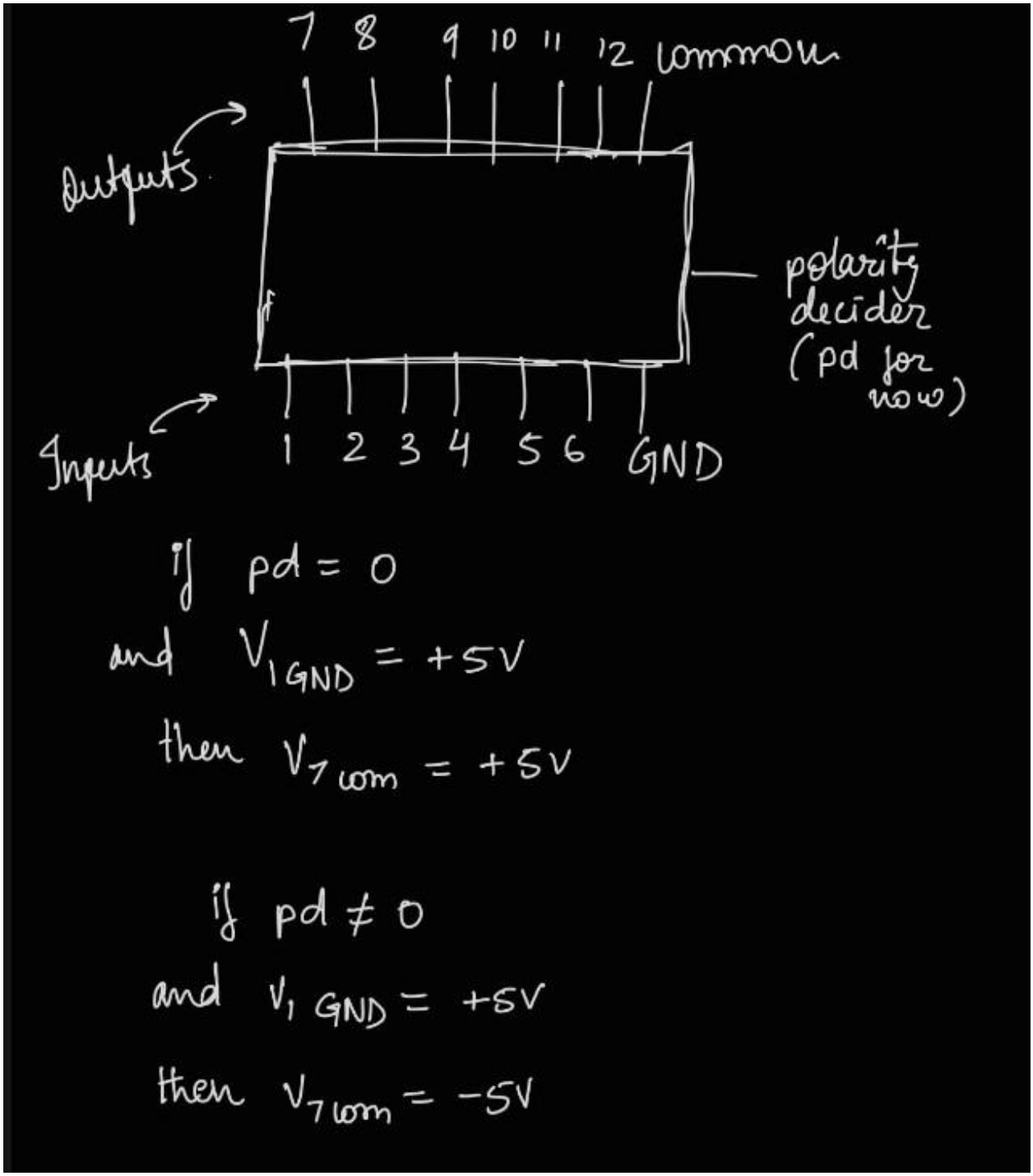
8) Acknowledgement

We would like to thank our institute IITM, for providing us with an opportunity to work on this idea and believe in our project. We would also like to thank CFI’s Product Design club and its heads, Gaurav and Akash for constantly reviewing our work and providing helpful insights to improve our work and Abhigyan for being a part of our discussions on multiple facets of product and providing reviews. We would also like to thank the E-Cell for giving us insight into the marketing aspects of our product. We as a team thank all the other people who have been involved with us in various ways to help us work efficiently.

Appendix

A) Datasheets and Calculations.





if $pd = 0$

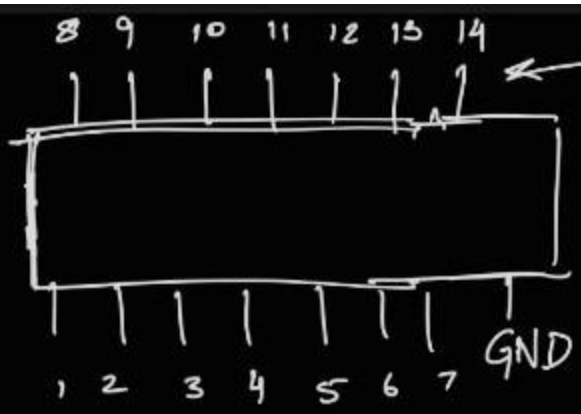
and $V_{1\,GND} = +5V$

then $V_{7\,com} = +5V$

if $pd \neq 0$

and $V_{1\,GND} = +5V$

then $V_{7\,com} = -5V$



Example if.

1 2 3 4 5 6 7

0 1 0 0 0 0 1

then output +5V from pin 9

if

0 1 0 0 0 0 0

then output -5V from pin 9

if 0 0 0 0 0 0 0

then no voltage from outputs.

total pins → (14)

let number of switches be (n)

number of pins simultaneously high = (y) = (3)

number of pins for output = (z)

" " " " input = ($14-z$)

$2^{14-z} \geq 3n$

0	0	1
0	1	0

$${}^{z}C_1 + {}^{z}C_2 + {}^{z}C_3 \cdots {}^{z}C_y = (3n)$$

~~If $y = 3$~~

$$z + \frac{z(z-1)}{2} + \frac{z(z-1)(z-2)}{6} \geq 3n$$

(n is number of switches)

$n = 27.064$

$z = 7.657$

$z = 7$ (integer) (or 8, both will do)

$n = 21$

do, atmost 21 switches per main circuit

7/14

If $y = 2$,

$n = 12$

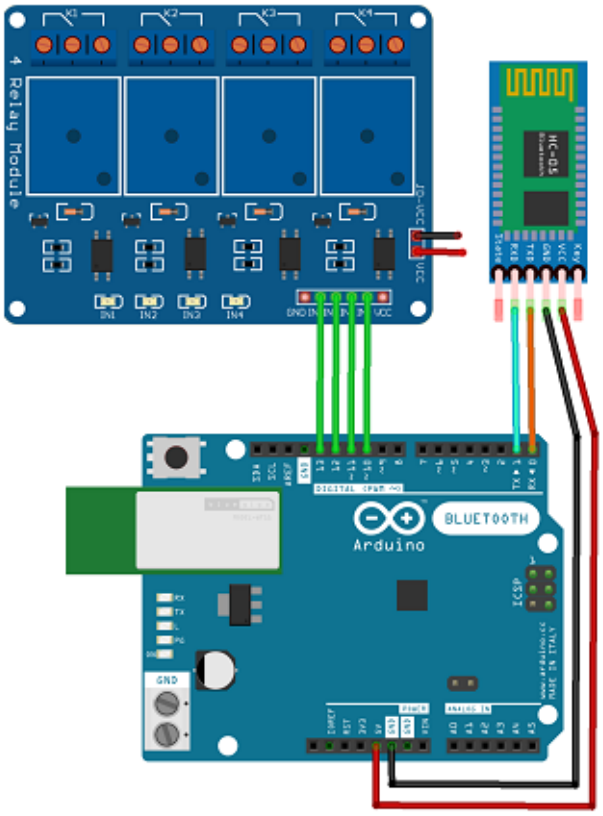
$z = 8$

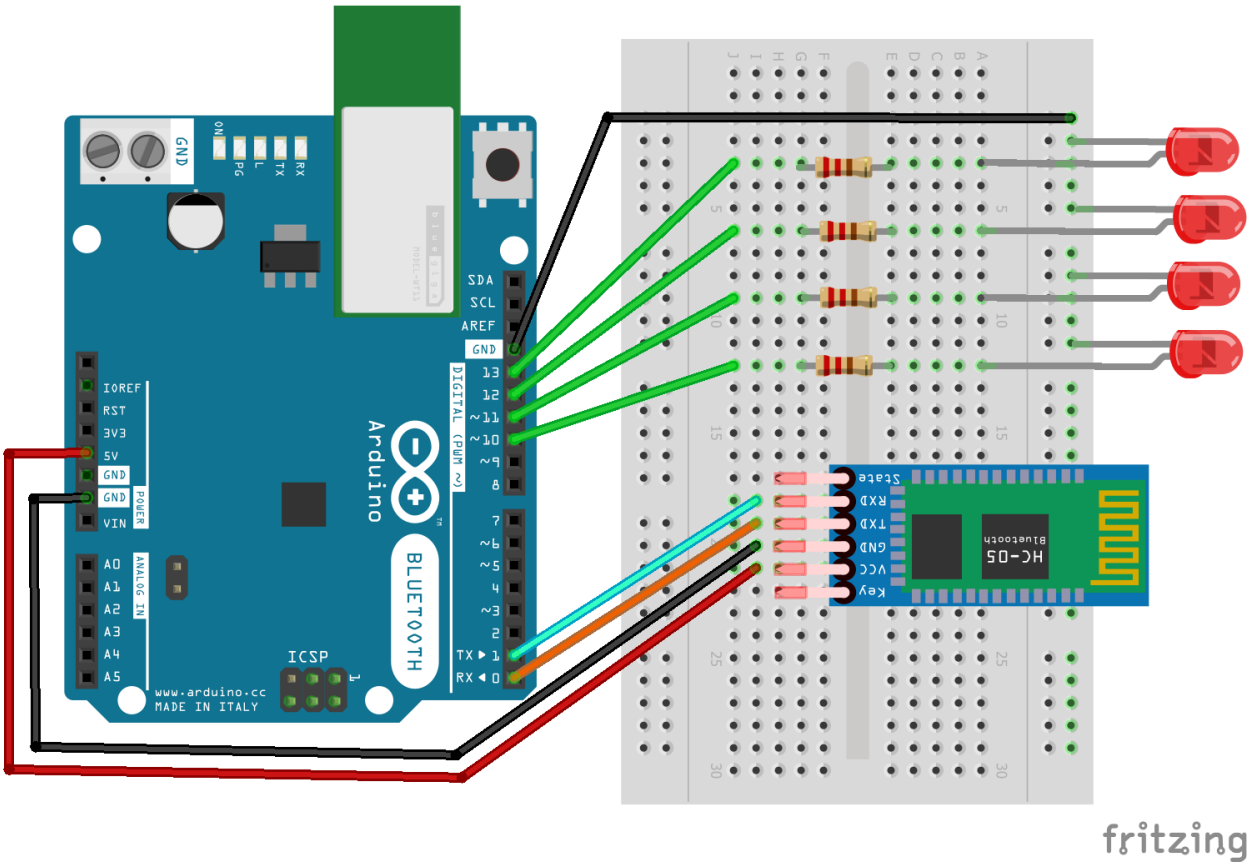
Drawback

Multiple switching simultaneously will cause an issue.

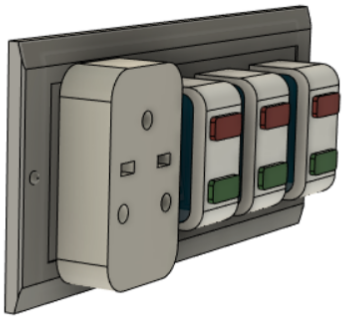
B) Electrical Schematics:

Below is the schematic for controlling 4 led bulbs / 4 relays with arduino and a HC05 module

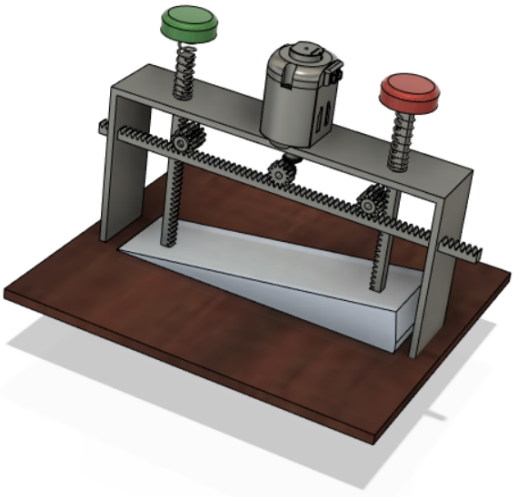




CAD models:



Initial renders



Mechanism explanation
(rack and pinion method)

C) Source Code

Arduino code for programming the microcontroller.

```
#define RELAY_ON 0
#define RELAY_OFF 1
#define RELAY_1  4
char data = 0;
void setup() {
// Set pin as output.
pinMode(RELAY_1, OUTPUT);
// Initialize RELAY1 = off. So that on reset it would be off by default
digitalWrite(RELAY_1, RELAY_OFF);
Serial.begin(9600);
Serial.print("Type: 1 to turn on the bulb. 0 to turn it off!");
}
void loop() {
 if (Serial.available() > 0) {
data = Serial.read();        //Read the incoming data and store it into variable data
  Serial.print(data);       //Print Value inside data in Serial monitor
Serial.print("\n");       //New line
if(data == '1'){
digitalWrite(RELAY_1, RELAY_ON);
Serial.println("Bulb is now turned ON.");
}
else if(data == '0'){
digitalWrite(RELAY_1, RELAY_OFF);
 Serial.println("Bulb is now turned OFF.");
}
}
}
```