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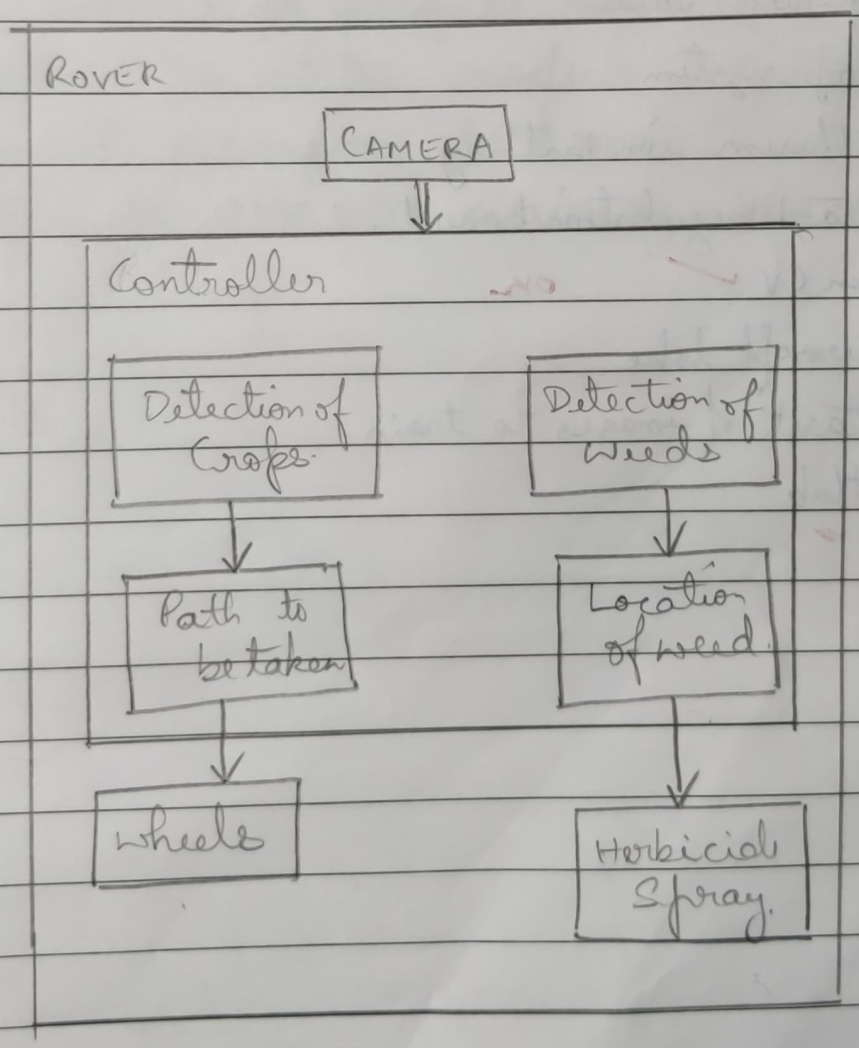
21EC13

AUTOMATED WEED REMOVER

- To scale the field (Row crops)
- To detect weeds alongside the crops.
- To neutralize the weeds.

- Block Diagram:



- Requirements:
  - Rasberry Pi 4.
  - Pi camera
  - Wheels
  - Aluminium frame
  - DC motors
  - L298 Motor driver
  - Solenoid value
  - pump system
  - Lithium ion battery
  - Voltage regulation board.
  - Open CV ✓ OK.
  - Microsoft loke
  - Dataset of images to train.
  - Matlab ✓

~~Work~~ Tasks completed:

- Coming up with the idea & inital design
- Researching current technologies available
- Created a rover prototype using H bridge and BO motors.
- Color grading method for path detection was implemented.
- The whole project was split into modules. In those modules, we were able to finish camera feed module and the module related to driving the motors.

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Day 1

- ~~We~~ Brushing up on whatever tasks were completed ~~up till~~ previously.
- Software implementation
- Alogrithms tested for scaling & movement of the rover in the field
- Canny edge detection model
- Figuring out ways to reduce the processing power required from 2 boards to 1
- Rover testing in a ground plan.

* Power calculations to select motor to be done

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Day 2

- Brushing up on the previously completed tasks.
- Since our alloted work time for the project did not match correctly with our time tables, ~~all members~~ ~~we~~ we could only get 2 productive days out of the 4 in a week. Plus one of our group members had gone out for internship, so we had to refigure our work-split.
- Some problems ~~very~~ were clearly visible:

> We were behind schedule.

> We needed to buy the parts & directly implement the project

↳ We could not do this earlier due to our sem end exams and we were short on funding.

> Our estimated budget for the project was 25,000, which would be shared & borne by us 4 group members.

> Parts would require on an average, a weeks time to arrive

> In our design, only a solenoid valve was used, we did not consider the actual spraying part of the system

> Before buying the aluminium for building, initial cardboard design should be made to get a scale and visual representation, so it is easier for further calculations & error detection.

> Placement of camera needs to be decided, since we reduced our cameras from 2 to 1.

> Getting the rover from home to college every time will be an issue, assembling & disassembling.

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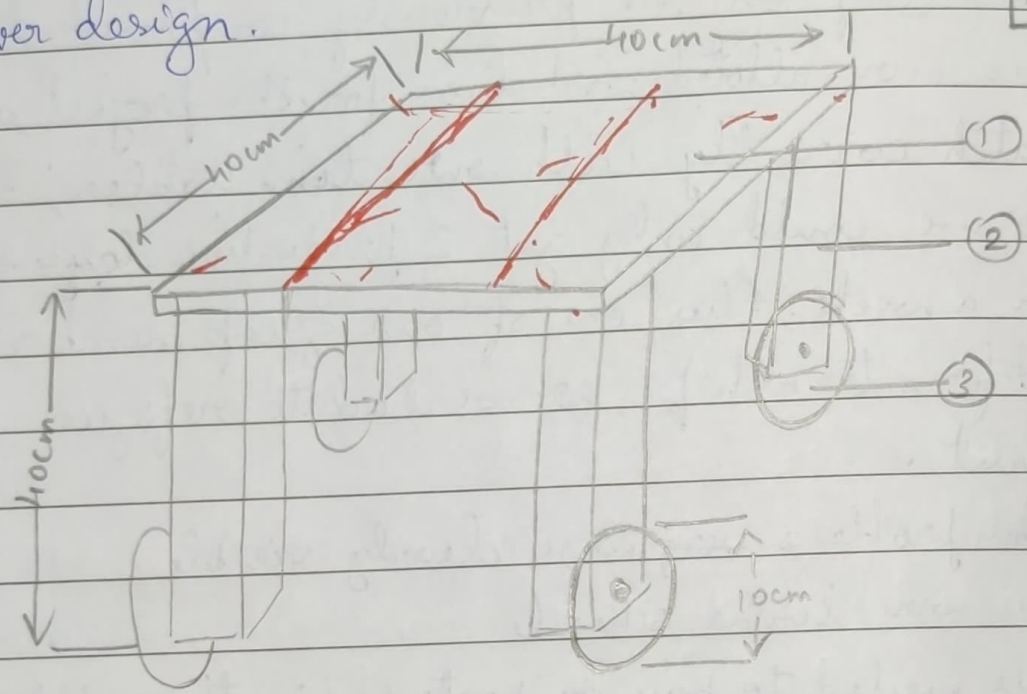
Day 3

- Rover design.

Design 1



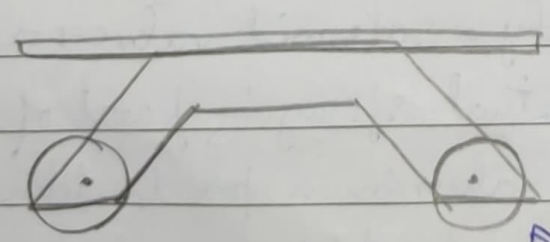
① : Perforated aluminium sheet + support frame

② : Aluminum channels

③ : Trolley wheels/wheelchair wheels.

Design 2

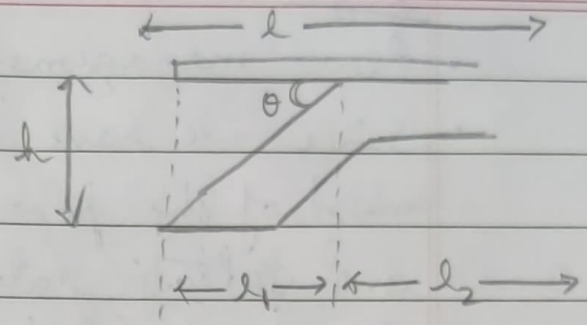
Side view:



} Rejected design for legs

- We first came up with this design, but after calculating the optimal angles required for strength, while also limiting the total side of the rover, we ~~rea~~ realised that this design isn't feasible, because the rover length increases as you change the angles.

- keeping height fixed to 40cm;



$h = 40$ cm

Assume $\theta = 45°$

$l_1 = \cancel{\tan 45°} \dfrac{40}{\tan 45°}$

$l_1 = 40$ cm.

$l_1 \times 2$ (because 2 sides)

$l_1 = 80$ cm.

even without assuming l_2, the total length has reach 80cm, which is too long for manuvering in the row crop field.

- We had also chosen this leg design because it would join 2 legs into 1 single piece, but later found out that ~~it will~~ we have fabrication issue.
- So we resorted to design 1.
- We decided on aluminium frame as it is both light weight & strong enough for our design.
- The total weight is estimated to be around 5Kg.
- Trolley wheels were the ~~est~~ easiest to source and the diameter of these wheels would be ideal for use to test the design.

design 1 is ok

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Day 4

- Power management calculations.
- Since we have 2 main devices that would consume most of the power and they had different current and voltage rating, we had to decide wether to use 2 different batteries or use a single battery and then provide a power regulation board.
- The rasberiyPi consumes, 5V x 3A = 15 W [P = V.I]
- The motor, (assuming) consumes, 12V x 1.5A = 18W
- 4 motors = 18 x 4 = 72W.
- Ideally we need it to run for hours together but considering atleast 1 hour of run time.

  time = 1 hour.
- Misc devices that ~~draw~~ consume power = 10W.
- Total power required = 10 + 72 + 15 = 97W ~ 100W
- For 1 hour = 100W x 1h = 100Wh [Q = It]
- Because Li-ion battery comes ~~on~~ in 'Ah' specification, assume 12V as max voltage required, 100/12 = 8Ah or 8000mAh.

  [Wh/V = Ah]
- For now, a single large battery with a power regulation board is chosen.

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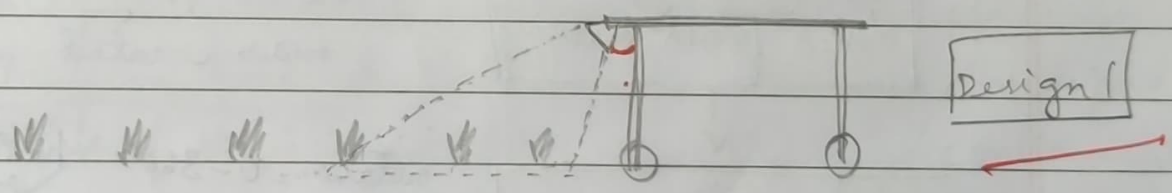
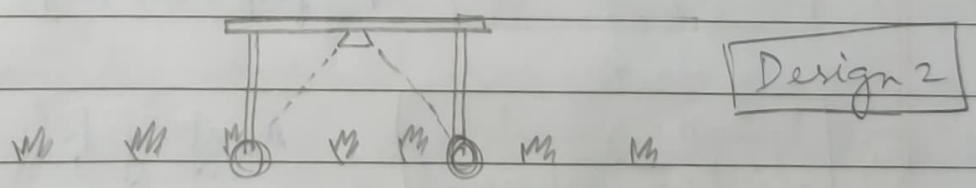
Day 5

- Assuming we get the battery, the charging time will be an issue during testing and demonstration
- Alternatively, we could use an adapter with the same power specifications, only of testing & demo.
- Sourcing such a 'specific' adapter was difficult, this idea is on hold for now.
- Camera placement on the rover body:





- Design 1: The camera is placed infront of the rover, tilted downwards.
- Design 2: The camera is mounted directly under the rover.
- We chose design 1, as ~~it~~ the video feed has better visuals of the crop layout, them in design 2.
- Also, after one row of crops is done navigating, ~~the rover will be~~ it will be difficult to switch over to the next row with design 2. as it only provides video feed of whatever is below the rover.

Design 1 looks OK

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Day 6.

- The previously synthesis images got deleted; so we had to make a new batch. ← ensure proper backup
- We used a simple ~~alog~~ algorithm for this : use drive

① Collect few object images — Photos of ~~crops~~ weeds were taken

↓

② Cut out only the object from the image — Selecting only the weeds, .png file was created

↓

③ Apply, rotation, resize, change position, flip — rotation = 0°–360°; resize = 50%–150%; flip = left, right, up, down; position = picture resolution minus 20px saftey

↓

④ Paste the generated object on background image — A jpeg file is created.

- By changing the values in ③, thousands of images can be generated.
- The no. of image to be ~~generated~~ generated is decided & random value for variables in ③ is automatically chosen.

26/2/21

Day 78

- We met our project guide, Anil Sir and he suggested us some points to look into:-

> Wheel speed compensation: Because our rover is supposed to run on the field, the terrain of the field needs to be considered, more specifically, the uneven surface. Some sort of mechanism/device needs to be made/used to get the wheel speeds of each wheel. A cheaper alternative is by using accelerometers.

> Tank in legs: One solution for managing the liquid weight of the body (which keeps changing continuously) is by designing the tanks inside the pillars used for the legs. By doing this, the liquid used for spraying can be equally consumed from each pillar/leg.

> Herbicide research: More research had to be done about the exact kind of herbicide that we will be using along with tabulated results.

> Fish tank pump: The spray system in our design only had a solenoid valve. The would only acts as a ~~lof~~ tap & not a spray. We had ideas for a pump system, but Sir suggested that we should use ~~a~~ the fish tank pump. That power would be sufficient.

> Plant height research & table: Research needs to be done on all the crops the we are targetting, their growth stages & max height. All this must be tabulated.

- Chilly, brinjal, carrots are some examples.
- Transplanting should also be considered.
- Suspension: Sir suggested spring suspension to be added to each wheel. This will require mechanical design knowledge
- We can use, mono shock design, pneumatic miniature suspensions.
- Kinematics of vehicles ⟶ This book to refer.
- Liquid weight management: Our design included a tank which was fitted on top of the rover, Since the liquid keeps moving in the tank, there is chances of the rover toppling.
- Talk to Muralidhar Sir about mechanical design issues.

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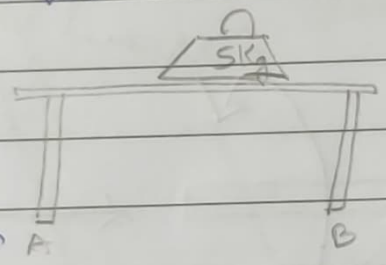
Day 8

- Spoke to Muralidhar Sir about various issue related to Mechanical design.
- Belt driven wheels: This design idea could be used for uneven terrain. But because we are not going for an all terrain vehical, this idea is scraped. Plus, it will cause more design issue & budget issues.
- 

Load division is giving by, total load ÷ no. of legs.

→ 5Kg load / 2 legs = 2.5Kg Per leg.

∴ At point A 2.5Kg of load is acting.

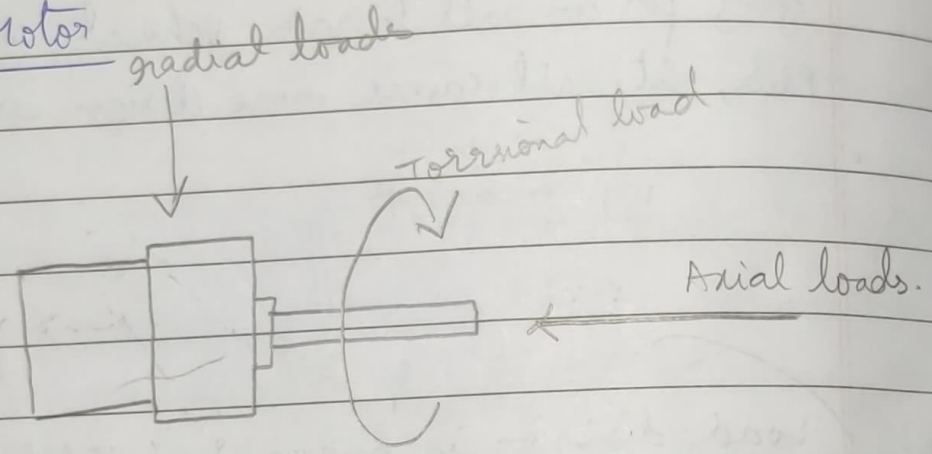
- Our design has an estimated max load of 5Kg

∴ 5Kg/4 = 1.25Kg per leg.

- Websites to ~~by~~ buy parts: Robu.in, Robokits.co.in, NSK electronics.com, shakedeal.com, local shops.
- Solar panel: Sir suggest that, instead of going of a battery, we should try implementing a solar panel. Solar panel of 100W output is needed. But if cloudy atmosphere exists on the field then, this idea is not feasible, also testing will be an issue for us. also budget.

- Voltage remains the same among all motors but current gets divided to each.
- Our estimated max load current is 1.2A.

  ∴ 1.2 × 4 = 4.8A is required from PSU.
- Loads on Motor



While fitting the motor onto any surface, we should make sure that no radial or axial loads are acting on the motor body. This causes damage to the motor.

- ~~too~~ Providing more current than the max current tolerable ~~or running~~ causes damage to the motor windings.
- Torque: measured in Kg-cm, it should be more than the load acting.

We know that 1.25Kg load is acting.

$T = K \times I \times t$

radius of the wheel is also considered when calculating load.

~~rad~~ radius = 5cm

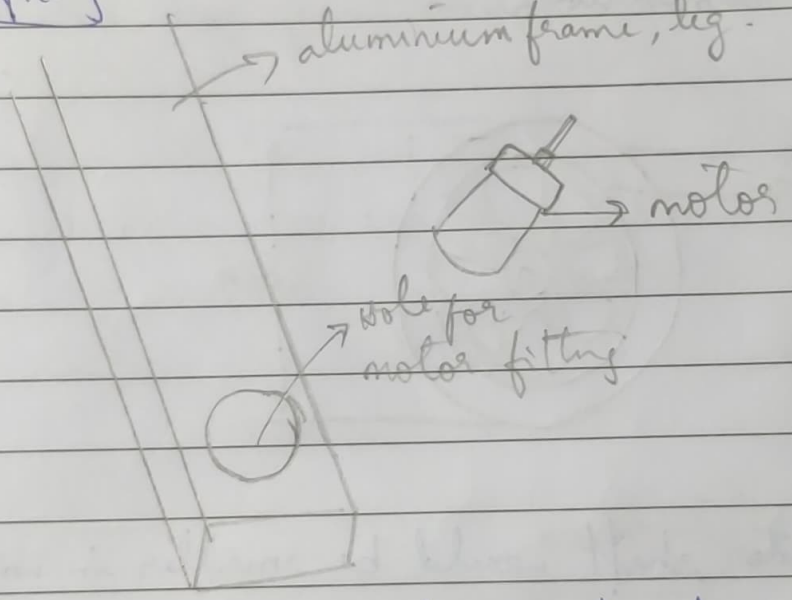
Motor = 5Kg-cm Torque

Torque available = $\frac{5 Kgcm}{5cm}$ = 1Kg-cm

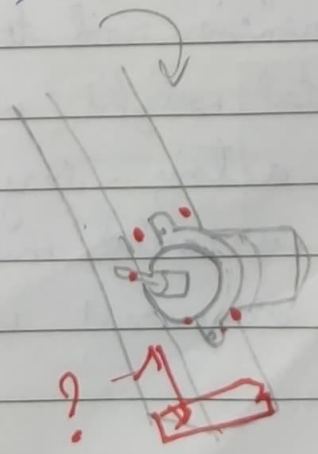
Not enough

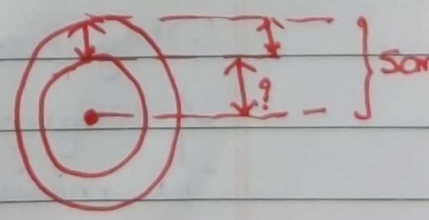
- Flange bearings can be used to transfer the load acting ~~fr~~ on motor to bearing. Alternatively pillow bearings can be used.
- H-bridge can be used as a motor driver. L298N

- <u>motor fitting</u>:



- Initial idea was to make a cut out in the frame to place the ~~legs~~ motors but, as discussed with Sir we had to scrap this.
- Instead we will mount the motor on the legs with brackets.





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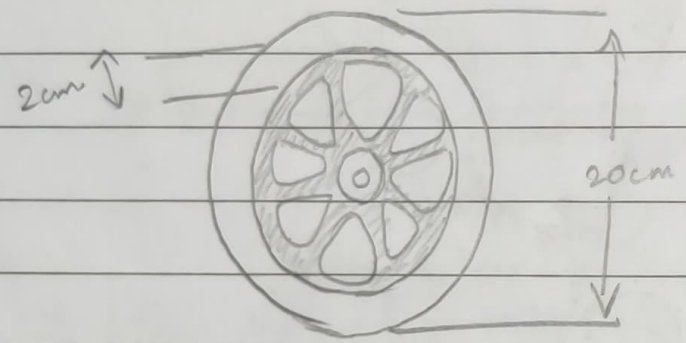
Day 9

- Motor & wheel choosing:

For the wheels, we decided to go with the wheel chair wheels, front wheels, as it is small enough, ~~thin~~ less width of tyre and good structural strength.

- Wheel dimensions.



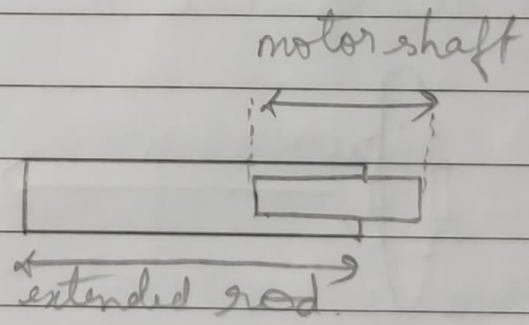
- The motor shaft would be smaller in width when compared to the inner diameter of the wheel mounting hole.
- The mounting of motor to wheel would be direct, we would increase the shaft length of the motor by making a metal extenension rod to the shaft.
- Since the assumed total weight was 5Kg, per leg 1.2Kg load would be acting. By choosing a motor of 10Kgcm. or more, we could meet the requirement. The minimum RPM required was 60RPM.

3/3/21

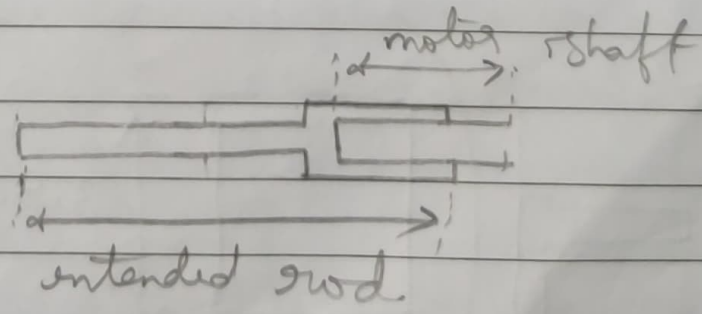
Day 10

- Completed the work book and logged all the activities done till today.
- Tried to find parts in Karkala, but failed to find any that met our requirements.
- We will try to search again in mangalore, if not we will buy from amazon or any other website.

Design1



Design 2



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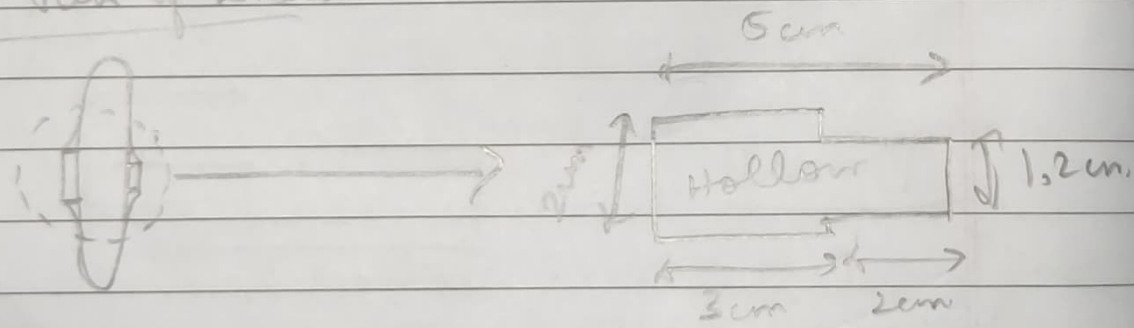
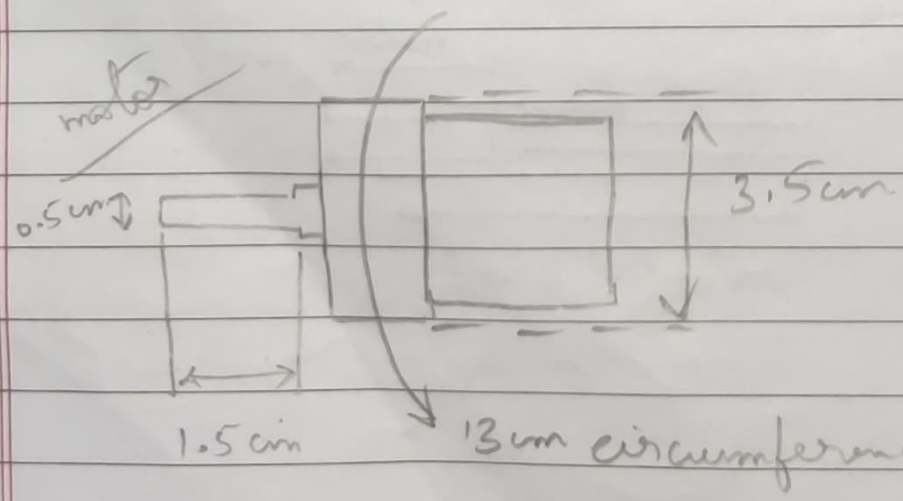
Day 11

- We brought a motor of 10 Kg-cm - 100 RPM, 12V, 7.5A max load current. But the shaft length was 1.2 cm, which was no where enough to fit into the wheel.
- This was again confirmed by Muralidhar Sir, he told us about the change in shaft length will cause losses this we had not considered. We needed a motor of higher power rating & RPM.
- Tried to export a Microsoft lobe model to Resberry but Microsoft lobe website was down.
- We reordered another motor from amazon which has wheels included.
- Design issue:

Front view of wheel.





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Day 12

- Rover weight calculations

Motor → 400g × 4 = 1600g → 1.6Kg

Battery → 500g

Rasberry Pi → 300g (incl. accessories)

Tank → 200g

Pump → 50g.

Frame → 750g (skeleton)

Misc → 300g.

Total = 3700g. + (1Kg safety)

≈ 5Kg

Per leg 1.25 Kg.

Motor choosing

- Step 1: Total weight calculation
- Step 2: Max speed is set to 0.3mps — 0.8 m/s.
- Step 3: Terrain consideration, an average inclination of 15° is considered

(to calculate for uneven terrain we take a slight angle of inclination, the effect is approx. same)

Angle of incline = arc tan (0.15)

≈ 8.5°

- acceleration time = 0.2 seconds

- Traction wheel rotation speed.
- wheel diameter = 100 mm.

$$N_T = \frac{60 V_n}{\pi D_n}$$

$V_n \rightarrow$ Nominal velocity

$D_n \rightarrow$ Diameter.

$$N_T = \frac{60 \times 0.3}{\pi \times 0.1 m} = 60 \text{ RPM}$$

- Friction is ignored for now.

Thrust force (Force needed to overcome gravity on the slope we assume (0.15°))

$$F_T = g \times k (m_R + m_L)$$

$g = 9.8 \ m/s^2$

$k = 0.15 \rightarrow$ Max slope.

M_R = Rover weight

M_L = Max load weight

$$F_T = 9.8 \times 0.15 (3.700 + 1)$$

$$F_T \approx 6.909 \ N.$$

Assuming we move at nominal speed of 0.3 m/s

$$P_l = F_T V_n$$

F_T = Thrust force

V_n = Nominal speed.

$$P_u = \cancel{6.38}\ 6.909 \times 0.3 = 2.0727 N.$$

It is a mechanical power for the entire rover so we need = 0.5181 ≈ 0.5W per traction power.

- Torque for the Traction wheel.

$$T_T = \frac{1}{2} \times \frac{D_W}{2} F_T$$

D_W → wheel diameter

F_T → Thrust force

$$T_T = \frac{1}{2} \times \frac{0.1}{2} \times 6.386 \approx 0.1596 \approx 0.16 Nm.$$

WKT, 1kgcm = 0.098 Nm

$$\therefore T_T = 1.632 \text{ kgcm}.$$

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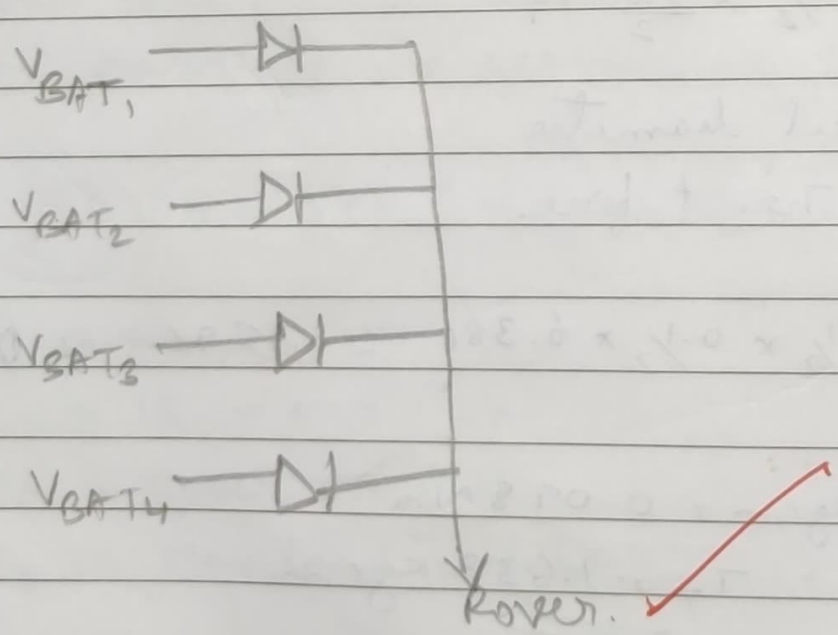
- Battery consideration:
  we need 7.5A current to each motor.
  4 motors = 30A.
  P = 12×30 = 360W.
  which is not feasible, this will be very heavy battery.
- thus increasing the total weight, thus needing more torque, thus needing larger battery to drive
- Anil Sir suggest using smaller multiple batteries.
- 2200mAh batteries is series → example
- 

- Li-Po batteries can be used, but they are expensive
  ↳ light weight

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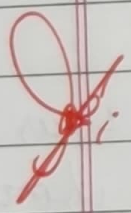
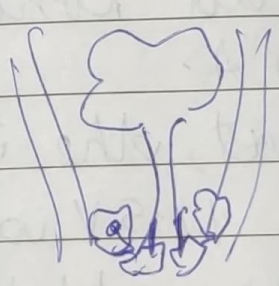
Day 13

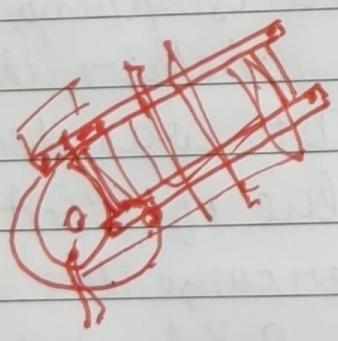
- The second motor which we purchased after doing the force estimation had arrived.
- We rigged up a circuit to check the functionality of the motor. The motor was working fine.
- Then we tested the motor's maximum current consumption at no load condition and found it to be 0.4 A.
- Next, the input to the motor was set to 11.5 V and a small stopping force was applied to see whether the motor could overcome it. It was found that the current value of 0.4A was not sufficient to overcome the applied force. A current of 0.8 A was required to overcome the applied force.
- The wheel which we brought along with the motor was attached to the motor and the same setup was made. It was found that the stall current was around 1.3A.
- Since we were unable to accurately measure the load bearing capacity

of the motor, we decided to measure the input current with load in the next lab session.

- Slight heating issues were found. (We might need to find a way to cut the power supply when motors are stalled).







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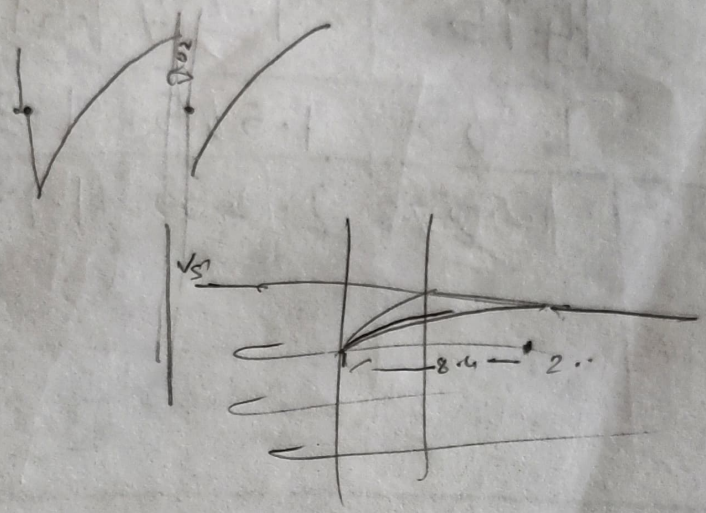
* What is tank gets empty?
* Motor mounting on which faces of one 8 legs
* Tank mounting - detect water empty

* Torque Testing of Motor

Applied voltage (volts)	Trial 1	Trial 2	Trial 3
4.8	1.415	1.214	1.518
6	1.565	1.565	1.56
9	1.875	2.255	1.935

α	18	36	54	72	90	108
V_L	9.86	8.56	7.42	5.43	3.61	2.70



T

Current	Voltage	Temp. 30s	1min	2min	3min	5min
380mA	5V	95.7	95.8	95.8	95.8	
390mA	6V	96.1	96.2	96.4	96.6	
430mA	9V	97	97.2	97.5	DEATH 97.9	
? Loud	12V	98.6	99.3	100.5	101	
? Loud.	15V	101.6	102.3	104.4	106.9	108

Base Temp = 95.70

Use relay for motors instead of H bridge