Team CosmicCreators

COSMIC CYCLE CHALLENGE

TARGETS

To develop a cost and material efficient electric bicycle model for current day sustainable commutation, we have optimized the following targets:

- **Range - 28km**
- **Top speed - 18-22 km/h**
- **Mass - 23 kg**
- **Retail Price - Rs 30,000**
- **Good safety factor- >10 on average**

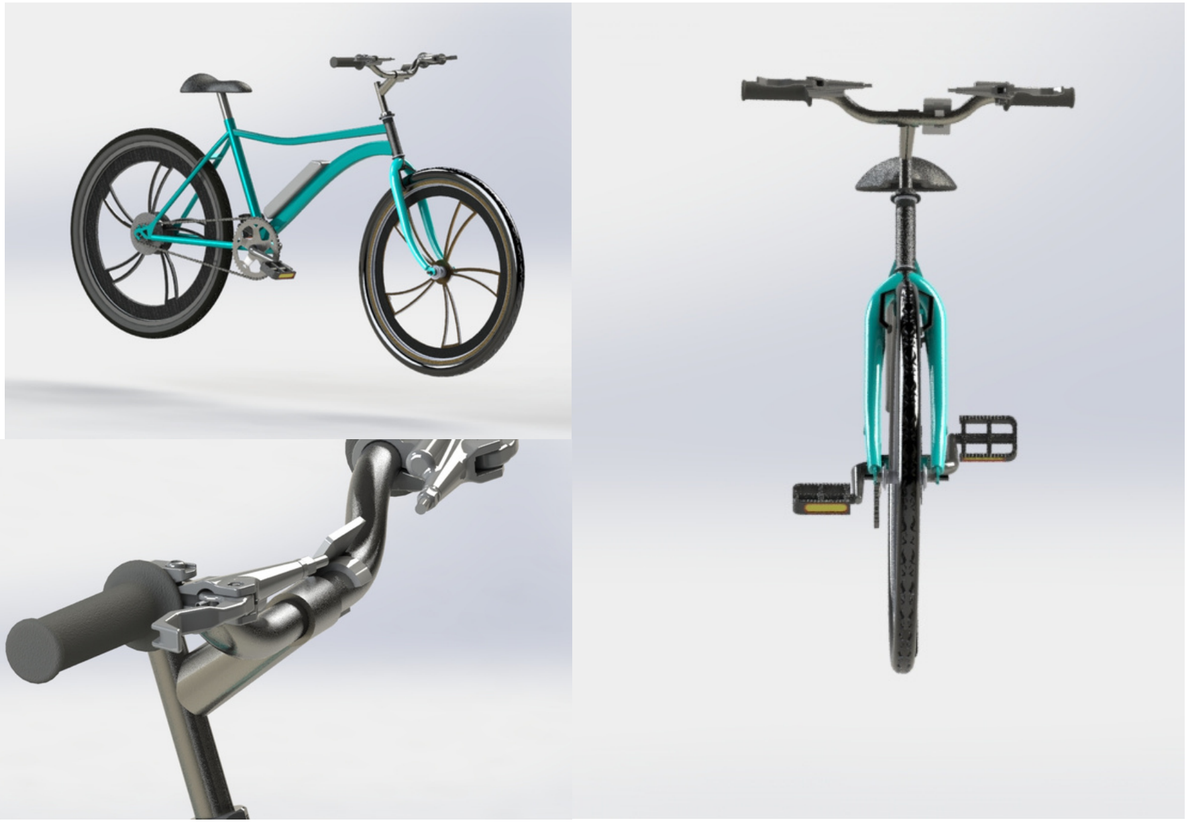
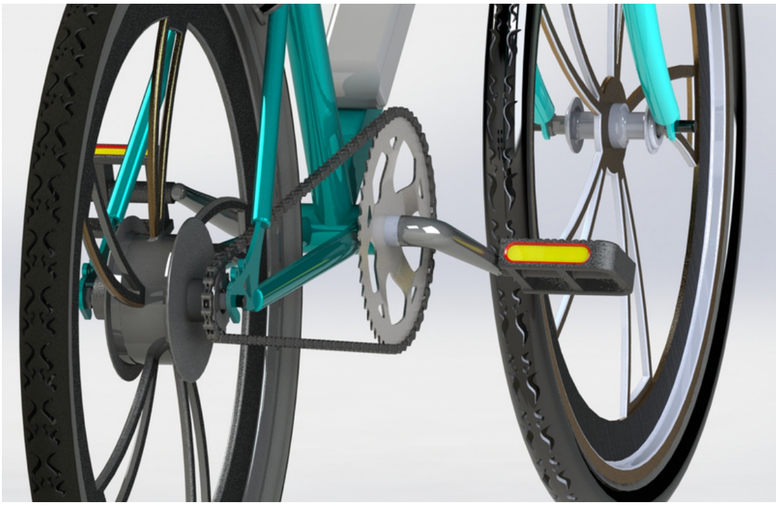


TABLE OF CONTENT



FRAME

Since our design focuses on practicality and cost-efficiency, we have chosen to implement a classic frame design which will reliably perform all the functions needed from it, while remaining feasible in cost.

- **Material** (see ANSYS analysis) - Structural Steel
- **Mass** (see ANSYS analysis) - 4.203 kg

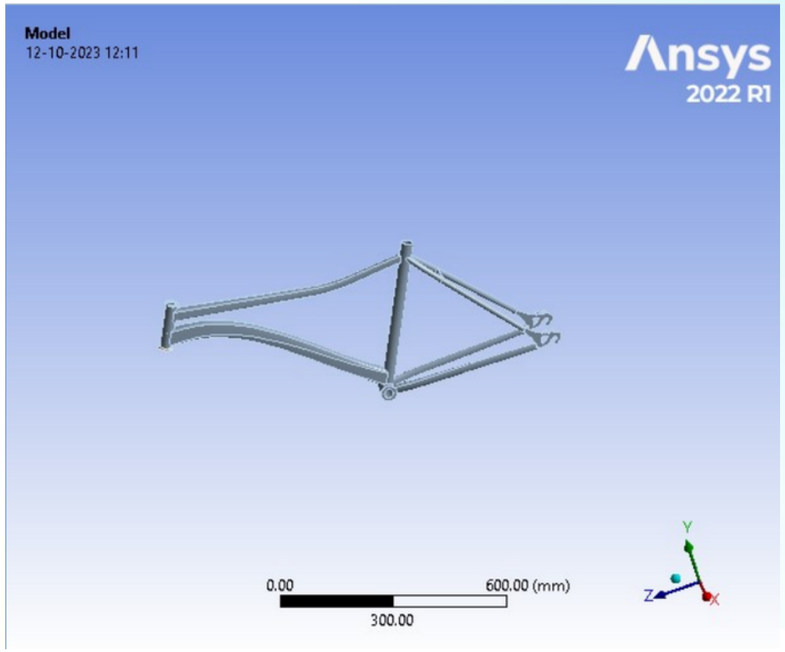
ANSYS ANALYSIS

In order to understand the physical characteristics of our design, we have performed an analysis on ANSYS.

Materials: Structural Steel

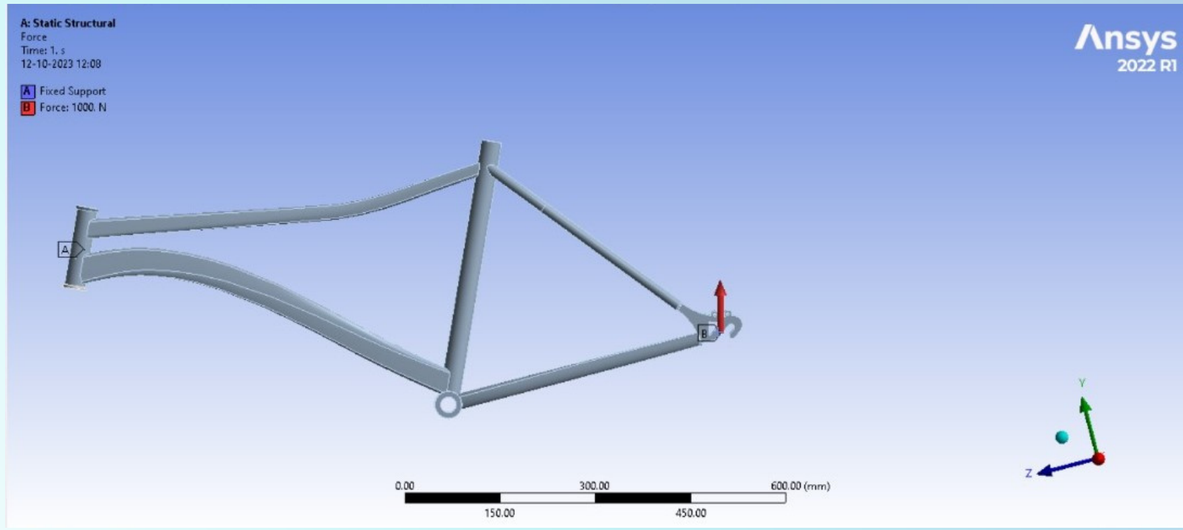
Properties	
Volume	5.3542e+005 mm³
Mass	4.203 kg

Geometry



Applied Force

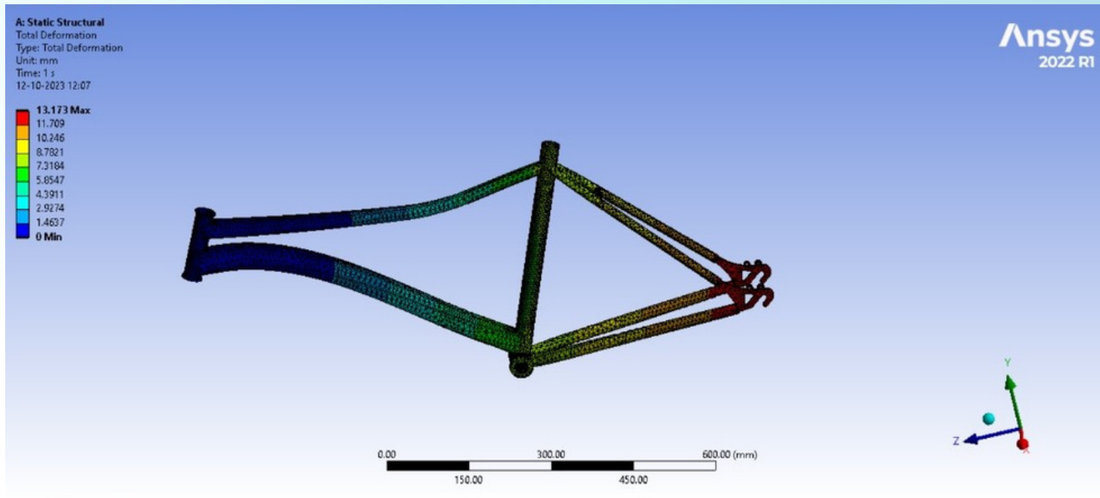
Type	Fixed Support	Force
Define By		Vector
Applied By		Surface Effect
Magnitude		1000. N (ramped)
Direction		Defined



Total Deformation

TABLE 19
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

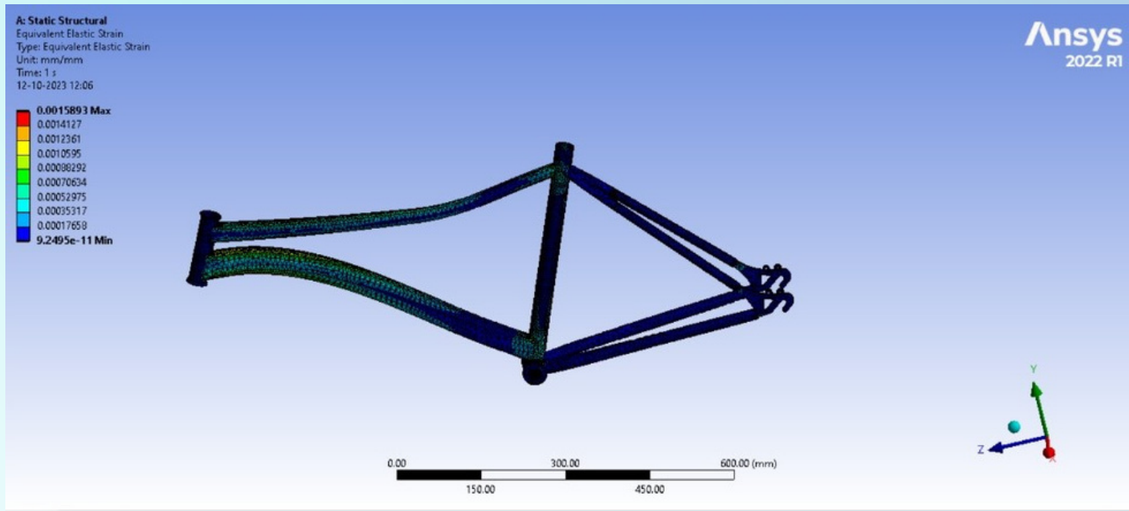
Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	0.	13.173	6.1745



Equivalent Elastic Strain

TABLE 18
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain

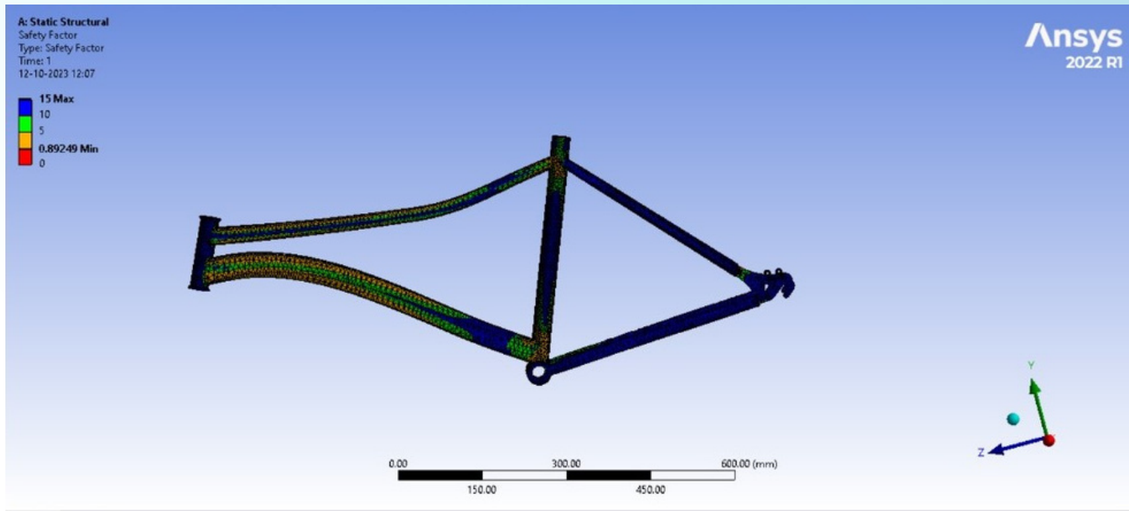
Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.	9.2495e-011	1.5893e-003	2.1341e-004



Safety Factor

TABLE 22
Model (A4) > Static Structural (A5) > Solution (A6) > Stress Tool > Safety Factor

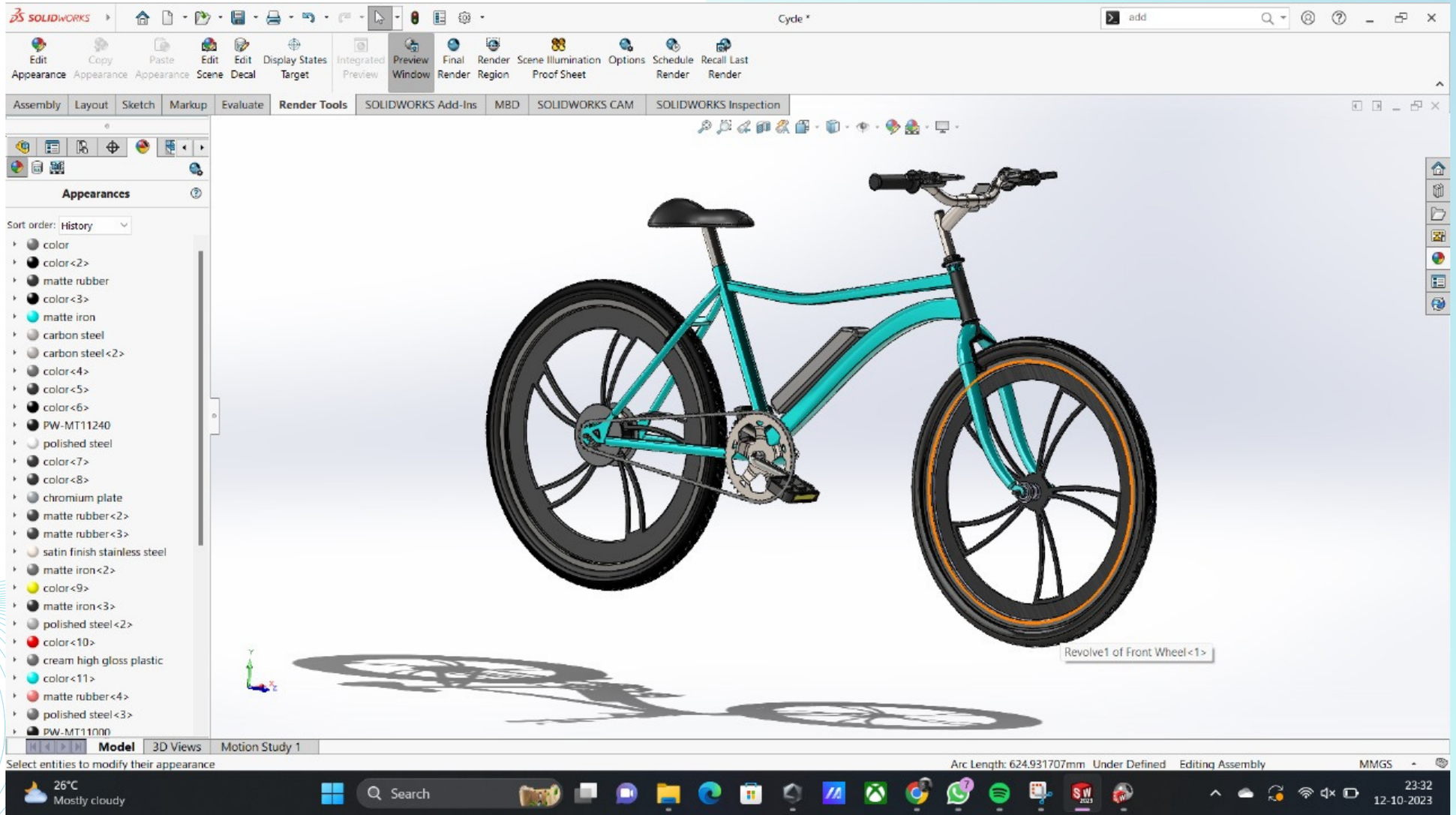
Time [s]	Minimum	Maximum	Average
1.	0.89249	15.	10.278



Conclusion

Maximum Total Deformation	**13.173 mm**
Maximum Equivalent Strain	**1.5893e-003**
Factor of Safety	**10.278**

3D MODEL


SOLIDWORKS
Cycle *
add
Edit Appearance
Copy Appearance
Paste Appearance
Edit Scene
Edit Decal
Display States Target
Integrated Preview
Preview Window
Final Render
Render Region
Scene Illumination Proof Sheet
Options
Schedule Render
Recall Last Render
Assembly
Layout
Sketch
Markup
Evaluate
Render Tools
SOLIDWORKS Add-Ins
MBD
SOLIDWORKS CAM
SOLIDWORKS Inspection
Appearances
Sort order: History
color
color<2>
matte rubber
color<3>
matte iron
carbon steel
carbon steel<2>
color<4>
color<5>
color<6>
PW-MT11240
polished steel
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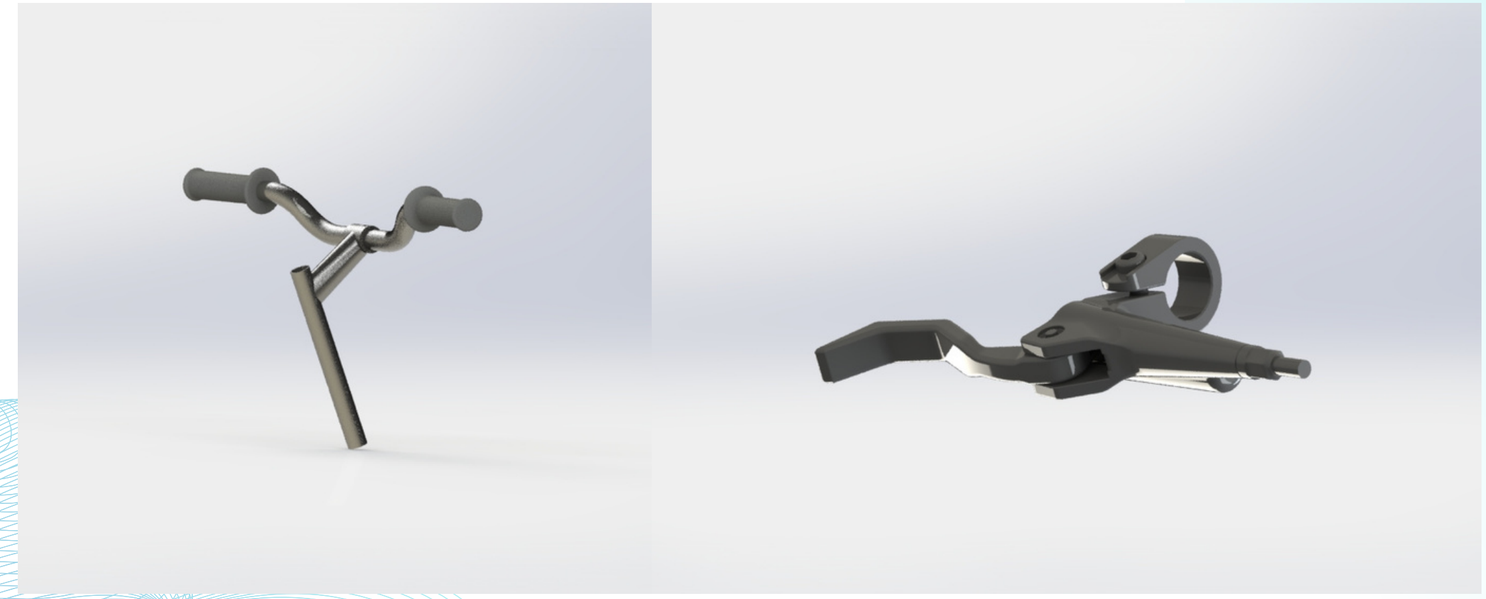
chromium plate
matte rubber<2>
matte rubber<3>
satin finish stainless steel
matte iron<2>
color<9>
matte iron<3>
polished steel<2>
color<10>
cream high gloss plastic
color<11>
matte rubber<4>
polished steel<3>
PW-MT11000
Revolve1 of Front Wheel<1>
Model
3D Views
Motion Study 1
Select entities to modify their appearance
Arc Length: 624.931707mm Under Defined Editing Assembly
MMGS
26°C
Mostly cloudy
Search
23:32
12-10-2023

HANDLEBAR
BRAKE MASTER CYLINDER



In order minimize the use of proprietary parts, we opted for a simple, effective and easily modifiable design.

- **Material -** Structural steel and synthetic rubber (grips)

FRONT FORK

A simple rigid fork is used, which can be substituted a shock absorber fork at a higher price.

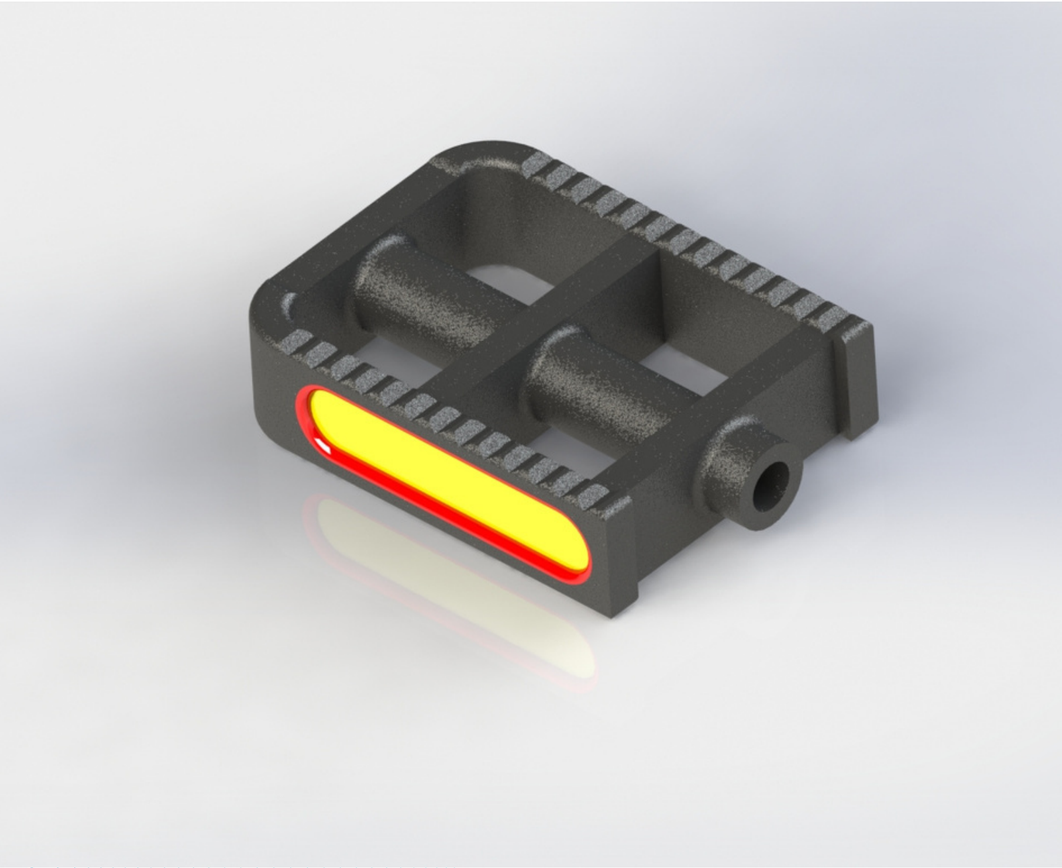
- **Material -** Structural steel and ABS plastic (fittings)

SADDLE

A comfortable, 3D contoured design is used, which can be switched out according to preference.

- **Material -** Foam/rubber (seat), structural steel

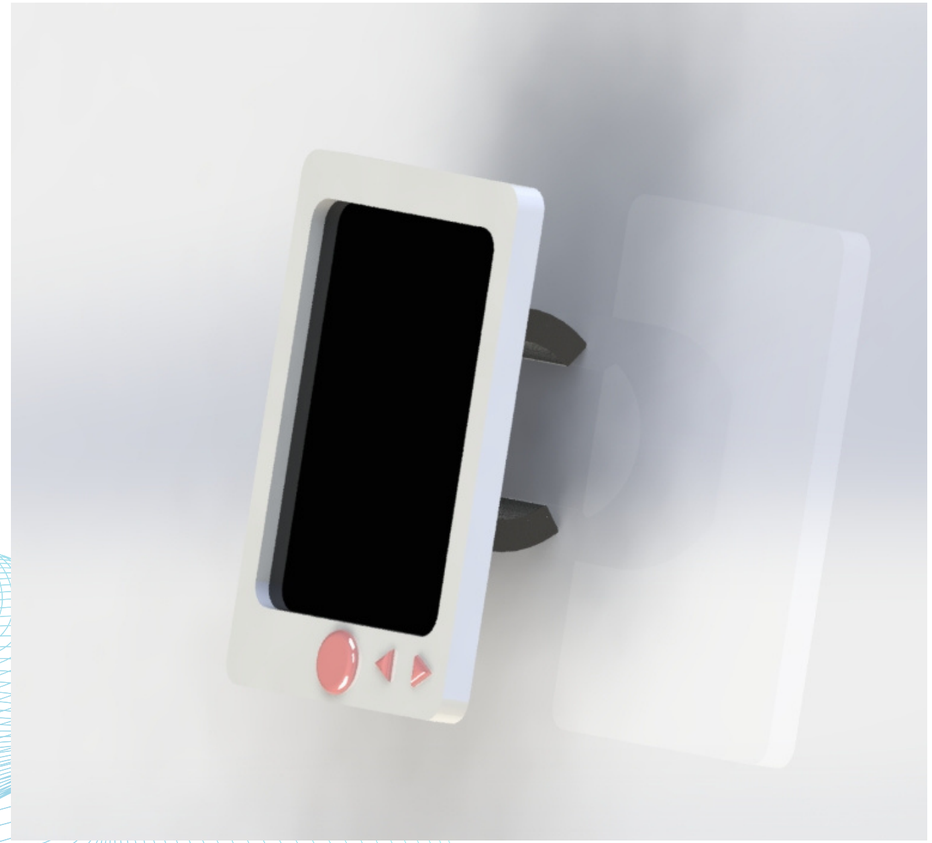
PEDAL



We have chosen to retain the pedal and sprocket-chain design which will be able to operate independently of the motor, to facilitate manual operation.
Basic pedal design with grooves and reflectors.

- **Material** - ABS plastic

DISPLAY



A cost-effect LED display which will show essential information such as range, charge, speed, etc.

- **Material -** Plastic, Rubber (buttons)

WHEELS

A stylish and modern spoke design was made.

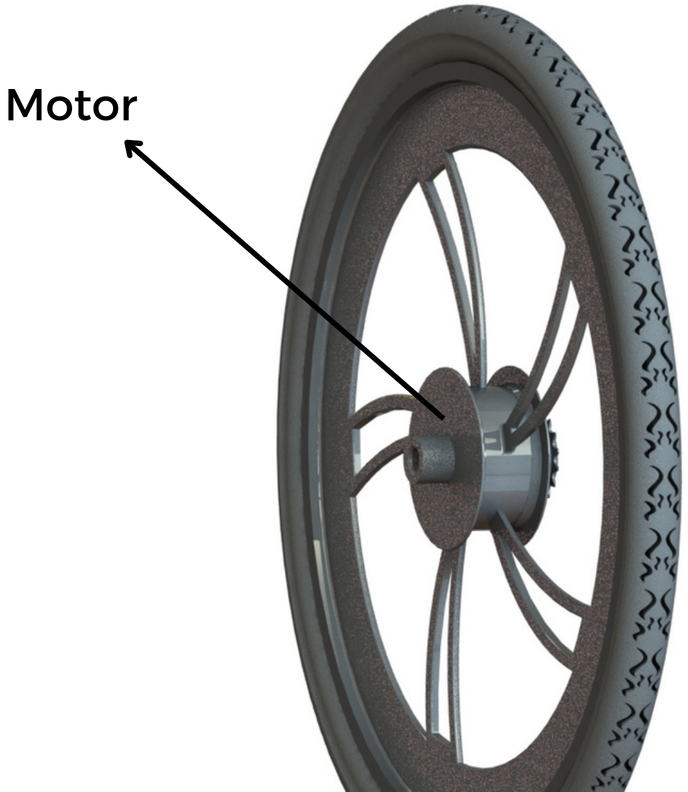
- **Material -** Stainless steel

POWERTRAIN CALCULATIONS

Motor Calculations:

Motor we used:

BLDC Hub Motor

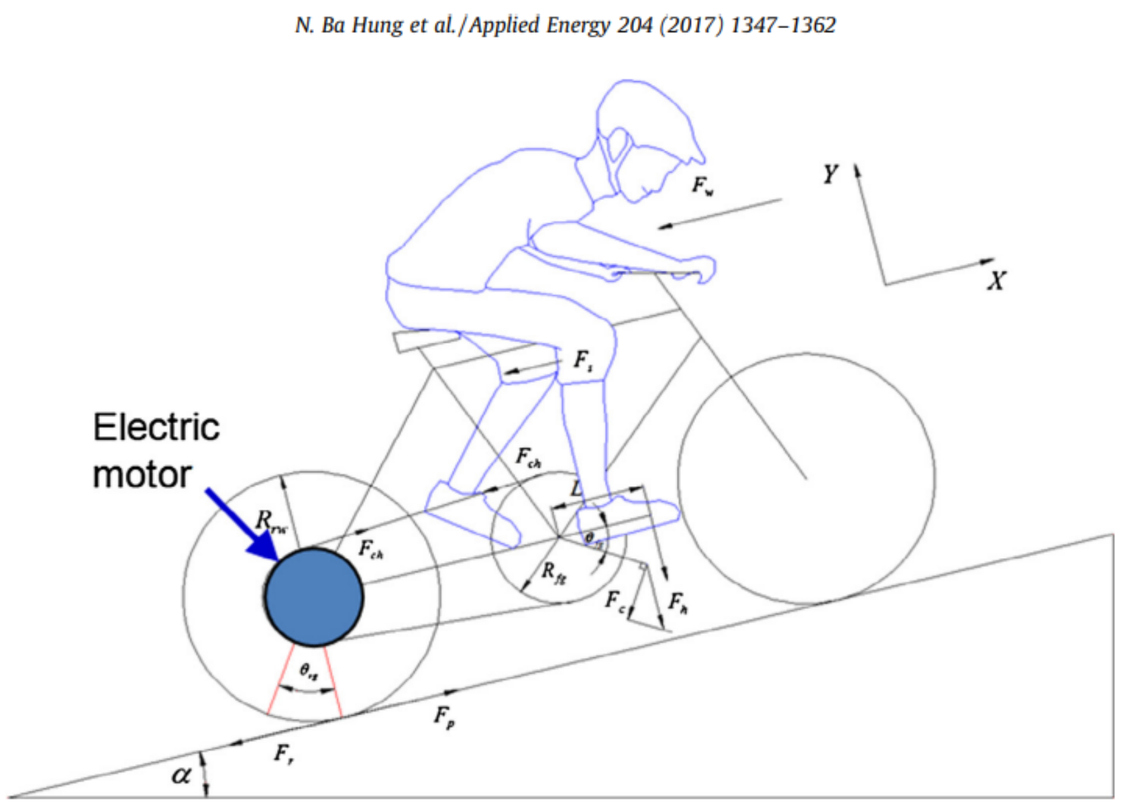


Solidworks Model

- Mass = 3.03 kg
- Retail Price = ₹6,277.60 (Incl. GST)

https://robokits.co.in/e-bike/hub-motor/e-bike-24v-350w-bldc-hub-motor-300rpm

Motor Calculations:



Equations required for simulation:

$$F_p - (F_r + F_s + F_w) = M\frac{d^2x}{dt^2} = Ma$$

$$F_p \cdot R_w = T_p$$

$$T_p = F_{ch} \cdot R_{rg}$$

$$F_{ch} = \frac{1}{R_{fg}} \cdot L \cdot F_h \cdot \cos\theta_{fg}$$

$$P_{drag} = \frac{C_d \cdot \rho \cdot A}{2} \cdot (v_g + v_w)^2 \cdot v_g$$

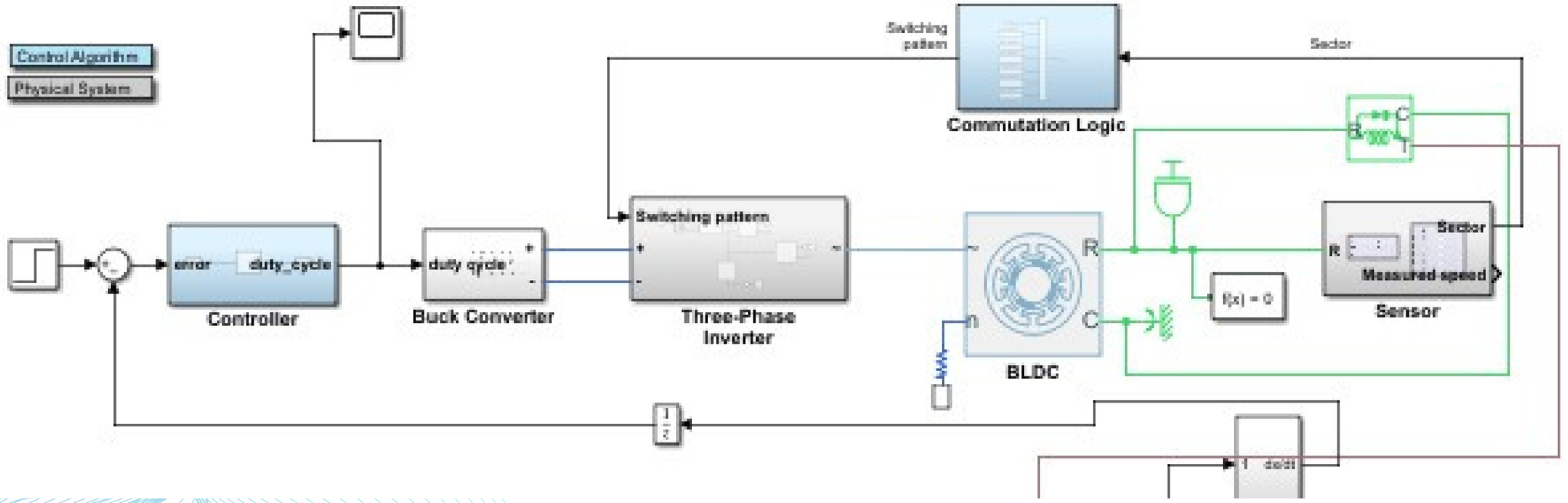
Motor Calculations:

F_p is the propulsion force,
F_r is the rolling resistance force, $F_r = 9.81 \cdot M \cdot C_r \cdot \cos\alpha$,
F_s is the slope resistance force, $F_s = 9.81 \cdot M \cdot C_r \cdot \sin\alpha$,
C_r is the rolling resistance coefficient,
F_w is the wind resistance force, $Fw = [C_d \cdot \rho \cdot A \cdot (v_w + v_g)^2]/2$,
C_d is the coefficient of drag,
ρ is the density of air (kg/m^3),
A is the frontal area (m^2),
v_w is the wind speed (m/s),
v_g is the ground speed (m/s),
M is the total mass of bicycle (M_b) and rider (M_r) (kg),
x and a are the distance (m) and acceleration (m/s^2), respectively.

Assumptions used in calculations:

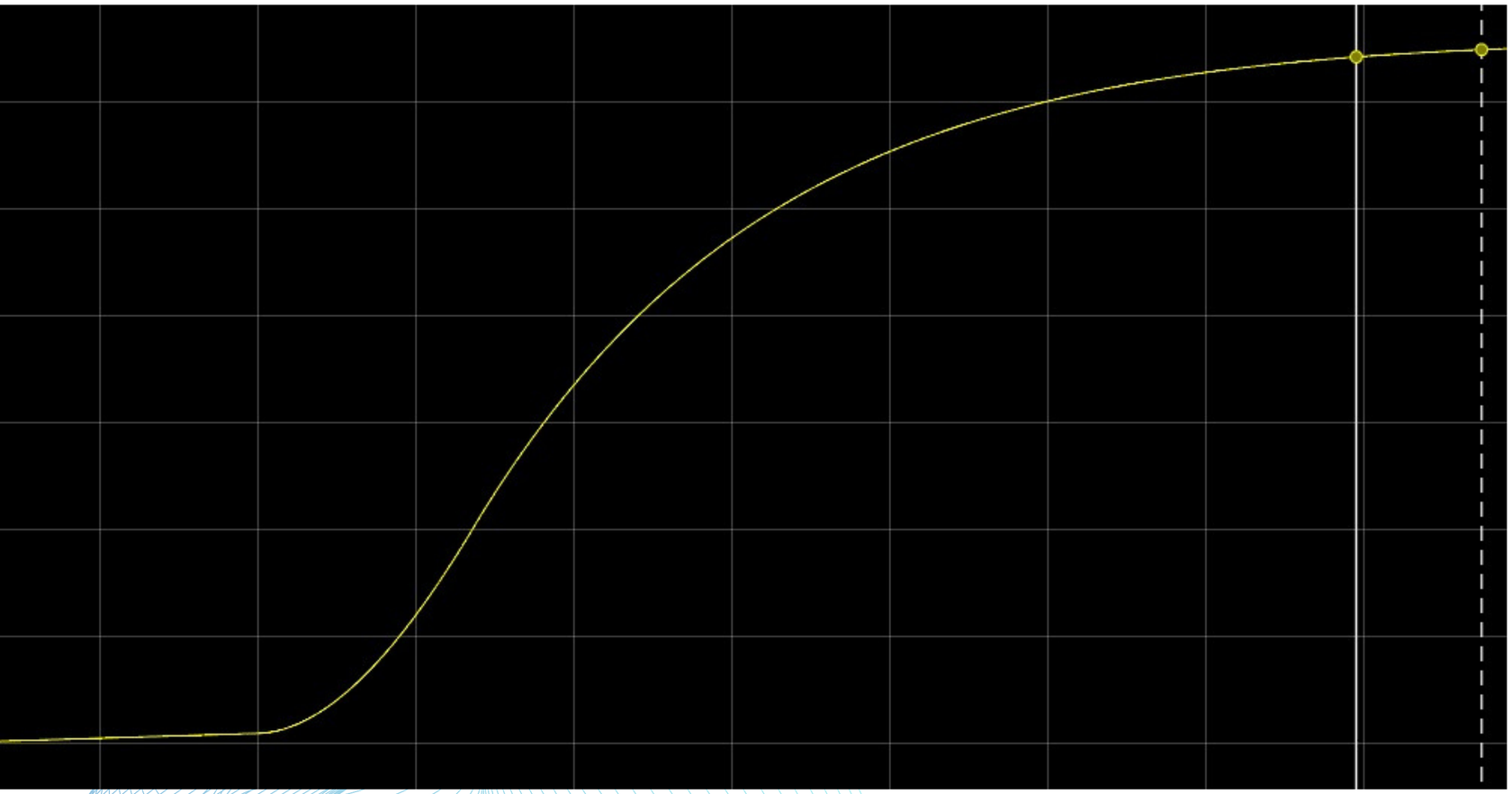
- Cd = 1.1
- A = 0.51 m^2
- Rho(air) = 1.024 kg/m^3
- Mb = 23 kg, Mr = 60 kg (average)
- M = 83 kg (average)
- g = 9.81 m/s^2
- Cr = 0.01
- alpha = 7 degree = 0.122 rad
- L = 0.145 m
- Fh = 60 N
- Rgh = 12 cm

Motor Calculations: Simscape Model



Motor Calculations: Simscape Model

Result: Velocity Profile



Conclusion:

Top speed = 5.5 m/s

Battery Calculations:

(via MATLAB)

batterycal2.m

```
1   %calculation of BLDC HUB motor
2   C:\Pratin\MATLAB\batterycal2.m
3   Power = 250;
4   dist = 28000;
5   top_speed = 5.5;
6   E = Power*(dist/(top_speed*3600));
7   capacity = E/nominal_volt
```

Command Window

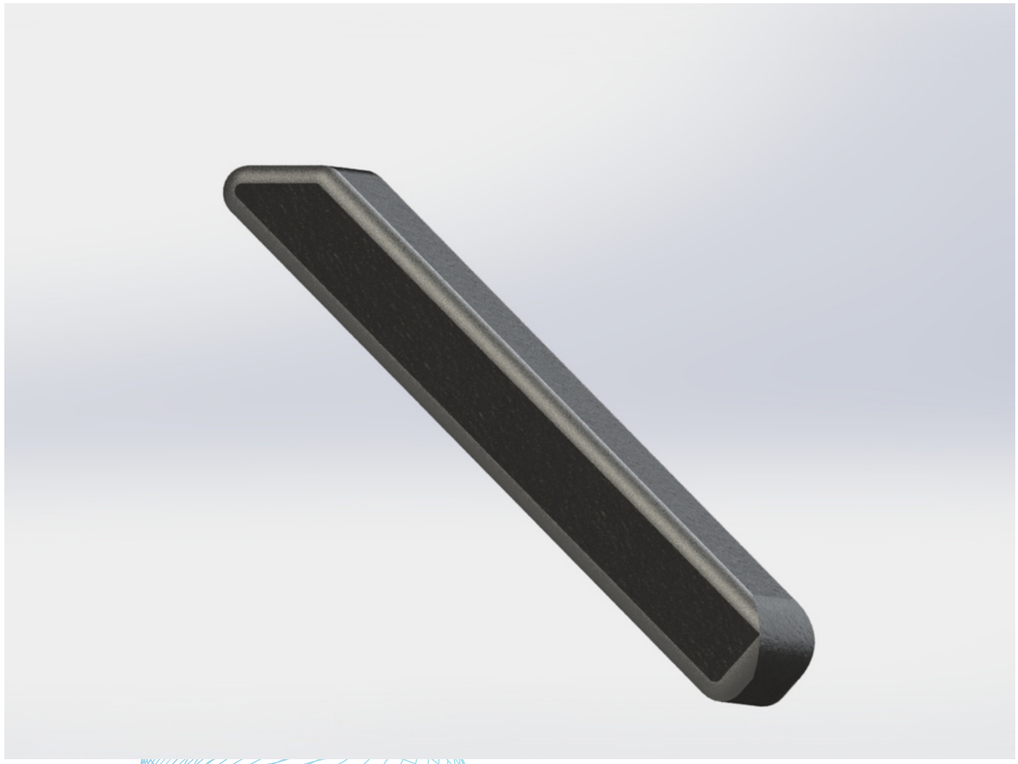
```
One time cache generating ...
>> batterycal2

capacity =

   14.7306
```

Specifications:

- Calculated Energy consumption = 353.53 Wh
- Calculated capacity = 14 Ah
- Target range on full charge = 28 km

Battery Specifications:

(Our battery model)



- Battery Pack Voltage = 30 V
- Cell Voltage = 3.6 V
- Cell Capacity = 3 Ah

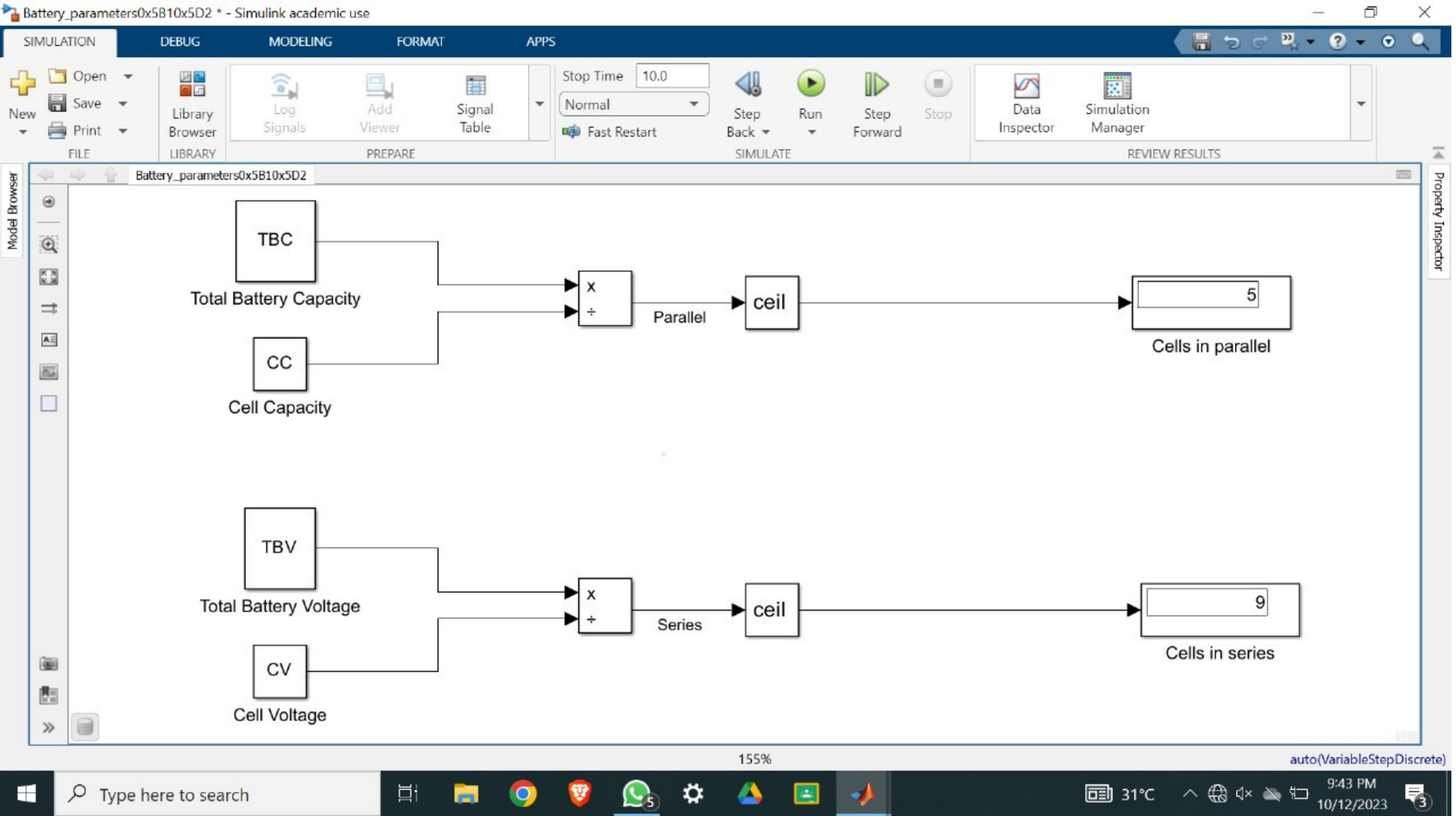
Cycle Hub Motor Kit
Lithium-Ion Battery

- Mass = 2 kg
- Retail Price = ₹13,300

https://www.amazon.in/dp/B0BPMSM215?ref_=cm_sw_r_mwn_dp_EEZ05J7CRBBN4ZNFXBN0

Battery Specifications:

Calculation of number of cells in series and parallel (via Simulink)



Result:

- Number of cells in series = 9
- Number of cells in parallel = 5

Mass and Cost Calculation:

Body:

- **Mass** = Mass of Frame + Mass of Other Components = 4.203 kg + 13.767 kg = **17.97 kg**
- **Cost** = **Rs 10,000***

Powertrain:

- **Mass** = Mass of Battery + Mass of Motor = 2 kg + 3.03 kg = **5.03 kg**
- **Cost** = Cost of Battery + Cost of Motor = Rs 13,300 + 6,277.60 = **Rs 19,977.6 = Rs 20,000 approx.**

Total Mass: 23 kg

Total Cost: Rs 30,000 approx.

Considering a run-of-the-mill bicycle with no gears, no suspension and V-brakes costs around Rs 5,000; including miscellaneous components such as digital display, and labour/transport cost, the maximum cost will be Rs 10,000.

THANK YOU!