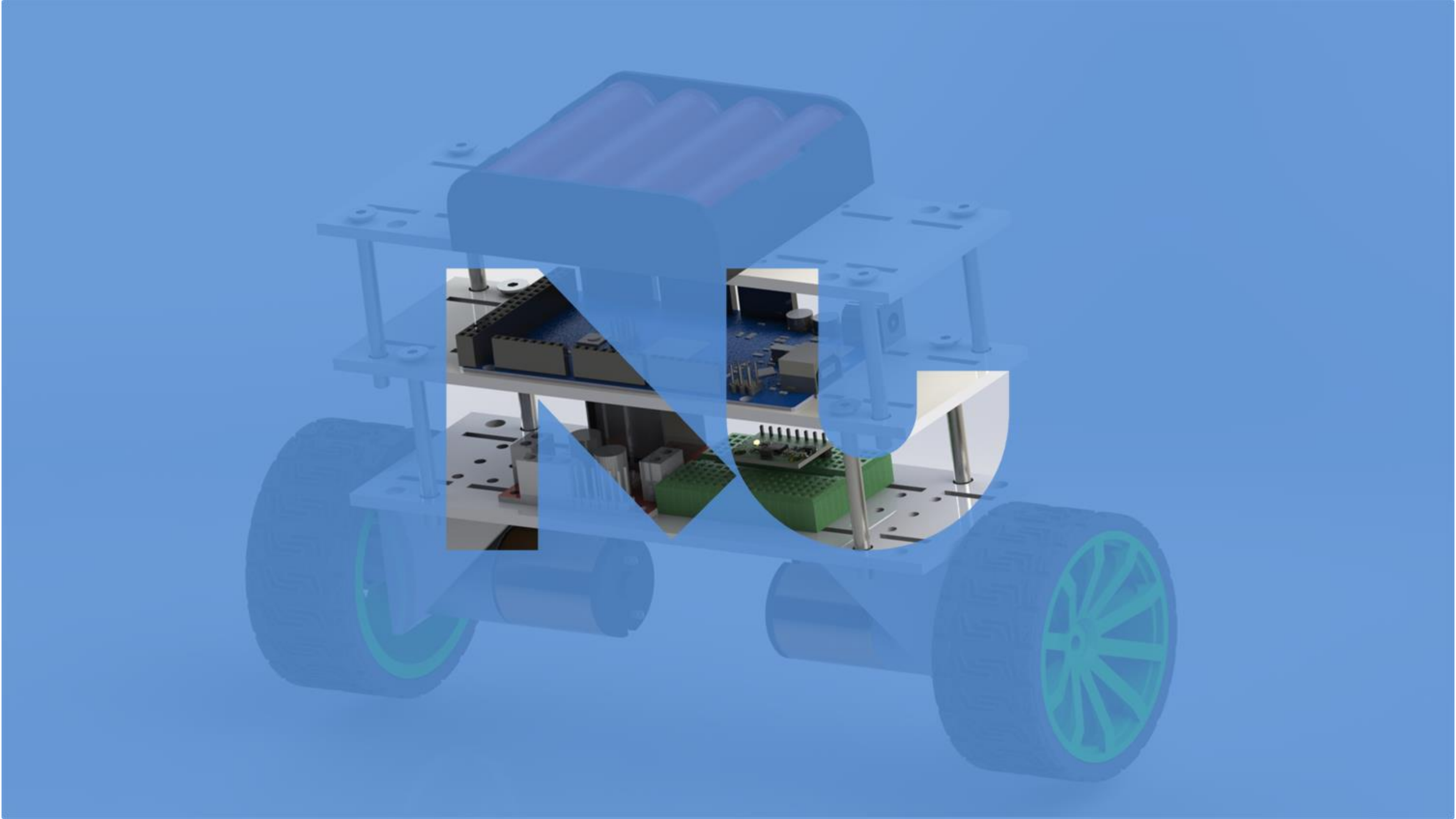
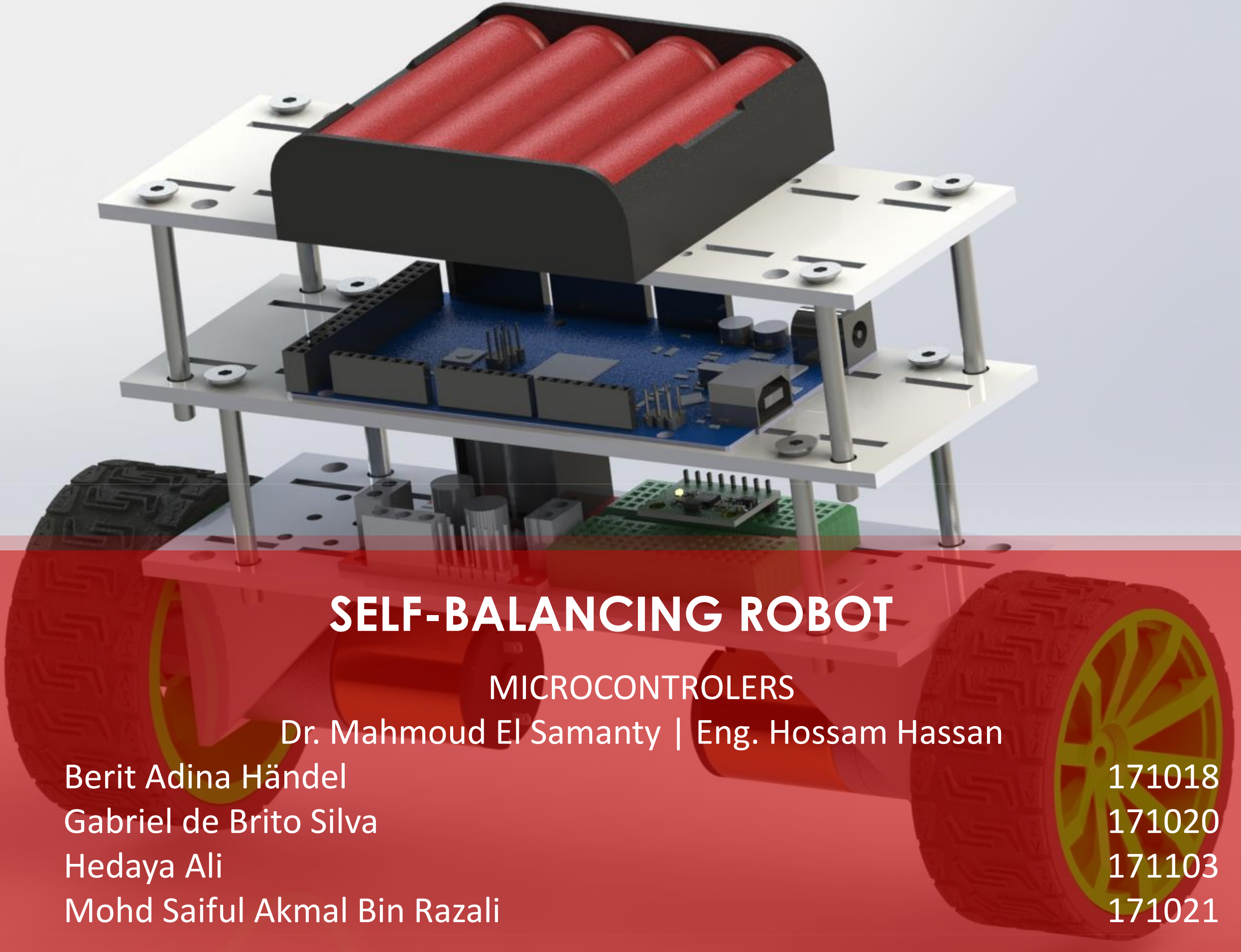
NU





SELF-BALANCING ROBOT

MICROCONTROLERS

Dr. Mahmoud El Samanty | Eng. Hossam Hassan

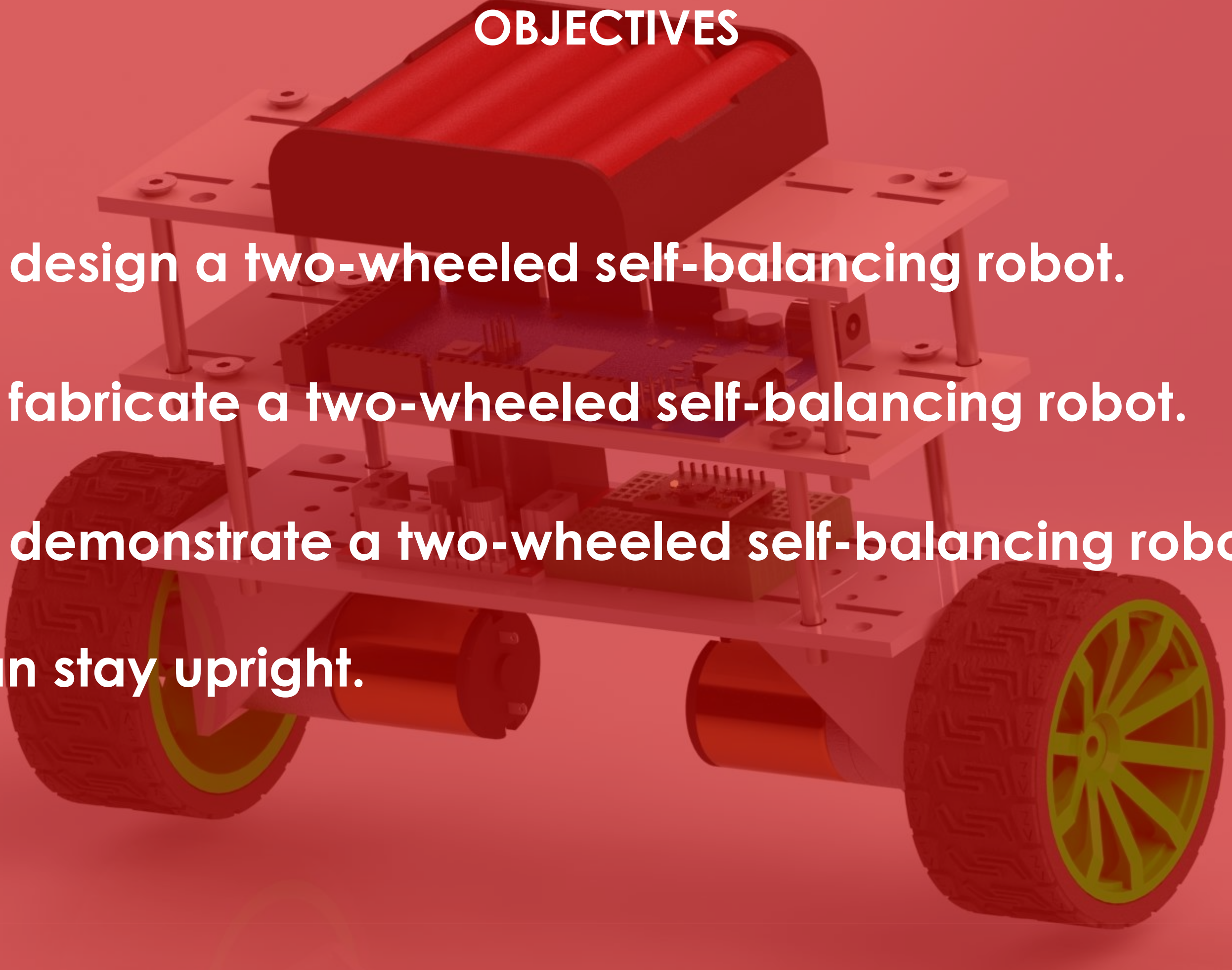
Berit Adina Händel 171018

Gabriel de Brito Silva 171020

Hedaya Ali 171103

Mohd Saiful Akmal Bin Razali 171021

OBJECTIVES



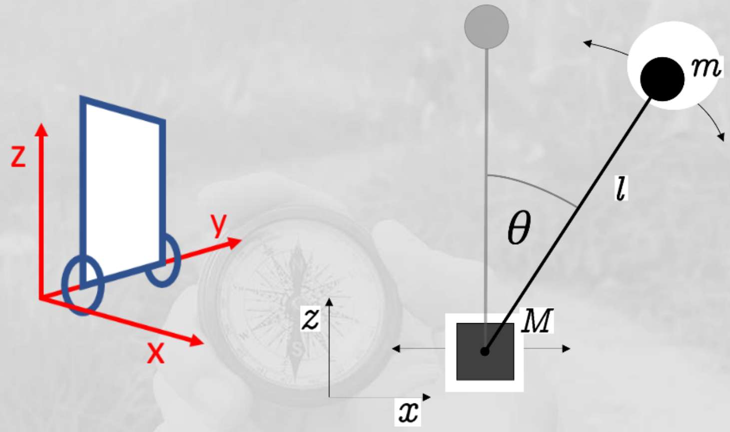
- To design a two-wheeled self-balancing robot.
- To fabricate a two-wheeled self-balancing robot.
- To demonstrate a two-wheeled self-balancing robot that can stay upright.

INVERTED PENDULUM

THEORETICAL ANALYSIS

we assume that the robot is mainly unstable in rotation around the wheel axis. Therefore, the model becomes 2-diminsional (z- and x-axis) and 2-DOF (position on x-axis and inclination angle).

The pendulum consists of a mass, which is connected to the base's mass. The pendulum can freely rotate around the joint point and the base's mass can be move along the x-axis



INVERTED PENDULUM

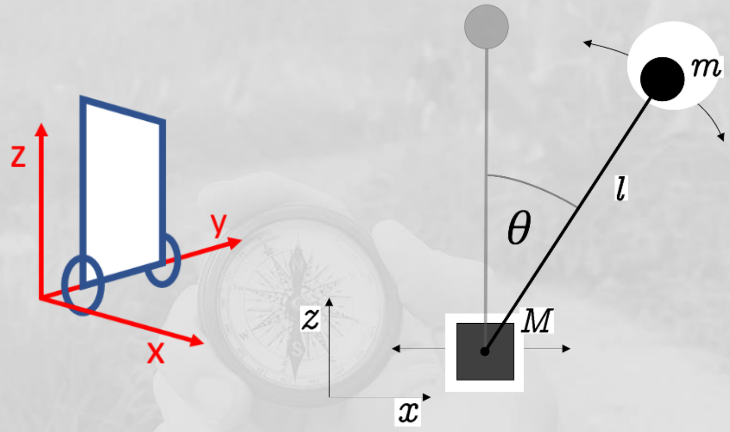
THEORETICAL ANALYSIS

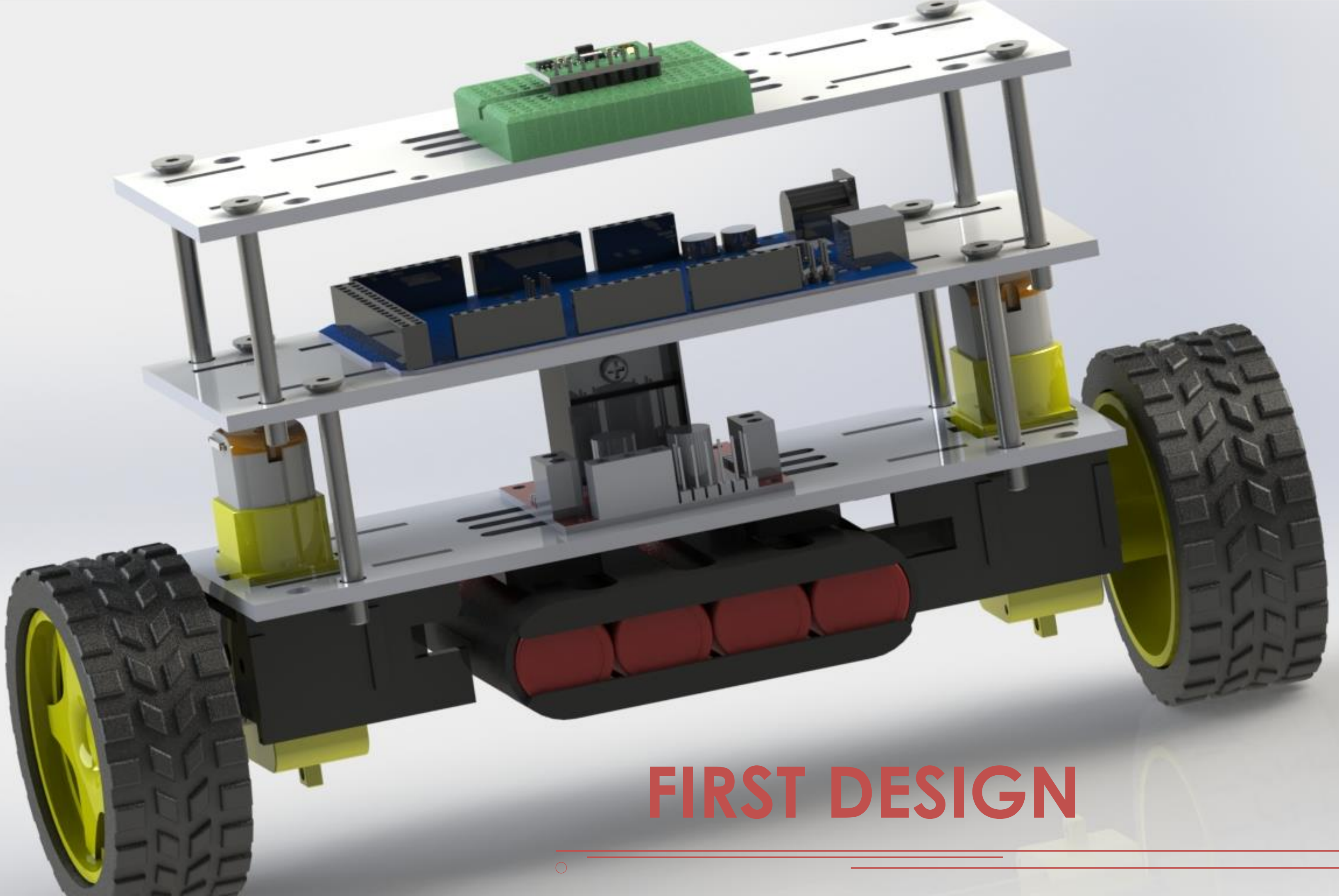
$$L = T + V$$

$$= \underbrace{\frac{1}{2} M \dot{x}_M^2}_{\text{kin. energy of mass M}} + \underbrace{\frac{1}{2} m \left(\dot{x}_m^2 + \dot{z}_m^2\right)}_{\text{kin. energy of mass m}} + \underbrace{\frac{1}{2} J \dot{\theta}^2}_{\text{rot. energy of mass m}} \underbrace{- m g z_m}_{\text{pot. energy of mass m}}$$

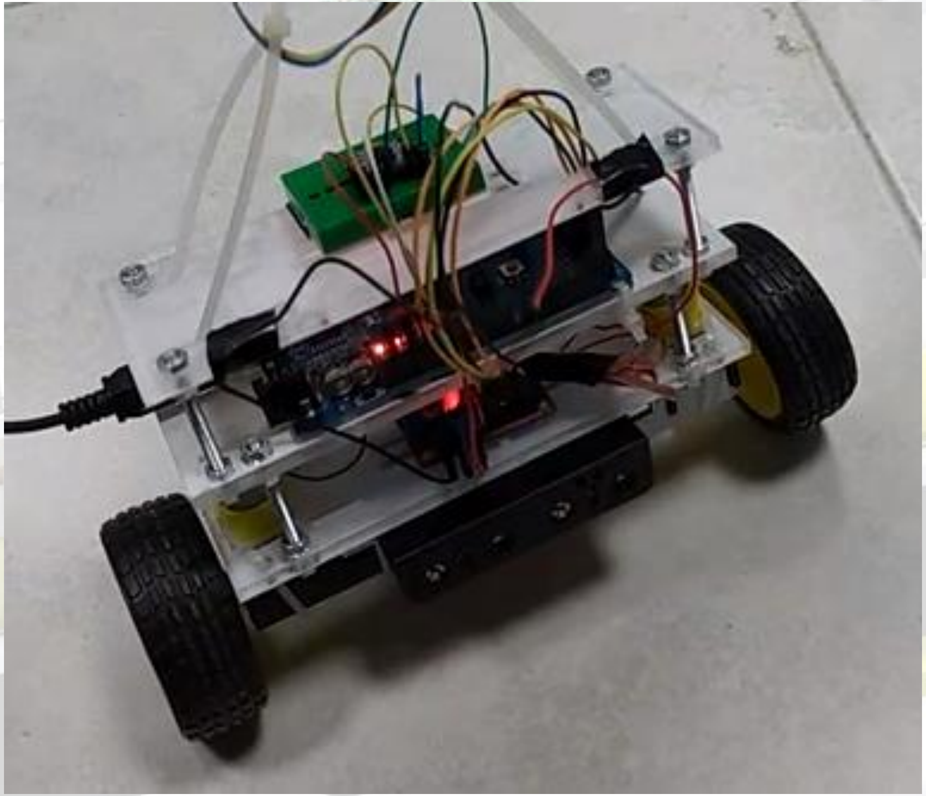
$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) - \frac{\partial L}{\partial \theta} = \underbrace{-\beta \dot{\theta}}_{\text{damping of the pendulum}}$$

$$\ddot{\theta} = \frac{1}{2\,l}\left(-\frac{\beta}{m\,l}\,\dot{\theta} + g \sin(\theta) - \cos(\theta)\,\ddot{x}\right)$$

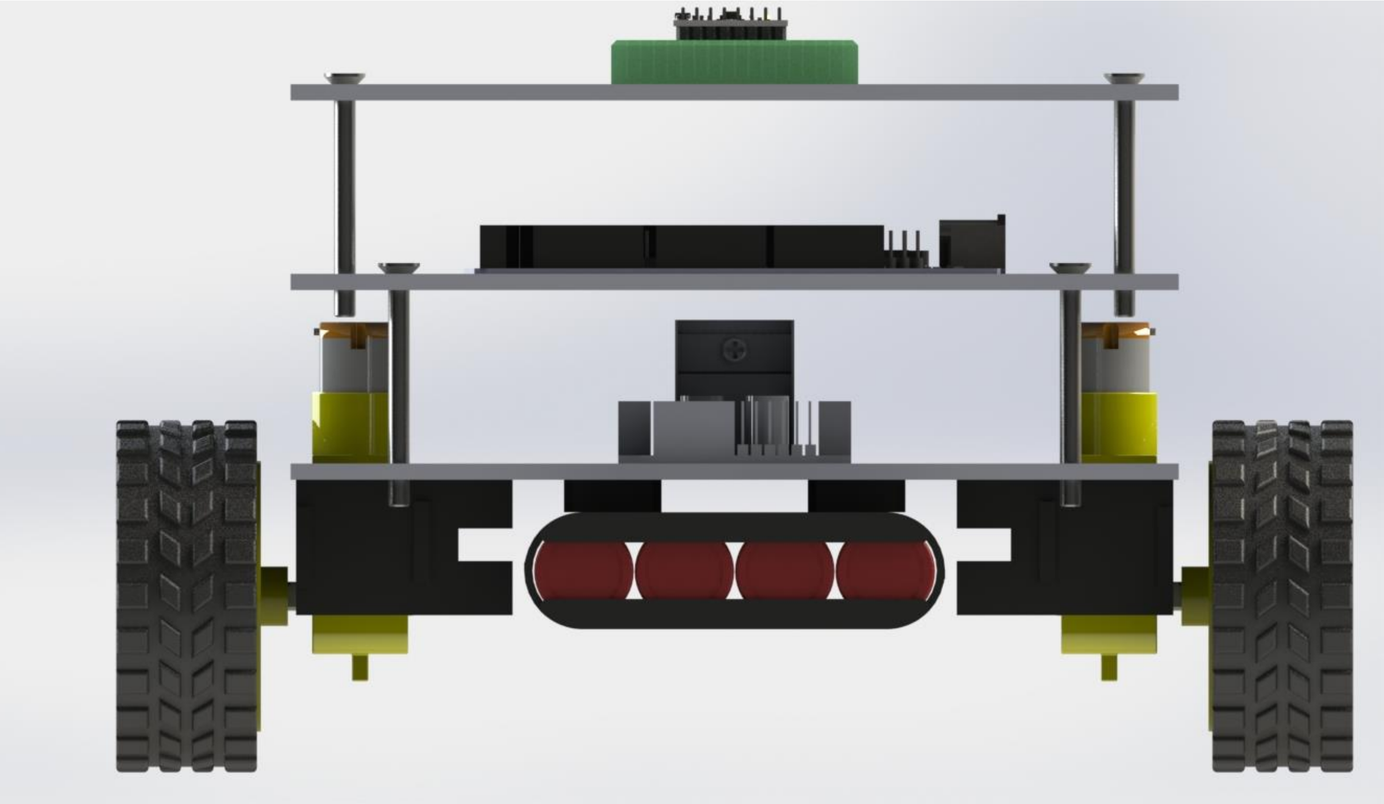


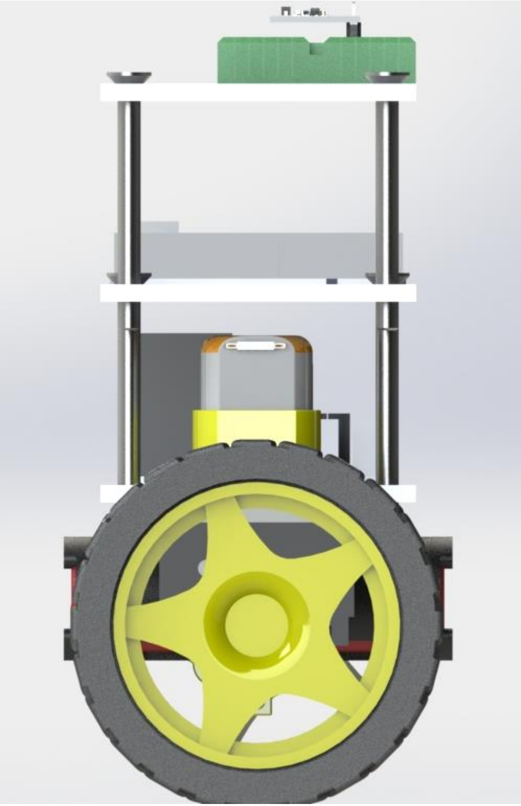


FIRST DESIGN

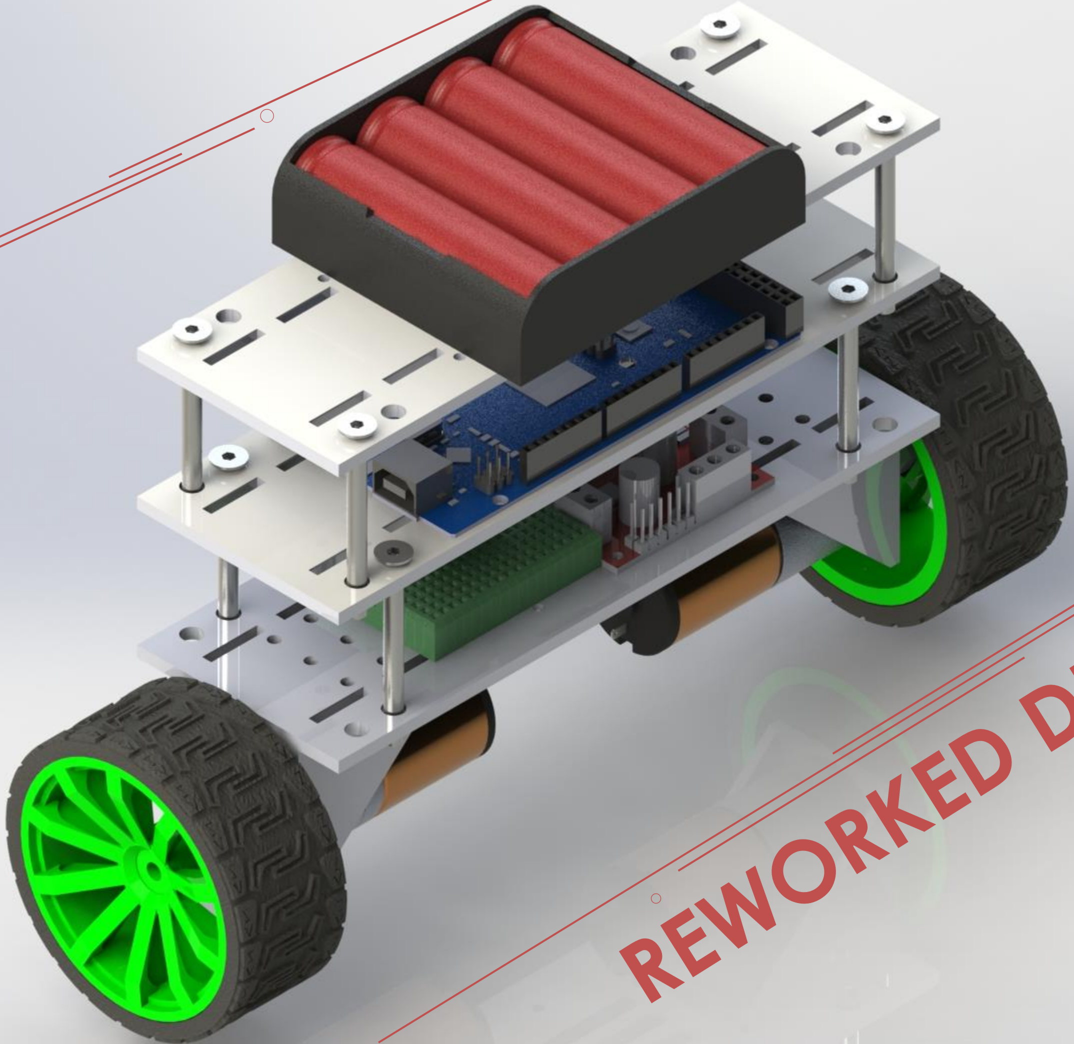


FIRST DESIGN



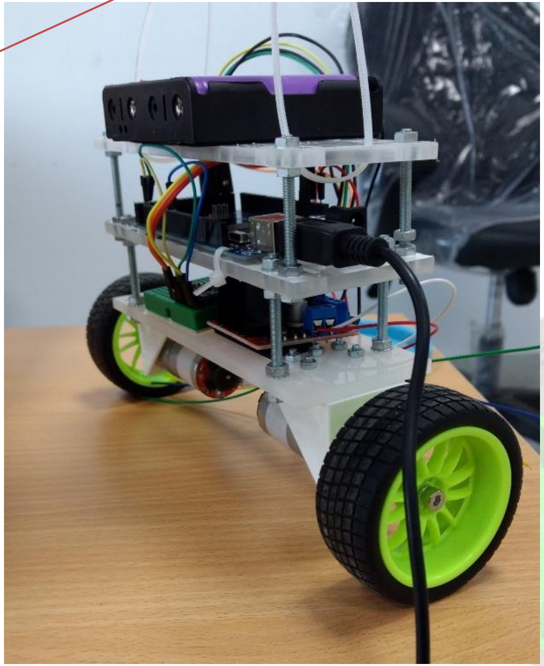


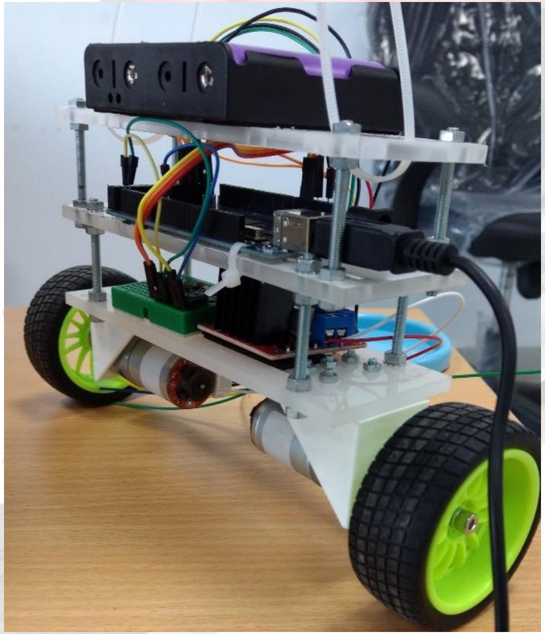
- The battery is located at the below of the chassis of our self-balancing robot.
- However, we faced a difficulty whereby our self-balancing robot is not able to balance very well due to the center of mass is located below the pivot point which make our self-balance robot difficult to balance itself.
- Therefore, after some discussion we decided to change our design.

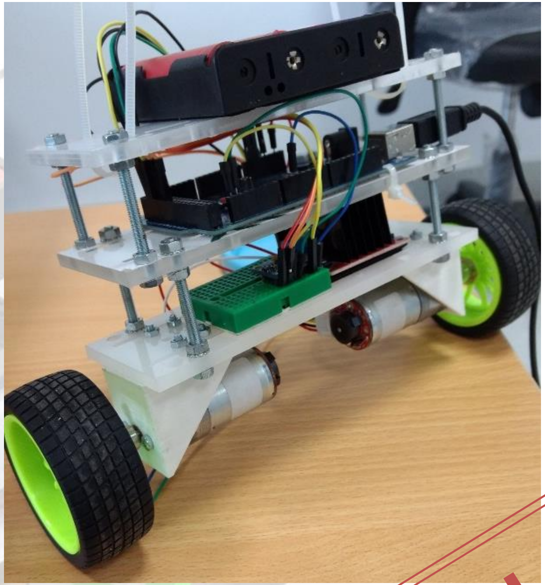


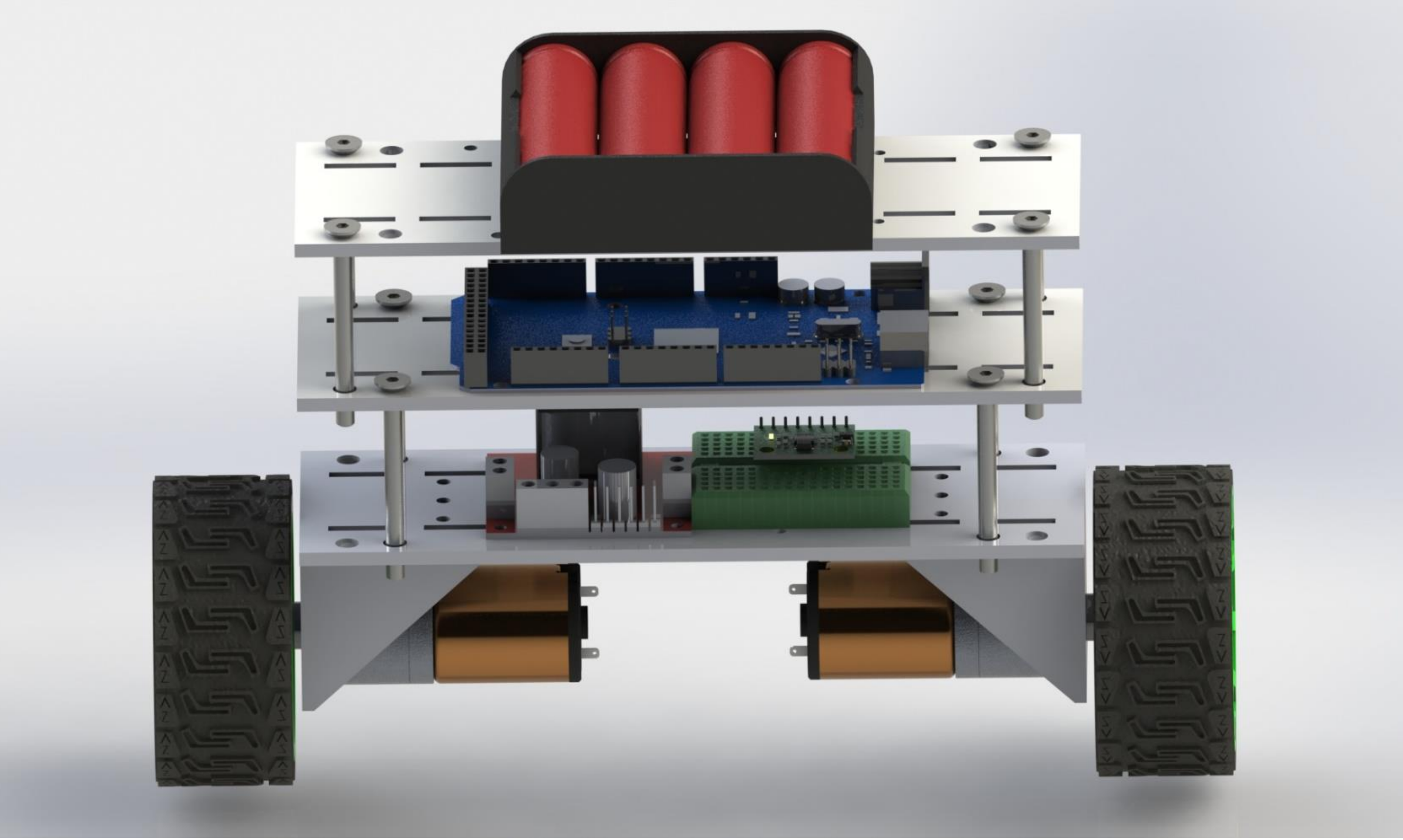
REWORKED DESIGN

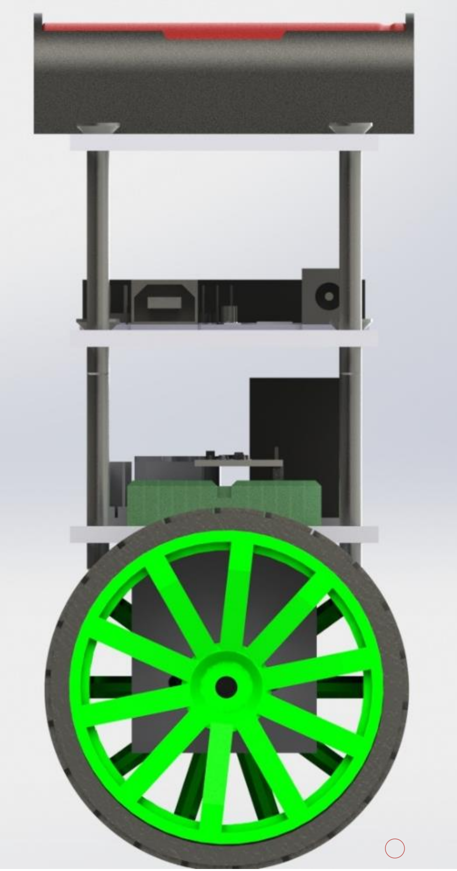
REWORKED DESIGN



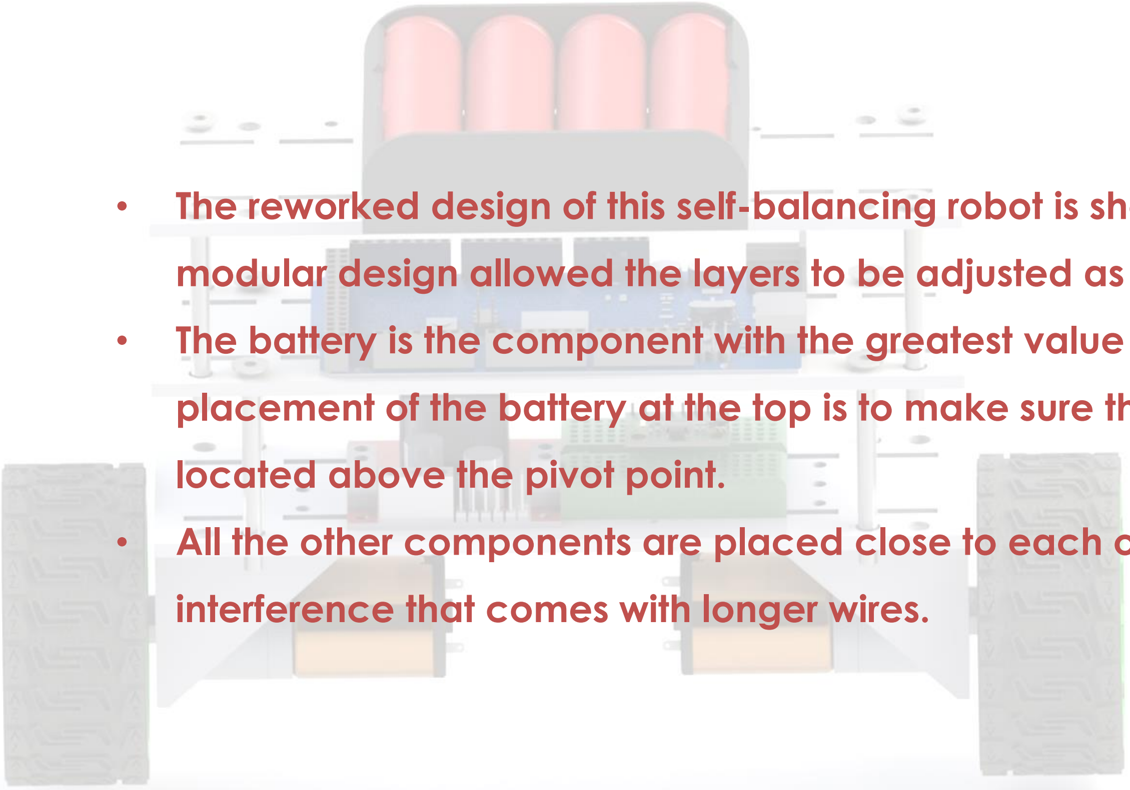




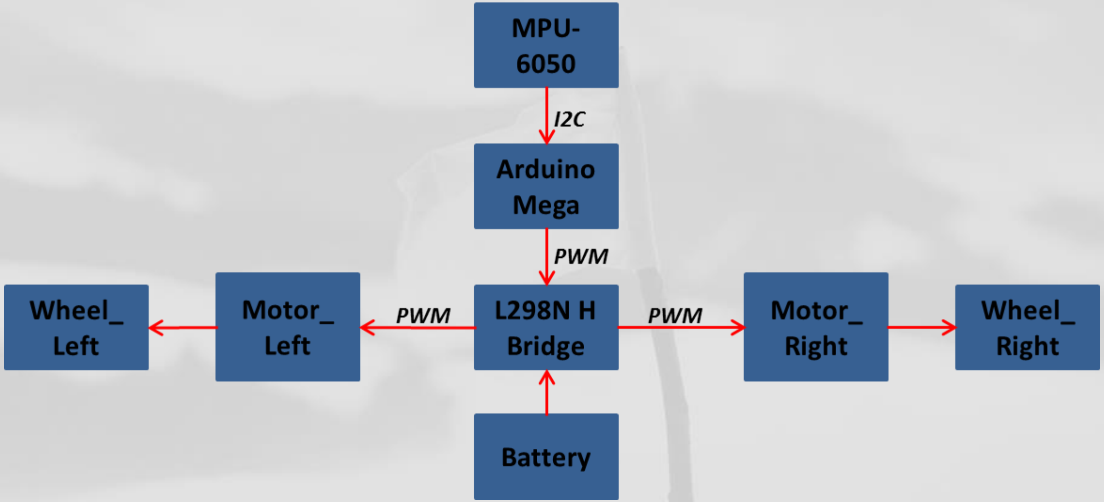




- The reworked design of this self-balancing robot is shown below. The modular design allowed the layers to be adjusted as needed.
- The battery is the component with the greatest value of density. The placement of the battery at the top is to make sure that the centre of mass is located above the pivot point.
- All the other components are placed close to each other to avoid interference that comes with longer wires.



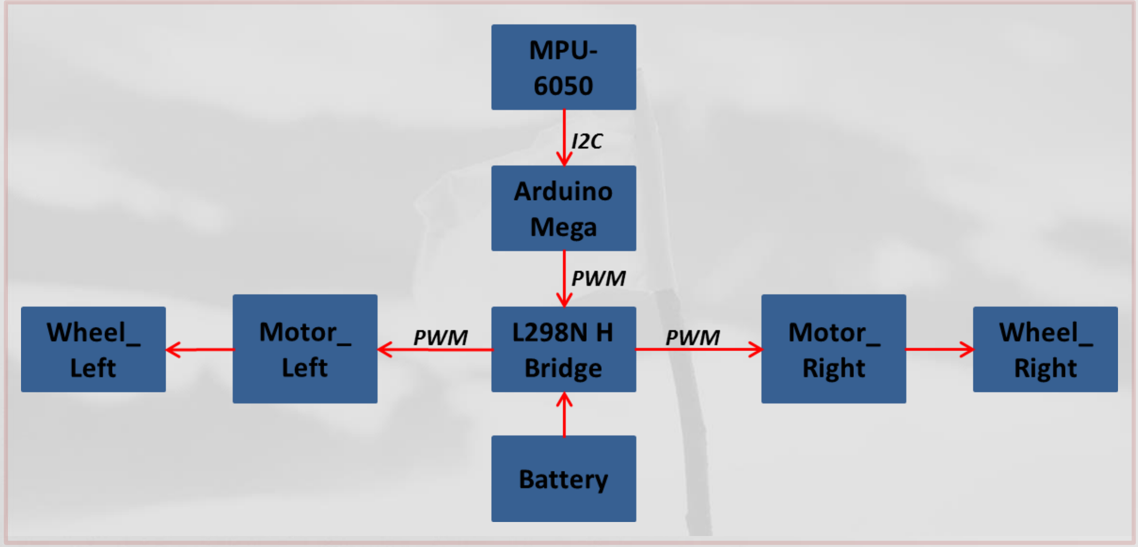
COMPONENTS AND CONNECTIONS



COMPONENTS AND CONNECTIONS

- Arduino Mega will read a raw data from the measurement sub-system which in this case is MPU-6050.

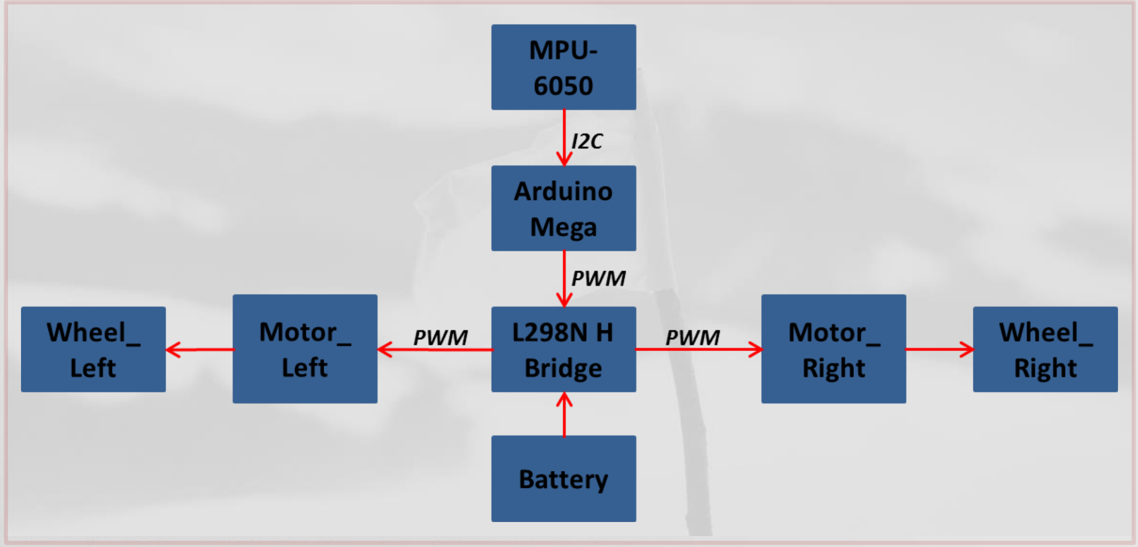
- Arduino Mega reads raw data from the measurement sub-system and sends PWM signals to the motor driver to be converted to mechanical motion.



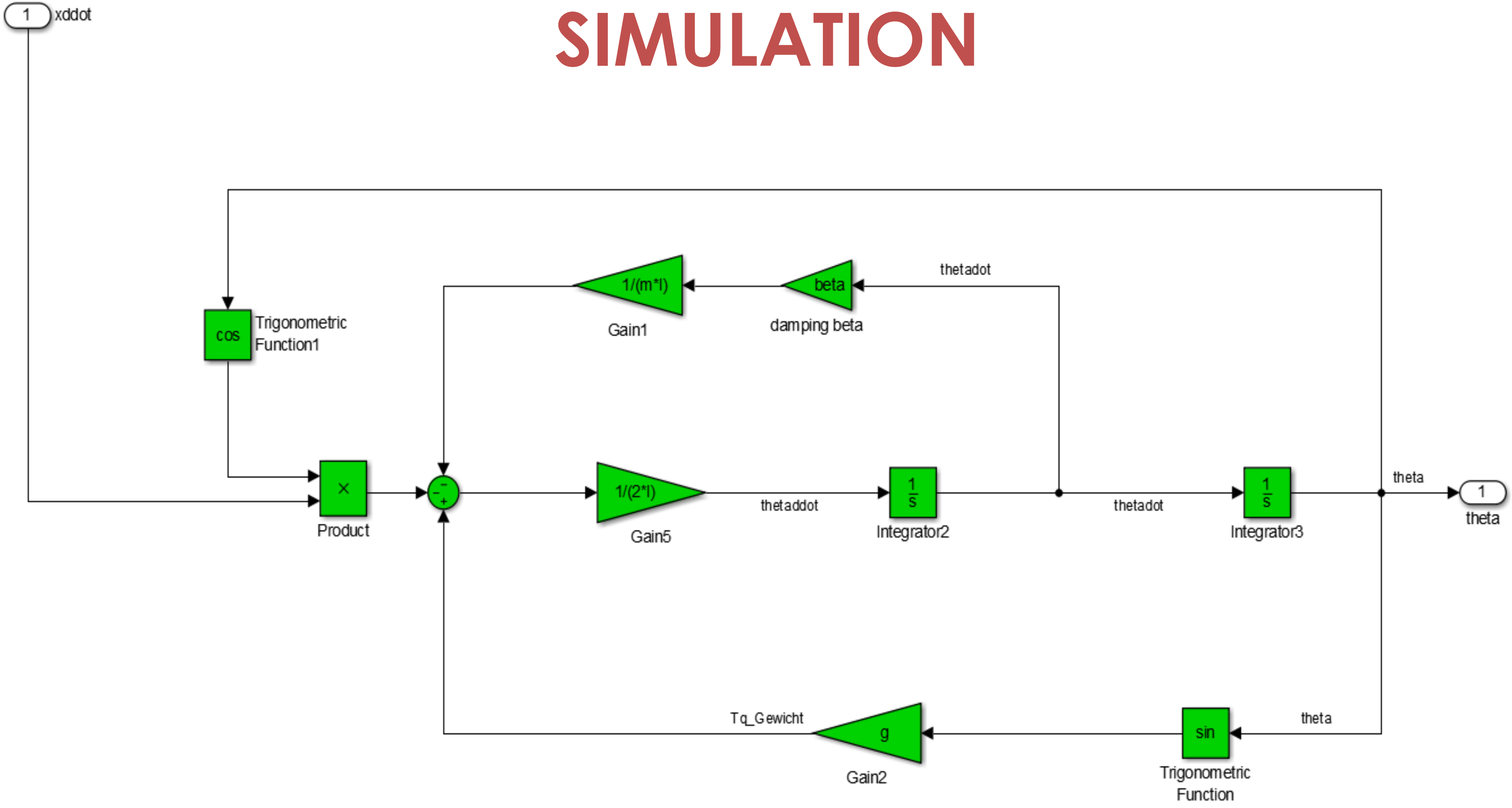
COMPONENTS AND CONNECTIONS

- When fresh IMU data is received, the MPU-6050 filters out sensor noise, and then fuse the data from the two sensors together to produce a single reading of tilt.

- Once the current tilt is known, the MPU-6050 calculates the error from the desired tilt, in this case the vertical, and then uses PID to control the PWM output to the motor driver sub-system.



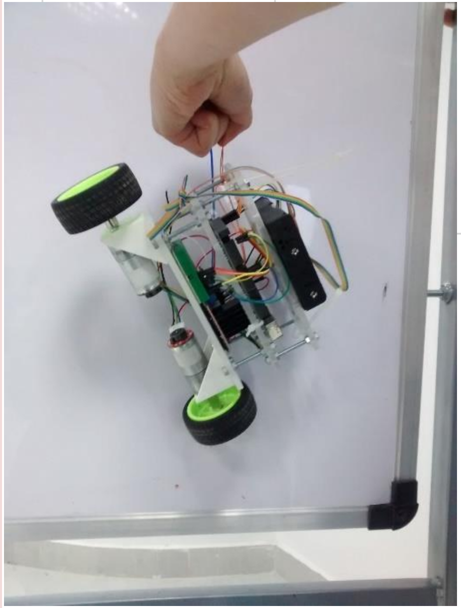
SIMULATION

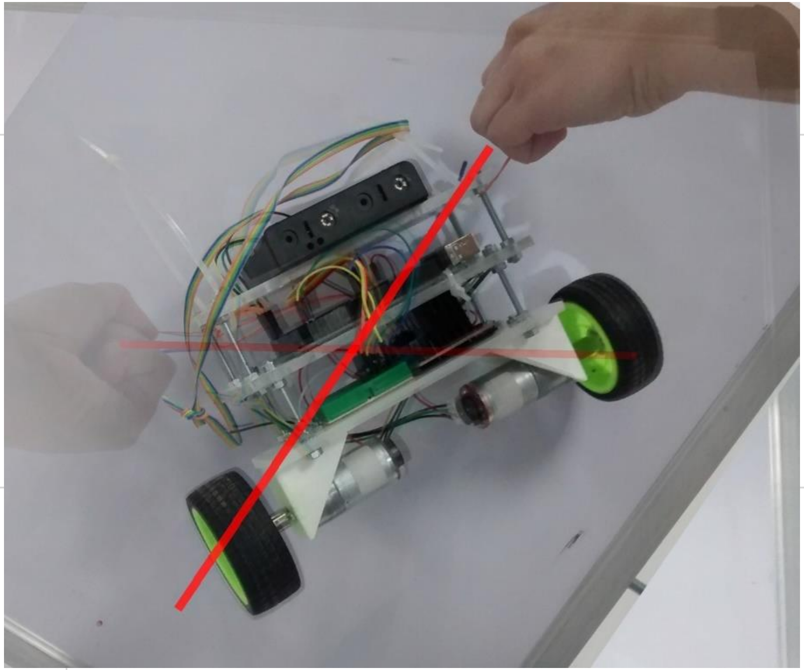


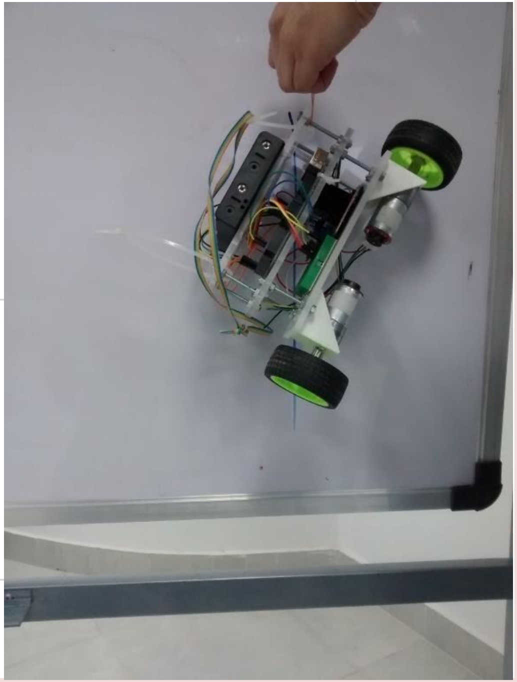
1
xddot
cos
Trigonometric Function1
Product
1/(m*l)
Gain1
beta
damping beta
thetadot
1/(2*l)
Gain5
thetaddot
1
s
Integrator2
thetadot
1
s
Integrator3
theta
1
theta
Tq_Gewicht
g
Gain2
sin
Trigonometric Function
theta

SIMULATION

1 xddot







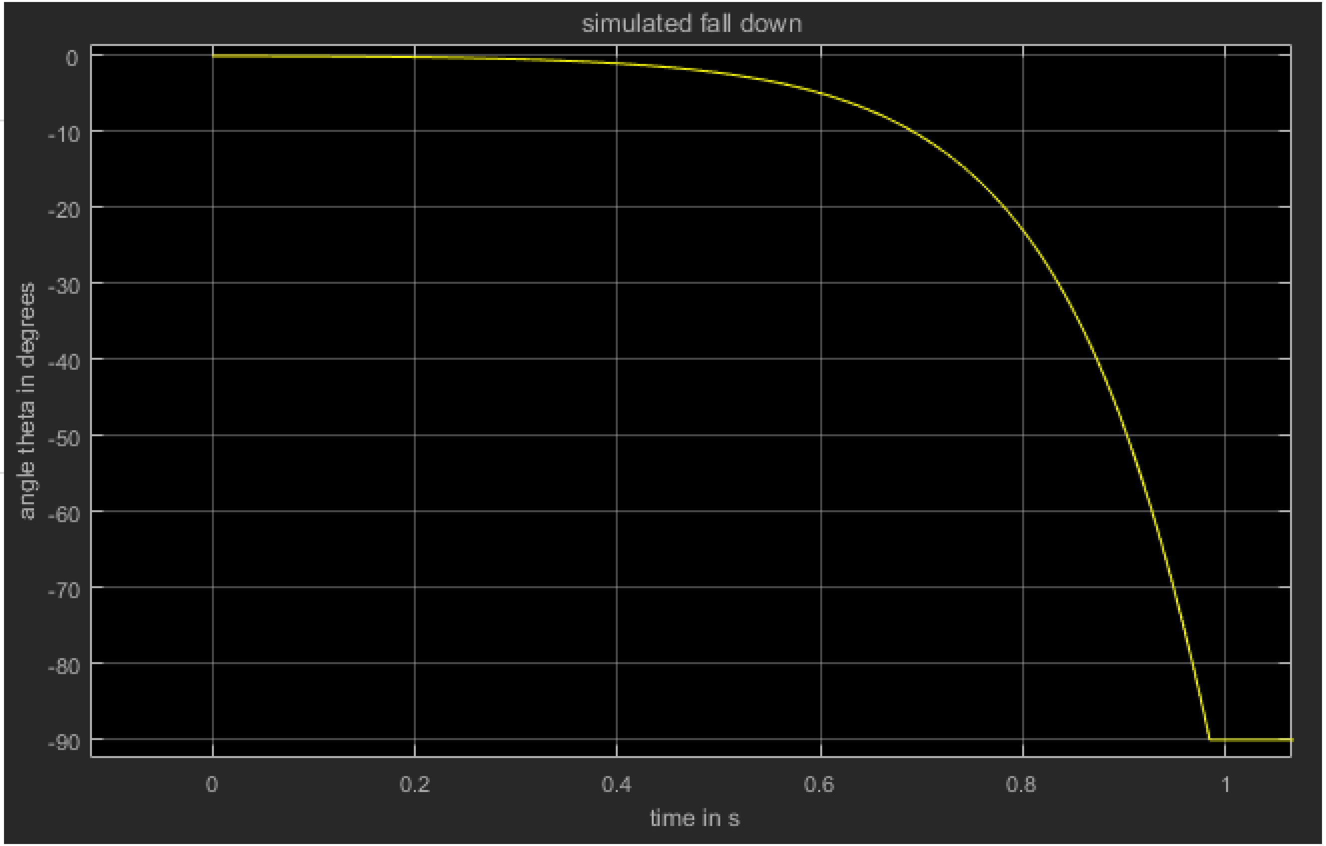
Tq_Gewicht

g

Gain2

SIMULATION

Name	Value
beta	1.0000e-03
f_sampling	30
g	9.8067
l	0.0825
m	0.7840
r	0.0325
tout	*1000x1 double*



DEMONSTRATION

THANK YOU

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Fall/2017