250 Watt Gearbox

Coursework

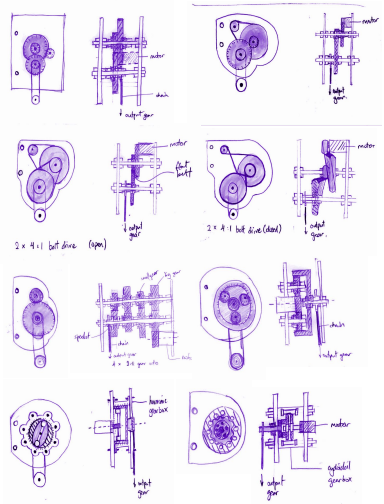
Introduction

The aim of this project was to **adapt a bicycle** such that an electric motor **provides assistance** whilst pedalling.

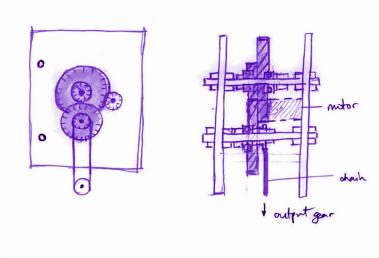
- The brushless DC motor will be controlled by an **Arduino**.
- Tested by measuring the **distance travelled in 30 seconds**.
- It must comply with **UK regulations.**

Double Diamond Decision Process

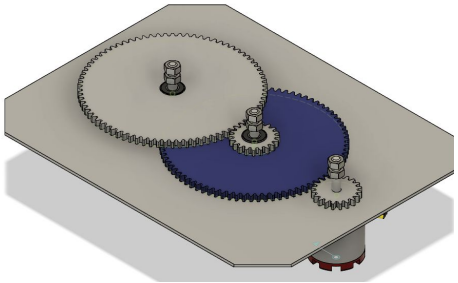
Discover



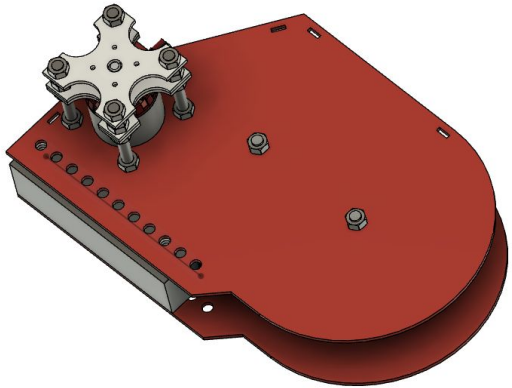
Define



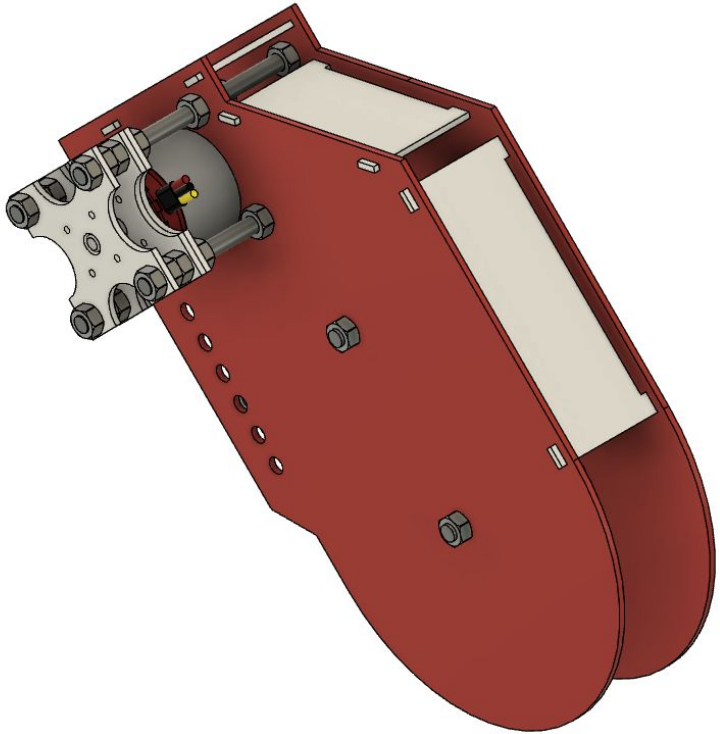
Develop

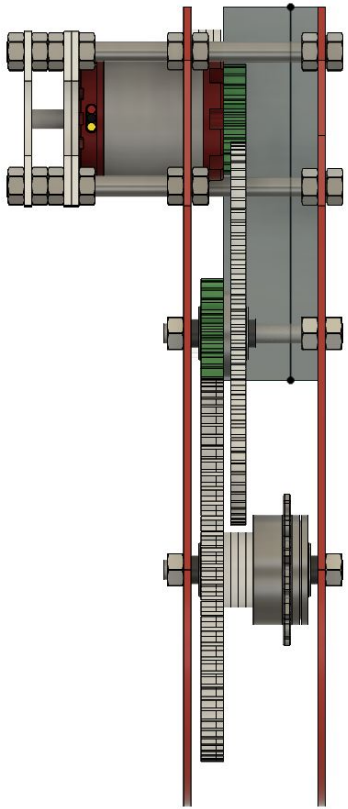


Deliver

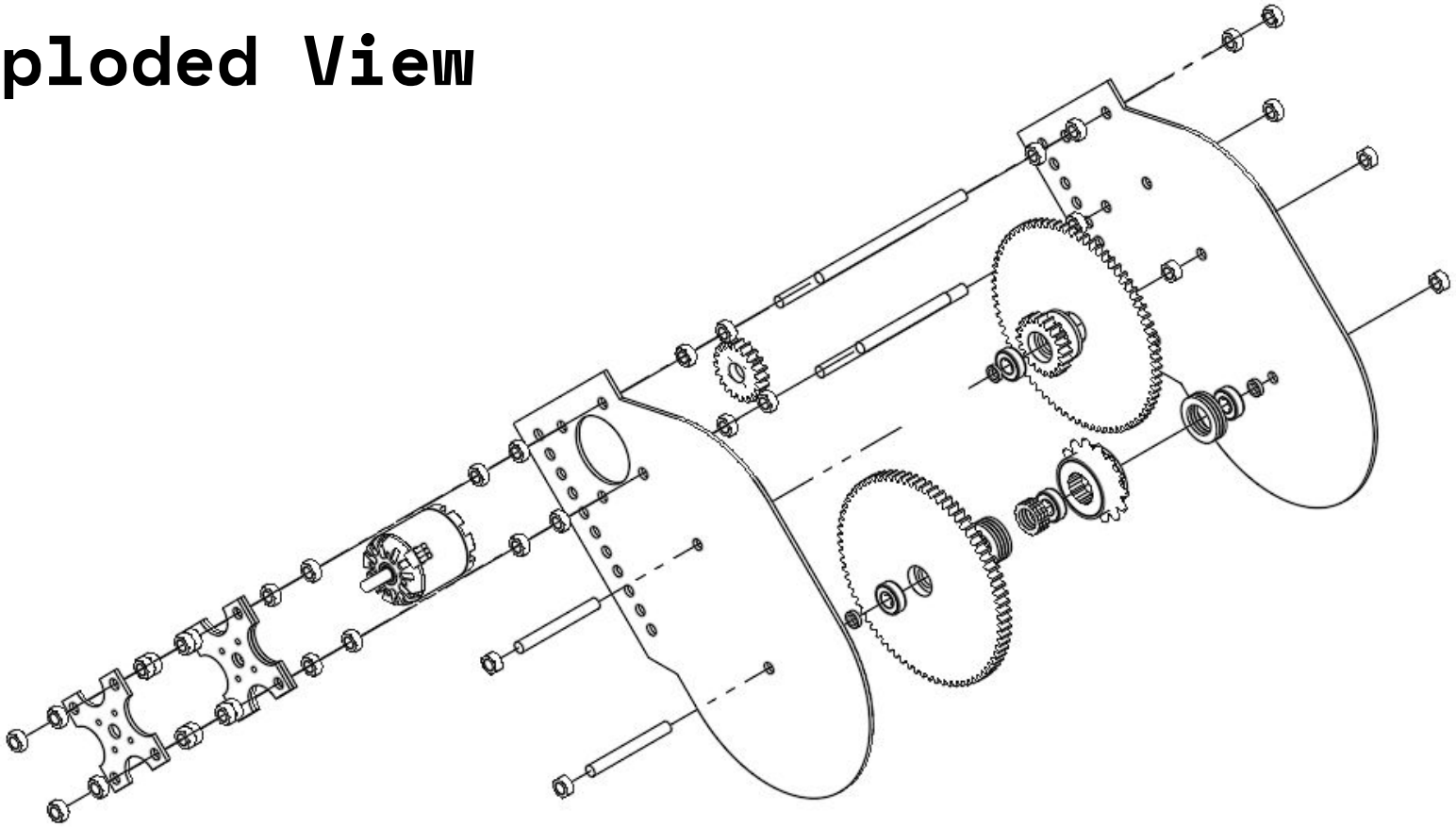


Final Design

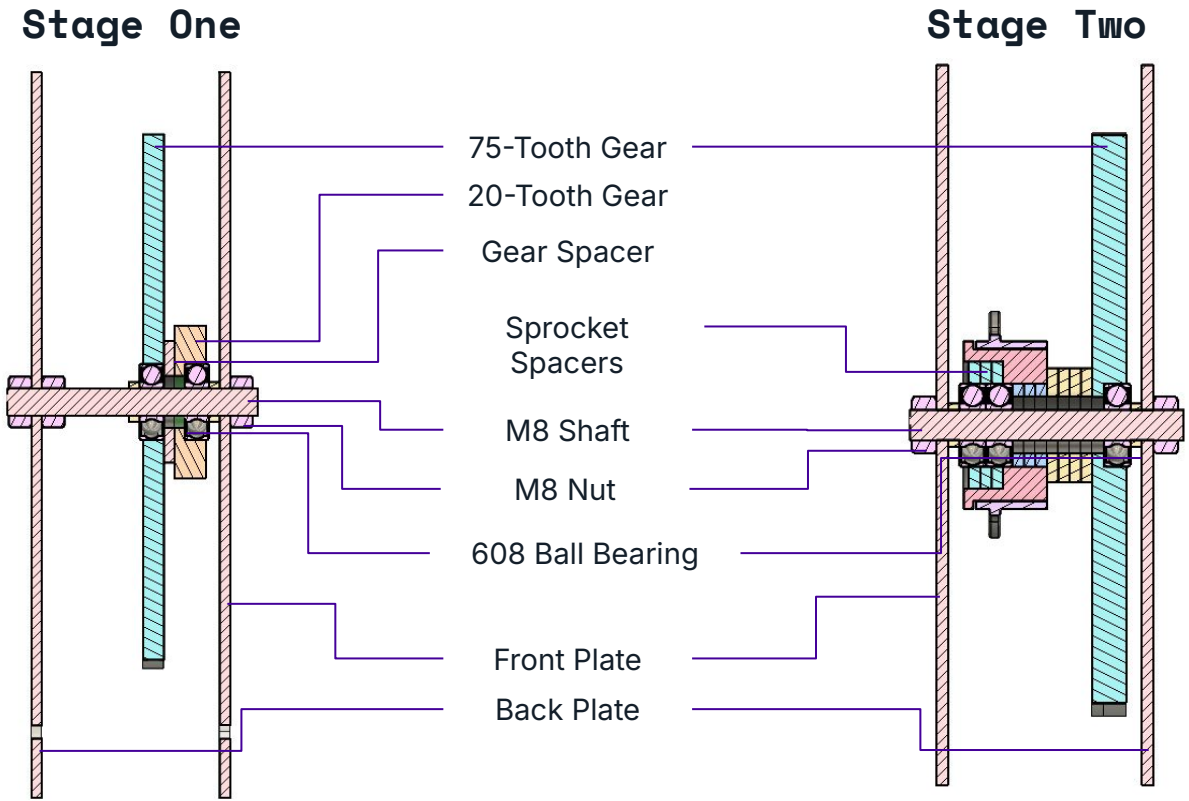




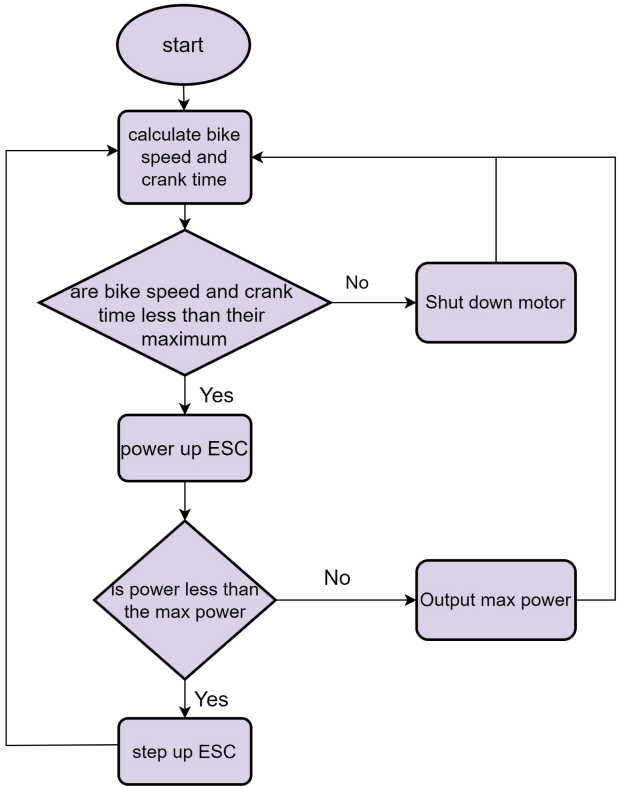
Exploded View



Cross-Section View

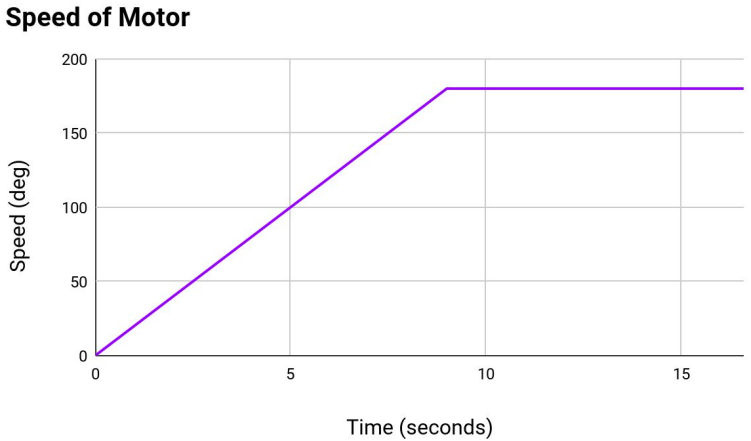


Code

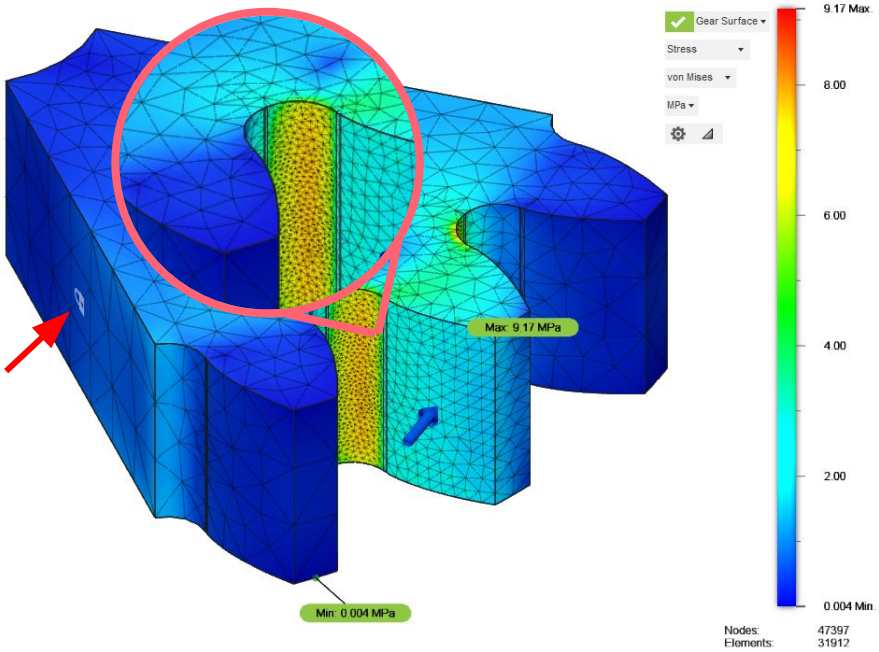


Modifications were made to the source code to **improve accuracy** and optimise **power output**.

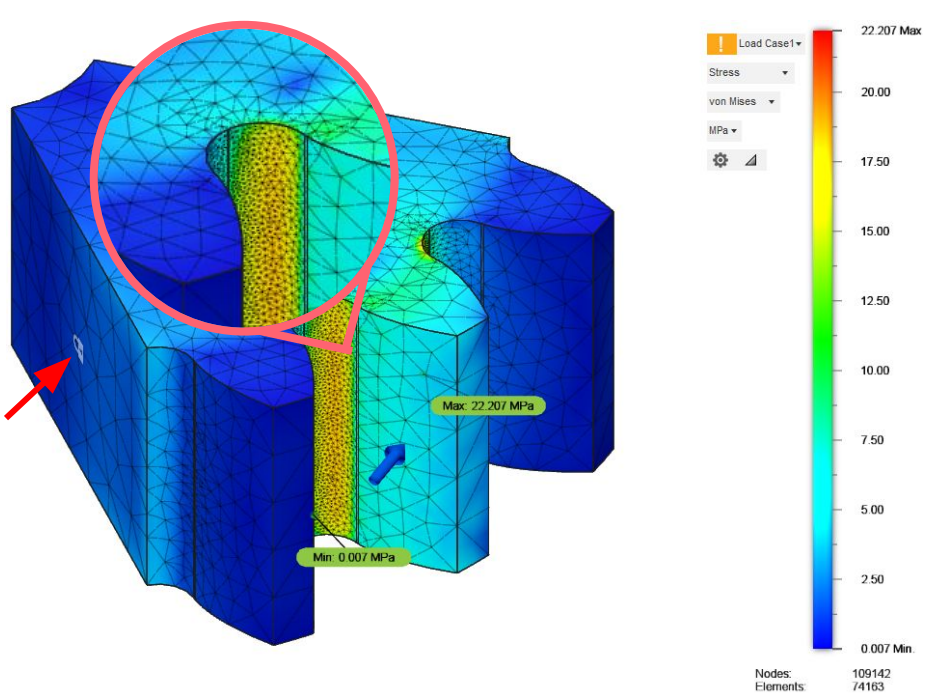
- Maximum power increased to 180°
- Initial power set to 0°



Analysis: Static Analysis FEA

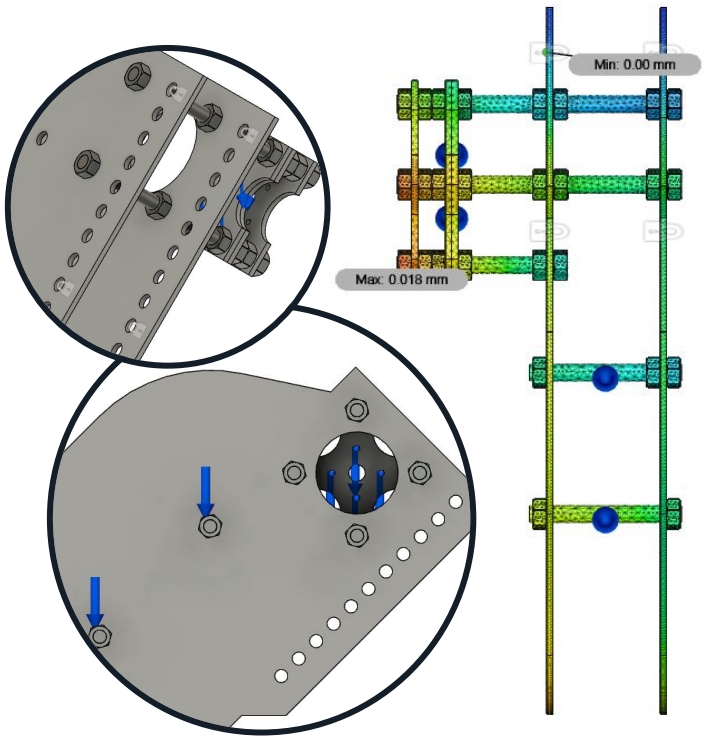


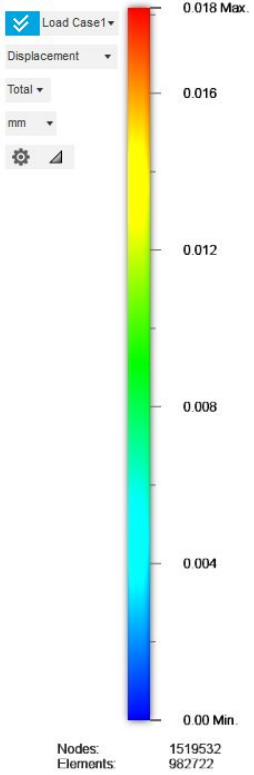
1st Stage



2nd Stage

Analysis: Static Analysis FEA





Loading Conditions

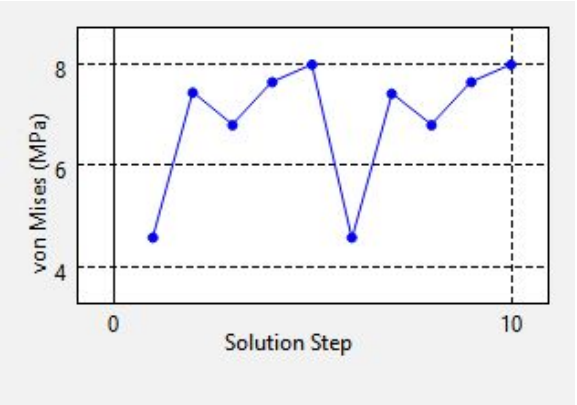
- 10N downwards on motor mount
- 5N downwards on 1st Stage
- 10N downwards on 2nd Stage

Mesh Quality

982,722 elements at 4% element size

Results

- 4.3% stress convergence rate
- Maximum displacement of 0.018mm



Analysis: Compiled FEA Results

SIMULATIONS						
Test Case	**Force Applied (N)**	**Module Size (mm)**	**Thickness (mm)**	**Fillet Radius (mm)**	**Max Stress (MPa)**	**Safety Factor**
No Reduction	35.37	2	6	1.15	9.2	5.9
No Reduction, at edge	35.37	2	6	1.15	16.4	3.3
1:3.75 Reduction	132.63	2	6	0	52.5	1.0
1:3.75 Reduction	132.63	2	6	1.15	34.4	1.6
1:3.75 Reduction	132.63	2.2	6	1.29	30.9	1.7
1:3.2 Reduction	113.18	2	6	1.15	29.2	1.8
1:3.75 Reduction	132.63	2	9	1.15	22.5	2.4
1:3.75 Reduction	132.63	2	9	1.18	22.2	2.4
1:3.75 Reduction, at edge	132.63	2	9	1.18	40.0	1.3

Appendix | FMEA Page 1

Failure Modes and Effects Analysis							
Component	**Function**	**Failure Mode**	**Effect**	**Likelihood**	**Severity**	**Criticality**	**Action**
Gear shaft (M8 threaded bar)	Mounts the gears	Shaft fails due to bending stresses	Gears and metal shaft ejected and no torque would be transmitted.	1	4	4	No action taken as the stresses on the bars were far less than the yield stress
First stage gears	Provides first torque transmission	Gear teeth break off due to stresses	Gear teeth ejected and no torque transmitted.	2	3	6	FEA was conducted on the gear teeth and a suitable safety factor was applied resulting in a minimum thickness of 9mm
Second stage gears	Provides first torque transmission	Gear teeth break off due to stresses	Gear teeth ejected and no torque transmitted.	2	3	6	FEA was conducted on the gear teeth and a suitable safety factor was applied resulting in a minimum thickness of 9mm
Brushless DC PM motor	Provides the torque for the system	Wiring entrapment in the gear system	Stop the gear system from moving and/or break the wire insulation	2	3	6	The motor housing is designed so the wiring is kept well away from any moving components
Brushless DC PM motor	Provides the torque for the system	Motor becomes disconnected from the first gear	No torque supplied to the gear system	1	3	3	The motor and gear are joined by 4 M2 screws which should easily withstand the torque transmitted

Appendix | FMEA Page 2

Failure Modes and Effects Analysis							
Component	**Function**	**Failure Mode**	**Effect**	**Likelihood**	**Severity**	**Criticality**	**Action**
Gear housing	Protects moving gears and mounts the system onto the bike.	Bending stresses on the backboard are too high leads to backboard breaking	Gear shafts will break off	2	3	6	FEA was conducted on the housing and was found to not break under the applied stresses
Arduino control system	Controls the speed of the motor.	Motor doesn’t shut off after the bike reaches 15mph	The bike would break regulations and be illegal.	1	3	3	The code ensures the motor will shut off at this speed from hall effects sensors on the wheels
Arduino control system	Controls the speed of the motor.	Motor doesn’t shut off when the user stops pedalling	The bike would break regulations and be illegal.	1	3	3	The code ensures the motor will shut off if the bike hasn't been peddalled for 5 seconds from hall effects sensors on the wheels

Appendix | FMEA Page 3

Failure Modes and Effects Analysis							
Component	**Function**	**Failure Mode**	**Effect**	**Likelihood**	**Severity**	**Criticality**	**Action**
Motor housing	Keeps the motor in place	Motor housing doesn't hold the motor in place	Causes vibrations within the system	2	3	6	The motor housing is connected by 4 screws and 4 M8 bolts to ensure an interference fit
Fasteners	Holds components in place	Nuts come loose and fall off.	Moving parts become exposed. Nuts and other components ejected.	1	3	3	No action was taken as the system is only required to operate for 30 seconds
Adhesive	Joins layers of the gears	Adhesive fails (comes unstuck)	Thickness of the gears would be reduced making them more suseptible to breaking	1	3	3	The adhesive will be cyanoacrylate

Contributors

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Note: This deck is an edited variant of the original presentation. Changes were made for visual clarity and relevance.