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EML4551-2

Team 509: Floating Shock Absorber for Gate Control

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Abstract

The abstract is a concise statement of the significant contents of your project. The abstract should be one paragraph of between 150 and 500 words. The abstract is not indents.

Keywords: list 3 to 5 keywords that describe your project.

Disclaimer

Your sponsor may require a disclaimer on the report. Especially if it is a government sponsored project or confidential project. If a disclaimer is not required delete this section.

Acknowledgement

These remarks thanks those that helped you complete your senior design project. Especially those who have sponsored the project, provided mentorship advice, and materials. 4

- Paragraph 1 thank sponsor!
- Paragraph 2 thank advisors.
- Paragraph 3 thank those that provided you materials and resources.
- Paragraph 4 thank anyone else who helped you.

Table of Contents

List of Tables

List of Figures

Notation

Chapter One: EML 4551C

1.1 Project Scope

Project Description

Over time, gates tend to sag and bounce when closing. This is because there is not usually gate support opposite of the hinges, and the weight of the gate puts all stress on the hinges so that over time there is a noticeable shift. Typically, bouncing is not wanted but mostly ignored. It has become a common factor in owning a swinging gate that it is not usually addressed. Gate sagging is usually fixed by readjusting hinges or the post where it attaches. Product developers have investigated ways to reduce these issues but have come up short to severely reducing bouncing and sagging. To try to reduce or eliminate these issues, the gate lock and process of closing a gate must be designed to accommodate for factors that cause them.

Key Goals

One goal of this project is to have a gate locking system that compensates for the sagging of longer gates. As stated by Ghost Controls, longer gates sag at the end opposite the hinges which results in alignment issues of the lock and receiver of the gate locking system. Another goal of this project is to counteract the bouncing of the gate as it reaches the closed position. Also stated by Ghost Controls, as the gate closes and the lock and receiver of the gate locking system reach contact with one another, bouncing is experienced in this contact, and this causes a delay in the latching and locking of the gate. This gate latch/receiver system should also be designed to be commercially produced for the sale and distribution at a profitable scale.

Market

For our market we are targeting people or companies that we believe to be most likely to purchase a Ghost Controls lock. There are two different groups that will be targeted. Our primary market are customers with homes or gated communities who have gates and would like a dependable lock to feel safe and secure in their home. Large corporations like Walmart or farmers could also be seen as a primary market. They could also have gates that would need a lock like for their storage facilities or for locking up different animals so that they do not get out. The secondary market would be businesses who install gates for others. Ghost Controls sells gate locks to installers that have their own clients that require their services but want a Ghost Controls lock on their gate. Homeowners who do not really know exactly what they want hire outside sources to find the locks they would like. Another type of secondary market would be those who just show videos of how to install gates online. In the "Do It Yourself" category of videos, creators can use these gates to show how to install it in any sort of fashion.

Assumptions

Throughout the project there are assumptions that are made. With that being said, we can assume that the user will have knowledge of how to set up and operate a Ghost Controls gate opening system. Although it will be explained on how to set up and operate the gate system, a reasonable adult will have a basic understanding how to operate it. We can also assume that the user will physically be able to operate a Ghost Controls gate opening system remote controller. Another assumption that can be made is that there will be some form of power supply for the system to run on. The gate will be assumed to undergo the issues, bouncing and sagging, that have described previously. We will also assume that weather will be a negligible factor in the operation of the gate lock.

Stakeholders

Stakeholders are persons or entities that have an interest or investment in a project. The stakeholders for this project are Ghost Controls, Dr. Shayne McConomy, Dr. Jonathan Clark, and the FAMU-FSU College of Engineering.

Ghost Controls is the sponsor of this project and is contributing funding and facilities that will make this project possible. The outcome of this project will provide Ghost Controls with research, tested designs, and potentially a marketable product that could increase the performance of their gate systems and the satisfaction of their customers.

Dr. Shayne McConomy is the Senior Design Coordinator and is responsible for evaluating the project's progression, as well as guiding the team through the course of the project with deadlines and deliverables.

Dr. Jonathan Clark is the faculty advisor for this project and is available for consultation regarding the development of properly functioning prototypes, including the implementation of design ideas and engineering principles.

The success of this project is representative of the education received at the FAMU-FSU College of Engineering and its preparation of students to apply their education to engineering challenges.

1.2 Customer Needs

The following questions were asked and responses were given with a certain demographic of consumer in mind. This consumer is a person who has Ghost Controls gate systems installed on their gates. These consumers have trouble with their gate bouncing when attempting to close and deals with their gate sagging over time. These issues create a problem with gate systems over time. Therefore, understanding what these people struggle with will help to narrow down and guide our design process.

Questions:

What is the main problem you deal with your gate or gate system?

"Sometimes I notice that when the gate is closing, the lock will hit the latch and bounce off, not allowing the gate to latch."

Interpreted Need: Have the ability to reduce, if not eliminate, bouncing of the gate off the latch.

How do you normally deal with sagging or bouncing in your gate?

"For sagging, we usually have to adjust the latch or refix the post and for bouncing, we usually hand close the gate."

Interpreted Need: Have the ability to also eliminate the need for adjusting the gate or post due to sagging

How often do you open your gate per day? Per week?

"With my family, we usually have the gate opening around 6 times a day and around 30 times a week but when we have friends over, it is much more. "

Interpreted Need: Have the ability to align and prevent sagging regardless of how often the gate is operated.

How quickly did the gate begin to sag?

"In less than a week the gate has begun to sag."

Interpreted Need: A crucial point to focus on is how to omit sagging from the gate.

Do you find the current gate and system easy to maintain?

"The system is very manageable. However, there are moments due to sag that the gate and system do not function efficiently."

Interpreted Need: The system has the ability to function efficiently even with a little sag and bounce.

How much would you be willing to invest in improvement to the current problems with the system and gate?

"I feel that I would be willing to invest around $100 to improve the system."

Interpreted Need: Improvement to system and gate is less than installment of original system.

Are there any small annoyances with your gate system?

"The gate is loud when it is slammed closed. I worry that things might get loose or broken over time due to the violent slamming and shaking of the gate."

Interpreted need: Gate lock makes gentle and quiet contact with the receiver.

Is your gate ever used in unconventional circumstances?

"Sometimes my kids climb on and over it instead of opening it. I've even caught them riding it while its opening and closing."

Interpreted need: Gate locks even if the lock's vertical position changes.

What environment do you operate your gate in?

"I have one on my residential driveway and another on the dirt road leading to my hunting property."

Interpreted need: Ability to be used in rugged and residential environments where water, dirt, and foliage may be present.

Do you normally leave your gate in an open position or in a closed position?

"At night the gate is always closed but during the day it may stay open for hours at a time. It all depends on the day, but most of the time, the gate is closed."

Interpreted need: Gate lock has the ability to close the same whether the gate is normally in an open position or a closed position.

Are there any noticeable circumstances when the gate fails to close or lock properly?

"Sometimes if the gate was not closed during a storm the gate may have problems closing properly. It is mainly after the gate has been left open for a long time. Also when it hits something when closing, it doesn't often close right after that."

Interpreted need: Ability to close and lock after collision or strenuous force applied to the gate.

This information was gathered from the customer using an interview where the pointed questions were asked. The customer was assumed to represent a wide range of users due to his use of the Ghost Controls system on both his residential property and his hunting property. From the customer, many desires and needs that the customer expressed became prevalent. The customer emphasized the desire for the gate to lock under all circumstances. This includes the circumstances of environment, collisions with external objects, and internal movements (bouncing, sagging, etc.). The customer also expressed the desire for the gate to not be loud when closing and opening and for the price to not be significantly impacted for these improvements.

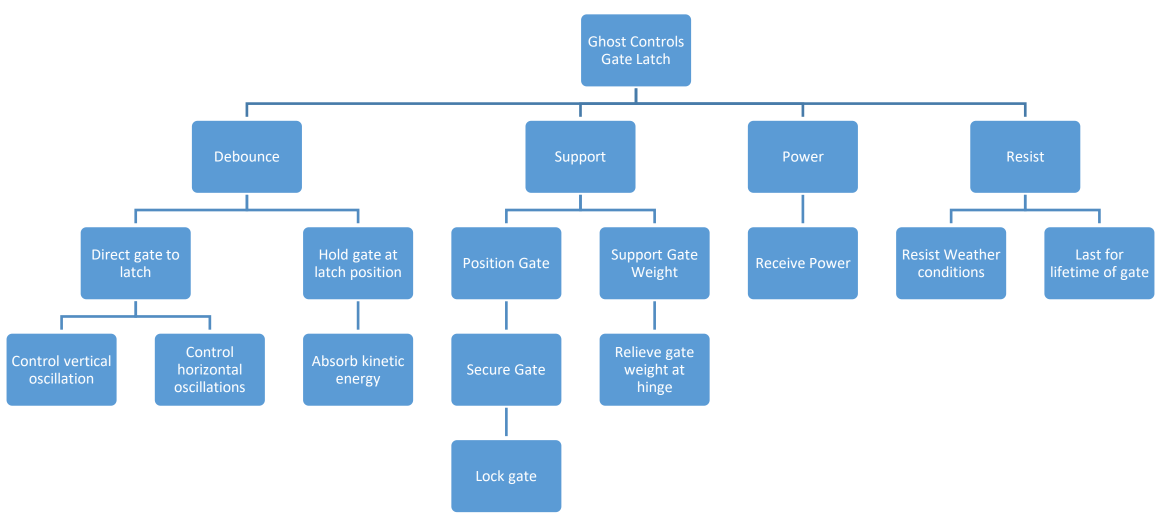
1.3 Functional Decomposition

Introduction

In the functional decomposition we dissected the whole system of our gate and divided those subsystems into smaller sections and examined them individually. By doing this were able to identify any function of the Ghost Lock and break it down to understand the individual tasks of the gate latch.

Function Generation

To develop the functions seen in Figure 1, we explored the tasks that the device needs to perform. These tasks were identified earlier in the customer needs, assumption, project description, and assumptions. Using these tasks, major and minor functions were identified that would produce the fully functioning and reliable gate latch system.



Hierarchy Chart Reasoning

In our hierarchy chart there are three systems that we decided were the main things to focus on for the Ghost Lock: *debounce*, *support*, *power*, and *resist*. *Debounce* focuses on the lock and gate not bouncing when they come together to secure the gate into place. *Support* applies to the gate not continuing to sag with the applied system incorporated into it. The system *power* deals with the amount of power we would require for the gate and lock system to function efficiently and not lead to bouncing or sag. *Resist* system will focus on what we need to do to make our system have longevity. We chose these as our systems to focus on the main purpose of this project: reduce or eliminate bouncing of the gate as it moves and locks and eliminate sag. By focusing on the systems *debouncing*, *support*, *power*, *and resist* we are able to dissect and make it clear how we should approach the issues.

The *debounce* system is divided into two subsystems: *direct gate to latch*, and *hold gate at latch position*. *Direct gate to latch* includes *control vertical oscillation* and *control horizontal oscillation*, so that the oscillations will not prevent the gate from aligning properly. *Hold gate at latch position* requires the system to *absorb kinetic energy* so that it does not bounce out of the latch.

The *support* system is divided into two subsystems: *position gate* and *support gate weight*. *Position gate* includes *secure gate* so that it can be positioned, and *secure gate* includes *lock gate*. Support gate weight includes *relieve gate weight at hinge.*

The *power* system has one subsystem: *receive power*. If the system will be powered it will need to receive an adequate amount of power.

The *resist* system has two subsystems: *resist weather conditions* and *last for lifetime of gate*. Both of these subsystems are required to accomplish the primary function.

Connection to Systems

The cross-reference chart, shown below, is used for comparing the functions of the gate lock as they relate to the larger systems. The rows marked with an "X" signify the larger system of the gate lock that the function has an influence on. Most of the functions have the prospect to have an influence on numerous larger systems. This can be seen, for example, in the case of the function *Lock Gate*. The function *Lock Gate* relates to the larger systems of *Support* (holding the gate up in the locked position, etc.), *Power* (power actuated locking mechanism, etc.), and *Resist* (hold up in weather, etc.). From the table, the system with the most functions affected is the *Support* system. This is fitting as the main problem to be solved by the locking mechanism is to support the gate by the control of bounce and sag. The other systems (*Debounce, Power, and Resist)* all comprise three functions of the overall system, which alongside *Support*, have a major impact on the success of the overall functionality of the gate lock system. The outcome of this project is to control the gate into the locking position regardless of sag, bounce, or environmental conditions; while it is necessary to *Debounce, Power, and Resist*, the main priority of the project in the design process is the support of the gate for the successful use of the locking mechanism.

System Functional Decomposition				
Function	Debounce	Support	Power	Resist
Control Vertical Oscillation	X	X		

Control Horizontal Oscillation	X	X		
Absorb Kinetic Energy	X		X	
Lock Gate		X	X	X
Relieve Gate Weight at Hinges		X		
Receive Power			X	
Resist Weather Conditions				X
Lasts for Lifetime of Gate				X

Integration

Within the functions of the Ghost Lock there is more than one function that is integrated into systems. Controlling the oscillation of both the horizontal and vertical direction are incorporated into the systems of *debounce* and *support*. By controlling the oscillation while the gate is in motion, we can have a steadier gate that as it reaches the lock to close bouncing will be less likely to occur, and this will lead to less chances of sag if we are able to have a steadier system hold the gate. The function of absorbing kinetic energy is integrated into the systems *debounce* and *power*. As the gate closes there is bouncing between the gate and lock. To remove this, absorbing the kinetic energy of the moving gate and lock is something we would like to add to the system. The power provided into the system will relate to the speed that the gate performs at. The function of locking the gate relates to the three systems *support*, *power*, and *resist*. This is due to many factors effecting the gate such as weather, obstructions, sagging of the gate, and the power needed to keep the gate locked and functioning efficiently.

Action and Outcome

The gate lock will need to mitigate gate oscillations to ensure that the gate lock and latch align and reduce the impact of the lock contacting the latch. The gate lock will also need to compensate for gate sag while the gate is in the closed position. This will reduce the stress at the hinges and the need to realign the lock and latch over time.

1.4 Target Summary

Target Derivation and Validation

The targets for this project will act as quantifiable goals by which the proper function of the project can be measured against and verified, and the metrics are the means by which these will be validated for a design or prototype. The targets are based on the functions that have been previously defined according to the project needs, and the respective sub-functions derived from these primary functions. Each primary function has corresponding targets and metrics by which the function can be verified and proved sufficient. Some of the targets specified will be critical to the successful function of a prototype, while others will act as desired goals that are not required for the prototype to function.

The validation of the targets will be ensured through measurements of initial prototypes, and the behavior of the prototypes will be used to perform any necessary calculations and further refine a design that meets the specified targets. The targets for this project can be measured and verified using simple measuring instruments such as rulers and timers.

Debounce Targets and Metrics

The aim for the gate bouncing while it closes is there to be no bounce at all. The gate and latch must immediately attach to each other and not continuously bounce once the gate reaches the latch. There is no range of how well the gate should latch and not bounce at the interaction. If the gate continues to bounce when it collides with the latch, then the target is not reached. Our system's ability to correct the bounce will be tested multiple times to confirm if it is the most efficient option for canceling out bounce between the gate and latch. There should be around a 95% completion rate for the system to debounce the gate. Decreasing the vertical and horizontal oscillations of the gate is a target to focus on to eliminate bounce. As the gate closes the gate should not have sporadic movement and transition to a close position smoothly with no shaking as it closes. To assess the control of the vertical and horizontal movement of the gate cameras to record the vertical movement and horizontal movement will be used and measure the amplitude of the bounce. We would like the amplitude of these oscillations to be between 1-5 in as it locks. A final target we will focus on to aid in eliminating bounce is absorbing the kinetic energy of the moving gate. For any speed the gate is at while closing, the gate and latch need to be able to come together and not collide. Our system should be able to absorb the energy of the moving object as it reaches the latch to close. Absorption of the kinetic energy should lead to the velocity of the moving gate to reach 0. The velocity will be measured to determine whether the gates energy has been absorbed to reach the latch without crashing due to speed.

Support Targets and Metrics

To ensure that the gate does not sag over time, it is important that the support system is able to hold the gate at a specific height while the gate is in the closed position. This height can vary from gate to gate but the height between the lock on the gate and the latch on the post should not vary greater than ±0.125 inches. The 0.125 inches comes from the space that is available between the lock and latch wall. The support system should be able to correct gate positioning if the gate has sagged within 5 inches of the desired position. To measure these targets, the vertical height difference from the desired position to the current position can be found using a ruler or measuring tape. The support system should be able to secure an end gate weight of up to 50 lbs. To calculate this target, a weighted scale can be used to determine the downward force the end of the gate produces.

Power Targets and Metrics

Based on the power supplied to the other peripherals of the gate lock system, it was concluded that the potential voltage to be supplied to the gate lock will be 12 V. This voltage level matches the voltage that is already present in the gate system, making the sourcing and integration of this power especially simple. The power would be sourced from the present solar charged, DC battery that powers the gate actuating arm. To provide any other voltage would be an unnecessary cost, as the 12 volts supplied would be ample to drive any solution. To quantify this target, the voltage could easily be measured with a simple multimeter.

Resist Targets and Metrics

To ensure that the gate locking system is resistant to weather conditions, it is essential that the material to be used in the construction of the gate lock is corrosion resistant. To do this, the lock system will be made from the same material that the existing Ghost Controls product is made from; powder coated steel. After consulting the project sponsor, it was clear that the desire of Ghost Controls is to maintain a product that is similar to their existing products in terms of manufacturability, and with Ghost Controls already designing the gate system to resist weather conditions, it was clear that the use of the existing material would be best for this purpose. To do this, maintaining a uniformity in the materials of the products that they manufacture cut down on the overall manufacturing costs of the gate lock. This added to the conclusion to continue with the current product material in the structure of the new gate locking system. This metric would easily be qualified using the same steel as the existing gate lock structures are manufactured out of.

The other function falling under the *Resist* system is that the gate lock would last for the lifetime of the gate. The lifetime of a gate can be hard to quantify, but other factors can be used to estimate what the perceived lifetime of the gate should be. One of these is the average duration of homeownership. The median extent of homeownership in the United States is 13 years (Evangelou, 2020). This estimates the average ownership of the gate, and if that is multiplied by the company supplied average of 30 opening and closings of the gate per week, the total opening and closing of the gate over the lifetime of the gate is 20,280 cycles. Therefore, the target for the gate is to be designed to handle 20,280 cycles of opening and closing. This can be tested by using a continuous testing of opening and closing a model gate system every minute over the course of 14 days to reach the threshold of 20,280 cycles. The gate lock will then be inspected for damage that would prohibit the gate lock system from working properly.

Targets Outside of Functions

To ensure the manufacturability and profitability of the gate lock system, the solution to the gate locking system must not add more than $20 to the final price of the gate locking system. This target and metric is by request of our sponsor. One of the values of the company is that the value added by the feature must match the value added to the price of the system. The company sees the value added of a fully functioning locking system to translate to about $20, so the added price target of the lock is set as such.

The current design of the gate locking system has a no tamper design where the attachment bolts of the receiver hitch are inaccessible when the gate latch is in the locked position. This means that the redesigned gate locking system must be secure and invulnerable to tampering. The attachment points of the locking system must be inaccessible in the locked position to ensure that the lock cannot be interfered with when locked.

The gate lock must be able to latch onto any standard gate, having modal attachment point. The gate lock must have attachment options to gates rails of standard sizes from 0.50” to 2.50” in diameter (McHone Industries, 2016).

Summary and Catalog

The targets for each of the functions are summarized in the table below. The targets that are bolded are the critical targets that must be met for a design to be considered functional. The targets are currently based on values that are expected to ensure desirable results and fulfillment of the project needs. However, as concepts are refined and prototypes are tested, the numerical values of the targets are subject to change if it is determined that other values are more realistic or will produce more desirable results.

System	*Function*	*Target*	*Metric*
Debounce	Controlling the vertical and horizontal oscillations of the gate	1-5 [in]	Height
Debounce	**Absorb the kinetic energy**	**0 [m/s]**	**Velocity**
Support	Correct gate position	< 5 [in]	Height
Support	**Position if out of line of latch**	**< 0.125 [in]**	**Height**
Support	Relieve gate end weight	50 lbs	Weight
Power	Receive Power	12 [V]	Electrical Potential
Resist	Resist Weather Conditions	Steel	Material
Resist	**Last for Lifetime of the Gate**	**12,280 [cycles]**	**Cycles of use**

1.5 Concept Generation

Concept generation is extremely useful in formulating, conceiving, and devising many solutions for the project at hand. Many generation tools were implemented to create a list of one hundred design concepts. These concepts all present possible solutions to accomplish the objective of the project.

Concept Generation Tools

Numerous techniques were employed in the concept generation process to create the list of one hundred conceptual designs. These techniques included brainstorming, crapshoot, morphological chart, and biomimicry. Small changes were made to robust concepts to differentiate the concepts. With the addition of each of these modifications, eliminations, and rearrangements, new concepts were generated.

Medium Fidelity Concepts

After concept generation, five concepts were chosen for medium fidelity concepts. These concepts were chosen as medium fidelity concepts for their suitable features, but they were not fully considered for high level prototyping. These medium fidelity prototypes (shown below) are helpful for creating and discerning certain design characteristics, functions, and purposes that are desirable in the solution to the project.

Medium Fidelity Concepts

Concept Number	Description
1	Robotic arm that stops the gate before it closes and closes softly.
47	Wheels on bottom to support gate.
92	Redesign latch to have gate decelerate with friction while closing.
73	Sliding soft close mechanism like drawer soft close.
2	Flared receiver to guide lock into place

High Fidelity Concepts

Of the one hundred concepts generated, three were chosen as high fidelity concepts. These concepts combine the best of the characteristics, functions, and purposes that are desirable in the solution to the project. The high fidelity concepts are listed below.

High Fidelity Concepts

Concept Number	**Description**
64	Hook that follows cam-shaped motion and captures gate.
56	Flared, sliding receiver paired with strong magnet to overcome sagging so that gate self-locks.
36	Ramp track for bottom of the gate to push gate sag upwards

1.6 Concept Selection

House of Quality

To create a house of quality comparison chart, a pairwise comparison was first used to establish the importance weight factor of each of the customer requirements. These customer requirements were those established over dialog with a customer of a Ghost Controls as well as the project sponsor. For more details on the customer needs, see section 1.2 of this paper. In the pairwise comparison chart, binary logic of 1 and 0 were assigned to determine the importance of customer needs as compared to each other. As a result of this, it is seen that locking and safety are the top priority for the project, with noise and volume being the least priority.

Table 1: Pairwise Comparison

Binary Pairwise Comparison												
Customer Need	1	2	3	4	5	6	7	8	9	10	11	Total
1. Reduce Bounce	-	1	0	0	1	1	0	1	0	0	1	5
2. Reduce Sagging Effects	0	-	0	0	1	1	0	0	0	0	1	3
3. Locking	1	1	-	1	1	1	1	1	1	1	1	10
4. Cost	1	1	0	-	1	1	0	1	0	1	1	7
5. Noise of System	0	0	0	0	-	0	0	0	0	0	1	1
6. Ease of Installation	0	0	0	0	1	-	0	0	0	0	1	2
7. Durability	1	1	0	1	1	1	-	1	0	1	1	8
8. Maintenance	0	1	0	0	1	1	0	-	0	0	1	4
9. Safety	1	1	0	1	1	1	1	1	-	1	1	9
10. Weather resistance	1	1	0	0	1	1	0	1	0	-	1	6
11. Volume	0	0	0	0	0	0	0	0	0	0	-	0
Total	5	7	0	3	9	8	2	6	1	4	10	n-1 = 10

This importance weight factor, shown in the last column of the pairwise comparison chart, was then used in the house of quality. The decomposed functions of the gate locking system (engineering characteristics) are compared to the customer requirements for impact on the specific customer requirement. An exponential scale of the function impact on the customer requirement is used in this comparison (3^n). This number, multiplied by the importance weight factor, added up down the rows, and normalized by the raw score, determines the relative weight factor (importance) of the engineering characteristic.

Table 2: House of Quality

		Engineering Characteristics							
Improvement Direction		↑	↑	↓	↓	↑	-	-	↑
Units		in	m/s	in	in	lbs	V	n/a	cycles
Customer Requirements	**Importance Weight Factor**	**Control Oscillation**	**Absorb Kinetic Energy**	**Correct Gate Position**	**Position Latch**	**Relieve Weight at Hinge**	**Receive Power**	**Resist Weather Conditions**	**Last for Lifetime of Gate**
Reduce Bounce	5	9	9			1			
Reduce Sagging Effects	3	3		9	9	9			
Locking	10	9	3	9	9			3	1
Cost	7								3
Noise of System	1	9	9	1	3		1		
Ease of Installation	2				3		3		
Durability	8							3	9
Maintenance	4			9		3			9
Safety	9		3						
Weather resistance	6			1		3		9	
Volume	0							3	3
Raw Score	866	153	111	160	126	62	7	108	139
Relative Weight (%)		17.67	12.82	18.48	14.55	7.16	0.81	12.47	16.05
Rank Order		2	5	1	4	7	8	6	3

For the house of quality table, our most important functions are *Correct Gate Position*, *Control Oscillation*, and *Last for Lifetime of the Gate.* The least important functions are *Receive Power* and *Relieve Weight at Hinges.* The other functions make up a middle ground of nearly equally weighted functions. The results of the house of quality help us evaluate concepts to determine if they complete functions that are truly more important for the success of our project in fulfilling the customer needs.

Pugh Chart

A Pugh chart is a great way to compare designs to that of a standard design that already exists. While making the Pugh chart we listed the eleven metrics that were most important to the Ghost Controls gate project.

Table 3: Concepts

Concept Number	Description
Medium Fidelity	
1	Robotic arm that stops the gate before it closes and closes softly.
2	Wheels on bottom to support gate.
3	Redesign latch to have gate decelerate with friction while closing.
4	Sliding soft close mechanism like drawer soft close.
5	Flared receiver to guide lock into place
High Fidelity	
6	Hook that follows cam-shaped motion and captures gate.
7	Flared, sliding receiver paired with strong magnet to overcome sagging so that gate self-locks.
8	Ramp track for bottom of the gate to push gate sag upwards

Table 4: Pugh Chart 1

Selection Criteria	Existing Ghost Controls Locking System	Concepts							
		Con. 1	Con. 2	Con. 3	Con. 4	Con. 5	Con. 6	Con. 7	Con. 8
Reduce Bounce	DATUM	+	+	+	+	+	+	+	+
Reduce Sagging Effects		+	+	S	S	+	+	+	+
Cost		-	-	-	-	S	-	-	-
Locking		+	+	+	+	+	+	+	+
Noise of System		+	S	S	+	-	+	-	+
Ease of Installation		-	S	S	-	S	-	-	-
Durability		-	S	-	-	S	-	-	S
Maintenance		-	-	-	-	S	-	-	S
Weather Resistance		-	S	S	-	S	-	-	S
Safety		S	S	S	+	S	S	S	S
Volume		-	-	S	-	-	-	-	-
# Pluses(+)		4	3	2	4	3	4	3	4
# Satisfactory(S)		1	5	6	1	6	1	1	4
# Minuses(-)		6	3	3	6	2	6	7	3

The initial results of our first Pugh found that concepts 2, 3, 5 and 8 would be the most suitable concepts to move onto further evaluation when comparing to the existing Ghost Controls locking system. Concept 5 had the highest ratio of pluses and satisfactory to minuses, so it was chosen as the new datum.

Table 5: Pugh Chart 2

		Concepts		
Selection Criteria	Concept 5	Con. 2	Con. 3	Con. 8
Reduce Bounce	DATUM	S	+	+
Reduce Sagging Effects		+	S	+
Cost		-	-	-
Locking		-	S	S
Noise of System		+	-	+
Ease of Installation		-	S	S
Durability		-	-	S
Maintenance		-	S	-
Weather Resistance		-	S	S
Safety		-	S	-
Volume		-	-	-
# Pluses(+)		2	1	3
# Satisfactory(S)		1	6	4
# Minuses(-)		8	4	4

The result of our second Pugh chart shows that high fidelity concept #8 (Table 3) will best redesign the locking system. While comparing this design to new datum, concept 5, it was determined that it would be better suited reducing bounce, reducing sag, and reducing noise of the system while being the same in the areas of locking capabilities, ease of installation, durability, and weather resistance. While going through the chart, it was determined that medium fidelity concept #8 (Table 3) was our best design option to the current locking system to the fact that it will be the same in four aspects as well as improving upon four aspects. All of the other design concepts also improve in some respects, but also deteriorate some of the others. While deciding which concept improves the most, improvements and deterioration of aspects must be taken into consideration, meaning you have to weigh the pros and cons. While weighing all of the pros and cons, it was a pretty easy decision to decide that high fidelity concept #8 is the best option going forward. Our second-best option being medium fidelity concept #5 (Table 3) due to the fact that it improves the current locking system in three aspects but deteriorates the current locking system in two aspects. A design that got thrown away as soon as the Pugh chart was completed was medium fidelity concept #2 (Table 3) because it is already a simple solution to this problem that is currently on the market.

Analytical Hierarchy Process

The analytical hierarchy process is used to mathematically evaluate any bias in the importance that is attributed to design criteria. The Criteria Comparison Matrix below compares the importance of each criterion to every other criterion similar to a pairwise comparison, but a numeric value is associated with the relative importance. Values of 1, 3, 5, 7, and 9 are given where 1 represents that the criteria are equally important and 9 represents that the first criterion is significantly more important to consider than the second criterion. When one criterion is deemed to be less important than another, the inverse values represent this relative importance. The criteria in the leftmost column are compared with the criteria in the upper row, so that a 3 at an intersecting block would mean that the corresponding criterion in the leftmost column is deemed slightly more important than the corresponding criterion in the upper row. The sum and average of each row and column is also represented in the matrix below.

Table 6: Criteria Comparison Matrix

Criteria Comparison Matrix														
Criteria		1	2	3	4	5	6	7	8	9	10	11	Total	Avg 2
1	Reduce Bounce	1	3	0.14	0.2	3	5	0.2	3	0.33	0.14	7	23	2.09
2	Reduce Sagging Effects	0.33	1	0.14	0.14	3	3	0.14	0.2	0.14	0.14	5	13.2	1.2
3	Always Lock	7	7	1	3	9	7	3	5	3	1	9	55	5
4	Low Relative Cost	5	7	0.33	1	9	5	0.33	5	0.33	5	9	47	4.27
5	Quiet	0.33	0.33	0.11	0.11	1	0.2	0.11	0.14	0.11	0.14	3	5.6	0.51
6	Easy Installation	0.2	0.33	0.14	0.2	5	1	0.2	0.33	0.2	0.2	3	10.8	0.98
7	Durability	5	7	0.33	3	9	5	1	3	0.2	1	7	41.5	3.78
8	Low Maintenance	0.33	5	0.2	0.2	7	3	0.33	1	0.2	0.33	7	24.6	2.24
9	Safety	3	7	0.33	3	9	5	5	5	1	5	7	50.3	4.58
10	Weather Resistant	7	7	1	0.2	7	5	1	3	0.2	1	7	39.4	3.58
11	Small Form Factor	0.14	0.2	0.11	0.11	0.33	0.33	0.14	0.14	0.14	0.14	1	2.8	0.25
Total		29.3	44.9	3.85	11.2	62.3	39.5	11.5	25.8	5.86	14.1	65		
Average 1		2.67	4.08	0.35	1.02	5.67	3.59	1.04	2.35	0.53	1.28	5.91		

The criteria comparison matrix was then normalized to form the normalized comparison matrix shown below. The normalized comparison matrix is made by dividing the value of each block by the sum of the column the block is in. After doing this, the sum of each column will be 1 and the value of each block will represent the percentage weight or importance of the corresponding row's criterion relative to the other row's criteria when compared to the column's criterion. The average of each row is displayed on the right, called the criteria weight, and is representative of the importance of the criterion relative to one another.

Table 7: Normalized Comparison Matrix

Normalized Comparison Matrix													
Criteria		1	2	3	4	5	6	7	8	9	10	11	Criteria Weight
1	Reduce Bounce	0.03	0.07	0.04	0.02	0.05	0.13	0.02	0.12	0.06	0.01	0.11	0.058
2	Reduce Sagging Effects	0.01	0.02	0.04	0.01	0.05	0.08	0.01	0.01	0.02	0.01	0.08	0.031
3	Always Lock	0.24	0.16	0.26	0.27	0.14	0.18	0.26	0.19	0.51	0.07	0.14	0.220
4	Low Relative Cost	0.17	0.16	0.09	0.09	0.14	0.13	0.03	0.19	0.06	0.35	0.14	0.141
5	Quiet	0.01	0.01	0.03	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.05	0.015
6	Easy Installation	0.01	0.01	0.04	0.02	0.08	0.03	0.02	0.01	0.03	0.01	0.05	0.027
7	Durability	0.17	0.16	0.09	0.27	0.14	0.13	0.09	0.12	0.03	0.07	0.11	0.124
8	Low Maintenance	0.01	0.11	0.05	0.02	0.11	0.08	0.03	0.04	0.03	0.02	0.11	0.056
9	Safety	0.10	0.16	0.09	0.27	0.14	0.13	0.44	0.19	0.17	0.35	0.11	0.195
10	Weather Resistant	0.24	0.16	0.26	0.02	0.11	0.13	0.09	0.12	0.03	0.07	0.11	0.121
11	Small Form Factor	0.00	0.00	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.012
Sum		1	1	1	1	1	1	1	1	1	1	1	1

After calculating the criteria weight, the weighted sum, consistency vector, and consistency index were calculated to find the consistency ratio. The consistency ratio is representative of the amount of bias that has been shown to each criterion when determining its relative importance. The goal is for the consistency ratio to be less than 0.1, and this was achieved with our attributed importance of each criterion. Our highest consistency ratio was 0.094, while our average was 0.055. This is a good result considering it is safely below the maximum of 0.1.

Table 8: Consistency Check

Consistency Check					
Criteria		Weighted Sum	Consistency Vector	Consistency Index	Consistency Ratio
1	Reduce Bounce	0.7497	12.9078	0.0318	0.0211
2	Reduce Sagging Effects	0.3626	11.7593	0.1419	0.0940
3	Always Lock	3.0579	13.8950	-0.0472	-0.0313
4	Low Relative Cost	2.0898	14.8695	-0.1142	-0.0756
5	Quiet	0.1866	12.1375	0.1032	0.0683
6	Easy Installation	0.3276	12.0300	0.1139	0.0754
7	Durability	1.8099	14.5466	-0.0930	-0.0616
8	Low Maintenance	0.6941	12.4340	0.0745	0.0494
9	Safety	2.9418	15.0728	-0.1269	-0.0841
10	Weather Resistant	1.6485	13.6646	-0.0299	-0.0198
11	Small Form Factor	0.1514	12.8322	0.0384	0.0254
Average		1.27454794	13.2863118	0.08317194	0.05508076

The results from the consistency check mean that we can look back to the criteria weight to understand which criteria were deemed most important. The most important design criteria for this project's consideration have been determined to be that the gate is ensured to always locks, the design is safe, and that it has a low cost relative to the total cost of the gate system.

These results were used to focus on three design criteria by which to evaluate the most competitive designs from the Pugh charts above. The designs which were considered at this level were designs 5 and 8. They were compared with regard to each of the three design criteria and given a weight that accorded to their relative performance. These weights were then normalized and are shown in the final rating matrix below.

Table 8: Final Rating Matrix

Final Rating Matrix		
Criteria	Concept	
	5	8
Always Lock	0.5	0.5
Safety	0.75	0.25
Low Relative Cost	0.75	0.25
Total	2	1

The final rating matrix shows that concept 5 outperformed concept 8 when evaluated according to these criteria. Although the total of concept 5 is twice that of concept 8, the margin between the two is quite small as concept 5 only slightly outperformed concept 8 with regard to two of the three criteria. Concept 8, however, has been found to outperform concept 5 in general and specifically with regard to reducing bounce and sagging. Because of the concept 8's performance in these other area, it will be selected as the final design.

Selection

Our team has decided on the concept idea 8. In this concept we will create a ramp that catches onto the gate as it is closing and guides it up into the latch eliminating sag as it closes. Concept 8 fulfills the primary needs that we require our gate system to fill. It *corrects gate positioning* and *controls oscillations*, by guiding the gate into the latch using a ramp. When we compare the tables of the pairwise comparison, house of quality, and analytical hierarchy process to concept 8, we have determined that the most important qualities are met by concept 8. When comparing concept 8 to the other concepts within the Pugh chart and final rating matrix, we feel that concept 8 best meets the design criteria required to perform well for this project.

1.8 Spring Project Plan

Chapter Two: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan.

Appendices

Appendix A: Code of Conduct

FAMU/FSU College of Engineering
Department of Mechanical Engineering
Code of Conduct
Team 509: Floating Shock Absorber for Gate Control

Names:	Contact Email:
Coltin Fortner	cf17h@my.fsu.edu
Yvener Labady	yl17c@my.fsu.edu
Brandon Schrader	bps18b@my.fsu.edu
Jordan Steverson	jcs19r@my.fsu.edu

Date: 8/31/2021

Mission Statement

Team 509 is committed to creating and ensuring a positive work environment that supports professionalism, respect, originality, and taking responsibility. These values will not only be upheld within in the group, but also whenever members are in contact with advisors, contractors, suppliers, or administration. Every member of this team will contribute a full effort to design a project that meets Senior Design requirements and exceeds sponsors expectations.

Roles

Manufacturing Engineer: Coltin Fortner

- Responsible for the researching and overseeing the manufacturing methods and materials used for the prototypes and final design of the project. This involves taking into account the cost, ease, and effectiveness of different manufacturing and material options to provide an efficient and viable design for a profitable product.

~~Software~~ Test Engineer: Yvener Labady

- ~~Responsible for writing software programs that will be used in the hardware. Analyses areas of hardware and program and identifies parts that need modification in the program. Researches and learns new technologies that are helpful to design~~. Test the different gate systems that we will manufacture. Identify errors and make changes to the system tested until changes are acceptable for use on a gate with a Ghost Controls lock system.

Design Engineer: Brandon Schrader

- Responsible for the overall design of the project. Needs to be knowledgeable in the complex workings of the original problem and develop ideas and methods of solutions to that problem. Keeps all design documentation and is responsible for keeping track of and turning in team reports.

Systems Engineer: Jordan Steverson

- Responsible for assessing systems, determining problems, and providing solutions to issues that arise in a project. Also assists in designing systems, upgrading systems, maintaining systems and brainstorming possible improvements that can be made to a system in the future.

All Team Members

- Work on specific assigned tasks of the project
- Collaborate with others
- Embody mission values
- Look to achieve the project goals and success
- Delivers on commitments
- Adopt team spirit
- Listen and contribute constructively (feedback)
- Be effective in trying to get message across
- Be open minded to other’s ideas
- Respect other’s roles and ideas
- Be ambassador to the outside world in own tasks

Communication

The main form of communication will be over phone, text-messaging, and Basecamp. For fast communication among the group, preferably phone and text messaging. For long term goal setting and task list, Basecamp will be used as well as regular meetings of the whole team. Email will be a secondary form of communication for issues not being time sensitive and it will also be the main form of communication with advisors and sponsors. For the passing of information, i.e. files and presentations, Basecamp will be the main form of file transfer and proliferation.

Each group member must have a working email for the purposes of communication and file transference. Members must check their emails at least twice a day to check for important information and updates from the group. Although members will be initially informed via a phone call, meeting dates and pertinent information from the sponsor will additionally be sent over email so it is important for each group member to check their email frequently.

If a meeting must be canceled, an email must be sent to the group at least 24 hours in advance.

Any team member that cannot attend a meeting must give advance notice of 24 hours informing the group of his absence. Reason for absence will be appreciated but not required if personal. Repeated absences in violation with this agreement will not be tolerated. After 5 violations, a special meeting with all the group members will be called to discuss further action. If no foreseeable resolution comes to bare, the matter will be taken up with Dr. McConomy.

Team Dynamics

The students will work as a team while allowing one another to feel free to make any suggestions or constructive criticisms without fear of being ridiculed and/or embarrassed. If any member on this team finds a task to be too difficult it is expected that the member should ask for help from the other teammates. If any member of the team feels they are not being respected or taken seriously, that member must bring it to the attention of the individual first, and if disregarded, then to the whole team in order for the issue to be resolved. We shall not let emotions dictate our actions. Everything done is for the benefit of the project and together everyone achieves more.

Ethics

Team members are required to be familiar with the NSPE Engineering Code of ethics as they are responsible for their obligations to the public, the client, the employer, and the profession. There will be stringent following of the NSPE Engineering Code of Ethics.

Outside Obligations

Team member obligations outside of the project will be respected and accommodated so far as they do not interfere with the completion of project-related tasks, group meetings, and fair contribution to the group. Regular (weekly) obligations will be accounted for during the initial scheduling of regular meeting times. Members should notify the rest of the group as soon as a new obligation arises that may interfere with project tasks or meetings so that the group can plan accordingly. Members are expected to treat planned meetings as obligatory to reduce the number of interruptions and schedule changes necessary. If a team member repeatedly fails to notify the group of outside obligations, or fails to treat group meetings as obligations themselves, the team member will be addressed (see attendance policy).

Dress Code

Team meetings will be held in casual attire. Sponsor meetings and group presentations will be business casual to formal as decided by the team per the event. Dress must be uniform between members.

Weekly and Biweekly Tasks

Team members will participate in all meetings with the sponsor, advisor, and instructor. During said times ideas, project progress, budget, conflicts, timelines, and due dates will be discussed. In addition, tasks will be delegated to team members during these meetings. Repeat absences will not be tolerated.

Attendance Policy

Attendance is mandatory to all meetings if no excuse is present. Discussion of meeting excused is expounded upon under "Communication" heading. Attendance of team members is kept in Basecamp and will be taken at every meeting (team meeting, sponsor meeting, advisor meeting, etc.). If issues arise with a lack of attendance by a team member, they should refer to the "Conflict Resolution" heading. This includes for when external support is needed.

Decision Making

Decision making is conducted by consensus and majority of the team members. Should ethical/moral reasons be cited for dissenting reason, then the ethics/morals shall be evaluated as a group and the majority will decide on the plan of action. Individuals with conflicts of interest should not participate in decision-making processes but do not need to announce said conflict. It is up to each individual to act ethically and for the interests of the group and the goals of the project. Achieving the goal of the project will be the top priority for each group member. Below are the steps to be followed for each decision-making process:

- Problem Definition – Define the problem and understand it. Discuss among the group.
- Tentative Solutions – Brainstorms possible solutions. Discuss among group most plausible.
- Data/History Gathering and Analyses – Gather necessary data required for implementing Tentative Solution. Re-evaluate Tentative Solution for plausibility and effectiveness.
- Design – Design the Tentative Solution product and construct it. Re-evaluate for plausibility and effectiveness.
- Test and Simulation/Observation – Test design for Tentative Solution and gather data. Re-evaluate for plausibility and effectiveness.
- Final Evaluation – Evaluate the testing phase and determine its level of success. Decide if design can be improved and if time/budget allows for it.

In the case of a tie vote, differences will be discussed with a faculty advisor and a revote will occur.

Conflict Resolution

In the event of discord amongst team members the following steps shall be respectfully employed:

- Communication of points of interest from both parties which may include demonstration of active listening by both parties through paraphrasing or other tool acknowledging clear understanding.
- Administration of a vote, if needed, favoring majority rule.
- Advisor intervention.
- Instructor will facilitate the resolution of conflicts.

Statement of Understanding

Statement of Understanding By signing this document the members of Team 1 agree all of the above and will abide by the code of conduct set forth by the group.

Name	Signature	
Coltin Fortner	Coltin Fortner	9/7/21
Yvener Labady	Y. Labady	
Brandon Schrader	Brandon Schrader	9/7/21
Jordan Steverson	Jordan Steverson	9/7/21

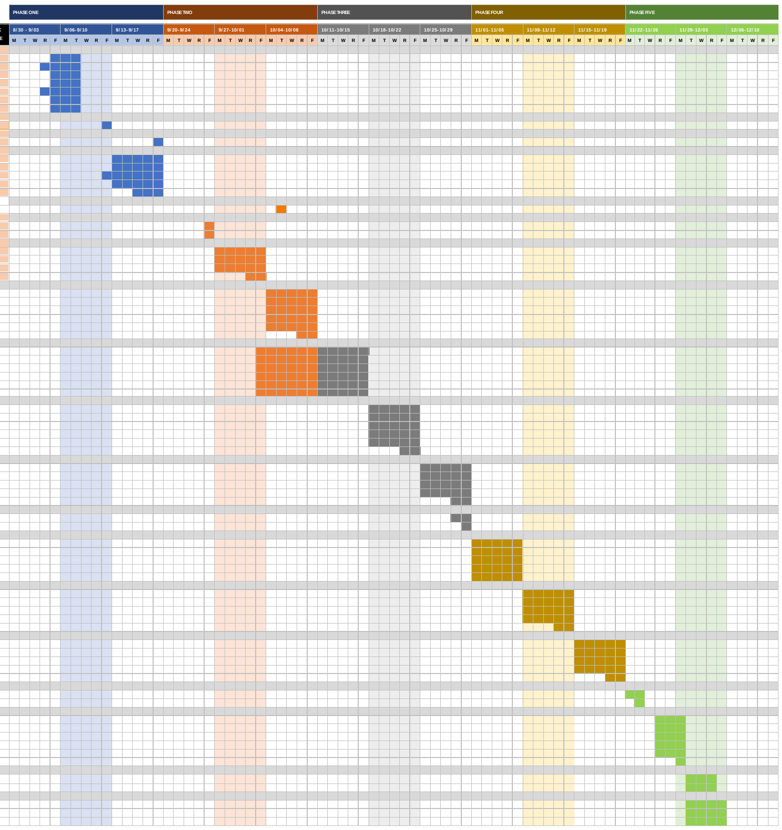
Appendix B: Functional Decomposition

Appendix C: Work Breakdown Structure

TEAM SHOCK WORK BREAKDOWN STRUCTURE

PROJECT TITLE	Floating Gate Lock
PROJECT MANAGER	Darryl Beadle
COMPANY NAME	Ghost Controls
DATE	9/30/21

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	% of TASK COMPLETE
1	Code of Conduct					100%
1.1	Mission Statement	Jordan	9/4/21	9/7/21	3	100%
1.2	Outside Obligations	Coltin	9/4/21	9/7/21	3	100%
1.3	Team Roles	All	9/4/21	9/7/21	3	100%
1.4	Communication	Brandon	9/4/21	9/7/21	3	100%
1.5	Dress Code	Yvener	9/4/21	9/7/21	3	100%
1.6	Attendance Policy	Brandon	9/5/21	9/7/21	2	100%
1.7	Notification/Responses	Jordan	9/4/21	9/7/21	3	100%
2	Adviser Meet and Greet					100%
2.1	Meeting Minutes	All	9/10/21	9/10/21	0	100%
3	Sponsor Meet and Greet					100%
3.1	Meeting Minutes	All	9/17/21	9/17/21	0	100%
4	Project Scope					100%
4.1	Project Description	Jordan	9/13/21	9/17/21	4	100%
4.2	Key Goals	Brandon	9/12/21	9/17/21	5	100%
4.3	Market	Yvener	9/10/21	9/17/21	7	100%
4.4	Assumptions	Jordan	9/13/21	9/17/21	4	100%
4.5	Stakeholders	Coltin	9/15/21	9/17/21	2	100%
5	Staff Meeting					0%
5.1		All	10/5/21	10/5/21	0	0%
6	Adviser Meeting 1					100%
6.1	Pre Adviser Meeting 1	All	9/24/21	9/24/21	0	100%
6.2	Post Adviser Meeting 1	All	9/24/21	9/24/21	0	100%
7	Customer Needs					100%
7.1	Customer Statements	Jordan	9/27/21	10/1/21	4	100%
7.2	Interpreted Need	Yvener	9/27/21	10/1/21	4	100%
7.3	Explaination of Results	Coltin	9/27/21	10/1/21	4	100%
7.4	Grammar Review	Brandon	9/30/21	10/1/21	1	100%
8	Functional Decomposition					
8.1	Explaination of Results	Jordan	10/4/21	10/8/21	4	0%
8.2	Connection to Systems	Yvener	10/4/21	10/8/21	4	0%
8.3	Smart Integration	Coltin	10/4/21	10/8/21	4	0%
8.4	Functional Resolution	Brandon	10/4/21	10/8/21	4	0%
8.5	Graphics	Yvener	10/4/21	10/8/21	4	0%
8.6	Grammar Review	Jordan	10/7/21	10/8/21	1	0%
9	VDR1					
9.1	Introduction	Jordan	10/1/21	10/15/21	14	0%
9.2	Project Brief	Yvener	10/1/21	10/15/21	14	0%
9.3	Background	Coltin	10/1/21	10/15/21	14	0%
9.4	Project Scope	Brandon	10/1/21	10/15/21	14	0%
9.5	Customer Needs	Yvener	10/1/21	10/15/21	14	0%
9.6	Functional Decomposition	Jordan	10/8/21	10/15/21	7	0%
10	Targets					
10.1	Matching Targets with Metrics	Jordan	10/18/21	10/22/21	4	0%
10.2	Methods of Validation	Yvener	10/18/21	10/22/21	4	0%
10.3	Measurements	Coltin	10/18/21	10/22/21	4	0%
10.4	Critical Targets	Brandon	10/18/21	10/22/21	4	0%
10.5	Summary and Catalog	Yvener	10/18/21	10/22/21	4	0%
10.6	Grammar Review	Jordan	10/21/21	10/22/21	1	0%
11	Concept Generation					
11.1	100 Concepts	All	10/25/21	10/29/21	4	0%
11.2	5 Medium Fidelity Concepts	Brandon	10/25/21	10/29/21	4	0%
11.3	3 High Fidelity Concepts	Yvener	10/25/21	10/29/21	4	0%
11.4	Concept Generation Tools	Jordan	10/25/21	10/29/21	4	0%
11.5	Grammar Review	Coltin	10/28/21	10/29/21	1	0%
12	Adviser Meeting 2					
12.1	Pre Adviser Meeting 2	All	10/28/21	10/29/21	1	0%
12.2	Post Adviser Meeting 2	All	10/29/21	10/29/21	0	0%
13	Concept Selection					
13.1	House of Quality	All	11/1/21	11/5/21	4	0%
13.2	Pugh Charts	Yvener	11/1/21	11/5/21	4	0%
13.3	AHP	Coltin	11/1/21	11/5/21	4	0%
13.4	Final Selection	Brandon	11/1/21	11/5/21	4	0%
13.5	Grammar Review	Yvener	11/4/21	11/5/21	1	0%
14	VDR2					
14.1	Introduction	All	11/8/21	11/12/21	4	0%
14.2	Project Brief	Yvener	11/8/21	11/12/21	4	0%
14.3	Targets	Coltin	11/8/21	11/12/21	4	0%
14.4	Concept Generation	Brandon	11/8/21	11/12/21	4	0%
14.5	Grammar Review	Yvener	11/11/21	11/12/21	1	0%
15	Risk Assessment					
15.1	Identification of Risks	All	11/15/21	11/19/21	4	0%
15.2	Accidents Identified	Yvener	11/15/21	11/19/21	4	0%
15.3	Hazard Avoidance/Saftey Measures	Coltin	11/15/21	11/19/21	4	0%
15.4	Emergency Contact/Response	Brandon	11/15/21	11/19/21	4	0%
15.5	Grammar Review	Yvener	11/18/21	11/19/21	1	0%
16	Adviser Meeting 3					
16.1	Pre Adviser Meeting 3	All	11/25/21	11/26/21	1	0%
16.2	Post Adviser Meeting 3	All	11/26/21	11/26/21	0	0%
17	Bill of Materials					
17.1	Line Items/Order Needs	All	11/25/21	11/29/21	4	0%
17.2	Vendor Identification	Jordan	11/25/21	11/29/21	4	0%
17.3	Line Item Maturity	Yvener	11/25/21	11/29/21	4	0%
17.3	Project Maturity	Coltin	11/25/21	11/29/21	4	0%
17.4	Project/Unit Cost	Brandon	11/25/21	11/29/21	4	0%
17.5	Grammar Review	Yvener	11/29/21	11/29/21	0	0%
18	VDR3					
18.1	Get Poster materials	All	11/30/21	12/2/21	2	0%
18.2	Put Poster Together	All	11/30/21	12/2/21	2	0%
19	Spring Project Plan					
19.1	Plan for Engineering Day	All	11/30/21	12/3/21	3	0%
19.2	Plan for Finals	All	11/30/21	12/3/21	3	0%
19.3	Plan for Graduation	All	11/30/21	12/3/21	3	0%



Appendix D: Concept Generation

1. Robotic arm that stops the gate before it closes and closes softly
2. Flared receiver to guide lock into place
3. Flared receiver paired with jack under gate that stops the gate from sagging
4. Flared receiver paired with robotic arm that stops the gate before it closes and closes softly
5. Sliding receiver that adjusts to the height of the lock
6. Jack under gate that stops the gate from sagging
7. Gun that shoots incoming gate, causing it to slow as it approaches
8. Sliding receiver paired with grabber arm that grabs the gate before it closes and closes softly
9. Sliding receiver paired with air bag that inflates to slow the gate before bouncing can occur
10. Butler that opens and closes the gate
11. Jet engine to force the gate closed
12. Dynamite
13. Ratcheted receiver that the lock pushes up or down to the correct position
14. Grabber arm that grabs the gate before it closes and closes softly
15. Drone to pull gate to proper position
16. Pile of frogs to use as a biomass damper
17. Rubber chicken
18. Flared, sliding receiver paired with jack under gate that stops the gate from sagging

19. Flared, sliding receiver paired with robotic arm that stops the gate before it closes and closes softly
20. Air bag that inflates to slow the gate before bouncing can occur
21. Balloon for cushioning impact
22. Helium Balloon to prevent sagging
23. Foam for dampening
24. Whoopie cushion
25. Air piston
26. Hydraulic self-close
27. Close gate slower to avoid bouncing
28. Underground magnet that is pushes gate upward
29. Strong magnet to overcome sagging so that gate self-locks
30. Spring metal arm to compensate for bouncing
31. Control gate motor
32. Propelled air toward gate to slow before latching
33. Legs
34. Flared receiver paired with grabber arm that grabs the gate before it closes and closes softly
35. Flared receiver paired with air bag that inflates to slow the gate before bouncing can occur
36. Ramp track for bottom of the gate to push gate sag upwards
37. Spring rubber arm to compensate for bouncing

38. Sliding receiver paired with leaf spring attached at hinge end to help compensate for sagging
39. Flared, sliding receiver paired with leaf spring attached at hinge end to help compensate for sagging
40. Camera vision to control robotic arm
41. Chameleon tongue actuator to grab and reel in gate
42. Coil spring to stop the gate from bouncing off post
43. Flared receiver paired with strong magnet to overcome sagging so that gate self-locks
44. Sliding receiver paired with jack under gate that stops the gate from sagging
45. Birds holding on to gate
46. Parachute
47. Wheels on bottom to support gate
48. Leg that drags on ground that extends to correct length once closed
49. Linear actuator
50. Flared receiver paired with sliding receiver that adjusts to the height of the lock
51. Flared receiver paired with ratcheted receiver that the lock pushes up or down to the correct position
52. Sliding receiver paired with strong magnet to overcome sagging so that gate self-locks
53. Flared, sliding receiver paired with ratcheted receiver that the lock pushes up or down to the correct position
54. Flared, sliding receiver paired with grabber arm that grabs the gate before it closes and closes softly

55. Flared, sliding receiver paired with air bag that inflates to slow the gate before bouncing can occur
56. Flared, sliding receiver paired with strong magnet to overcome sagging so that gate self-locks
57. Mechanic system with arms that catches gate as it closes and goes into a certain position
58. Automated turnbuckle (has control to turn it)
59. Pulley system incorporated into the ghost lock system that holds up gate
60. Jet engine to force the gate closed paired with wheels on bottom of gate to keep from sagging
61. Leaf spring attached at hinge end to help compensate for sagging
62. Flared receiver paired with leaf spring attached at hinge end to help compensate for sagging
63. Linkage and slider lifting mechanism that is actuated by the motion of the incoming gate
64. Hook that follows cam-shaped motion and captures gate
65. Jet engine to force the gate closed paired with spring metal arm to compensate for bouncing
66. Jet engine to force the gate closed paired with grabber arm that grabs the gate before it closes and closes softly
67. Hook system that captures and lifts gate along with a magnet system to support the gate from sagging
68. Large airfoil along top of gate to generate lift as the gate is closing
69. Leaf spring on post to stop gate from bouncing

70. Leaf spring on lock to stop gate from bouncing
71. Leaf spring on bottom of gate with wheel to stop vertical bouncing and sagging
72. Robotic arm that detects gate position and velocity and stabilizes and closes incoming gate
73. Sliding soft close mechanism like drawer soft close
74. Gate latch made using material with large thermal expansion, so that it can be heated to expend and accept gate, and cooled to hold gate securely
75. Double wishbone style shock absorbing closing arm
76. Implement mini drones to power on and rise to a certain height once gate is opening and closing to not sag throughout
77. Hydraulic lift to relieve gate weight once it is closed
78. Ramp at end of gate path with rollers to guide gate to close position
79. Threaded rod spun using dc motor to move in and out and bring gate in
80. 1 DOF (up and down) support with wheels
81. Ramp at end of gate paired with a flared receiver to guide gate into latch
82. Ramp at end of gate paired with pile of biomass to stop gate from bouncing
83. Ramp at end of gate paired with whoopie cushion to stop from bouncing and alert when gate is closed
84. Spring door stop with rubber end to slow gate before closing
85. Rack and pinion with torsional spring
86. Rack and pinion with dc motor control
87. Powered lever with hook that lifts to support gate and hold gate closed

88. 2017 BMW X5 soft close system with logos and vin numbers scratched off for copyright purposes
89. Jayson's car's leaf springs recycled to be used to compensate for gate sag
90. Robotic legs that walk the gate closed
91. Magnet on underground track that repels the bottom of the gate to prevent sagging
92. Redesign latch to have gate decelerate with friction while closing
93. Strong magnet to overcome sagging so that gate self-locks paired with extendable leg as backup for sag
94. Dr. Clark's one-legged hopping robot brings gate in slowly
95. Ramp at end of gate paired with rubber chicken to stop from bouncing and alert when gate is closed
96. REX legged robot guides the bottom of the gate in
97. Microgravity teams project but reversed so negative gravity to support gate weight
98. Tungsten Steel gate so that gate does not sag
99. Electromagnet ramp system with PID control that pulls gate up to latch
100. Inflatable balloon with air pump that can increase and decrease in pressure and size to close the gate softly

References

There are no sources in the current document.