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Team 09: Sprag Clutch Addition to Reciprocating Lever Transmission

Daniel T. Dudley;Samuel E. Grambling;Iain C. Marsh;Grant T. Parker;Angela N. Trent

FAMU-FSU College of Engineering 2525 Pottsdamer St. Tallahassee, FL. 32310

Abstract

The project goal is to improve bicycle transportation with a Reciprocating Lever Transmission (RLT) designed by our sponsor Gordon Hansen. The RLT replaces the traditional pedals on a bicycle with crank arms that move in a vertical direction as opposed to a rotational motion. Our main goal is to design and build a new, working model that will increase the power created by a minimum of 10 percent when compared to a traditional bicycle. The RLT advances include the addition of sprag clutches and slight changes to the previous design. Sprag clutches are rotational clutches that are driven in one direction. They transmit forces made by the crank arms to the driveshaft. The added clutches and the change in pedal arm length from seven inches to fourteen inches allow for easier pedaling up an inclined plane, less stress on rider's joints, and overall ease of transportation. To include the sprag clutches, we are creating computer models of special bevel gears to hold the clutches. Other goals of the team include designing the RLT for ease of maintenance, compactness, and a lightweight design.

Acknowledgement

These remarks thank 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.

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Notation

AICP	American Institute of Certified Planners
AP	Average Power
NP	Normalized Powed
RLT	Reciprocating Lever Transmission
	Remember to delete all borders

Chapter One: EML 4551C

1.1 Project Scope

Project Description

To make the addition of sprag clutches to a reciprocating lever transmission, and improve power generation in an everyday bike.

Key Goals

Key goals for this project are to gain a power advantage of at least 10% over a normal bicycle with the addition of the sprag clutches which will lead a more efficient means of transportation over a normal bike. The gain in power and reciprocating lever transmission will reduce the amount of strain on a person's joints and make this bike a greener alternative to cars for people as a means of transportation.

Market

Anyone looking for a more efficient way of riding a bike, or looking for an easier means of transportation. A secondary market would be any bike enthusiasts, exercise equipment, or for other human powered vehicles.

Assumptions

For this project, the team will need to assume that a normal bike frame will work for this design to test the project. The team will also need to assume no complications will arise with the addition of the sprag clutches to the reciprocating lever transmission, or in the ability to obtain to obtain sprag clutches from the very few manufacturers. Since the vertical motion of the pedals is different from a normal bike, the group will need to assume that the new motion is easy to learn and that no complications will arise.

Stake Holders

Gordon Hansen, the sponsor of the project. Gordon has invested years of his time and money to see this idea come to fruition. Professor McConomy is invested in our team's success as our professor. All the individual members of the group have stake in the success or failure of this project, as it can determine whether the members of the group graduate. Any user of the bike who are expecting an easier means of pedaling over a conventional bike.

1.2 Customer Needs

Gordon Hansen, AICP is currently studying long crank bicycle powertrain design, and investing strategies that facilitate neighborhood diversity. Gordon's current interests follow four decades of private and public sector professional experience in land-use planning and design. Gordon was issued United States Patent US8763481 on July 1, 2014, for a Reciprocating Lever Transmission utilizing one-way sprag clutches. The Reciprocating Lever Transmission allows much longer crank arms to be used in order to increase the available torque without increasing the rider's effort. The potential increase in power would primarily be used for climbing hills with less effort, and potential increases in speed would be primarily useful for demonstrating the increase in power available from the long crank arms used with a Reciprocating Lever Transmission. The previous two FAMU-FSU College of Engineering Senior Design Teams chose to use ratchet and pawl one-way clutch mechanisms rather than sprag clutches as identified in the patent. Gordon believes the one-way ratchet and pawl mechanisms used by the previous teams are less reliable than one-way sprag clutches - and that the relatively small diameter axles used by the previous teams may have contributed to multiple component failures. Gordon anticipates that utilizing 14” long reciprocating crank arms and sprag clutches will result in a minimum of a 10% power increase, and reduce knee and hip stresses when compared to conventional 7” long crank arms.

Using the specifications described by our sponsor, we will focus on 14-inch long crank arms that will transmit power to the output shaft using sprag clutches.

1.3 Functional Decomposition

The addition of sprag clutches to the reciprocating lever transmission of a bicycle must provide several functions that enable the transmission to operate as needed by the customer. The pedals must transmit power to the output shaft by use of the sprag clutches. The sprag clutches must allow the bicycle to coast when pedaling input has stopped. The pedals are not to move if there is no input force applied to them. Another function of the RLT is while one pedal is forced down, the other pedal must be returned to its position closest to the ride at the same angular velocity as the pedal moving away. The RLT must have the ability to adjust the neutral position; The neutral position is the angle of the RLT on the bicycle that both pedals are parallel to each other. This should be adjustable to provide ergonomic motion for riders of different sizes. The RLT must allow for the bicycle to be rolled backwards without interference from the one-way drivable sprag clutches. The RLT must provide support for interchangeable derailleurs to accommodate the rider’s preference. The final function of the RLT is that it must limit pedal travel from contacting the ground.

1.4 Target Summary

Addition of Sprag Clutches

- *Purpose:* The addition of sprag clutches to the RLT design could potentially increase the torque output of the drive train.
- *Design Considerations:* Shaft size, RLT housing dimensions, shear force analysis.
- *Design Plans:* Obtain sprag clutches from distributor and begin sizing them to shafts. Analyze shear force on the shaft with the added sprag clutches.

Improvement in Gear Meshing

- *Purpose:* More effective gear meshing would lengthen the life of the bevel and pinion gears as well as increase the power output of the RLT.
- *Design Considerations:* Gear ratios, safety factors, bearing fittings in RLT housing, stress analysis on gear teeth.
- *Design Plans:* Produce CAD models with new design and run motion tests via CAD software. Design and manufacture new RLT with better gear meshing.

Efficiency Increase by 10%

- *Purpose:* An efficiency increase of 10% would lead to further research and development and potentially a new manufactured product.
- *Design Considerations:* Smooth RLT and sprag clutch interaction.
- *Design Plans:* Test power generation of traditional bicycle drive train designs and the RLT design. Compare power generation between the two and determine the efficiency increase.

Ability of Bike to Roll Backwards

- *Purpose:* More maneuverability will be attractive to customers.
- *Design Considerations:* Wingnut implementation to driveshaft (allows for backward rolling), disengagement of sprag clutch interaction.
- *Design Plans:* Experiment with different ways of disengaging sprag clutch to allow for the bike to roll backwards.

Chain Routing (With Team 20)

- *Purpose:* Develop an interface between Team 20 and Team 09 to route the bike chain from the RLT to the axle of the bike.
- *Design Considerations:* Collaborate with Team 20 on how they plan on routing the bike chain. There should be no interference between the bike chain and function of the bike.
- *Design Plans:* Route the chain in a way that does not interfere with the function of the bike.

Longer Crank Arms

- *Purpose:* Longer crank arms will create a larger moment and lead to more power production.
- *Design Considerations:* Crank arm material, crank arm shape design, shear stress analysis, user compatibility.
- *Design Plans:* Develop CAD models of crank arms, run stress analysis tests via CAD, implement best design.

1.5 Concept Generation

The RLT consists of several systems including the pedal return mechanism, crank arms, output shaft design, reverse mechanism, and pedal travel limiter. For each system, two concepts were generated during team ideation sessions with our sponsor for a total of 10 concepts. Each system is required as part of the design making a total of 30 different design combinations. The systems and concepts explanations can be found in Table 1.

Table 1

Concept Generation – Systems and Concepts

System	**Concept**	**Detail**
System 1 (Pedal Return Mechanism)	Concept 1	RLT with bevel and pinion gears
System 1 (Pedal Return Mechanism)	Concept 2	RLT without bevel and pinion gears
System 2 (Crank Arm)	Concept 1	Linear 10.5-inch arm
System 2 (Crank Arm)	Concept 2	Tapered 14 inch, splined arm
System 3 (Pedal Travel Limiter)	Concept 1	Stop tab
System 3 (Pedal Travel Limiter)	Concept 2	Recessed housing

System 1: Pedal Return Mechanism

The pedal return mechanism is the system that returns the non-driving pedal to the position closest to the rider at the same velocity of the opposite pedal being driven away from the rider.

Concept 1.

With the main focus of our project being the inclusion of sprag clutches to the reciprocating lever transmission (RLT) and being supplied with the previous year's reciprocating lever transmission, we would like to simply add sprag clutches onto the driveshaft of the existing design. The current design uses bevel and pinion gears to facilitate the motion of the crank arms. The drive shaft would be housed within the housing and surrounded by sprag clutches that will transmit the torque from the crank arms.

Concept 2.

In an effort to save weight, bevel gears and pinions can be removed from the housing. The RLT would consist of two independent moving crank arms, a drive shaft, and sprag clutches. Without the gears, the rider will not have to rely on the motion of the pedal moving away from the rider to return the other pedal to the rider. This concept would be useful with the rider wearing shoes that can be attached to clips on the pedals. Any rider that is comfortable with wearing clips and dictating the speed and time at which the pedals return to the nearest position to the rider would benefit from this design. This concept would not be ideal for riders not used to the reciprocating motion or using clips because they would have to time the pedal motion since the gears used to guide crank arm repositioning are missing.

System 2: Crank Arm

The crank arm is the connection between the rider and the RLT. All pedal forces generated by the rider are transmitted to the RLT through the crank arms. It is important to have a strong and reliable design.

Concept 1.

The first concept is the previous year’s 10.5-inch linear profile crank arm. This arm design is connected to the RLT using four bolts and allows for the drive shaft to extend through between the four connection points. There are tabs extending on the inside surface that contact the bevel gears. These were found to be weak and sheared off under enormous stress. This arm design seen in Figure 1 is light and easy to manufacture.

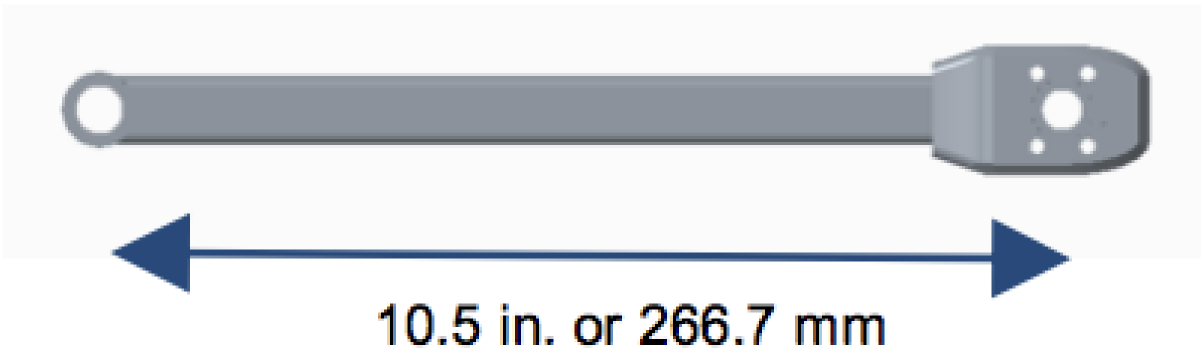


Figure 1. Current 10.5-inch crank arm with linear profile. (Beckford, Khayata, Pustelniac, & Roddenberry, 2017)

Concept 2.

To meet the customer's needs, a 14-inch crank arm design is necessary. The pedal attaches to the RLT using splines. A tapered profile is needed to minimize weight while accommodating holes for pedal attachments and attaching to the RLT with a sleek design. Splining the crank arm is a way that ensures strength and safety when pedaling with high torques caused by the increase in crank arm length. Figure 2 shows the second concept of the crank arm with the tapered design due to the different size holes.

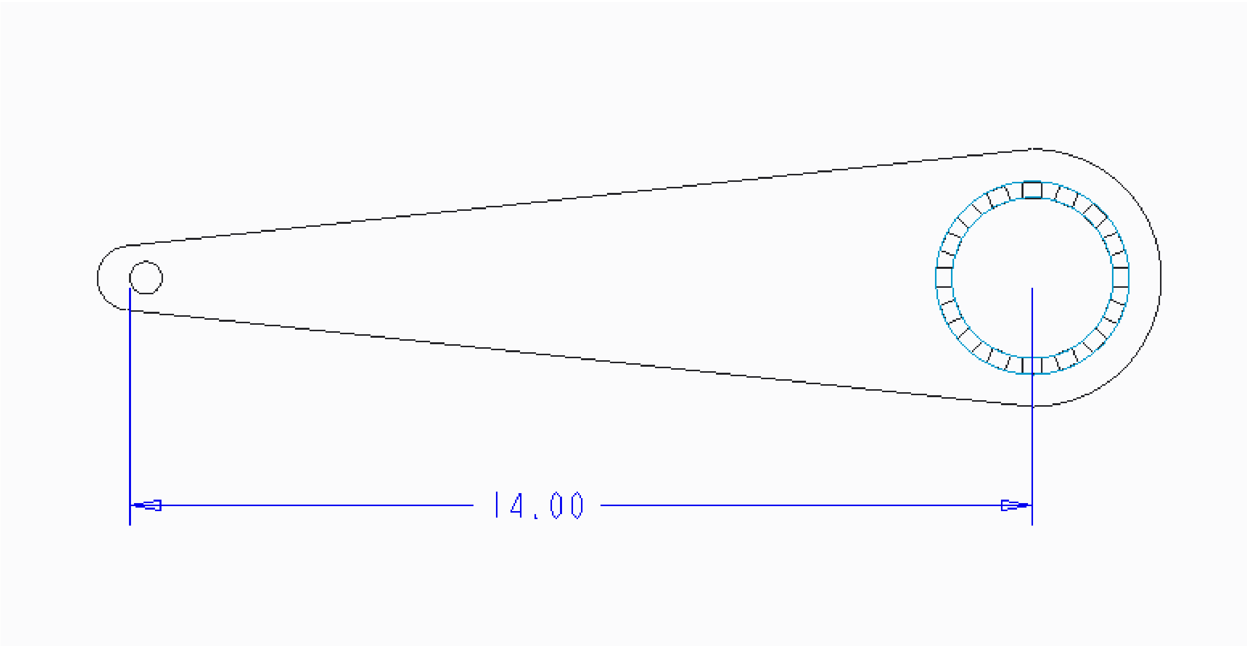


Figure 2. 14-inch crank arm with tapered profile and splined hole to attach to RLT.

System 3: Pedal Travel Limiter

This system limits the angular position the pedals can travel to avoid them from contacting the ground when on a bicycle. Its secondary function is to define a range of motion for the pedals so that the rider does not have to rely on muscle memory to decide when to change the driving pedal.

Concept 1.

The simplest method to limit the motion of the pedals is to create protruding tabs on the housing that the crank arms will contact. These are simple and inexpensive to manufacture; however, a tab on the external shell of the RLT is not aesthetically pleasing and may not be able to hold up to the repeated stress of resisting pedal motion.

Concept 2.

Another method is to recess the housing and provide a prescribed range of motion for the crank arms. This would effectively limit the arm motion while providing a sturdy design.

1.6 Concept Selection

Four concepts for the design of the RLT were generated revolving around two systems. The two systems are the crank arms and the pedal travel limiter. Each of these systems has two concepts that are interchanged to combine for a total of four different design concepts. The omission of gears within the RLT is a violation of the sponsor's patent, thus requiring gears to be included in the final design.

The four concepts are as follows:

1: 14-inch tapered crank arms and protruding tabs (SEE FIGURE 1)

2: 14-inch tapered crank arms and recessed housing (SEE FIGURE 2)

3: 10.5-inch linear crank arms and protruding tabs (SEE FIGURE 3)

4: 10.5-inch linear crank arms and recessed housing (SEE FIGURE 4)

**NOTE: In the below figures, the blue crank arms represent 14-inch crank arms and the red crank arms represent 10.5-inch crank arms.

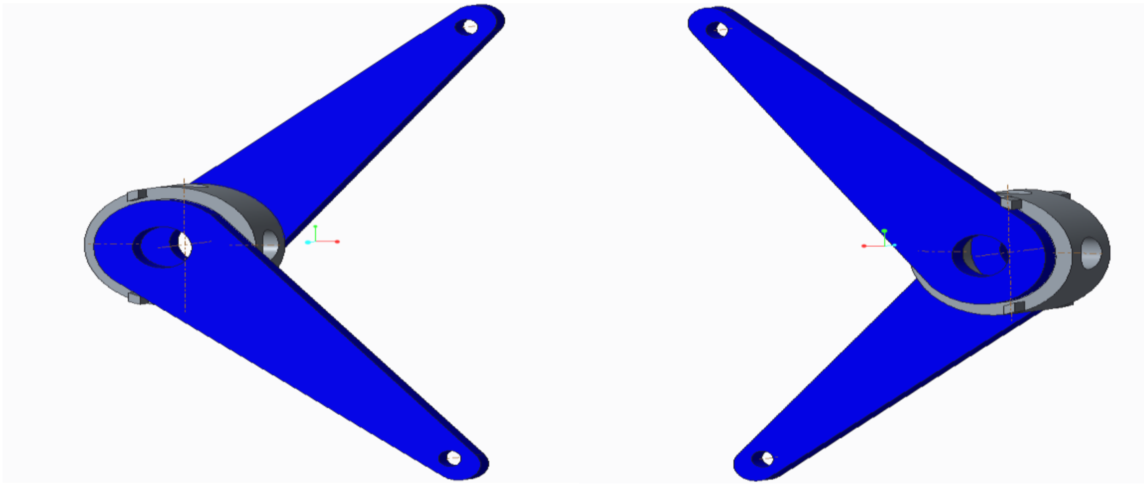


Figure 3. 14-inch Tapered Crank Arms and Protruding Tabs

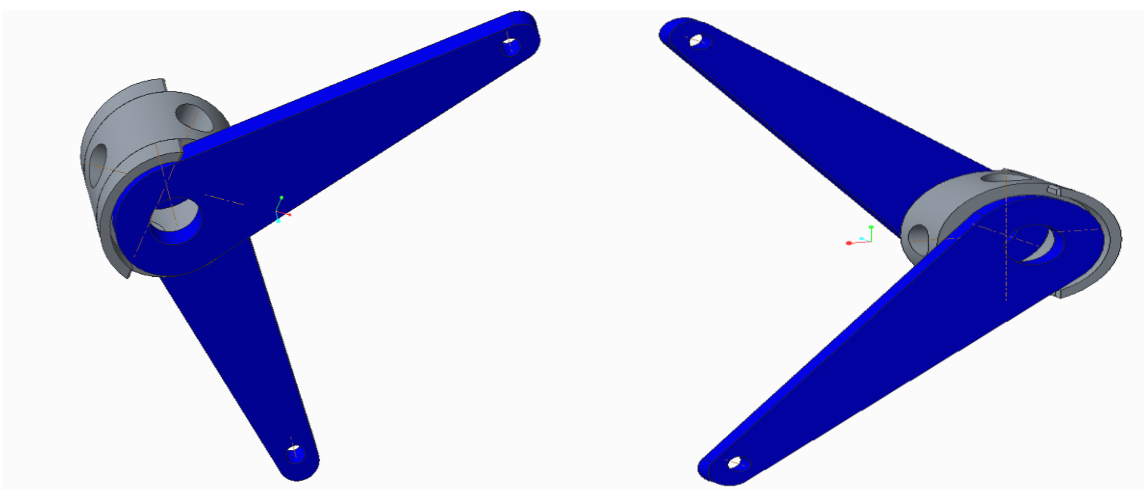


Figure 4. 14-inch Tapered Crank Arms and Recessed Housing.

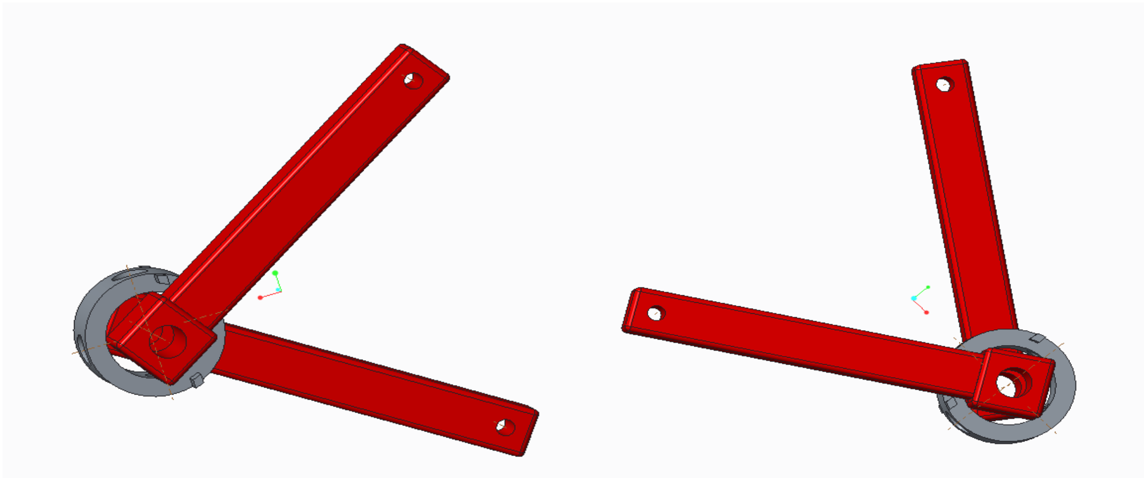


Figure 5. 10.5-inch Linear Crank Arms and Protruding Tabs.

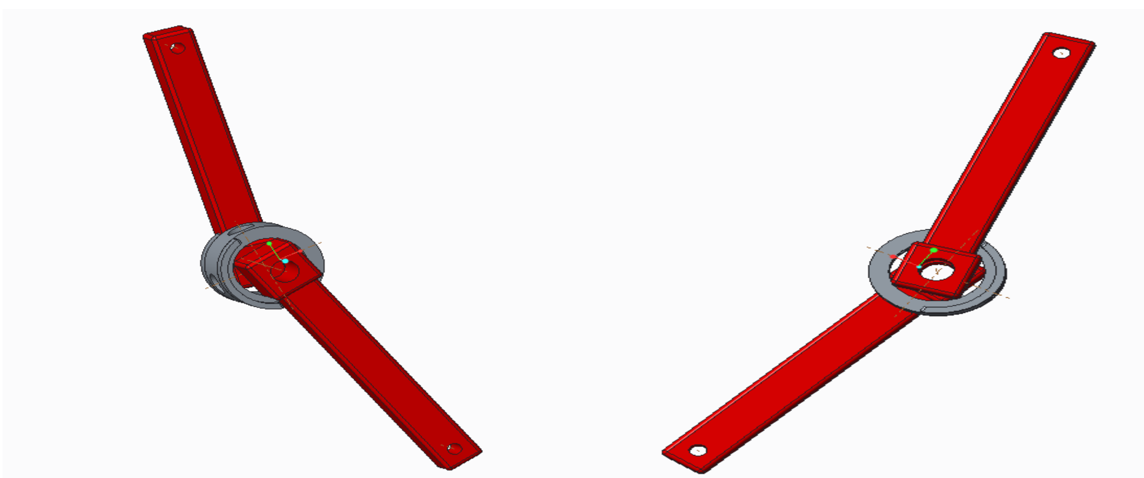


Figure 6. 10.5-inch Linear Crank Arms and Recessed Housing.

Figures 1-4 give 3-D representations of the concepts for the RLT. The protruding tabs as well as the recessed housing are connected to the housing in all of the figures. The housing is grey, as well as the protruding tabs and the recessed housing. As seen, the crank arms are positioned such that they are almost making contact with the protruding tabs and the recessed housing. This gives the representation of the crank arms being in their most extreme position (the position in which the crank arms can no longer move without making contact with the protruding tabs or recessed housing). In figure 4, 10.5-inch linear crank arms and recessed housing, the range of motion is extremely large and would result in an uncomfortable if not impossible pedaling motion.

The concept selection process uses the Pugh Chart. This style of examination compares the design concepts to the datum which is a traditional bicycle. The concepts will be compared through selection criteria such as cost, weight, and ease of service. To decide which concept would be used, each concept underwent scrutiny using different criteria to determine the best choice. The criteria chosen were based off what potential customers would be concerned about when purchasing this product. The Pugh Chart can be seen in the table on the following page.

Table 2
Selection Criteria

		Concepts			
Selection Criteria	**Traditional Bicycle**	**1**	**2**	**3**	**4**
Cost	Datum	-	-	-	-
Weight		-	-	-	-
Power Produced		+	+	S	S

Weather resistance		+	-	+	-
Ease of pedaling		+	+	+	+
Storage volume		S	S	S	S
Ease of service		-	+	-	+
Durability		-	+	-	+
# of Pluses		3	4	2	3
# of Minuses		4	3	4	3

Concept Selection Discussion

The concept used will be concept 2 with 14-inch crank arms and recessed housing. Concept 2 had the greatest number of plusses and the least number of minuses. Some concepts were eliminated since they did not meet the sponsor's requirements. So, while previous teams used 10.5-inch linear crank arms, our sponsor would like 14-inch linear crank arms for additional power and torque. Therefore, concepts 3 and 4 were eliminated from consideration. The remaining concepts (concepts 1 and 2) were evaluated using the Pugh Chart. The two concepts had the same rating in every aspect except three: weather resistance, ease of service, and durability. Concept 1, 14-inch tapered crank arms with protruding tabs, has the advantage in weather resistance since the protruding tabs do not create any openings in the housing that will need to be sealed to keep dirt and water out. However, concept 1 does not have the advantage when it comes to ease of service and durability. The tabs would experience a lot of stress due to the crank arms making contact with them and would likely break consistently. Due to this problem, they would also require maintenance frequently to be fixed or replaced. Concept 2, 14-

inch tapered crank arms and recessed housing, would have some problems with weather resistance but could be sealed to prevent this problem from occurring. The recessed housing will be much more durable since it will be manufactured into the housing and have a lot more strength than just protruding tabs, and therefore much less likely to shear off. Since the probability of them shearing is much lower there would be much less service required. So, based off of the sponsor's requirements of a 14-inch crank arms, and the greater plusses and minuses of the recessed housing in the Pugh Chart, concept 2 was chosen to be the concept moving forward in this project.

The concept of omitting gears in the RLT is a violation of other patents. Therefore, gears are included in concept 2. The concept would have four pinion gears instead of five in the previous design. This would allow for lower cost of the pinion gears and easier manufacturing of the housing. As for the bevel gears, the sponsor requested that the gear teeth be manufactured onto a longer metal cylinder. However, this would increase the cost to manufacture these bevel gears.

1.8 Spring Project Plan

Team 09 will have the Spring of 2018 to complete the sprag clutch addition to the reciprocating lever transmission senior design project. The timeline provided will set goals and deadlines for Team 09 to keep the project progressing continually and to ensure it will be completed on time. We anticipate the project to be completed by Monday, April 2, 2018 and given to Team 20 to begin assembling their vehicle which will be used in the ASME Human Powered Vehicle Competition on April 20, 2018. Testing and analysis were given for a total of two weeks to allow extra time for parts to be manufactured and delivered.

Timeline

Mon	Jan 8, 2018	Semester Begins
Fri	Jan 12, 2018	CAD Model Completed
Fri	Jan 19, 2018	FEA Completed
Fri	Jan 26, 2018	Design Refinements Completed
Wed	Jan 31, 2018	Parts Ordered
Mon	Feb 26, 2018	RLT Build Completed
Fri	Mar 2, 2018	Testing Completed
Fri	Mar 9, 2018	Analysis Completed
Sat – Sun	Mar 10 – 18, 2018	Spring Break
Fri	Mar 23, 2018	Design Refinements Completed
Mon	Apr 2, 2018	Project Completed and Delivered to Team 20
Thu	Apr 12, 2018	Engineering Design Day
Fri	Apr 20, 2018	ASME Human Powered Vehicle Competition
Mon – Fri	Apr 30 – May 4, 2018	Final Exam Week
Sat	May 5, 2018	Florida State University Graduation

Chapter Two: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan.

Appendices

Appendix A: Code of Conduct

Mission Statement

Team 9 is committed to ensuring a positive work environment that supports professionalism, integrity, respect, and trust. Every member of this team will contribute a full effort to the creation of maintenance of such an environment in order to bring out the best in all of us as well as this project.

Roles

Each team member is assigned a billet with a specific responsibility that will contribute to the success of the team.

Team Leader – Iain Marsh

Manages the team, delegates tasks, and finalizes decisions. When votes between decisions are even, the team leader will break the tie. The team leader will communicate with the sponsor and the instructor and relay the information to the rest of the group. The team leader is responsible for submitting les to be turned in.

Financial Advisor – Daniel Dudley

Manages the budget and maintains a record of all transactions with the project account. Any product or expenditure requests must be presented to the advisor, whom is responsible for reviewing and the analysis of alternate solutions. Once the request is granted, the team will be notified and the order submitted.

CAD Designer – Grant Parker

Manages progress of up-to-date designs and records ideas for designs. The design engineer is in charge of finalizing the design and ensuring that all components work harmoniously with another.

Web Developer – Angela Trent

Maintains web development and provides assistance to team members when applicable or necessary.

Quality Engineer – Samuel Grambling

Ensures all documents are grammatically and factually correct before being submitted. Creates a log of all successes and failures to be integrated into designing the ideal design.

All Team Members

- Respect other's opinions and tasks
- Be professional to the team and outside world
- Complete assigned tasks prior to the deadlines
- Communicate effectively and efficiently
- Commit to every responsibility

Communication

The main form of communication will be conducted over GroupMe among the group and through team meetings. Emails will be used to easily send files and data amongst each other and allow for the forwarding and transfer of necessary information.

Each member must have a working electronic device that can access the social-messaging application GroupMe allowing for an ease of communication among the group. At short notice meetings will be notified through GroupMe. Members will be informed about planned meetings, important information, presentations, and deadlines through email. Meeting cancellations must be sent through email with at least 24 hours in advance. Within 24 hours, notices will be sent through GroupMe.

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 of taken seriously, that member must bring it to the attention of the 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 will be respectful and courteous to the client, the employer, the public, and every group member. In addition, each team member is to follow the NSPE Engineering Code of Ethics.

Dress Code

Team meetings will be held in casual attire. Presentations and sponsor meetings will be business casual to formal as decided by the team per the event.

Weekly and Biweekly Tasks

Team members will conduct meetings with the sponsor, advisor, and instructor as necessary. During these times, project ideas, progress, budget concerns and timelines will be discussed. Meetings may be scheduled on Tuesday and Thursday between the times 12:30 and 14:00 hours. Emergency meetings may be held on Tuesday and Thursday evenings immediately after Senior Design class. Repeated absences will not be tolerated.

Decision Making

It 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 date 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.

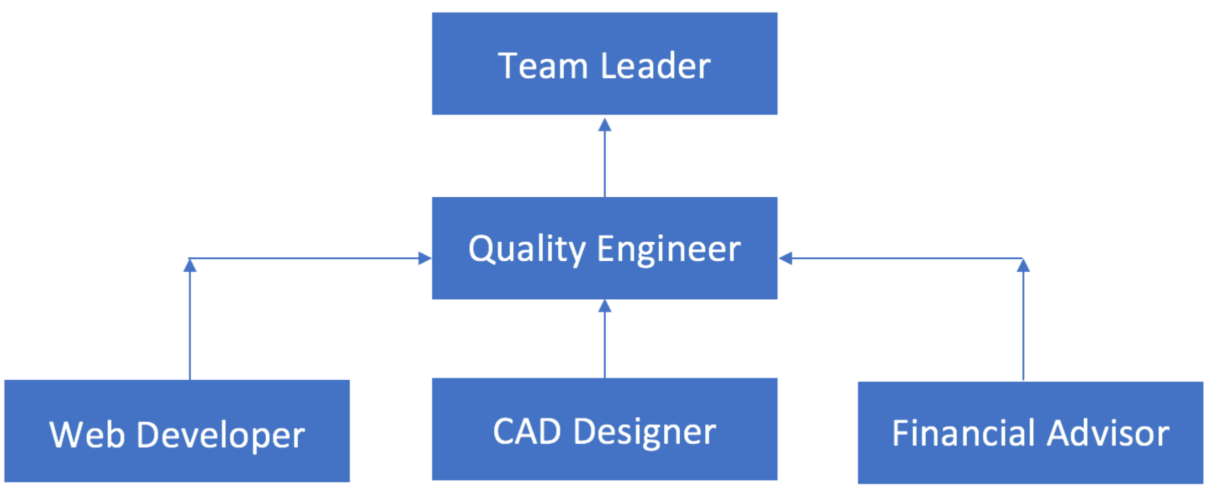
Code of Conduct Amendment Process

Concerns regarding the amendment may be brought forward at a meeting. It must be read and understood by each member before suggestions to the amendment may be submitted. When finalized, the amendment must be typed and signed by every member before its addition to the code of conduct.

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 tools acknowledging clear understanding.
- Administration of a vote, if needed, favoring majority rule.
- Team leader intervention.
- Instructor will facilitate the resolution of conflicts.



Statement of Understanding

By signing this document, the members of Team 10 agree to all of the terms above and abide to the Code of Conduct set forth by the Team.

Name	Signature	Date
S. Evan Grambling	[signature]	9/21/17
DANIEL DUDLEY	[signature]	9/21/17
Grant Parker	[signature]	9/21/17
IAIN MARSH	[signature]	9/21/17
Angela Trent	[signature]	9/21/17

Appendix B: Functional Decomposition

The addition of sprag clutches to the reciprocating lever transmission of a bicycle must provide several functions that enable the transmission to operate as needed by the customer. The pedals must transmit power to the output shaft by use of the sprag clutches. The sprag clutches must allow the bicycle to coast when pedaling input has stopped. The pedals are not to move if there is no input force applied to them. Another function of the RLT is while one pedal is forced down, the other pedal must be returned to its position closest to the rider at the same angular velocity as the pedal moving away. The RLT must have the ability to adjust the neutral position; The neutral position is the angle of the RLT on the bicycle that both pedals are parallel to each other. This should be adjustable to provide ergonomic motion for riders of different sizes. The RLT must allow for the bicycle to be rolled backwards without interference from the one-way drivable sprag clutches. The RLT must provide support for interchangeable derailleurs to accommodate the rider’s preference. The final function of the RLT is that it must limit pedal travel from contacting the ground.

Appendix C: Target Catalog

Metric	**Yes**	**No**
Transmit Power from Crank Arms to Output Shaft via Sprag Clutches	X	
Increase Efficiency	X	
Limit Pedal Travel from Contacting Ground	X	

Sub-system Metrics	**Targets**
Sprag Clutches	US $300
Shafts	US $100
Crank Arms	2 kg
Housing	4 kg
Number of Sprag Clutches	8
Number of Bevel Gears	2
Number of Pinion Gears	4
Number of Crank Arms	2
Power (50 RPM – 70 RPM)	110 W
Pedal Force (50 RPM – 70 RPM)	200 N
Crank Arm Length	355.6 mm
Output Shaft Diameter	25.4 mm
Cadence	60 RPM

Appendix A: APA Headings (delete before website)

Heading 1 is Centered, Boldface, Uppercase and Lowercase Heading

Heading 2 is Flush Left, Boldface, Uppercase and Lowercase Heading

Heading 3 is indented, boldface lowercase paragraph heading ending with a period.

Heading 4 is indented, boldface, italicized, lowercase paragraph heading ending with a period.

Heading 5 is indented, italicized, lowercase paragraph heading ending with a period.

See publication manual of the American Psychological Association page 62

Appendix B Figures and Tables (delete)

The text above the cation always introduces the reference material such as a figure or table. You should never show reference material then present the discussion. You can split the discussion around the reference material, but you should always introduce the reference material in your text first then show the information. If you look at the Figure 7 below the caption has a period after the figure number and is left justified whereas the figure itself is centered.

Figure 7. Flush left, normal font settings, sentence case, and ends with a period.

In addition, table captions are placed above the table and have a return after the table number. The second line of the caption provided the description. Note, there is a difference between a return and enter. A return is accomplished with the shortcut key shift + enter. Last, unlike the caption for a figure, a table caption does not end with a period, nor is there a period after the table number.

Table 2
The Word Table and the Table Number are Normal Font and Flush Left. The Caption is Flush Left, Italicized, Uppercase and Lowercase

Level of heading	Format
1	**Centered, Boldface, Uppercase and Lowercase Heading**
2	**Flush Left, Boldface, Uppercase and Lowercase**
3	***Indented, boldface lowercase paragraph heading ending with a period***
4	***Indented, boldface, italicized, lowercase paragraph heading ending with a period.***
5	*Indented, italicized, lowercase paragraph heading ending with a period.*

References

[1] Beckford, D., Khayata, N., Pustelniac, A., & Roddenberry, M. (2017). *HANS Cycle - Reciprocating Lever Transmission.* Retrieved from https://www.eng.famu.fsu.edu/me/senior_design/2017/team08/Final_Poster.pdf