Project Title

Project Plan

Team 15

Client: Max Balzer

Adviser: Mani Mina

Bret Tomoson

Max Balzer

Grant Larson

Brett Nelson

Mark Fowler

Zachee Saleng

sdmay19-15@iastate.edu

sdmay19-15.sd.ece.iastate.edu

Table of Contents

List of Figures

Include a **LIST** of all figures used. Be sure images throughout paper have same indexing.

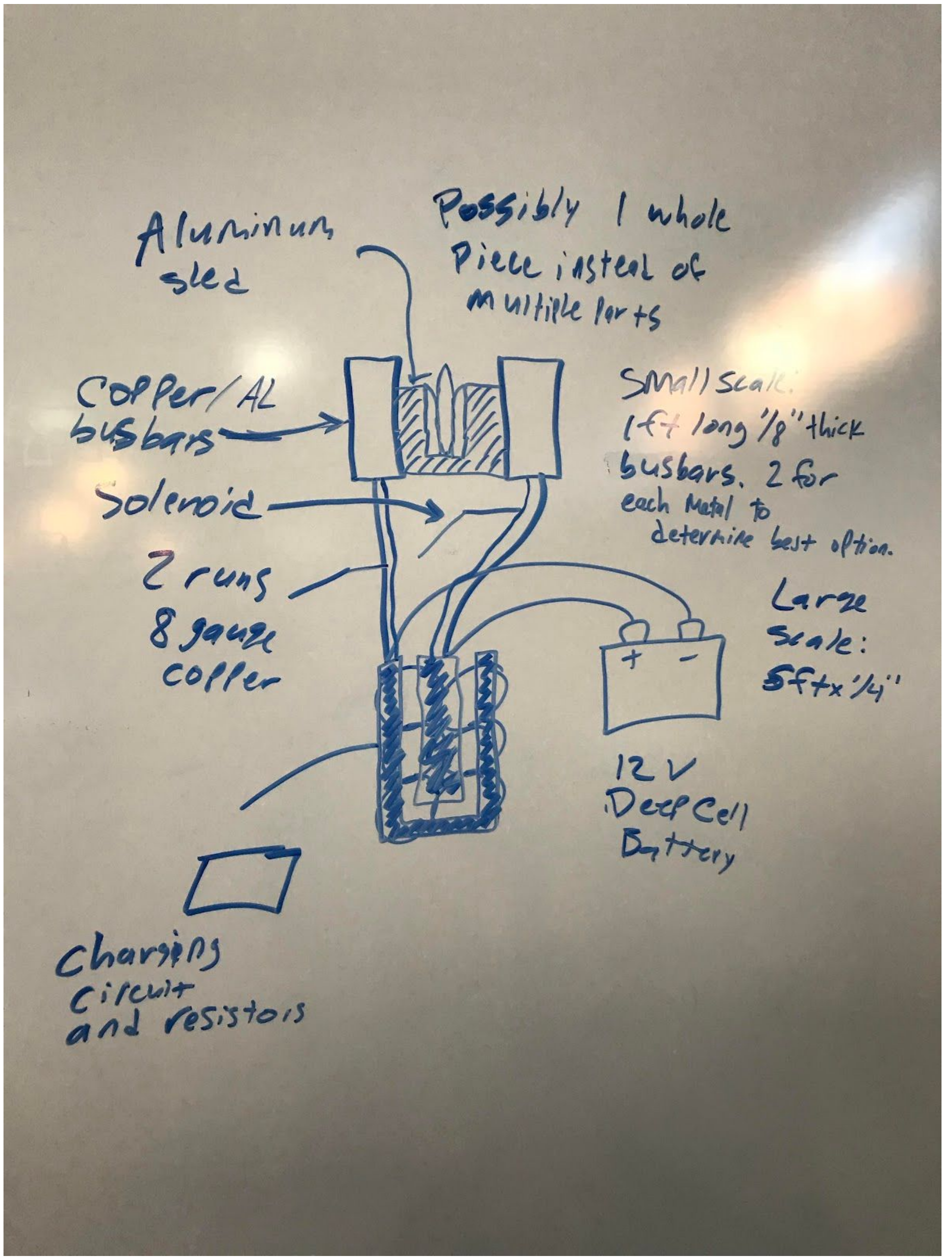


Figure 1: Overall design for small and large scale project with proposed materials.

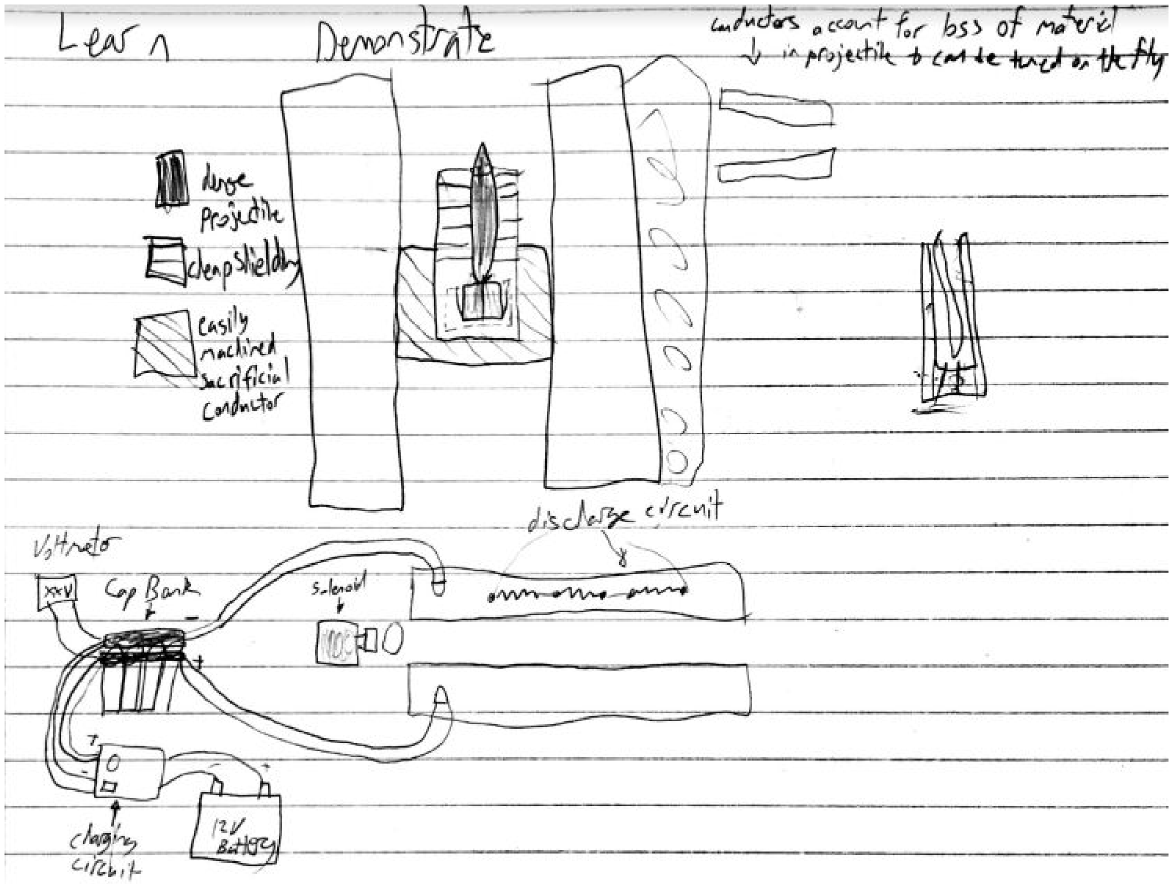


Figure 2: Projectile Early Model with General Layout

List of Tables

ex. Table 1: Timeline of proposed work schedules for the Spring semester.

- Near the end of the Fall semester we will have a small scale demo project to test materials for degradation and best overall design for projectile and project.
- By the end of the Fall semester we will have the large scale project based upon our demo project
- By the end of the Spring semester we will have the overall project finished. This will include the project from the Fall semester with our motors and hydraulics added.

List of Symbols

List of Definitions

Please include any definitions and/or acronyms the readers would like to know.
example: ASA: American Standards Association

NOTE: This template is a work in progress. When in doubt, please consult the project plan assignment document and associated grading rubric.

1 Introductory Material

1.1 Acknowledgement

The Rail Gun Project team would like to thank Iowa State University and the Professors of the College of Engineering for their help and support through this process. Also, thank you to Professor Mani Mina for his mentorship and sharing of expertise in magnetics.

If a client, an organization, or an individual has contributed or will contribute significant assistance in the form of technical advice, equipment, financial aid, etc, an acknowledgement of this contribution shall be included in a separate section of the project plan.

1.2 Problem Statement (2 paragraphs+)

Currently, the only option for how firearms (projectile launchers) shoot objects is combustion. While this method is proven and effective, there is a power limit to combustion and also a lack of precision at high speeds due to the lower energy. Railguns have the ability to power projectiles of greater mass at a much higher velocity due to the concentration of energy that is possible with EM propulsion.

At a large scale, rail guns can fire at a speed three times that of standard ammunition rounds. Our goal is to see if it is practical and possible to do the same on a smaller scale.

– This is included so that the reader will have the correct conception of the problem and the solution approach upfront. Each shall be written in a non-technical manner that a lay person would understand.
– Consists of two components, each separated and clearly identified:

-General problem statement – defines the general problem area
-General solution approach – defines the proposed solution approach
-This section should also highlight the purpose of the project, what you are trying to do.

1.3 Operating Environment (one paragraph +)

Our end design will be operated in the outdoors so it must be able to withstand different weather conditions. The rail gun will be encased in a water-resistant material to keep the components dry and easily portable for quick relocations.

– For any end product other than simply a calculation or simulation, it is essential to know the environment in which the end product will be used or to which it is expected to be exposed or experience. For example, will the end product be exposed to dusty conditions, extreme temperatures, or rain or other weather elements?
– This information is necessary in order to design an end product that can withstand the hazards that it is expected to encounter.

1.4 Intended Users and Intended Uses (two paragraph +)

Our team intends our product to be used by the military and not the public. Our project is a weapon that is dangerous to those who are not experienced with the functionality and design. This is why it is not intended for the public use, only military and those with knowledge on the project design and safety measures.

Our project will be a scaled model of what the military uses. Possible uses for our rail guns include replacing turrets and artillery cannons with this technology. This will improve our technology in weapon systems used to protect our nation.

– To properly design an end product that will provide the maximum satisfaction and perform in the most efficient manner, it is essential to understand the end user and the associated end uses.

1.5 Assumptions and Limitations

Assumptions:

1. The military needs/wants new technology
2. The difference between magnetic and combustion projection is great enough to warrant investment
3. Rail guns can be just as accurate as current technology

Limitations:

1. The cost of this project may be too high for certain applications

2. Rail guns at this stage are single-shot devices
3. The rail gun will need a cool-down and recharge period between shots
4. The heat release may be too high for hand-held usage

– Two separate lists, with a short justification as needed.
– Extremely important, as it can be one of the primary places where the client can go to determine if the end product will meet their needs.
– Examples of assumptions: The maximum number of simultaneous users/customers will be ten; Blue is the best background color and will be used; The end product will not be used outside the United States.
– Example of limitations: The end product shall be no larger than 5”x8”x3” (client requirement); The cost to produce the end product shall not exceed one hundred dollars (a market survey result); The system must operate at 120 or 220 volts and 50 or 60 Hertz (the most common household voltages worldwide).
– For limitations, include tests not performed, classes of users not included, budget/schedule limitations, geographical constraints, etc.

1.6 Expected End Product and Other Deliverables

List the end product and any other items, along with a brief description, that will be delivered to the client prior to the end of the project.
– If the end product is to be commercialized, the description shall be of the commercialized end product.
– It shall be in the form of a technical product announcement, as opposed to a product advertisement, and shall not include a list of technical specifications.
– Any other items that will be delivered to the client shall also be included and described unless their definition and description are obvious.
– Examples might include a household power supply to eliminate the need for batteries, a user’s manual, or other project reports.
– There shall be at least a one-paragraph description for each item to be delivered.
– Delivery dates shall also be specified.

By the end of the Fall semester, the final project will be a functional weapon system. It will use electromagnetics to fire a projectile with the use of capacitors and a 12V battery. The deliverables will include a capacitor bank, battery, metal rails, solenoid, wires, and conductive projectile.

The capacitor bank will consist of 10 450V capacitors connected using aluminum. The use for the capacitor bank is to store current in the form of energy used to charge the metal rails to induce the electromagnetic field.

The battery will be used to charge the capacitor bank. The battery is where the whole project starts. It will charge the capacitors to our specified voltage in order to create the means to fire the projectile.

The metal rails are used to carry current in order to create the electromagnetic field. The rails must be conductive because the electromagnetic field is created by a current running through a conductive metal.

The solenoid is used for the initial push of our projectile into the electromagnetic field. With a capacitor gun, the projectile must have an initial velocity when entering the electromagnetic field. This is because of the high currents and the force emitted by the field. If the projectile had no velocity when it entered the field, such as being set down, it would melt in place.

Wires will be used to carry current from the capacitor bank to the rails. These wires must be able to handle high amounts of current, which is why we decided to use 2 runs of 8 gauge wire. These are a vital part to the design because without them, it would be difficult to transfer the current to the rails.

Lastly, the projectile is what makes this a weapon. The projectile must be conductive so that it can experience force by the electromagnetic field. The projectile will enter the field and experience what is known as the Lorentz force. This is created by the current and magnetic field and is what will give the projectile its final velocity when it travels from the beginning to the end of the field.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

Describe the goal of the task. Depending on the type of project, the resultant end product can vary significantly:
– An actual hardware/software product – The design of a product
– A process to accomplish something
– A service to be performed
– A simulation or a set of calculations – Some combination of the above

The end goal of this project is a working railgun that has been designed to the clients specifications.

2.2 Functional Requirements

List and explain the functional requirements of the project. This would include all the technical requirements you fulfil during your senior design project.

- Shoot projectile
  - The requirement is that the project effectively shoots the projectile a minimum of 100ft
- Multiple rounds
  - Must be able to fire multiple shots in a reasonable time
  - Rails must be able to withstand multiple shots before needing changed
- Muzzle Energy
  - The muzzle energy of the railgun should show that with our design and sufficient funding, an EM propulsion device can be of similar power to chemical propulsion.

2.3 Constraints Considerations

List and explain the constraints and non-functional requirements of the project. This is where you would enlist non-technical requirements. This may still be a fundamental deliverable that your client needs at the end of the semester.
Discuss the **standard** protocols that you follow in your lab or for writing code. Are these approved by standard organizations like IEEE, ABET etc. Will any of your practices be considered unethical by such organizations? Discuss how standards are applicable to your project.

Safety
The design of the railgun should be in a way that the end-user could follow general firearm safety guidelines with extended caution for enclosed electrical components. Training for safe operation would only be needed to highlight electrical hazards and also safety when charging and loading the device.
Operability
The device should be able to be reloaded serviced and transported with a team of 2-3 people. Sustained fire should be possible with the use of replacement rails when needed.
Durability
The device should be able to withstand calm outdoor weather while operating. The device should be able to dissipate heat in a time faster than it takes to reload and recharge. The rails should be able to handle repeated fire with a change of rails after no less than 10 shots with a goal of over 50.

2.4 Previous Work And Literature

Include relevant background/literature review for the project
– If similar products exist in the market, describe what has already been done
– If you are following previous work, cite that and discuss the **advantages/shortcomings**
– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available
Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Currently there are three main categories of railguns that have been created before: small physics demonstrations, hobbyist creations, military weapons. The small physics demonstrations are usually seen in youtube videos or classrooms that want to demonstrate the principles of EM motion through a physical device. These devices generally have enough power to move a small projectile a few feet across a classroom at most and are in an open package to demonstrate the different components required. The hobbyist creations are generally in a package size similar to the budget and knowledge of the creator and are used as a fun projectile shooter. These devices are generally designed to shoot a marble to playing card sized object across a yard or about 50ft. This distance is generally limited to the ballistics of the projectile and the power outputted by the capacitors. Finally, the military railguns that have been created are very large and are designed to replace mobile missile defense systems. These systems operate in the 3-32MJ range and have a footprint that is meant to be on a trailer pulled by a semi or similar sized truck.

Our design is going to focus in th kJ range of power and be useful as a more durable and accurate hobbyist sized railgun. The focus of our project with the limited budget we have is to produce a design that can cost the same as a hobbyist railgun but have the trajectory and ballistics closer to firearms.

2.5 Proposed Design

Discuss possible solutions and design alternatives.

The solutions would include a fully electronic capacitor gun. Previously built projects use software and air compression to provide the initial velocity into the magnetic field. Our team's design includes a solenoid to be used for the initial push. The solenoid gives a quick and powerful push, therefore we think it will work. We do have a few design alternatives based on materials and size of our rails and projectile. With the rails, we are going to test whether aluminum or copper is best to use and use the other material for the sled. This way we can determine which pair of materials is best to prevent the most degradation of the rails due to the heat and friction of firing. Also, we are going to test alternatives to the design of our projectile. Our initial thought is to make it like a sled. It will be in the design of a U shape so that we can place any material inside of the sled. That way the projectile does not have to be conductive throughout. This gives more options for projectile materials. The other alternative to the projectile is to use one piece of conductive metal which will be cut and shaped to a specific design to minimize air resistance and velocity losses. The single body design will be more expensive to manufacture but easier to design and potentially lighter.

2.6 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.
Discuss possible solutions and design alternatives.

The strengths to our product are its superior firepower compared to standard combustion. With the potential to be farther away from harm we could have more of our soldiers return home from combat. The power created from the magnetic fields is also more powerful than standard ammunition so better “results” are expected.

Potential weaknesses for our design are that the rate of fire is not automatic. After each shot the rail gun would need to be cooled and recharged. Because of the large amount of current being created the rail gun will release lots of heat which could be hazardous if being held by someone. Therefore, this device would need to be placed down before usage.

Possible solutions to the heat problem can be as easy as having a more conductive and heat-resistant metal like titanium. Unfortunately, we will not be able to use titanium because of its cost and our limited project budget. A more advanced coolant system could also be designed, but that also runs into a cost issue and increases the design complexity and likely failure rate.

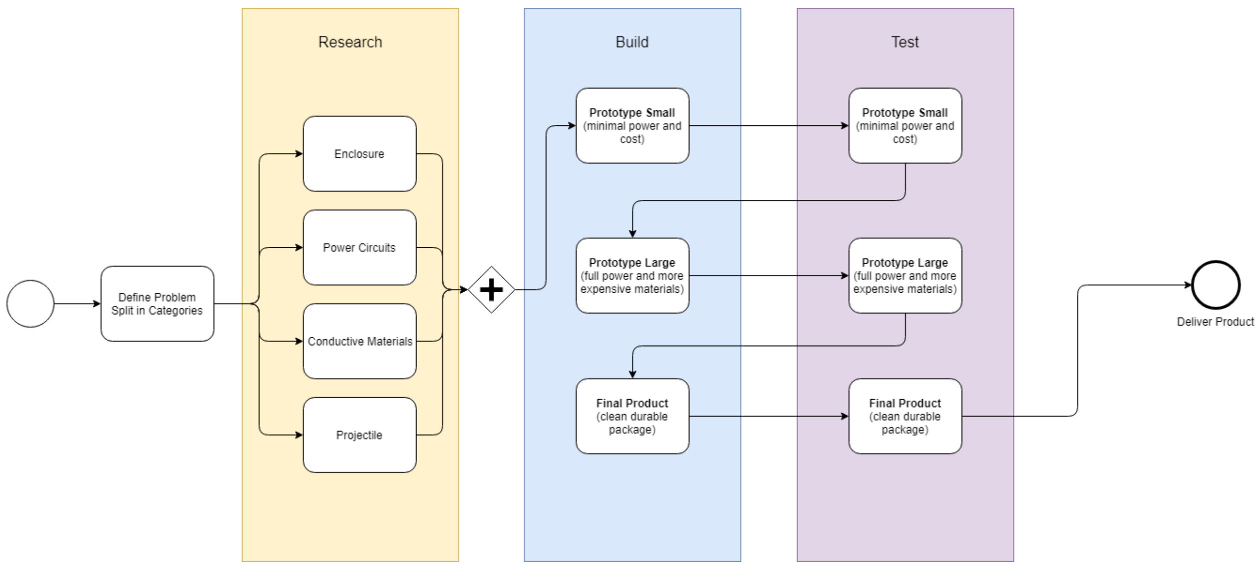
2.7 Safety Considerations

Include any safety concerns you find applicable to you project.

Concerns we have right now are users carelessness, heat release, and high voltages. This railgun is a serious piece of equipment and must be used only after proper training. The operator must stay away from the muzzle at all times and wear eye and ear protection similar to a standard firearm. The user must also be wearing heat-resistant gloves and refrain from touching the rails until cool. In addition to heat, the risk of electric shock is possible if the rails are charged before reloading the device. This will be prevented by a safety mechanism that will discharge the rails if the breach is open and there is access to the rails.

2.8 Task Approach

Describe any possible methods and/or solutions for approaching the project at hand. You may want to include diagrams such as flowcharts to, block diagrams, or other types to visualize these concepts.



2.9 Possible Risks And Risk Management

Include any concerns or details that may slow or hinder your plan as it is now. These may include anything to do with costs, materials, equipment, knowledge of area, accuracy issues, etc.

This project will require a variety of issues to overcome such as machining and testing of our product. We have reached out to friends and family to utilize machine shops and will be reaching out to labs on campus to utilize their tools to machine the various parts of our project. Getting permission to use the labs or getting the labs to machine the parts for us will be something we will look into.

The costs of the material will also be a factor that we will have to work around, we have already changed the scope of the project based on our projected budget. Capacitors are the part that will eat up the biggest chunk of our project, and if our rails do not hold up to repeated fire well then those will need to be replaced.

Setting up an area that will be safe to test the railgun is something else we have discussed. For the small version we may use aluminum foil to shoot but for the final scale version we will probably use a gun range to safely test our railgun.

2.10 Project Proposed Milestones and Evaluation Criteria

What are some key milestones in your proposed project? What tests will your group perform to confirm it works?
At the end of this semester we want to have a fireable railgun, whether that is just our small scale test version or our larger scale one we have not determined yet. In the next week or two we plan on purchasing material for the small scale version and machining the material soon after and to hopefully test it soon after that. Next semester we will work quickly to get the final railgun fireable and hopefully work to add other functionality to the whole apparatus.

2.11 Project Tracking Procedures

What will your group use to track progress throughout the course of this and next semester?

It is our goal that by the end of the fall semester we have a small-scale design ready to test. From these tests we expect to gather data on heat release, current, voltage, and magnetic field strength, and projectile velocity. This data will be used to better help us perfect the design when me move to a larger model.

For the spring semester we expect to have a final, physical product that has been tested. This is hoped to be functional and semi-practical.

Our progress will be tracked mainly through physical data and design work that we have gathered and completed.

2.12 Expected Results and Validation

What is the desired outcome?

The desired outcome for this project is to show that a electromagnetically propelled projectile can compete with a similarly sized conventional firearm using chemical propulsion.

How will you confirm that your solutions work at a **High level**?

Compare our test results to the performance of a conventional firearm, such as velocity and distance. Show that the railgun can return similar results repeatedly and not overheat and damage the rails. This comparison will also take into account the increase in performance and ballistics if more money was available to create the railgun.

2.13 Test Plan

Provide a functional test plan for the present project version
We will test the small scale railgun and determine any faults in our design and modifications to be made to our plan from there. The test will focus on power loss through current output to muzzle energy. Degradation of materials will be another aspect that is closely examined as this will ultimately determine the cost per shot of our design. Lastly, ease, speed, and safety of operation will be examined to determine any necessary changes. These tests will be used to drive changes in the design when scaling upwards in size and will be reevaluated under the final design.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

• A realistic, well-planned schedule is an essential component of every well-planned project
• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity
• A detailed schedule is needed as a part of the plan:
– Start with a Gantt chart showing the tasks and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.
– Annotate the Gantt chart with when each project deliverable will be delivered
• Completely compatible with a Agile development cycle if that’s your thing
How would you plan for the project to be completed in two semesters. Represent with appropriate charts and tables or other means.
Make sure to include at least a couple paragraphs discussing the timeline and why it is being proposed. Include details that distinguish between design details for present project version and later stages of project.

Our project is broken up into two different phases. The first phase deals with learning and understanding what exactly we will be doing. In this phase, we will develop a small scale model to help understand what we are doing. Once completed we will be able to gather information and use that to help with the next phase. The second phase is making a larger model that can be compared to a rifle of “x” caliber.

	Phases One	
Task	Start Date	End Start

Understand what exactly we are going to be doing	August 27th	September 5th
Create design of the project	September 5th	September 12th
All come together and figure out what design we all like	September 12th	September 19th
Start calculation the essential things we need	September 19th	September 26th
Starting finding materials that we would be using	September 19th	September 26th
Start figuring out how will are going to make our design	September 19th	September 26th
Have the calculation finished	September 26th	October 3rd
Have a parts list made and with prices	September 26th	October 3rd
(Here is a rough idea of what we have done so far. This will eventually be made into a gantt chart)		

3.2 Feasibility Assessment

Realistic projection of what the project will be. State foreseen challenges of the project.

Our project is going to be broken up into two different phases where the first phases include a smaller scale model where we will learn from that and gather information that will be used for the designing and completing of the larger scale.

The realistic projection for this project would be able to compare our larger scale model with a similar caliber size rifle and show the effects of using EM propulsion versus traditional methods for firing a projectile. Before we do that, we will first make a smaller scale model and learn from there.

When thinking about the foreseen challenges, we will need to deal with the heat that is going to be generated from the rails. Given the amount of current flowing through the rails, we need to be able to take that heat and dissipate it.

3.3 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be based on the projected effort required to perform the task correctly and not just “X” hours per week for the number of weeks that the task is active

As seen by the table below, (Table #) here is the schedule we followed by to complete this project. The majority of this project time will be dealing with the implementing and testing.

Task	Description	Estimated Time
Research Capacitor Gun	Research the needed information on what exactly we were thinking of doing. Understand what exactly a capacitor gun is	18 hours
Understand the theory why this works	After finding out what we want to do, we need to understand how it will work	18 hours
Draw up individual schematic of the project	Have everyone come up with their own vision of what the project should look like	18 hours
Deciding what materials to use	We needed to figure out what materials we will be using for this project	10 hours
Calculating the size of the sled for our projectile	We will be using a sled that will house a bullet that will be shot from the capacitor gun	15 hours
(To Be Continued)	We have not done these steps, here is a rough idea on what's to come	
Designing the small scale		
Testing and getting feedback		
Continue to large scale model		

3.4 Other Resource Requirements

We will need to purchase all of the materials for this project. The rails, sled, projectile, wire, capacitors, circuits for charging and discharging the capacitors will need to be made, solenoid for the initial push, etc. If we add other functionality to the railgun this list will be added to. We will need access to a machine shop or get someone to machine parts for us.

Identify the other resources aside from financial, such as parts and materials that are required to conduct the project.

3.5 Financial Requirements

If relevant, include the total financial resources required to conduct the project.

As of right now, we have not ordered any of the materials and do not know the prices yet.

4 Closure Materials

4.1 Conclusion

The goal of this project is to produce a railgun that will compete with a conventional firearm of similar size. We believe this plan outlines our goals and shows that we will have the necessary deadlines and materials to complete this task.

– The necessary materials and tools to complete this project have been outlined and shown. We will need to research and do the necessary calculations to determine the output we would like to achieve out of this railgun.

– All parts will need to be purchased and machined to our specific need. We will use a lab on campus to machine these parts. Researching previously build railguns to see the problems and solutions that have already been made will help us greatly and allow us to move faster in developing a better end product.

4.2 References

List all the sources you used in understanding your project statement, defining your goals and your system design. This report will help you collect all the useful sources together so you can go back and use them when you need them.

– This component shall completely identify any material taken from other sources and used in the development of the project to date or are known that will be used during the remainder of the actual project

– These references shall be complete so that any member of the plan's audience could find them

- Have these on a separate page.

https://physics.stackexchange.com/questions/378748/how-much-electrical-power-is-needed-to-melt-a-wire

http://www.litz-wire.com/New%20PDFs/Fusing_Currents_Melting_Temperature_Copper_Aluminum_Magnet_Wire_R2.011609.pdf

https://www.youtube.com/watch?v=NJRDclzi5Vg&t=4s

https://www.youtube.com/watch?v=wh3_bFTgPo8

4.3 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.

– Any additional information that would be helpful to the evaluation of the project plan or should be a part of the project record shall be included in the form of appendices

– Examples of project documentation that might be included are property plat layouts or microprocessor specification sheets germane to the proposed project.

Gantt chart