**PROPOSAL TO DEVELOP A TENIS BALL LAUNCHING SYSTEM**
A TECHNICAL OUTLINE

**PROBLEM**:

The goal of this project is to develop a catapult system that will be used to throw a tennis ball the farthest distance possible while meeting the design constraints. The cost of developing this mechanism should be minimized. Parts are encouraged to be taken from student's houses/apartments/garages. Purchases need to keep minimal.

**SCOPE & GOALS**:

The constraints of the mechanism are:

a. The mechanism should incorporate at least one 4-bar mechanism.
b. The motor is specified. The details are given in the Appendices.
c. The entire system must be made of wood.
d. The entire mechanism must operate within a window of 2ft x 2ft. The operating window must include the entire base plate.
e. The mechanism should be mounted on a base plate such that it can quickly clamp onto a table.
f. No parts of the mechanism should cross the start plane.
g. Position, velocity, and acceleration analysis using techniques learned in class must be possible for the model chosen.
h. If a spring is used, it cannot be preloaded. That is, no preloaded potential energy.
i. No magnets, chemical reactions, or biological sources of energy can be used.
j. The device must be designed, built, and tested in the allotted time.
k. For the competition, only the flipping of a switch can operate the mechanism. Everything else, including ball release, must be accomplished by the mechanism.

The design process should include the following stages:

1. Conceptual design phase. This includes the models that meet the requirements and can maintain a minimum cost for manufacturing.
2. Analysis & synthesis phase. Includes the displacement, velocity, and acceleration analysis. Solutions to various problems that arise during the analysis process will be solved before time is wasted in the manufacturing process.
3. Virtual prototype phase. This process will be performed in conjunction with the analysis process. Analysis and optimization of the m0del will be accomplished using ADAMS.
4. Manufacturing phase. The mechanism will be built based on the model obtained in the analysis process. This process includes the testing of the model, and reconstruction when necessary.

5. Report writing process. Includes the details of each stage design, and analyzes the success of the mechanism. The report writing team should keep track of the document for each stage of the design process.

*Our Goal:*

The time allotted to each stage is limited. The mechanism must be completed before December 5. The project time line is given in the Appendix. We decided each member of the group should pay 10 dollars to cover motor and material costs. This provides a budget of 80 dollars. We estimate the expenses will be below this amount. Since the time allotted for this project is very limited, the fundamental strategy we decided on for this project is:

1. Simple.
2. Cost effective.
3. Can use the knowledge that we learn in MAE412 to analyze the motion of the mechanism.
4. Can be easily manufactured.
5. Write an effective report that shows what we accomplished.

To achieve these goals, we decided to divide our group into different sub group that get things done more effectively. This is given in the Solutions part.

*Our Measures of Success:*

Our measure of success for this project is that everyone learns something from what we have done. We hope that not only we can constuct a mechanism that works well, but also to learn how to cooperate in a group. For the competition, we have a goal of making it into the finals of the competition. For the model, we will consider a stable, working model, a systematic testing report and a final report that describes our model well sill be considered successful. By fully utilizing the constraints that we have, we can optimize our model based on the following criteria:

a. Make full use of the two-revolution constraint.
b. Shoot the ball at a 45° degree angle.
c. Shoot the ball at the maximum velocity or maximum acceleration of the link that holds the ball.
d. The ball leaves the model at the highest position allowable, which is 2ft.
e. Make full use of the power of the motor.
f. The model behave as we aspect in our analysis and we can predict the motion of the ball by using our analysis tools, such as ADAMS and MATLAB.

If we can achieve all of the above criteria, we may say the project is a success.

**SOLUTION**:

1. The idea generation phase will be performed by the whole group to find out the most suitable solutions.
2. To be more effective, we decided to separate the group into four sub groups. They are:
    a. The Analysis group.
    b. The Virtual prototype group.
    c. The Manufacturing group.
    d. The Technical Writing Group.
3. The scope and responsibility of each group are listed in the Appendices.
4. The following are some of the models that we have come up with after the brainstorming process.

| Model 1 | Description |
|---|---|
| | By using a four bar mechanism, we put the motor at the input link, the holder of the ball at some position on the input link. The mechanism will be a double-rocker. When the motor turns the input link to a certain distance, the follower will limit the motion of the input and release the ball. The release angle will need to be determining by using the analysis method. |

| Model 2 | Description |
|---|---|
| | This model is basically looks the same as the first model that we have come up with. Only that the ball holder is attached to the follower. This required a crank rocker for the four bar mechanism. The motor will be attached to the input link. At some point, the ball will be released. This model required the well control of the power of the motor and we need the motor to turn for speed, because the limitation of two revolutions is given. We decided not to use this model. |

| Model 3 | Description |
|---|---|
| | This model use the combination of a spring and a slider to pull the spring to a certain distance and release it. The problem of this model is that we need a motor that is able to pull the spring, the friction in the pulling process will reduced the power that the motor deliver, and it is not easy to manufacture. Furthermore, we cannot think if a good idea to disconnect the slider and the spring. |

| Model 4 | Description |
|---|---|
| | This model is basically a catapult system with a motor pulling the two links that is attached to the ground. There is an elastic band that connects the links and the motor pulls the links back to the corner. The problem for this model is that it has too many variables that make the analysis very complicated. Furthermore, we cannot think of a good solution for the cutting of the cord that pulls the bar to release the ball. |

| Model 5 | Description |
|---|---|
| | This model basically uses the slider to push the ball when the slider moves. The advantages of this model is that the release angle for the ball is easy to fixed. However, the slider moving path is not easy to determine, we need to gives the slider a path to move. This will in turns create a lot of friction that reduces the power of the motor. |

| Model 6 | Description |
|---|---|
| | This model is basically the combination of a catapult system with a four bar mechanism that pull the catapult system. This model is easy to manufacture and we can determine the motion of the four bars, as we desired it to move by using synthesis method. We decided to use this model for our project. Below are the description of this model. |

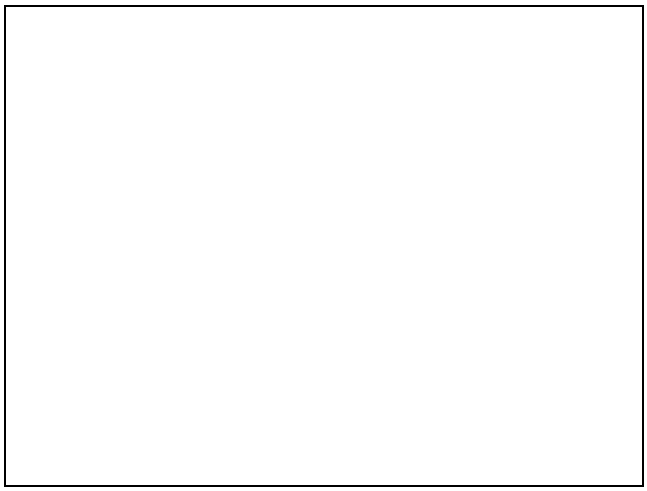
Currently, we are considering the use of model 6 as our design model. This model has the following advantages:

a. It uses the elastic materials to store the energy while the motor is used to drive the four bar mechanism to pull the elastic materials. The elastic material that we will probably use is a rubber band. The advantage of using the rubber band is that the maximum amount of energy produced by the motor can go into the flight of the ball.
b. Another advantage of using this model is that it is easy to construct.
c. We will basically find out the maximum torque that the motor can have after we get the motor. Then we will have to determine the elastic sensitivity of the rubber band that we are going to use. The Manufacturing group will do this entire task.
d. Another advantage of this material is that we can easily determine the angle that we want the ball to leave the system.
e. The challenge of this model is how can we make use of the advantage of 2 revolutions to fully stretch the rubber band. After the first turn of the input link, how can we maintain the pulled distance and continue to pull it in the second revolution.
f. Another challenge of this problem will be the design of the release mechanism. This must release the ball after the motor has turned for two revolutions.

The more details of the two separate system is shown bellow:

| | |
|---|---|
| The catapult system | The four bar mechanism |

A possible solution to make use of the two-revolution constraint is that we make use of two gears which one has twice the diameter of another. As we attach the motor at the smaller gear, the motor turns two revolutions will cause the larger gear turn only one turn. We may have to consider this solution more in details because it also required the motor to have more power to deliver the gear.



The solution for the 2 revolution turn constraint.

More works should be done for the model that we have come up with. We will describe how our work will proceed in the next section.

Our work will proceed in the following manner:

**First week (11/11-11/16)**

a. Manufacturing group will have to build the motor and test the motor.
b. Manufacturing group will test the elastic sensitivity of the rubber band.
c. Analysis Group will have to find out the four bar mechanism to be use, the solution for the release mechanism and the 2 revolution constrain.
d. Virtual Prototype will have to start learning how to use ADAMS and draw a model of our design.
e. Manufacture group should have solution for the joints, links that we are going to use, and prepare them in advance.

**Second week (11/17-11/23)**

a. Virtual Prototype group will have to use ADAMS to run the Mechanism. Come out with a details design of the mechanism.
b. The model should be give to the Manufacturing group by 11/22.
c. Manufacturing group should prepare all the materials that going to use for the model.
d. The report-writing group should arrange their report and type in Microsoft Words.

**Third week (11/22-11/29)**

a. Start manufacturing the model. The model should be available on 11/29. The testing process will then begin.
b. The report writing should come out with an outline of the final report.

**Fourth Week (11/29-12/4)**

a. Manufacturing group will start testing the model and do the statistic testing for the model. Determine the performance of the model, and compare the result with the calculated value.
b. Prepare for the competition.
c. Report should be ready and finalized.

## CONCLUSION:

We will continue to discuss the problem arise in our process of the model. The final model that we built may not agree with what we have shown here. However, the modified model will base on what we have discussed here. The final model of our design will not vary far from what we have discussed here.

## APPENDIX:

THE THREE GROUPS & THEIR RESPONSIBILITIES ARE:

### *1. ANALYSIS GROUP:*

PERSON REQUIRED: 4 PERSON

PERSON INCHARGE:

1. DONNEL LONG – Group Leader
2. LENG-FENG, LEE
3. LEONG KOK KUAN
4. LAZATIN, PATRICK JOSE

WORK DISTRIBUTION:

1. ANALYSIS PART- All members of analysis group.
2. MATLAB - LAZATIN, PATRICK JOSE
3. PRO-ENGINEERING - DONNEL LONG & LENG-FENG, LEE
4. HAND SKETCH - LEONG KOK KUAN

Responsibilities:

1. Find out the constraints on the design, the problems will encounter in the design, the practicability of the design.
2. Perform analysis on the models that come out from the idea generation process.
3. Evaluate each model to find out the best model that is suitable for manufacture.
4. Perform details calculations, and if needed, use MATLAB to evaluate the model.
5. Cooperate with Virtual prototype group to test the model.
6. Documentation for each analysis and gives reasons why the model is chosen.

## *2. VIRTUAL PROTOTYPE GROUP:*

PERSON REQUIRED: 4 PEOPLE

PERSON INCHARGE:
1. LAZATIN, PATRICK JOSE –Group Leader
2. LENG-FENG, LEE
3. DONNEL LONG
4. KOK KUAN LEONG

WORK DISTRIBUTION:

1. ADAMS - DONNEL LONG & LENG-FENG, LEE
2. PRO-ENGINEERING - DONNEL LONG & LENG-FENG, LEE
3. AUTOCAD- DONNEL LONG
4. HAND SKECTH - LEONG KOK KUAN
5. MATLAB- LAZATIN, PATRICK JOSE

Responsibilities:

1. Cooperate with Analysis Group to evaluate the model using ADAMS Software.
2. Document each analysis that have made using ADAMS. Including the following:
    a. Positions, velocity, and if possible, acceleration analysis.
    b. The path of the ball follows.
3. Draw the final model by using CAD software. Potential software will be AUTOCAD, Pro-Engineering.
4. Test each model given by Analysis group and determine the best model.
5. Come out with a final model that including detail dimension of the model, the material to be use (cooperate with manufacturing group). With a front view, the side view, and the top view of the model.

### *3. MANUFACTURING GROUP:*

PERSON REQUIRED: 4 PERSONS.

PERSON INCHARGE:

1. LOUIS LOMBARDI, MICHAEL-Group oversight, materials acquisition, mechanism construction and testing.
2. MAALOUF, JACOB ZOUHAIR- Technical writing, mechanism construction and testing.
3. LI, YING Z- Materials testing and Feedback analysis.
4. MAGPILI, LEE-ANDREW V – Material acquisition and Material testing.

RESPONSIBILITIES:

1. Prepare the materials that will be used for the model. Provide information about the materials that will be use for the model. This including:
    a. Find the stiffness of the spring that will be used in the model, if any.
    b. Document the data for the testes performed in a technical format.
2. Test the motor and find out the maximum force output of the motor. The test should be performed as soon as the motor is available so that the testing result can available for Analysis group.
3. At least one member of this group has a car so that make the purchasing easy.
4. Able to get access to the machine shop easily.
5. To built a model base on the details given by the Virtual Prototype Group.
6. Find solutions for problems that encounter in manufacturing process.
7. Responsible for the order, storage, and transport of the model and materials use.
8. Document each materials use in the model and the solution for each problem encounter in the manufacturing process.
9. Testing of the model. Including systematically document the result of the testing. Perform a statistic analysis base on the result of the testing process.
10. Prepare a list of cost estimation for the entire project. This must be done before 8 Nov. 2001.

## 4. *TECHNICAL REPORT WRITING GROUP:*

PERSON REQUIRED: 3 PERSON (ONE FROM EACH ABOVE GROUP)

PERSON INCHARGE:

1. MAALOUF, JACOB ZOUHAIR- For Manufacturing Group.
2. LAZATIN, PATRICK JOSE – For Analysis Group.
3. LEE LENG FENG – For Virtual Prototype Group.

Responsibilities:

1. Each group will have to determine a report writing group member. This person will in charge of all of the documentation work done by the group.
2. This group will be responsible for the writing of the final technical report that is to be turned in.
3. The member of this group will be required to refer to the formal technical writing standard to write the technical report.
4. The member of this group must consistently document their work done during the entire project.
5. Our report will include the following part:
    a. The idea generation process.
    This section will include all the idea that we have come out with and explain how we choose our model. In this section, we will discuss the advantages of our model compare to other model that we have come out with.

    b. The motivation behind the design.
    In this section, we will discuss the reason why we choose our model, what is the motivation behind the design.
    c. Analysis and/or synthesis of the mechanism,
    This section will include all the calculation that we have made for our design, the technical solutions to our design, and the details design of our model.

    d. Virtual prototyping of the devices using ADAMS,
    This section will include all of the works that we have done either using pro-engineering, or ADAMS. We will also include the velocity and the displacement analysis for our point of interest on the model.

    e. Analysis the success of the devices.
    Base on the test result given by the Manufacturing group, we will evaluate the successfulness of our model. In this section, we will also discuss the problems that we have face in the manufacturing process, and the ways to improve our design.

BASIC COST ESTIMATION (Provided by Manufacturing Group)

| | *Materials* | *Quantity* | *Cost (dollars)* |
|---|---|---|---|
| 1 | Motors | 2 | 28 |
| 2 | Woods | - | 25 |
| 3 | Fastener | - | 5 |
| 4 | Spring, Elastic | 1 | 10 |
| 5 | Miscellaneous | - | 12 |
| | | Total | 80 |

GROUP 7 MEMBERS:

REPRESENTATIVE:

1. LENG-FENG, LEE

RESPONSIBILITIES:

1. Meet Prof. Krovi for problem encounter in the design.
2. Coordinate each groups.
3. Email each group member for the process of the project.

SECRETARY:

1. LOUIS LOMBARDI

RESPOSIBILITIES:

1. Keep the minutes for each meeting.
2. Email the content and the attendance of each meeting to all the members after each meeting.
3. Keep track of the attendance for each group member.
4. Documentation for each meeting.
5. Also a treasurer of the group.

GROUP MEMBERS:

| | NAME | EMAIL ADDRESS | PHONE NO. |
|---|---|---|---|
| 1 | LOUIS LOMBARDI, MICHAEL | lombardi@acsu.buffalo.edu | 839-3483 |
| 2 | MAALOUF, JACOB ZOUHAIR | maalouf@acsu.buffalo.edu | 716-836-8104 |
| 3 | MAGPILI, LEE-ANDREW V | lm4k@hotmail.com | 347-245-4641 |
| 4 | LONG DONNELL ALAN | dalong@eng.buffalo.edu | 829-5078 |
| 5 | LEONG KOK KUAN | kleong@eng.buffalo.edu | 636-1689 |
| 6 | LAZATIN, PATRICK JOSE | plazatin@eng.buffalo.edu | |
| 7 | LI, YING Z | yzli@eng.buffalo.edu | 691-8935 |
| 8 | LENG- FENG, LEE | llee3@acsu.buffalo.edu | 632-5632 |

We have read the above proposal and agree to the work distribution as indicated in this proposed outline.

The following is our signatures.

| | |
|---|---|
| NAME: LOUIS LOMBARDI, MICHAEL | NAME: MAALOUF, JACOB ZOUHAIR |
| NAME: MAGPILI, LEE-ANDREW V | NAME: LONG DONNELL ALAN |
| NAME: LEONG KOK KUAN | NAME: LAZATIN, PATRICK JOSE |
| NAME: LI, YING Z | NAME: LENG- FENG, LEE |