Session 3548

WINNING THE

WORLD PUNKIN' CHUNKIN' COMPETITION

WITH A STUDENT DESIGN PROJECT

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I. Abstract

The World Punkin' Chunkin' contest is a yearly affair of the Chamber of Commerce of the city of Lewis, Delaware. Department of Technology students entered the competition with a human powered, 20 ft long sling-shot type device and won the first place by throwing an 8-lb pumpkin 246 feet away.

The design of a pumpkin thrower was assigned to three Mechanical Engineering Technology students as a project for senior level "ETME 475 - Mechanical Systems Design" course. As a first step, each student worked on their own pumpkin thrower. During the final phase, students worked on the design and manufacturing of the different parts of the project. During the early Fall semester one student, with faculty supervision, worked on the project to redesign the pouch and tune the system. Students from the Engineering Society have also helped to set it up for tests and decorations. Competition day was of course a Department affair.

Students enjoyed working on this good engineering applications project. The Project required them to use their mathematics, machine design, computer programming, engineering analysis and reasoning, and dynamics knowledge.

This paper conveys our experiences with the project, shares my experiences in how to guide students towards a common goal in a systems design course and how to lead them to finish the project on time.

II. Introduction

Students in Mechanical Engineering Technology program at the University of Maryland Eastern Shore are required to take a senior level "ETME 475 - Mechanical Systems Design" course during their last semester. This course is 3 credit hours. Two hours are used for lecture and two hours are used for laboratory. Depending on who is taking the course and the type of projects planned, either no text book is required or Dr. Dieter's "Engineering Design" [1] textbook is used. The text is usually supplemented by Shigley’s "Mechanical Engineering Design" [2] textbook and any related material to help students in their design projects. No textbook was assigned for the semester when this project was initiated. Some chapters from Dieter and Shigley were covered. Some advanced mathematical topics, like "Numerical Integration", and "Energy Methods in Dynamics" were also covered. Since extensive parametric study was required students were also introduced to EUREKA and "TK-Solver" mathematical software.

The World Punkin’ Chunkin’ contest is a yearly affair of the Chamber of Commerce of the city of Lewis, Delaware. Competitions are held on the first Saturday of November each year. The contest consists of unlimited, human powered, and junior divisions. Within each class the competitors compete to throw an 8 to 10 lb pumpkin the farthest distance. At the unlimited class everything is allowed, except explosives. The human powered division is limited to using stored energy of one human being for a duration of minutes. Winners get the bragging rights for one year. There is no cash prize, but, a few caps with the ranking "First, Second, or, Third" stamped on them are given as souvenir to the participants of the winning teams.

The purpose of this design project was to design a pumpkin launch system to compete in the "World Punkin’ Chunkin’ Contest". Project was handled in two stages. Since there were only three students enrolled in the class, during the first stage, each student was asked to work independently to come up with a design. Students at this step have used FORTRAN, Pascal programming, EUREKA, and TK-Solver for parametric analysis. Since equations for dynamics solutions were non-linear due to drag and frictional forces, numerical methods were utilized in computer programming. As initial designs (project #1) students worked on two different types of sling-shot systems and a coil-spring loaded catapult type device to throw the pumpkin. During this preliminary design process ideas were exchanged between students and the faculty on how to improve their designs. Strength and dynamics calculations were carried out and systems were optimized for maximum range. At the end of the preliminary design process, which was the middle of the semester, each student have presented their project to the class.

After reviewing the constructibility, available resources, cost, safety, portability, and attainable maximum ranges of each project, faculty and students decided to scrap the catapult system and concentrate their efforts on a modified version of the two sling-shot systems proposed. During the final phase (project #2), students worked on the design and manufacturing of the different parts of the modified sling-shot system.

III. "Punkin’ Chunker" Design Project

As stated in the Introduction the purpose of this design project was to design a pumpkin launch system to compete in "World Punkin’ Chunkin’ Contest". Official rules for the Punkin’ Chunkin’ Contest are given in Table 1. Official rules for Human Powered Class are given in Table 2.

Table 1. Official Rules for the Punkin' Chunkin' Contest

1.	Pumpkins shall weigh between 8 and 10 pounds
2.	Pumpkin shall leave machine intact
3.	No part of the machine shall cross the starting line
4.	Absolutely NO EXPLOSIVES are allowed

Table 2. Official Rules for Human Powered Class

1.	Official rules of the contest apply.
2.	Entry shall consist of a machine using either springs, rubber cords, counter-weights, or any other device which uses the stored power of one human being in a maximum time period of two minutes.
3.	Contestants shall be given a maximum of two minutes from the start of cocking their machine until ready for firing using only the power of one human being.

As project #1 all students were assigned the same project and were encouraged to work on substantially different ways of throwing a pumpkin. Two students selected a sling-shot system with rubber cords and one of them selected a spring-loaded catapult system. In addition to the rules and regulations given in Tables 1 and 2, the students were also given a target range of 300 ft.

Initial student designs of three Punkin' Chunkers are given in Figures 1, 2 and 3. After analysis, parametric studies, and discussions on two types of systems, the catapult system was dropped from consideration mainly due to its weight and local unavailability of extension springs.

After completion of the first phase, students were assigned parts of the proposed new sling-shot system. A sketch of the final design is given in Fig. 4. Three students manufactured the design towards the end of semester. The pouch was manufactured by weaving a nylon rope. Since pumpkins were not available in May preliminary testing was done using water melons, water filled balloons and basketballs. However, tests indicated that we needed a better designed pouch so that the pumpkin will not be caught in the pouch, which happened about fifty percent of the tries. Projects were turned in, grades were passed, all three graduated, and the "better pouch" design was left for someone else to tackle.

During the following Fall semester, until the competition, one student worked on the project to redesign the pouch and to tune the system. In October, the Engineering Society got involved in it to take the project for competitions. Their responsibility was to water seal the project, help in testing, decorate the system, and help during competition. Photographs of the manufactured system is given in Figures 5 and 6.

The size of the system was determined by the available laboratory ceiling height and the transportability of the system. As seen in Fig. 6, the system consists of two triangular sections, one at the upper right and one at the lower left. The middle 7-foot square section, combines two triangular sections to form a ramp of about 20 ft long. They are attached to one another by a set of bolts. For transportation to the competition site, these three sections were disassembled, transported to the site in three pieces and were reassembled for competition.

Four empty wire spools, 3.5 inches in diameter and 3.5 inches in length, two on each side of the ramp, are used as pulleys. Two of the upper pulleys are used as load carrying pulleys. Lower ones catch the rubber cords and the pouch after launch. The ends of 8 rubber cords, each about 20 feet long and ½ inches in diameter, are fitted with hooks. One end of the cord is attached to a cord anchor-plate, as seen at the lower left hand side section. Elastic cords then go over the lower pulleys and around the upper pulleys from under the ramp to over the ramp. Other ends of the cords are attached to a pumpkin carrier pouch. There are six cords on each side of the ramp. Cord lengths are cut slightly longer than the length of the ramp to ease the connection of cords to the pumpkin pouch. The pouch is attached to a winch (Fulton T1200, 4:1 ratio, 1400 lb capacity, 8 inch handle, maximum mechanical advantage 61:1) [3] through a quick release mechanism and a 2 in. wide nylon strap belt. The pouch sits on a 8.5inx11.5in, rectangular shaped and (1/16) inch thick nylon sheet to reduce the friction between the pouch and the ramp. The pumpkin carrying pouch is a slightly modified horse saddle girth (also called roper cinch) obtained from a local farm store.

IV. Calculations and Parametric Studies

Using equations of projectile motion one can prove that when there is no drag force on the pumpkin during flight, maximum range is obtained when launch angle is 45 degrees. With 45 degree launch angle the range and the velocity are related by the following simple equation:

$\text{Range} = V_o^2/g$ .... (1)

where

V_o= Pumpkin velocity at launch

g = gravitational acceleration.

A velocity of 98.3 ft/s can be obtained from the equation for a 300 ft range.

(a). Use of Energy Methods to Calculate Pumpkin Velocity

When elastic cords are stretched elastic energy is stored in them. Upon launch the elastic energy is converted to kinetic energy (KE) of the pumpkin, KE of the pouch, KE of the cords and to the potential energy increase and/or decrease in the mentioned components. There are energy loses due to friction between the pouch and the ramp, drag on the pumpkin and its components and, possibly, frictional loses in the cords, etc. It was shown, by plotting the stretching force as a function of stretch length, that the spring constant of a cord is not linear and is more non-linear at low loads (short stretches). To simplify the parametric study a straight line fit to the data with an intercept was used for calculations. Students used FORTRAN, Pascal, EUREKA and TK Solver during preliminary design process. Their attempts were very specific to their designs, usually lengthy and required more time to input the data as well as to extract the results. Since numerical integration was required to include the effects of friction and drag, and since students did not have much time to waste, the author wrote a FORTRAN program for the parametric study of the final design. The program was used to see the effects of changes in pumpkin mass, drag coefficient, pumpkin size, friction coefficient between the pouch and the ramp, length of ramp, % cord stretch, number of cords, and the ramp angle.

(b). Effect of Drag Force

When there is drag on the pumpkin there is no simple equation to calculate the range since drag force is not constant. Assuming that the drag coefficient is constant, the drag force is a function of velocity only. Even with a constant drag coefficient, the equations of projectile motion need to be numerically integrated to find the range.

Drag force is given by

$F_D = C_D.rho.A_P.V_o^2/2$

where

C_D= Drag coefficient

rho= density of air

A_P=projected area of pumpkin

Initially and towards the end of the motion drag force is large since pumpkin is moving at high velocity. Drag coefficients for a spherical object moving in air can be obtained from Fluid Mechanics textbooks or Handbooks. Data indicate that the drag coefficient ranges from 0.3 to about 0.1 at the velocities 50-100 ft/s.

(c). Conclusions of the Parametric Study

The pumpkin mass was found to be very important in maximizing the range. Since the KE of the pumpkin is proportional to its mass and velocity squared, smaller mass means higher velocity for the same KE, thus, maximum range.

The drag on the pumpkin and the friction on the ramp was found to be not significant. Very large spring forces during launch easily overcomes frictional forces and any drag that exists during acceleration. Drag during the flight reduced the range by only few percent. Therefore, the effect of pumpkin size was not important either. Smaller pumpkin will have longer range. Roundness of the pumpkin was not studied. However, it is expected that more spherical pumpkins will create less turbulence, therefore, less drag. Lower drag means longer range.

An increase in percent stretch on the cords increased the range. However, the cords can only be stretch up to 70%. Therefore the maximum stretch was used in the design.

Increasing the number of cords increased the range as expected. However, since there was no physical space on a single pulley for more than six cords to sit side by side freely only six cords were used on each side. Adding another set of pulleys would have complicated the design substantially.

As ramp length is increased cord length increases. Therefore, its effect on the range was substantial. Since physical size was determined by our laboratory work area, ceiling and ramp door heights, material requirements, weight, and stability during transportation, about 14 ft high system was designed.

The ramp angle parametric study indicated that maximum range will be obtained when the angle is about 42.5 degrees. Since this value was very close to 45 degrees and difference between ranges for these two angles was less than a foot, the theoretical value of 45 degrees was used in design.

V. The Competition

The Punkin Chunker was tested and was ready a few days before the competition. Theoretical calculations indicated that we could reach up to about 400 feet range. However, actual tests showed that we could expect only about 250 feet range during competitions.

After about 2 hours drive we were the last one to reach to the site. Traffic to the site was very heavy and we got delayed to reach to the site. By the time we reached to the site middle sections of the field were taken. We were left with the outermost edge of the field. As it turned out, this was the best location to be since it gave us a very good visibility for spectators.

System was set up and the pumpkin was loaded in the pouch and the system was ready for cocking. With the "go" command rubber cords were stretched by cranking the winch handle within one minute, and it was ready to be released. At the end of the countdown the first shot was fired by pulling the ring on the quick release mechanism. Then the big crowd, the spectators, cheered and clapped their hands. We were able to throw the 8.5 lb pumpkin 246 feet away, a record throw. Although we obtained longer range during our second try it was disqualified since a small part of the pumpkin was shaved away by one of the pulleys. Our third and the last try did not go beyond the first one. Therefore, our official range was recorded as 246 feet. As competition continued we maintained our superiority. In fact, the longest range, after ours, was only about 86 feet. Thus we had about three times longer range than they did.

VI. Conclusions

The importance of laboratory experiences for students can not be overstated. Laboratory work provides them with direct experiences of testing various physical principles. It also provides experiences in handling equipment and training in experimental sciences which is necessary for them to ultimately carry out experiments and measurements themselves. Such experiences are provided by scheduled experiments in several courses and through design projects and independent study research projects like this one.

There are several lessons to be learned from similar design projects. The most important one is to keep Murphy's laws in mind and give yourself ample time. Get ready for a competition well ahead of time. If the competitions are repeated every year you might think that you have a very long time to prepare. However, if the competition has been around long enough time you shall be competing with the Masters.

The second important lesson is to make sure that you communicate with the student design team and make it very clear what you expect from them. Briefly describing the expectations does not really help unless you set a weekly progress goal and help them achieve the goals. You better put your expectations on paper and pass to them.

The third important point is, be ready to get involved and expect to spend a lot more time than you usually spend with design projects that are not for competition. After competing with this project and spending a lot of time on it, about four years ago, I am not yet ready to do another competition project. Who knows, we may have one next year.

Although we had some minor technical problems with the project, students liked dealing and solving these technical difficulties. This was one of the largest, but not necessarily more complicated, projects students were faced with in the Mechanical Systems Design course. Of course, especially the designers, participants and those who were not able to participate in actual competitions were very happy that we were the first in the Human Powered Division of "World Punkin' Chunkin' Competition" at Lewes, DE on Nov. 7, 1994.

Acknowledgments

Hard work of Bill Hallet, Orville Fleming, Kevin Williams and Hussein Mrech are acknowledged. Without their dedicated work this project would not have been completed.

VII. References

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2. Shigley, Edward and Mitchell, Larry, "Mechanical Engineering Design", McGraw Hill, 1983.

3. Fulton Performance Products, Inc. 50 Indian Head Drive, Mosinee, WI 54455-0008.

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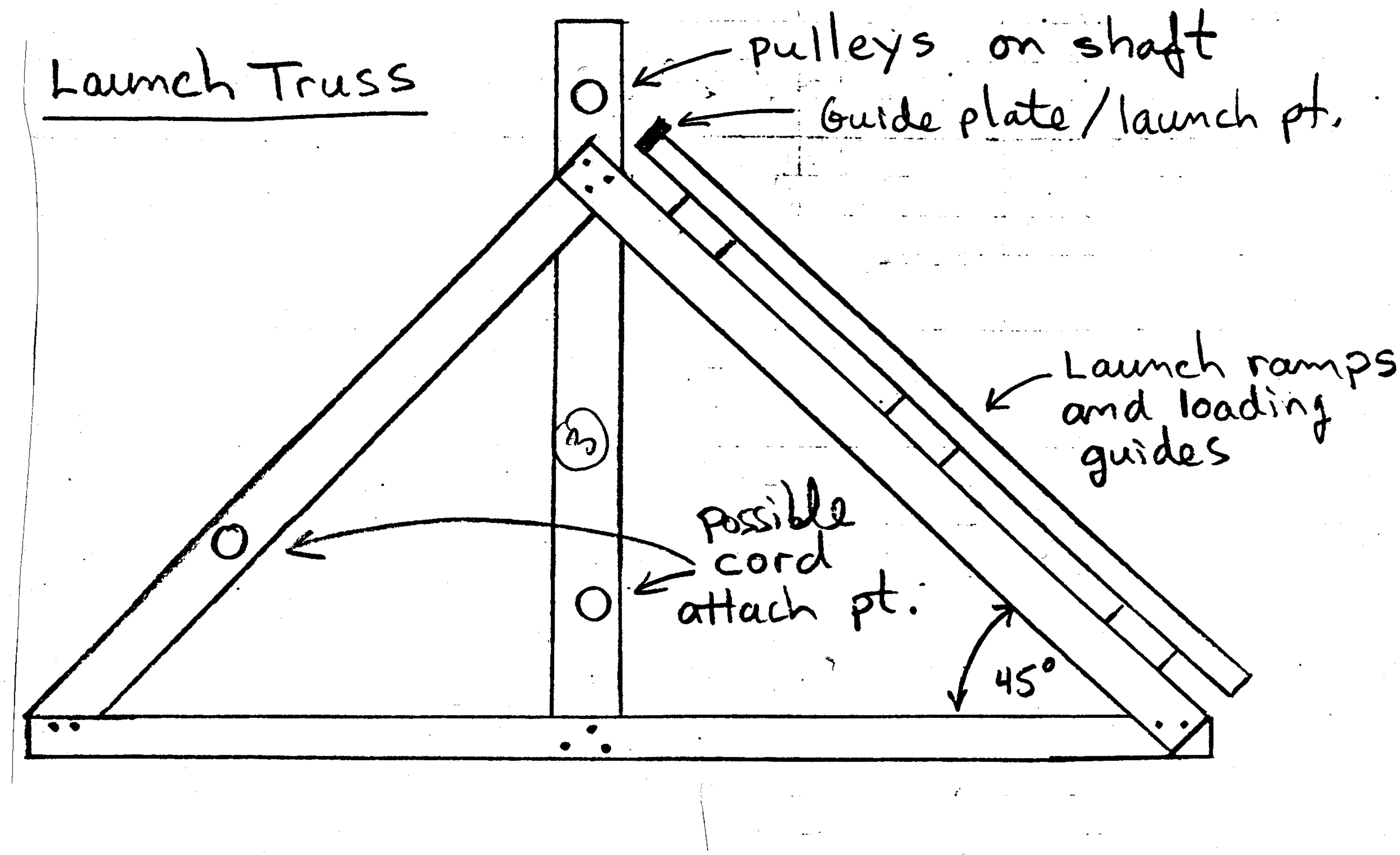

Figure 1. Initial Pumpkin Chunker Design by Kevin Weidner

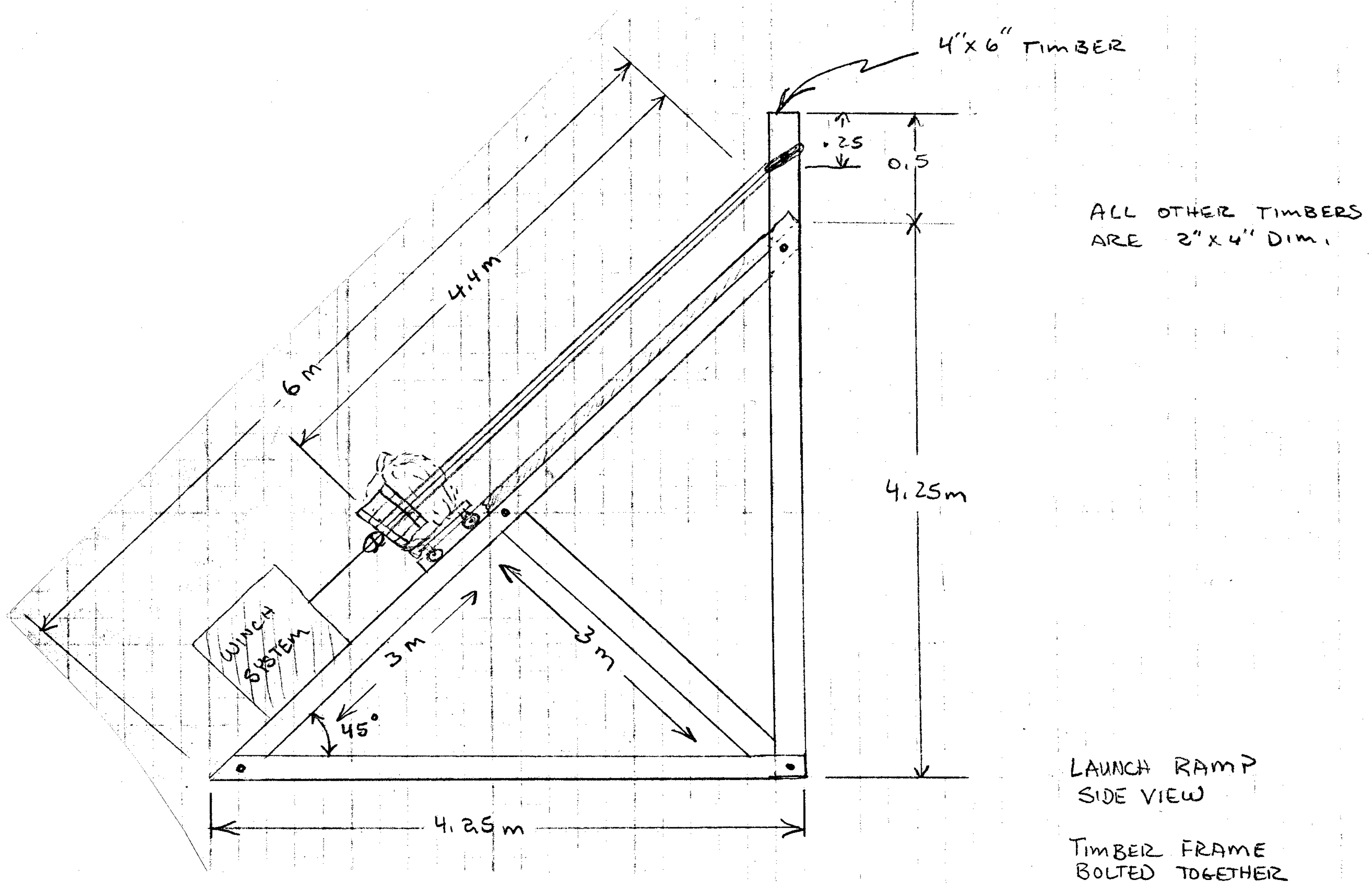

Figure 2. Initial Pumpkin Chunker Design by Bill Hallett

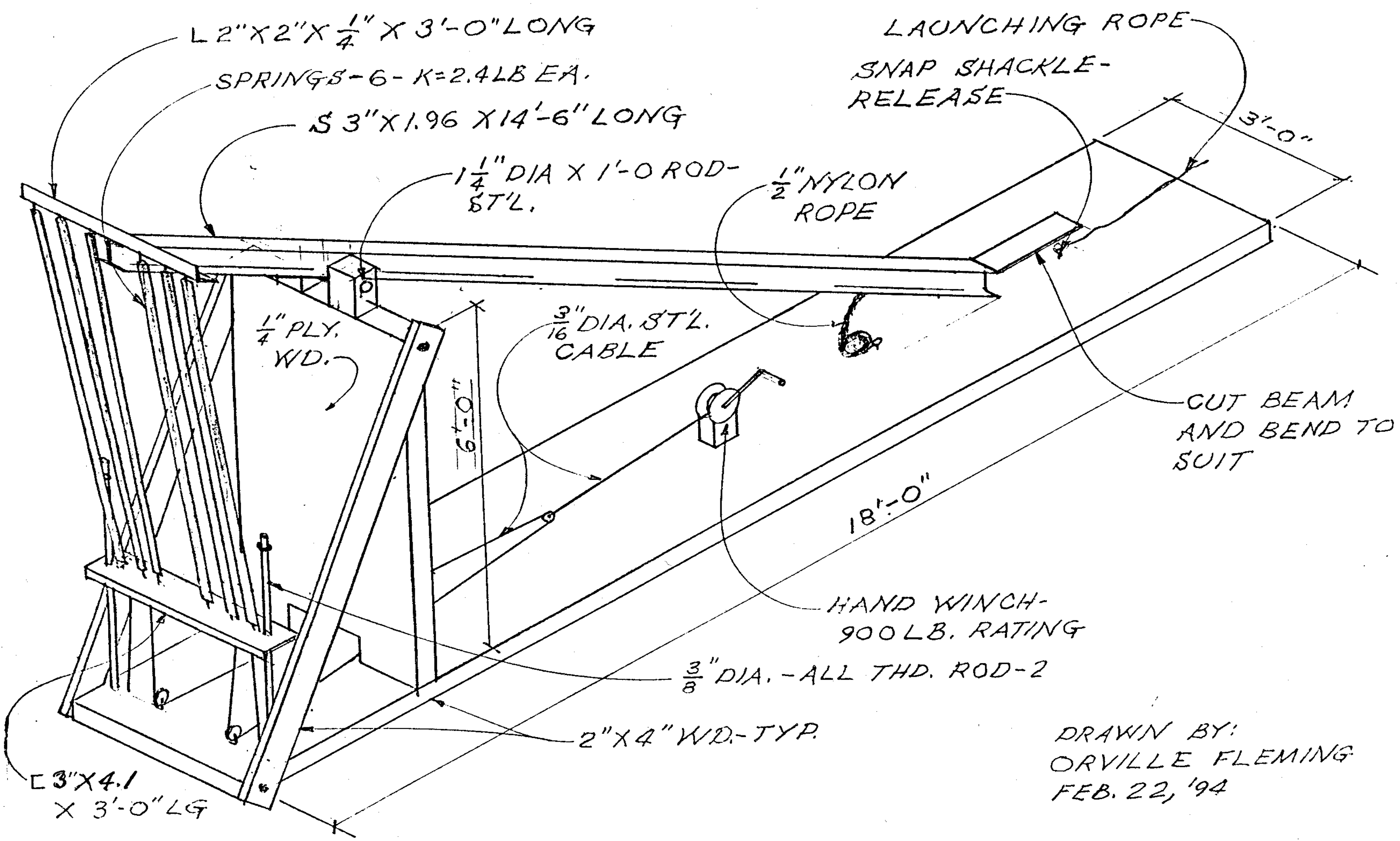

Figure 3. Initial Pumpkin Chunker Design by Orville Fleming

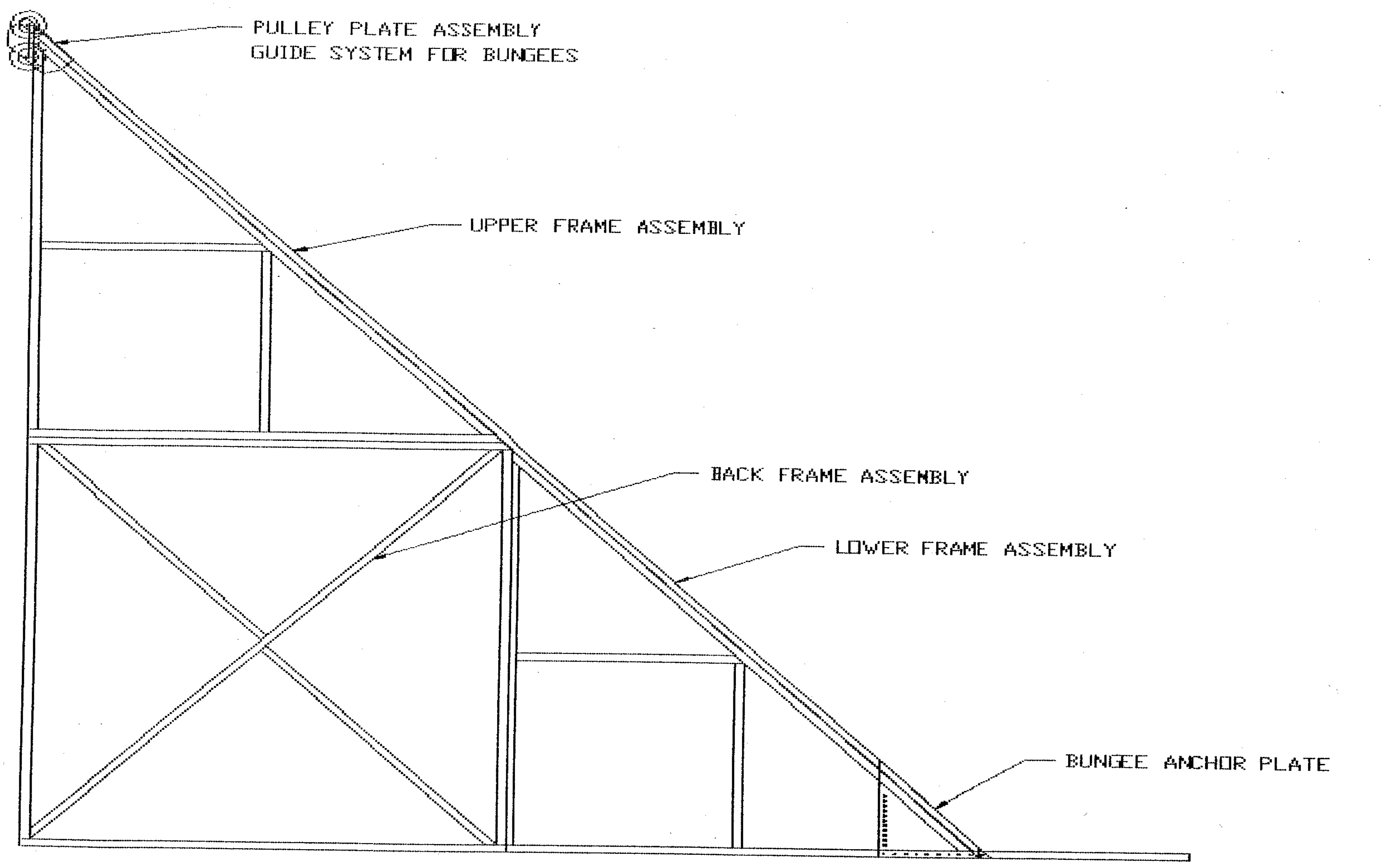

Figure 4. Optimized Pumpkin Chunker Design (Drawn by Bill Hallett)

Figure 5. Front View of Punkin Chunker with Competition Participants

Figure 6. Side/Front View of Punkin Chunker.