

# **Incorporating The ASME Design Competition Into Theory of Machines**

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## **ABSTRACT**

This paper describes experiences and observations on using the 2002 ASME National Design Contest (“Baseball Frenzy”) as the design project in the conventional Theory of Machines course required of all mechanical engineering students at the University of Wisconsin-Platteville (UWP).

This contest required student teams of four or fewer members to design and build a machine to project baseballs into a wooden box located 235 cm from the machine. The box consisted of three compartments with 20 cm diameter holes that balls were to be projected into.

Five student teams designed and built, uniquely different from each other, machines in an eight-week period. These machines, in varying degree, incorporated classical concepts taught in the Theory of Machines course. For instance, the paper sites how teams used crank-rockers, graphical linkage synthesis, linear actuators, cams and spring loaded arms, and gear trains to develop machines to project the baseballs into the three separate target holes.

The design process used, and the final results of the five machines are described, along with the successes and failures encountered during this process. Included are the experiences of a select team at the Region VI design competition.

It is argued that these experiences doing hands on building of machines greatly enhance the synthesis learning process that design requires; that real world experiences are gained from the activities; and that the most effective way for students to learn design is by doing open-ended design projects that require a device to be built, such as required in the ASME design competition.

## **INTRODUCTION**

This paper describes how the ASME 2002 Student Design Contest, “Baseball Frenzy”, has been successfully used in the Theory of Machines course at UWP. This course is a three semester credit course, that normally includes two 52 minute lectures pertaining to traditional theory of machines topics and a 104 minute lecture/discussion period which includes additional topics from theory of machines, the design process, and discussion/mentoring of student projects.

Five student design teams (out of a total of thirteen in the course) with four students per team selected the option of designing and building a machine for the student design contest. Some specifics of the contest are described in the subsequent section. The five unique from each other machines, along with some of the concepts they incorporated from theory of machines, are described.

Incorporating the ASME design competition into the course required doing hands-on building of these machines which greatly enhanced the synthesis learning process that design requires. Real world experiences were gained from this activity, and the most effective way for students to learn design by doing open-ended design projects that require a device to be built was accomplished.

### **PRIMARY OBJECTIVE OF CONTEST**

The primary objective of the contest was to build a fully automatic device that would toss baseballs into a rectangular box consisting of three separate compartments. The device had to fit inside a storage box 30 by 50 by 30 cm before assembly and 1 m by 1 m by 1m space upon assembly and was located 235 cm from the box. The three separate compartments of the box had 20 cm diameter holes cut in their top enclosures.

The device was to toss 30 baseballs within a two minute time into the three compartments. A scoring formula based on number of balls successfully tossed into the target holes was used to evaluate the device. By building a device that would rotate or move from one position to two other positions to toss balls into the three separate targets, a higher score would be obtained. The detailed design contest rules are provided in [1].

### **DESIGN SCHEDULE**

The five teams built uniquely different machines to meet the contest rules. The teams were assembled during the first week of winter semester, starting on January 22, 2002. The contest was held at the University of Evansville on March 15-17, 2002. Therefore the teams had only eight weeks to plan, design, acquire materials, and build and test a machine to meet the specifications set forth in the design contest rules. With this time constraint, the following schedule was tentatively used by each group [2] based on acceptable design processes:

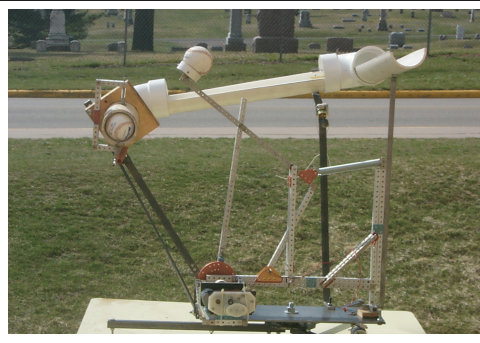
Week 1 (Jan. 21-27) Assemble teams, read and study the problem statement and existing "Questions and Answers"[1], and formulate any clarifying questions of the organizing committee.

Week 2 (Jan. 28- Feb. 3) Do background research and generate ideas for solving the problem.

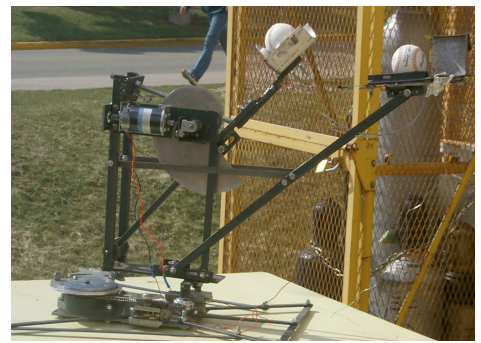
Week 3 (Feb. 4-10) Develop simple prototypes of parts of the system and perform simple tests and calculations necessary to validate your design concept

Week 4 (Feb. 11-17) Complete the design work and draw parts to be made and obtain parts and materials to build the first complete prototype. Run tests to observe its effectiveness and determine which ideas to improve.

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baseballs into the target holes. A drive gear failed on one machine just minutes before the competition started. Obtain additional back-up parts (including batteries), organize tools, materials and supplies for the regional contest held in Evansville, IN.

Mar. 15 Travel to Evansville with one machine shown in Fig. 1. Set up machine and test all evening. Machine successfully tossed 10 balls into target holes in 2 minutes. Newly purchased switches seem to be working. Disassemble machine in early morning and place parts in the required sized storage box.

Mar. 16 Regional student competition held. Successfully reassembled machine in the 30 minute allowed time and placed in designated confined storage area. An unexpected faulty switch could not be replaced in the two minute final set up/start up time resulting in disqualification.

### DESCRIPTION OF MACHINES

Figures 1-5 show the actual machines as built by the five teams.

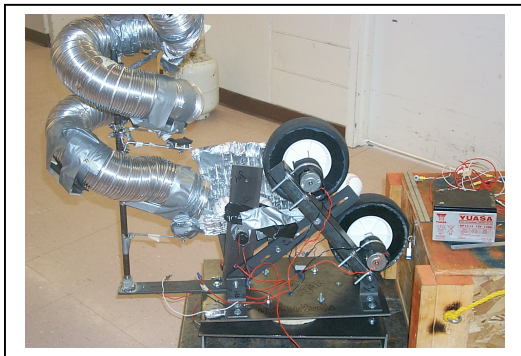
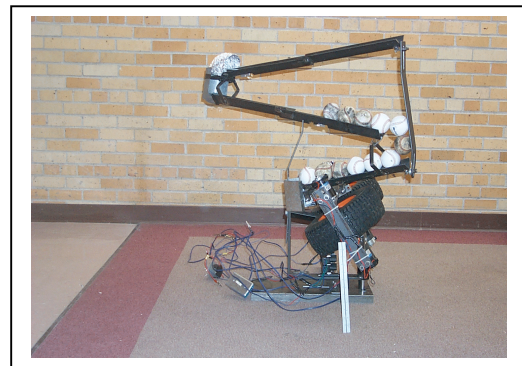


Fig. 1

o wheel thrower, 4-bar linkage  
position adjustment



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Fig. 2 Two-wheel thrower, linear  
actuator position adjustment

3 Four-bar linkage, spring loaded  
spring loaded arm

arm with cam launcher and  
Geneva mechanism for  
adjustment

Fig. 4 Cam driven,

with  
lead screw position  
position adjustment



Fig.

driven,

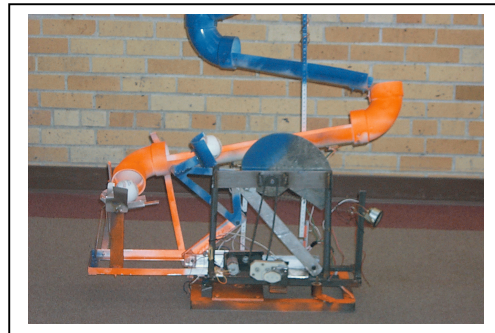


Fig. 5 Four-bar linkage, cam  
spring loaded with linear  
actuator position adjustment

To illustrate some of the  
in the designs, we now  
most important design features of the five baseball throwing machines.

engineering principles used  
briefly describe some of the

Team one's final design [2] (Fig. 1) shows a baseball throwing machine consisting of two wheels lying in the vertical plane. These wheels are motor driven with a gap between the wheels where the baseball would be directed to by the ball feeder. The launch angle and speed of the wheels were adjusted for proper tossing distance. A rotating arm driven by an electric geared motor was used to feed the balls into the wheel opening. By adjusting the input voltage the speed of the motor was controlled to obtain a desired feed rate of the balls to throw the required 30 balls in two minutes time. Another unique feature of this design was the use of a four-bar linkage to rotate the machine back and forth to sweep out the necessary arc length to align with the three target holes as the balls were being thrown. Using graphical position synthesis, a four-bar crank-rocker linkage was designed to sweep out the proper arc length to make the proper position adjustment of the ball thrower. The linkage was driven by a geared motor. The voltage supplied to the motors was provided by 12 volt Lantern batteries to meet the ASME requirements. This machine was entered in the ASME Regional Student Design Competition held in Evansville.

Team two's final design [3] (Fig. 2) shows a baseball thrower consisting of two wheels tilted out of the horizontal plane to obtain a proper launch angle for projecting the balls. Each wheel was driven by a permanent-magnet DC motor that supplied 24 volts at 0.3 amps of current with maximum rating of 2300 revolutions per minute (rpm). Using standard trajectory motion equations, the optimum launch angle and speed were determined. The final voltage sent to each motor driving the wheels had to be adjusted to obtain the desired rpm's of the wheels. The

rotation of the machine was accomplished using 12 volt high-torque door lock actuators with a “throw” of 0.75 inches. The rate of ball feed was controlled by a gear motor taken from a paper shredder. This motor drove an arm that flipped a baseball into the wheel opening every 2.14 seconds.

Team three’s design [4] (Fig. 3) shows a machine made of a four-bar “NonGrashof” linkage with a dyad added to drive the spring loaded linkage. The crank of the resulting six bar linkage was driven by two gear-reducer motors powered by 12 volt lantern batteries. After shooting one-third of the balls at the first target, the whole device rotated to the second target by energizing the motor on a lead screw attached to the front of the machine. A timer was used to control both when the motor starts and when it stops and allowed precise positioning of the machine to the second and then third positions.

Team four’s design [5] is shown in Fig. 4. This machine had a cam driven by a worm gear set, with spring loaded follower arm that projected the balls as the cam reached a cusp position on the follower. The timing device to change the position of the machine was controlled by a Geneva mechanism completely designed and built by the team. This machine performed very reliably in practice runs. Unfortunately, the gear in the worm gear train used to rotate the cam was made of plastic (although it appeared to be of steel) and failed just before the preliminary contest held on campus.

Team five’s design [6] is shown in Fig. 5. This machine used a four bar linkage that was cam driven and spring loaded. The actual ball holder was located on the coupler arm. The cam was driven by a gear train through a chain and sprocket. Linear actuators located on each side of the machine were used to position the machine to throw balls into the left and right targets after initially aiming at the center target. This machine actually was very accurate in hitting the first target. However, the linear actuators were accidentally destroyed the night before the contest at UWP by overloading them with too much voltage so this machine could not change positions.

## **BENEFITS OF ENTERING CONTEST**

There were many benefits to entering this contest. In the process of solving the baseball frenzy problem, the teams used many technical concepts from theory of machines, such as four-bar linkage synthesis, intermittent motion using a Geneva mechanism, addition of a dyad, cam design, and gear train design. In addition, teams were exposed to many other real-world design issues including exposure to vendors, time management, scheduling, decision making, team building, creativity, brainstorming, working with various tools and machines in the machine shop, and trial-and-error processes to find a solution to the design problem.

Teams also learned that verification of the design through testing is perhaps the most significant part of a project to ensure its success. For instance, team one that entered the Region VI contest made some last minute changes to their machine involving changing out some switches during the late evening before the contest and modification to the way the machine was rotated. These changes were made after the UWP contest to further improve their start up of the machine and accuracy of ball tossing. They had shot five balls into the targets at UWP. The changes did improve the accuracy of the machine and 10 or more balls were tossed into the targets the late

evening before the contest. However, they had little time to fully test the changes. The changes resulted in an unreliable and inadequately tested machine at the regional contest. The result was a machine that failed to start up due to a faulty switch that controlled the power to one of the motors used to turn one of the wheels used to toss the balls.

## **REFERENCES**

- [1] 2002 ASME STUDENT DESIGN CONTEST - Design Problem, “Baseball Frenzy”, [http://www.asme.org/students/design\\_contest/Y2002Rules.html](http://www.asme.org/students/design_contest/Y2002Rules.html).
- [2] American Society of Mechanical Engineers, 2002 Student Design Contest, “Baseball Frenzy”, L.Gliniecki, R. LaPlannte, A Timmerman, and J. Zitlow, A report to the Theory of Machines course, UWP, May, 2002.
- [3] Baseball Frenzy, T. Anderson, D. Kelnhofer, B. Peterson, and M. Wymore, A report to the Theory of Machines course, UWP, May 2002.
- [4] Baseball Frenzy, J. Andringa, T. Cummins, B. Pechan, and K. Woelfel, A report to the Theory of Machines course, UWP, May 2002.
- [5] The Little Thrower That Couldn't, M. Bulgrin, K. Hanke, E Ralph, and M. Smies, A report to the Theory of Machines course, UWP, May 2002.
- [6] ASME Baseball Frenzy, J. Copeland, A Kinsman, D. Kerrigan. And J. Toutant, A report to the Theory of Machines course, UWP, May, 2002.

## **BIOGRAPHY**

Daryl Logan is a Professor in the Mechanical and Industrial Engineering Department at the University of Wisconsin-Platteville. He received his B.S., M.S., and PhD. Degrees from the University of Illinois -Chicago. Dr. Logan's recent responsibilities have included teaching Theory of Machines, Finite Element Method, and Senior Design Project.