Using National Design Competition Projects as a Component of a Lower Division Design Course

Janak Dave, Thomas G. Boronkay
University of Cincinnati

Abstract

It has been observed that Engineering Technology students learn better by doing/building things. Applying theoretical concepts to practical applications enhances their overall understanding. This is especially true in the area of Mechanical Design.

In order to accomplish this, we, in the Mechanical Engineering Technology Department, University of Cincinnati, have incorporated National Design Competition projects (ASME, ASEE) in the lower division design course. Students design, build and test their models. This process helps students in visualizing results of their team design.

This paper describes the inclusion of these projects in our sophomore level Design of Machine Elements course. Student reactions to these projects and to the team work are also discussed.

Introduction

We have observed that students learn better by doing or building things and that application of theoretical concepts in designing and building a device, enhances their overall understanding. An Engineering Technology program usually has more hands on orientation than an Engineering program. Most courses in the Mechanical Engineering Technology program at the University of Cincinnati have a laboratory component. This is also true in the area of Mechanical Design. We are presenting our efforts to enhance the Design of Machine Elements course, so as to include designing, building, and testing a product.

Previous Approach

Associate Degree students in Mechanical Engineering Technology are required to take the following courses as a part of their design sequence.

Course	Credit hours
Engineering Drawing I	3
Engineering Drawing II	4
Statics	4
Mechanics of Materials I	4
Mechanics of Materials II	4
Design of Machine Elements	5

All of the above courses are one quarter in duration and all of them except Statics have a laboratory period associated with them.

In the Engineering Drawing courses students learn fundamentals of design and drawing, introduction to ANSI standards, dimensioning and tolerancing, fits, etc. In this sequence the student is assigned an individual design project which s/he completes each step of design process, starting from conceptual ideas and design to final working drawings. They are required to produce assembly drawings and bill of materials as needed for their design project. Since students have not taken Statics or sophomore level Mechanics of Materials courses, they are not required to perform any strength computations.

The four credit hours, Mechanics of Materials I and II courses consist of 3 hour lecture per week and a two hour laboratory session per week. The lecture component covers traditional strength of material topics, such as stress, strain, Mohr's Circle, normal and bending stresses, beams in combined loading and beam deflections. Reinforcement of the principles discussed in the lecture is obtained by performing hands on laboratory experiments. For example, obtaining experimental values of Young's Modulus, Poisson's ratio, continuous beam loading, stress concentration factor, constant stress beam, etc.

Design of Machine Elements is the only major Design course taken at the associate degree level. Typical topics covered in this course are design and selection of power transmission components, such as shafts, gears, bearings, chain and belt drive. In the past students were assigned two academic projects during the laboratory session. Typical projects are shown in figures 1 and 2. In the first project, students are required to size the cheek of the crankshaft. The second project consists of designing, analyzing and selecting various components of a power transmission system (Fig. 2). Normally, the first project is of shorter duration than the second one. However, these projects did not involve any conceptual design, final design, or building and testing a product. They focused on analysis and component selection and sizing. From the student's viewpoint these are, still academic projects.

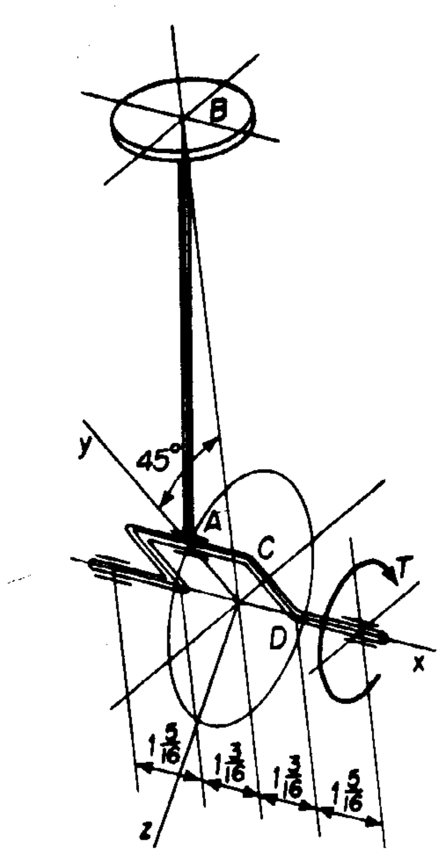
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Fig. 1

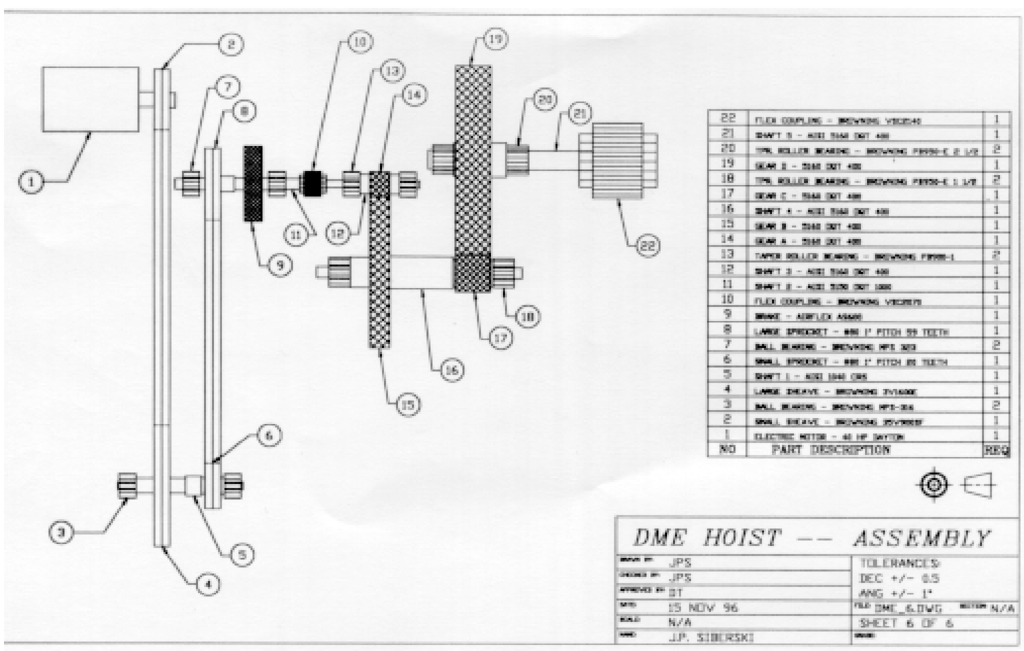
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Fig. 2

Current Approach

We have been using teams of 2-4 students for all projects for the past 5 years to simulate industrial practice. Students are required to specify commercially available components from catalogs, which satisfy the design parameters. In addition, they must give oral presentations and each team must submit a formal written report for the projects. We had to change our grading system to account for both team and individual efforts. All of the above variations to previous projects helped. However, students were not exposed to carrying out a complete project from conceptualization to designing, building, and testing a simple device. In order to overcome this, the project laboratory portion of Design of Machine Elements course was modified as follows:

For the last year, we have included a creative project in place of an academic one. This practical project replaced our crankshaft project (Fig.1). For winter 1996 quarter, the creative project assigned was based on a freshman design competition project, sponsored by EDG division of ASEE. The summer 1996 project was based on the national design competition sponsored by ASME for the year 1996-1997.

Both creative projects were modified to fit in our schedule and meet our needs. More descriptions of both practical projects as assigned to student teams are in the Appendix. More detailed assignments were also given to students each week. Depending on the type of project, all teams compete against each other. We observed that this adds to the excitement of doing their best and enhances their learning.

The first year project was to design a non-electric gate that can be operated by the driver inside a vehicle. The driver must be completely inside the vehicles at all times with the windows rolled up. Teams were given extra credit for demonstrating effectiveness of their design with an operating model.

The students were divided into 7 different teams. While the design and results of all teams were different, we had 5 uniquely different concepts, resulting in different designs. Two of the concepts are shown in figures 3 and 4. Fig. 3 is based on fulcrum and lever principle. Fig. 4 is based on torsional spring load to open the gate.

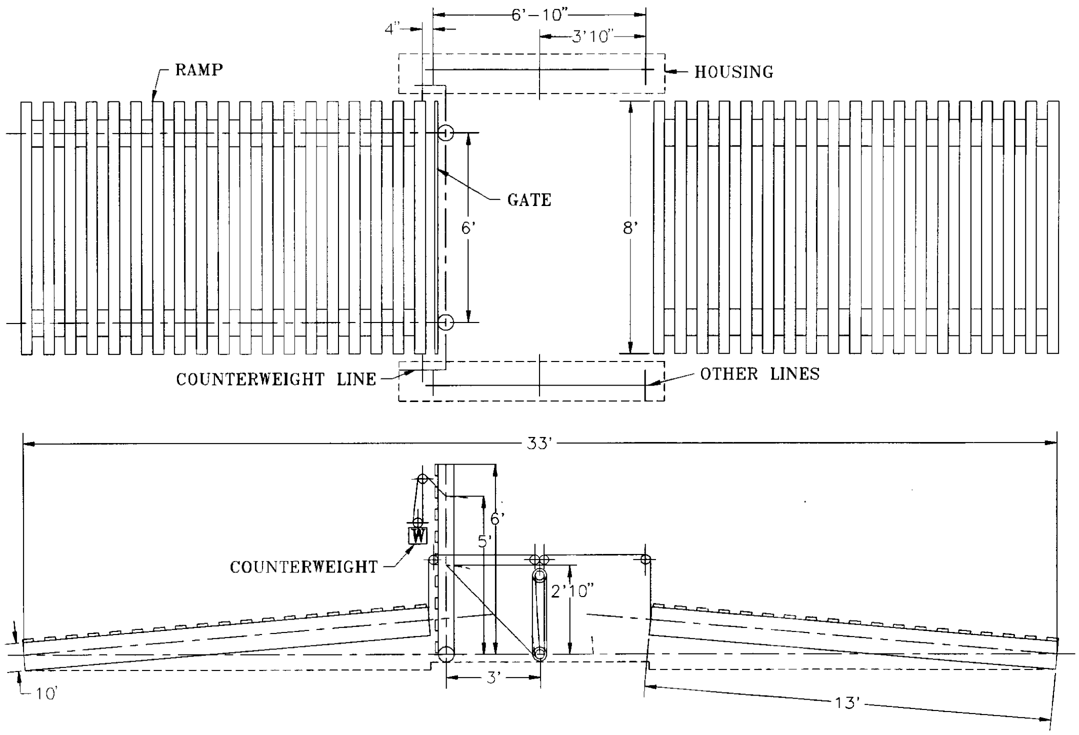
6'–10"
4"
3'10"
RAMP
HOUSING
GATE
6'
8'
COUNTERWEIGHT LINE
OTHER LINES
33'
6'
5'
W
COUNTERWEIGHT
2'10"
3'
10'
13'

Fig. 3

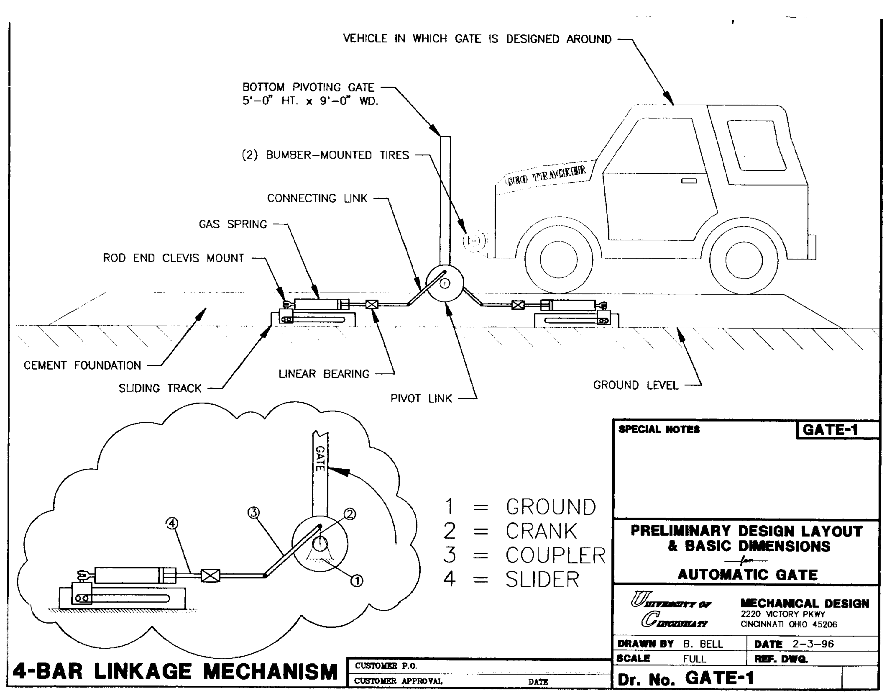
VEHICLE IN WHICH GATE IS DESIGNED AROUND
BOTTOM PIVOTING GATE
5'-0" HT. x 9'-0" WD.
(2) BUMBER-MOUNTED TIRES
CONNECTING LINK
GAS SPRING
ROD END CLEVIS MOUNT
CEMENT FOUNDATION
SLIDING TRACK
LINEAR BEARING
PIVOT LINK
GROUND LEVEL
GATE
1 = GROUND
2 = CRANK
3 = COUPLER
4 = SLIDER
SPECIAL NOTES
GATE-1
PRELIMINARY DESIGN LAYOUT
& BASIC DIMENSIONS
AUTOMATIC GATE
MECHANICAL DESIGN
2220 VICTORY PKWY
CINCINNATI OHIO 45206
DRAWN BY B. BELL
DATE 2-3-96
SCALE FULL
REF. DWG.
4-BAR LINKAGE MECHANISM
CUSTOMER P.O.
CUSTOMER APPROVAL
DATE
Dr. No. GATE-1

Fig. 4

The creative project assigned during the 1996 summer quarter, involved transporting two ping pong balls and a golf ball. The balls had to be moved from a given location to a box, maximizing distance and minimizing time. Only one 1.5 V battery and a Radio Shack DC motor (273-223) were allowed. Students were encouraged to come up with original ideas and were rewarded for meeting the goal as outlined in the competition. Four teams developed four different designs. The wining entry is shown in figure 5. This team will compete with entries from other universities at the 1997 ASME Region V conference.

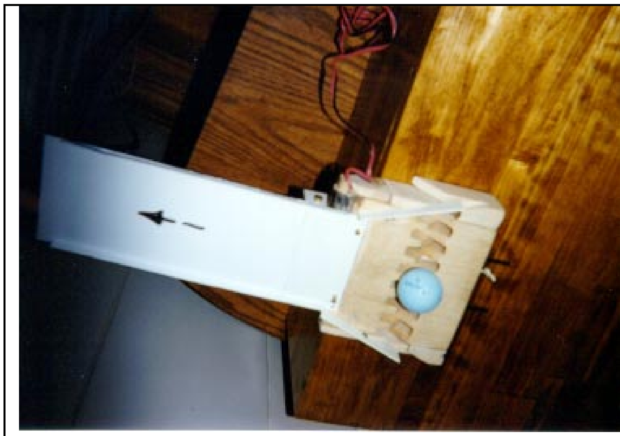

Fig. 5A

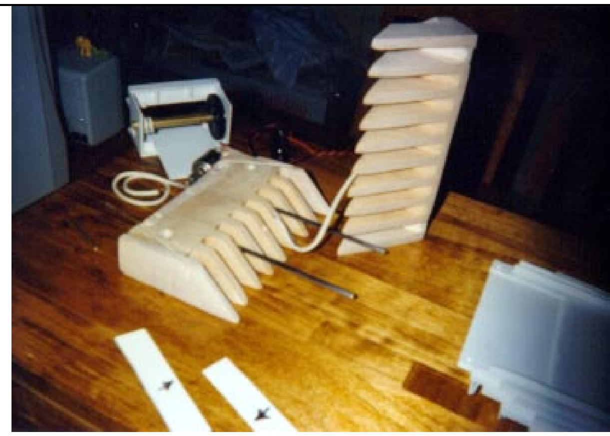

Fig. 5B

Advantages of this approach are:

- Quality, Quantity and availability of projects from various professional societies: Several professional societies and their divisions sponsor student competitions each year. For example, EDG division of ASEE, Gas Turbine division of ASME, ASME National Design Competition.
- Current Application projects: The topics selected by the sponsoring organizations for the competitions are always current.
- Cash prizes and travel awards for students: Winning student entries receive cash and/or travel awards from the sponsoring societies.
- Reduced Plagiarism: As projects are different every year, there is no possibility of student plagiarism.

As discussed above, only the laboratory session of Design of Machine Elements course has been modified.

Conclusion

Initial reaction of both groups of sophomore students was very enthusiastic. They liked the idea of a practical project. Many of them enjoyed building something and coming up with their own creation. Also, competing against other students and observing other entries gave additional insight in solving open-ended projects. Obviously teamwork, project management and consensus building, etc., were also mentioned as benefits. All the comments about the project and its effectiveness in improving learning as well as student feedback of this approach have been positive. No one questioned the merits of the project and the only complaint was about team composition or someone on the team not carrying their fair share. Considering our limited experience we are confident that this approach is beneficial to the lower division students. As of the submission date of the paper, this new approach was used only twice, hence no statistical analysis pertaining to the efficacy of this approach is available. It is anticipated that students will appreciate different types of projects requiring different approaches to design/build/test a device. In our opinion they will be better prepared for today's workplace and further design education.

This paper was initiated at an Undergraduate Faculty Enhancement (UFE) workshop supported by the National Science Foundation (NSF), Grant No. DUE-9455076, through the Division of Undergraduate Education (DUE), Directorate for Education and Human Resources(EHR).

APPENDIX I

Automatic Gate for Remote Locations

Design of Machine Elements
Practical Design Project
Winter 1996

Your group just got lucky and inherited a large property in eastern Kentucky. From time to time you plan to visit this property and keep an eye on it.

The objective of this project is for each group to design a gate that opens and closes automatically. Because the property is in a remote location, the operation of gate must be solely mechanical. Use of electricity for any part of design is to be avoided. The gate/device must open and close from either direction. You may design the device for a specific vehicle and any include modifications to vehicle as needed. The driver must remain completely inside the vehicle during opening and closing of the gate. The installation of the gate must be adaptable to existing wire fencing. The specific vehicle your group may choose can range from a small car to a large truck with a long trailer. The project consists of four major parts. Details of each part will be handed out separately.

During the quarter, the iterative design process shall be used to generate the "BEST" design solution for the mechanism described above. The final design must perform the desired function satisfactorily. You can purchase commercially available parts as long as they satisfy project requirements.

There will be an extra credit for the group that demonstrates using a working model of the gate and a car. (Toy car/trucks may be used.)

Note: This project was modified from a national design graphics competition sponsored by Engineering Design Graphics Division of ASEE.

APPENDIX II

Design of Machine Elements
Design Project
Summer 1996
Janak Dave

Many manufacturing and material handling applications involve moving objects from one place to another in an efficient manner. A company in our area has a particular application where they need to automate the process of moving a group of three parts from a platform into a package for shipment. In order to meet their needs, they have following specific requirements:

1. Design and develop a system to safely transport, without damage, two ping pong balls (halex 3-star) and one golf ball (Top Flite XL-regular) from the top of a platform to a box separated by a given distance 'd' as shown in the figure.
2. The outside dimensions of both the platform and the box are 16x16x32 cm and they are constructed from 1/4-in. grade 'A/C' plywood. The balls initially rest in 1/2" holes centered on top of the platform 8 cm. apart center to center. The golf ball is in the middle hole. The platform and box are placed on a 3/4"x4'x8' sheet of grade 'A/C' plywood placed on a level surface with 'A' side up.
3. The system is to be powered by a single Radio Shack Alkaline Enercell 1.5V AA battery and actuated by a single Radio Shack DC motor (Part no. 273-223). No extra energy sources or motors are allowed. Also, any energy storage devices (e.g., springs, capacitors, and rubber bands) must end the run with the same or more energy than at the start.
4. The design objective is to deliver the balls over the largest possible distance in the shortest amount of time. Your team is allowed to choose the distance d between the platform and the box. The minimum allowable distance is 50cm. Maximum distance is 211.8 cm. as box and platform must be on the plywood base. The box and platform must be placed in the position shown with 32cm sides parallel to 4' sides of plywood.
5. Once the system is assembled and in place, a start signal will be given and the system must deliver all three balls from the platform to the box. The transport time will be measured from the start signal to when the balls come to rest.
6. Once the system is started, no external communication, interaction or influence of any kind is allowed. The system must be autonomous.
7. The score for each team will be computed as follows:

   $X = d / \Delta t$, where,

   d = distance between the box and platform. $50 <= d <= 211.8$ cm.
   Δt = time from the start to when the balls come to rest in the box.
8. Additional objective is to perform above in less than one minute. The complete system must fit within the 16x16x32-cm. box before assembly and/or placement. The system must be assembled and in place, if assembly needed, in 5 minutes. Once assembled and in place, the system must not be in contact with anything except the base, box and platform.

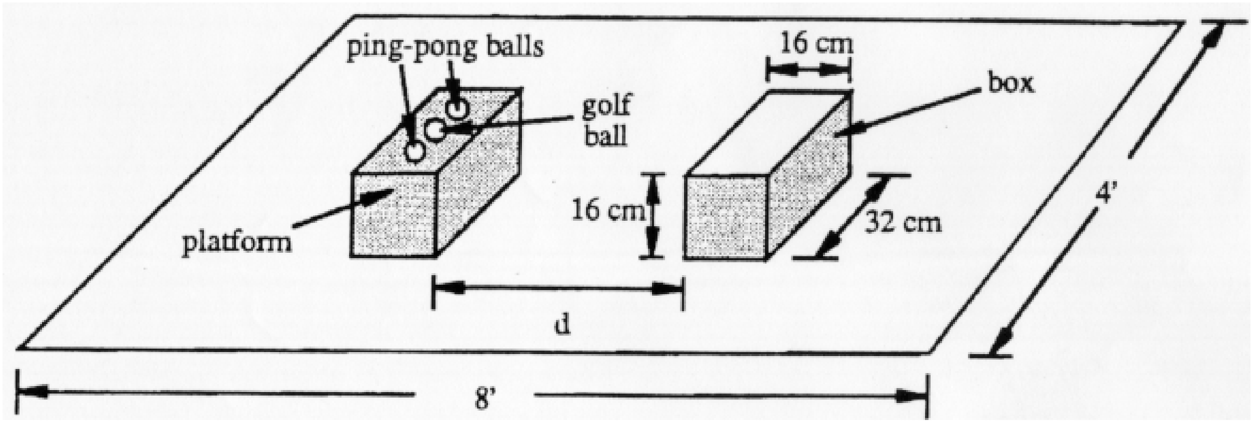

Fig. 6

As above project does ASME sponsor a modification of 1996-1997 NATIONAL design competition. The winning team satisfying all 8 conditions has a chance to win travel funds to Design Engineering conference.

References

1. Freshman Design Graphics Project, EDG division of ASEE, 1995, Washington D.C.
2. Design of Machine Elements by R. L. Mott, Merril Publishing, Columbus, OH
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4. Mechanics of Materials by Gere, PWS publishing, Boston, MA
5. National Design Competition, 1996-1997, ASME, New York, NY
6. Concurrent Engineering Design workshop at Austin, Texas sponsored by NSF. (August 1996)

JANAK DAVE
Dr. Janak Dave is an Associate Professor of Mechanical Engineering Technology at the University of Cincinnati. His areas of interest are Mechanical Design, CAD, CAE and Numerical Methods. His industrial experience is in the areas of product design and product management. He has been very active in professional societies and is currently a board member for Region V of ASME.

THOMAS G. BORONKAY
Dr. Boronkay is a Professor of Mechanical Engineering Technology at the University of Cincinnati. His areas of interest are: Mechanical Design, CAD, CAE, Concurrent Engineering and Product Development. He has twenty years of industrial experience and has been an invited speaker on concurrent engineering in Mexico, Finland and Estonia. He has been very active in professional societies and is currently the chair of the DEED division of ASEE.