# Engineering Design I: Medical Adhesive Pad Paper Backing Cutter Design and Development

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## Abstract

For the first time the project for the Fall 2001 "Junior Design" course at Baylor University was externally sponsored by Capital Marketing Technologies of Waco, Texas. They requested that the engineering students develop a device that cuts the paper backing on medical adhesive pads without damaging the pads themselves. The pads range in size from 2 x 2 in. to 4.5 x 4.5 in. for rectangular pads and 2 x 3.5 in. for kidney shaped pads. Pad thickness, including the backing paper is approximately 0.015 in. The backing paper thickness ranges from 0.003 – 0.004 in. Capital Marketing Technologies also specified that the single sided pads be cut at a rate of at least 40 pads per minute. Seven teams of 4 to 5 students each were formed, each to develop its own design. The first phase of the project consisted of a conceptual design and the construction of a prototype. This design period was short and the prototype was unrefined. During this process, our team brainstormed, built a prototype based on those ideas, and learned about what works and what does not work. With the knowledge we obtained during the conceptual design phase, we moved into the final design phase. The second design was based on a new concept and was much simpler than the first design. For simplicity and ease of construction, the number of moving parts was decreased from the first phase. The prototype that resulted in the final phase met most of the specifications of the compliance test. Documentation complete with safety and maintenance information, a technical description, and CAD drawings was prepared after the compliance test. At the conclusion of the course, all teams formally presented their final designs to Capital Marketing Technologies.

## Introduction

Students enrolled in Engineering 3380, Engineering Design I, at Baylor University registered for more than a typical textbook engineering class. In fact, there is no textbook required. Engineering Design I, otherwise known as "Junior Design," is a comprehensive class based on a semester long project encompassing team-based design, construction and testing of a device, and includes oral, written and graphical communication. The class generally consists of students in the first semester of their junior year who have completed only basic engineering classes such as Electrical Circuits and Statics. The Fall 2001 class had a special opportunity: The project was externally sponsored by Capital Marketing Technologies of Waco, Texas. Capital Marketing

Technologies (CMT) approached the Baylor University Engineering Department with a request that engineering students develop a device that cuts the paper backing on medical adhesive pads without damaging the pads themselves. The paper backing is similar to the backing on a band-aid. CMT desired to find a device that would cut the paper backing faster and more consistently than their current system. The pads range in size from 2 x 2 in. to 4.5 x 4.5 in. for rectangular pads and 2 x 3.5 inches for kidney shaped (double sided) pads. Pad thickness, including the backing paper, is approximately 0.015 in. and the backing paper thickness ranges from 0.003 – 0.004 in. The texture of the backing paper also varies between the different sizes and shapes of pads. CMT specified that the single sided pads be cut at a rate of at least 40 per minute.

The course was instructed by two engineering faculty members. One is a mechanical engineer and the other an electrical engineer. This provided instruction for both the electrical and the mechanical engineering aspects of the project. The professors divided the class into seven teams of 4 or 5 students each. From that point, each team was given the assignment to design and construct a device to meet CMT's specifications. The semester was divided into two phases. Phase I was a shorter time period for idea generation and testing. A prototype was produced, tested for compliance, and briefly documented. Phase II was a more extended, refined period in which the project was completed. Teams had the option of completely changing their Phase I design or modifying and enhancing it for improved performance. Phase II was complete with oral presentations and written documentation in the form of a progress report to instructors and an owner's manual for the client.

## The Project

### Phase I

Team 3 took a unique and simple approach to Phase I. The prototype consisted of five main components: the cutting mechanism, the roller/crank assembly, the conveyor assembly, the compression roller assembly, and the wooden housing. See Figure 1.1. The cutting mechanism consisted of an X-acto razor blade that was held in place by a steel rod and a clamping mechanism. The blade was positioned between the compression rollers and cut the paper backing as the pads moved past the roller assembly. The roller/crank assembly consisted of the main roller, which drove the conveyor assembly. The roller was manually driven by a crank, which the operator turned. The conveyor assembly consisted of the belt and a passive roller at one end of the belt. The belt was used to feed the pads into the cutting mechanism. The operator of the machine placed the pads on the belt with the paper backing face up and then they were fed into the compression roller assembly and past the cutting mechanism. The compression roller assembly consisted of two freely rotating rolling pins. These rolling pins were positioned so they provided pressure on the pads as they moved past the cutting mechanism. This prevented the pads on the conveyor assembly from bunching up or bypassing the cutting mechanism as the conveyor belt moved them past the cutting mechanism. The wooden housing was designed to provide protection and stability for the device. It was made of ¾ inch plywood and all other components were mounted into the housing.

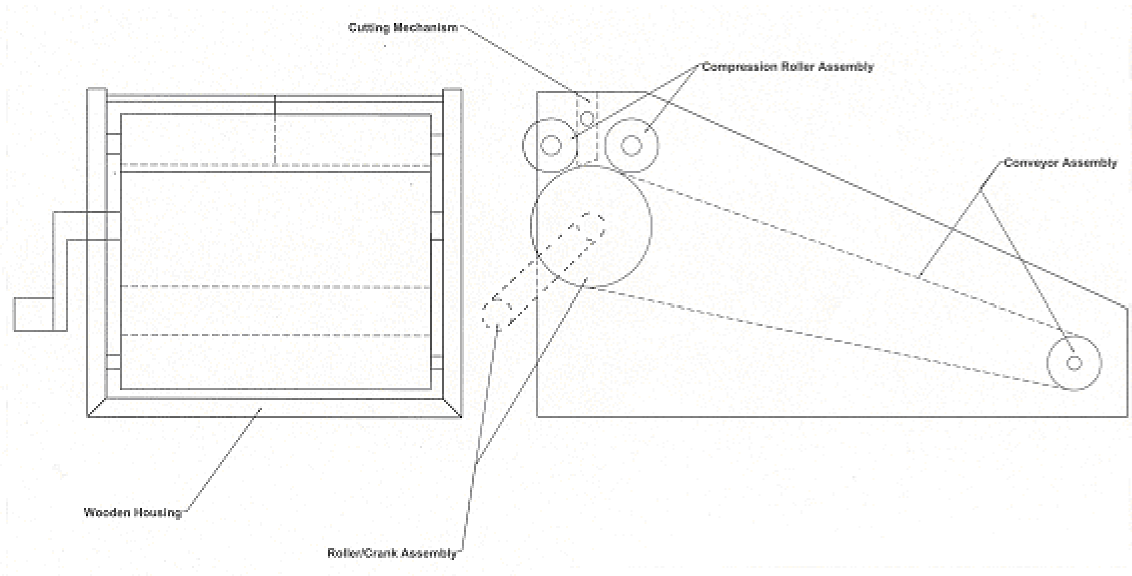


Figure 1.1
Orthographic view of Phase I prototype.

The main flaw in the Phase I design was its size. The prototype was built on a large scale, due to the choice and availability of materials, and was not practical for CMT's use. The prototype was completely manually operated, although original plans included adding an electric motor to replace the hand-crank that turned the main roller. The prototype was also inconsistent in its cutting due to a varying thickness in the conveyor belt that moved the pads past the cutting mechanism.

**Phase II**

After evaluating the results from the Phase I design, Team 3 decided to implement a completely new idea for Phase II. The team gained a great deal of knowledge of material availability and had generated many new ideas by the beginning of Phase II. The complete redesign included electrical power, smaller size, more consistent performance, better materials, and easier maintenance. The resulting prototype from Phase II was "The Cube."

Technical Description

"The Cube" was divided into four major components for the purpose of design and construction. These components included the housing, the power supply, the roller/motor assembly, and the cutting mechanism. See Figure 1.2.

The housing of the device is made of 0.5" condensed plywood and 1/16" sheet metal. The housing has an 8" x 8" piece of plywood as a lid. This is hinged to the vertical facing of the housing with two brass hinges. It also has a 6.5" feed chute cut into the top where the pads will be fed externally. See Figure 1.3. This chute is located just above the roller and cutting mechanism. From the chute is a 6.5" x 3.5" slab of sheet metal to guide the pads to the roller. A brass knob is assembled next to the chute on the lid to provide easy access to the internal works of the machine. Two of the vertical faces of the housing have a 6" extension, giving room for the pads to fall and collect under the device. The other two vertical faces are 8" in length. The bottom facing has another 6.5" x 2" chute directly under the roller of the machine. This chute enables the pads to fall from the device and be collected. From the chute are two more 6.5" x 3.5" sheet metal guides to direct pads into the lower chute. The metal is also tapered as it approaches the roller to reduce the chance of injury if the operator was to insert any extremities through the bottom of the device. The internal makeup of the device (the roller/motor assembly) is housed in an 8" x 8" x 8" volume. The inside of the vertical facing of which the cutting mechanism is mounted is a 7" x 7" piece of sheet metal. This metal sheet will enable the user to drop the pad vertically into the machine, and the pad will slide across the metal surface with very little friction.

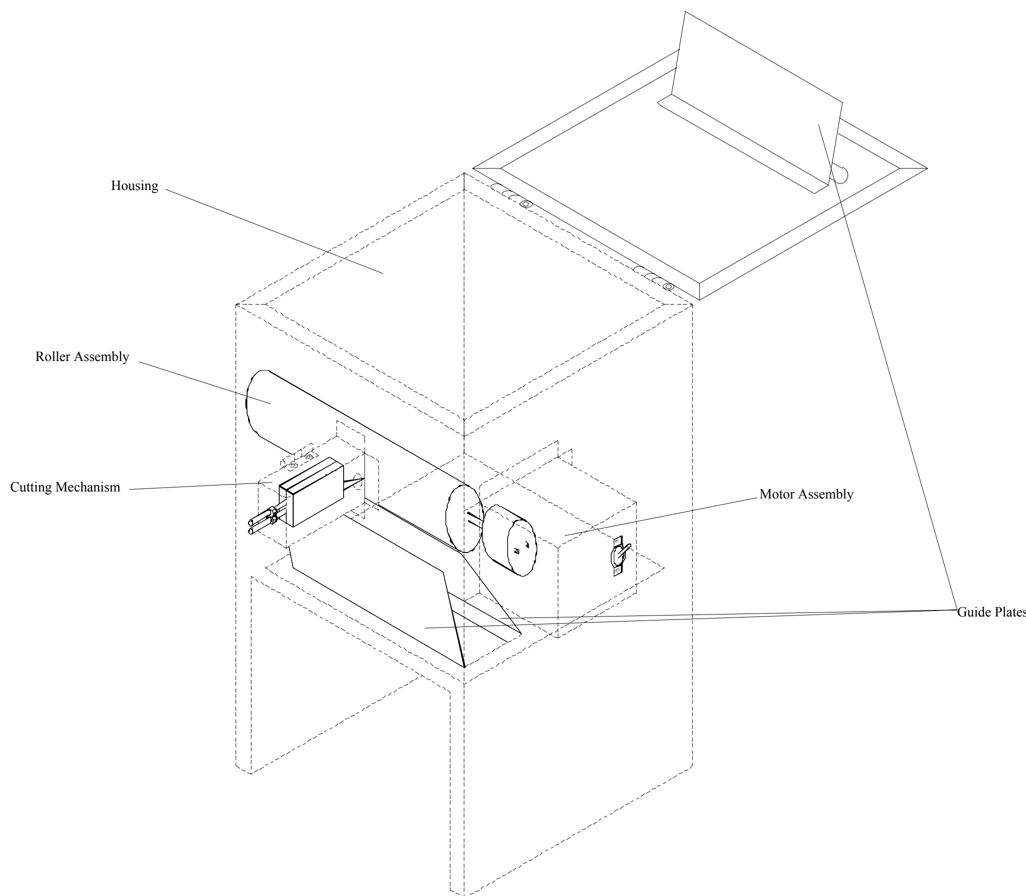


Figure 1.2
Isometric view of Phase II prototype.

The power for the device is provided through an adjustable 13.5/30 volt transformer. The transformer is adjustable to control the speed of the motor. Although not recommended, the transformer can be set on 30 volts for maximum RPM. The transformer can be plugged into any standard wall outlet. Located on the housing of the device is the smaller 2" x 2" x 2" power supply housing. This is mounted just above the motor and is made of sheet metal. The housing contains the wiring that connects the transformer to the motor. For ease of use, the housing has an external switch. This enables the user to plug in the machine and flip the switch to use the device.

The roller/motor assembly is the component that drives the device. The power to rotate the roller comes from an internally geared DC motor connected directly to the roller. This is attached to one of the 14" x 8" external facings of the housing. The roller has a 1.5" diameter and is 6.5" in length. The roller is made of aluminum, which was machined with a diamond pattern on the cylinder's surface to increase the grip on the pads. The shaft of the motor fits directly into the roller and is mounted with a hex set-screw located on the roller. A bolt, extended through the housing, attaches the opposite side of the roller to the opposite 14" x 8" facing. This bolt spins freely from the roller, due to the internally machined ball bearing. The roller is centered perpendicular to the cutting mechanism and slightly above the blade. It is also directly below the feed chute and directly above the collection chute to allow the pads to fall through the device.

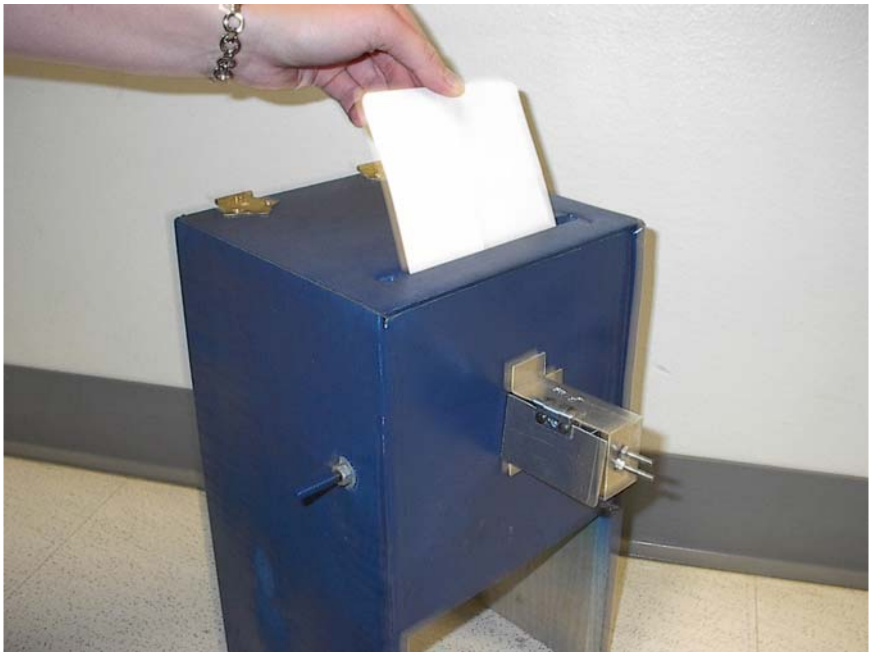

Figure 1.3
Phase II prototype with a pad being inserted.

The cutting mechanism is encased in a 2" x 2" x 2" metal housing located on a vertical facing closest to the roller as seen in Figure 1.3. The left most vertical facing is hinged to enable access to the blade mount. The blade is exposed to the pads on the inside of the device through a small slit on the 8” x 8” vertical facing. The 2” long blade is externally adjustable and internally replaceable. One can replace the blade by opening the hinged facing, unscrewing the two metal mounting plates, and removing the old blade. Setting the new blade into the groove and reattaching the blade mount will complete the replacement of the blade. Two guide bolts extend through the housing of the cutting mechanism. These bolts positioned with respect to the housing by two nuts. One nut is set internally and one is set externally on each bolt to insure that the cutting mechanism does not move. This design also enables the user to change the blade and not have to worry about readjusting the blade each time. However, if adjustments are needed, the user can simply loosen the nuts and adjust the blade in or out.

The Cube is actually a very simple design. The pad is inserted into the chute by way of the slot in the lid of the housing. The paper backing must be facing the cutting mechanism when inserted. The roller grips the pad and moves it past the cutting mechanism. As the pad moves pad the cutting mechanism, the X-acto blade makes a cut in the paper backing. The pad then falls out of the bottom chute of device. This path is shown by the red arrows in Figure 1.4. A digital photograph of the prototype with major components labeled is shown in Figure 1.5.

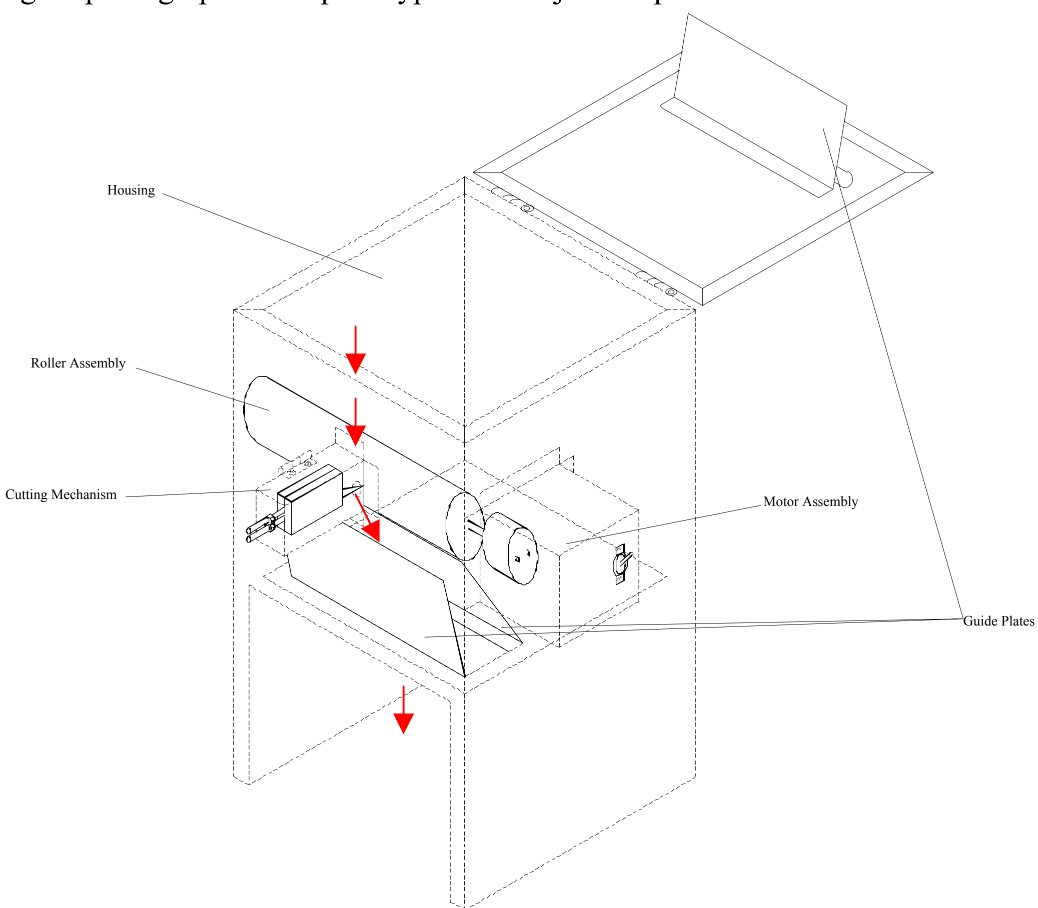


Figure 1.4.
Isometric view of prototype with arrows denoting path of pad through device.

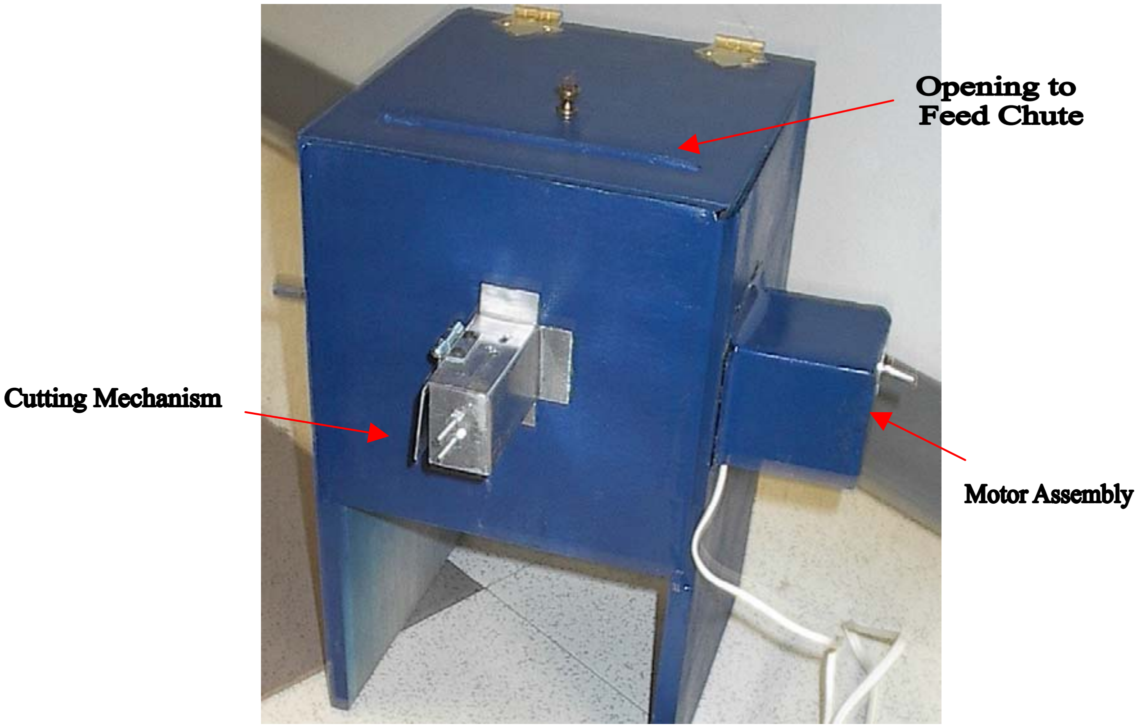


Figure 1.5
Digital photograph with major components labeled.

Compliance Test

The prototype for each team was tested for compliance with CMT's specifications. All groups were gathered together during the scheduled lab time with their projects along with any guests who were interested. Each team demonstrated the operation of their device with all of the different sized and shaped pads. A timed trial was given to see if the prototypes met the time requirement of 40 pads per minute with a rejection rate of less than 5%. This day had been highly anticipated by students participating in the project. Some devices performed better than others, some not as well as their designers had hoped, and some were spectacular.

Client Test and Owner's Manual

Although one might think that the compliance test would conclude the course, there was still much to be done. Each team was to prepare an Owner's Manual for CMT, and a copy for the instructors. The Owner's Manual included an introduction, safety information, operating instructions, maintenance information, design details and a complete bill of materials. Each team demonstrated its prototype to CMT and presented the accompanying owner's manual. At the end of the semester, all of the prototypes were delivered to CMT. Since that point, they have been using each prototype and testing them for their strengths and weaknesses. "The Cube" has been used quite extensively since the end of the semester.

## Conclusion

Junior Design provides students with a realistic view of engineering. Completion of the project requires applying the knowledge gained from previous classes. It also requires that students search for answers about topics not yet covered in classes. Teamwork is a very important aspect of the experience. The ability to work and communicate with other students to accomplish a common goal is a necessity. Besides gaining practical knowledge that can be applied to other required classes, participating students gained skills that will one day be helpful after graduation.

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