MECH 499 PROJECT
VIRTUAL AND PHYSICAL PROTOTYPING OF MECHANICAL SYSTEMS
WEB-CONTROLLED DOG BALL LAUNCHER

PROGRESS REPORT

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(Electrical contributions by Dave Wolowicz)
ABSTRACT

The purpose of this project is to gain design project experience while incorporating mechanical, electrical and computer components into a single, functioning prototype. The prototype is a web-controlled, automatic tennis ball launcher for dogs that would also periodically dispense treats for the dog. The unit has five main components: the ball launch mechanism, the ball feeder, the food dispenser, packaging, and electronics.

Existing ball launch designs were investigated including baseball launchers, tennis ball launchers and tennis ball launchers for dogs. The launch mechanisms included one or two spinning discs, pneumatics, and lever mechanisms.

The ball launcher is required to launch a variety of tennis balls of a variety of sizes and compressibilities a distance of 40 ft. Three types of launch mechanisms were considered: spinning disc designs, spring designs and pneumatic designs. Pneumatic designs were ruled out as being too expensive. A brief analysis and testing indicated that large forces would be required to charge a spring to launch a tennis ball. A simple analysis indicated that a single spinning disc design would be feasible and this design was chosen. The ball launch distance will be varied by controlling the motor speed.

Two spinning disc prototypes have been made. The second prototype used a 3450 rpm ½-¾ hp motor with a tube assembly to guide the ball and was capable of launching a soft tennis ball almost 30 ft and a hard tennis ball almost 60 ft.

Three solenoid mechanisms were considered for the ball feeder: a double gate, a lever, and a rotating wheel. The rotating wheel is being developed as the least expensive design and the best use of the solenoid. The proposed food dispenser design would use a small stepper motor to rotate a slotted disc. The packaging (mounting and enclosure) will be made out of wood.

The electrical system for the ball throwing machine is split into three main sections: the microcontroller, the sensors, and the control circuitry. The main component of the circuitry is the TINI microcontroller. TINI is a JAVA enabled microcontroller that has a TCP/IP stack built into it. The motor will be driven using the circuit outputs and an opto-triac driven high current triac. The control software will be written in JAVA and assembler for the TINI microcontroller.

A Pro/Engineer model is being developed for the ball launch mechanism simultaneously with prototyping. The ball feeder mechanism has been sketched out in AutoCAD and Pro/Engineer modeling is being worked on.

A schedule exists for the project. Modeling is slower than expected but the assembly is ahead of schedule. Overall the project is progressing according to the schedule.
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1 INTRODUCTION

The purpose of this project is to gain design project experience while incorporating mechanical, electrical and computer components into a single, functioning prototype. The chosen prototype is a web-controlled, automatic tennis ball launcher for dogs. The physical unit in the dog’s yard would be made up of a box containing electrically controlled mechanisms for receiving and launching the balls as well as for storing and dispensing small treats or food to reward the dog when the ball is returned to the machine. The machine would be web-controlled allowing the dog owner to activate the ball launcher from any computer with internet access.

The mechanical skills which will be gained in this project include:
- Computer aided design and modeling
- Computer simulation and analysis
- Design implementation and prototyping
- Project planning
- Integration of a mechanical system with electrical and computer elements

While not all of these project aspects will be directly addressed in this report, they appear explicitly and implicitly throughout the report.

This report will present the project progress to date. The design part of the report is split into two sections:
- The ball launch mechanism
- The ball feeder, food dispenser, housing and electronics.

The ball launch mechanism is the crux of the preliminary design and the report includes design alternatives, preliminary analysis, testing, design selection and preliminary prototype. The ball hopper / feeder and food dispenser are under development and the report covers alternative designs and current design direction. A short explanation of the electronic and computer components will be given.

Also included in the report will be the preliminary CAD modeling and the project status including a project schedule.

The project website was created by Dave Wolowicz and is located at: http://www.ece.uvic.ca/~dwolowic/balltoss.html.
2 BALL LAUNCHER

The ball launcher is the mechanism that is to launch the ball 40 ft. Ideally the ball range would be variable to accommodate for different size yards and to vary the game for the dog. A number of other commercially available products launch balls and these were investigated as a starting point for this design.

2.1 BALL LAUNCH ALTERNATE DESIGNS

Most of the machines found for automatically throwing balls were trainers for baseball and tennis. There were a variety of designs and price ranges available in these products. Three automatic tennis ball launchers for dogs were found.

The baseball throwers:

- One or two wheel design (each wheel is separately driven) (Figure 1)
- Rubber or grooved wheels
- Typical motor: $\frac{1}{2}$ hp, 110 VAC,
- Lever arm type machines were also available (Figure 2).

![Figure 1: One and two disc baseball throwers [1]](image)
Figure 2: Lever arm operated baseball throwers [2]

Tennis ball thrower:
- One or two wheel designs were available – typically two wheel
- Less expensive versions were air powered (Figure 3 below).

Figure 3: Air powered tennis ball thrower [3]

Ball launchers for dogs:

- The Lobster 202 Economy Ball Bucket (Figure 4) is a machine made as a tennis trainer but also marketed to the dog owner. It is air powered and has a large ball capacity and velocity capability.

Figure 4: Lobster 202 Ball Bucket [4]
• The Go Dog Go tennis ball thrower (Figure 5) is designed for dogs and has a launch adjustment of 15 to 30 ft and a 15 ball capacity. The ball launch is impact driven.

• The Tennis Twist by Sportstutor (Figure 6) is a machine for small dogs with an adjustable range of 10 to 20 feet and a 28 ball capacity. The Tennis Twist can be powered by AC or using “D” size batteries. The ball launch is most likely impact driven.

2.1.1 SPINNING DISC DESIGNS

One motor driving two spinning discs:
By using belt, pulley and gear systems, one motor can drive two spinning discs to propel the ball. This design could be configured with one continuous belt or the motor driving two belts. Since the discs must be spinning in opposite directions, the two belt system would require a pair of gears at one disc to accomplish this.

Figure 7 below shows a possible configuration of the single belt driving two pulleys system.
Figure 7: Single belt system

The advantages of this system over the dual belt system are:
- The simplicity of a single belt
- No double pulleys required
- All three pulleys can be the same
- One adjustment point for tensioning the pulley
- Belt tensioner (idler pulley) is part of system.

The disadvantages of the one belt system are:
- A flat belt is required because both sides will contact pulleys (require more belt wrap)
- More tension is required in the one belt
- Higher tension results in higher loads in the bearings.

A schematic of the dual belt system is shown below in Figure 8.

Figure 8: Dual belt configuration
The advantages of the dual belt system are:
- It can use a V-belt
- Better wrap around the pulleys and better power transmission
- Less belt tension is required resulting in less load on the bearings.

The disadvantages of the dual belt system are:
- More parts are required
- A double pulley is required on the motor
- A gear or twisted belt configuration must be used to change the rotation direction of one of the discs
- Adjustment of the belts is more complicated.

**Independently driven discs:**
One or two disc designs can be independently driven by separate motors. This allows the eliminations of the belts, pulleys and all the mounting and adjustments that are associated with them. Smaller motors can be used and there will be no loss of energy between the motor and the spinning disc.

**2.1.2 SPRING DESIGNS**
The spring designs would make use of the energy in the spring to launch the ball. The spring would activate an arm that would catapult the ball. The spring would have to be energized by an electric motor or solenoid, and another solenoid could release the arm to launch the ball. Figure 9 below shows a possible schematic for this design.

![Figure 9: Spring design](image)

One option that was discussed was timing the motor while energizing the spring to vary the ball distance, or using a ratcheting mechanism to hold the spring in a range of positions.
The advantages of the spring design are:
- It may not need a motor (or only needs one motor)
- It is potentially quieter (no high speed rotating masses)
- Energy only needs to be applied periodically when it is needed.

The disadvantages of the spring design are:
- It requires a high force solenoid, or a low speed high torque motor to charge the spring
- It could be difficult to engage and disengage the spring-arm system.

2.1.3 PNEUMATIC DESIGNS
A pneumatic design would use a compressor or fan and an accumulator or tank to store a large enough volume of compressed air to launch a tennis ball. A constriction in the exit type that is electronically controlled would be used to release the ball.

The advantages of the pneumatic design are:
- Simple design with few moving parts.

The disadvantages of the pneumatic design are:
- It is difficult to vary the ball range
- It is noisy
- It is bulky, requiring an air storage tank
- The components are expensive.

2.2 PRELIMINARY ANALYSIS OF LAUNCH COMPONENTS
A spreadsheet (developed by Aaron Bohnen) was used that calculates the trajectory of a spherical projectile when launched with a known angle and initial velocity. The spreadsheet takes gravity and air friction into account and is calibrated for varying air temperatures.

Based on drag coefficients for a tennis ball which are slightly lower than for a smooth sphere, an initial velocity of 11 m/s is needed to launch a tennis ball approximately 40 ft at a 45° launch angle.

A regulation sized tennis ball has the following dimensions and mass:
- Diameter: 2.5” – 2.625” or 63.5 – 66.7 mm
- Mass: ~ 58 grams
2.2.1 SPINNING DISC DESIGN ANALYSIS

An analysis was done on the spinning disc design to determine the rotational speed and power required by a motor to launch a ball at 11 m/s. To get an 11 m/s initial velocity a rotational speed of 2068 RPM is needed from two 4” discs or one 8” disc. The assumptions in this calculation are:

1. There is no slip between the ball and disc or fixed surface and the ball
2. The disc speed is constant while contacting the ball
3. The ball does not deform in contact with the disc.

The following table shows the starting power required from the motor to achieve a ball exit velocity of 11 m/s. The mass moment for the disc was taken from an actual pulley that will be used for initial testing.

<table>
<thead>
<tr>
<th>DISC OF KNOWN MOMENT</th>
<th>Disc OD</th>
<th>Number of discs</th>
<th>Mass Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 in</td>
<td>1</td>
<td>11.27 lb-in^2</td>
</tr>
</tbody>
</table>

|                        | 0.003298 kg-m^2 |
| Full speed             | 0.003298 kg-m^2 |
| Time to reach FS       | 1 s             |
| Angular Accel          | 216.5605 rad/s^2 |

| Starting Torque        | 5.79 ft-lb     |
| Starting Power         | 0.207 hp       |

| Ball Exit Velocity     | 11.0 m/s       |

For a time of 1 second to reach full speed 0.2 hp is required from an electric motor. This is a reasonable value and a motor of this size would be available.

2.2.2 SPRING DESIGN ANALYSIS

Some analysis was done on the idea of using springs to launch the tennis ball. The analysis was done to determine the feasibility of the idea. The analysis assumes a configuration similar to Figure 9, with a solenoid charging the spring which then transfers the energy to the ball. Table 2 shows an approximated calculation of the force required from the solenoid based on some assumed input quantities.
Table 2: Spring design analysis

<table>
<thead>
<tr>
<th>Input Quantities</th>
<th>Calculated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Ball and Holder</td>
<td>0.1 kg</td>
</tr>
<tr>
<td>Mass Bar</td>
<td>0.05 kg</td>
</tr>
<tr>
<td>Length Bar</td>
<td>0.3 m</td>
</tr>
<tr>
<td>Distance solenoid to pivot</td>
<td>0.03 m</td>
</tr>
<tr>
<td>Initial Velocity of Ball</td>
<td>11 m/s</td>
</tr>
<tr>
<td>Solenoid Travel</td>
<td>1 in</td>
</tr>
<tr>
<td>Total inertia about pivot</td>
<td>0.0105 kg*m^2</td>
</tr>
<tr>
<td>angle of travel (bar)</td>
<td>40.3 deg</td>
</tr>
<tr>
<td>angular velocity</td>
<td>36.7 rad/s</td>
</tr>
<tr>
<td>angular acceleration</td>
<td>957 rad/s^2</td>
</tr>
<tr>
<td>torque required</td>
<td>10.0 Nm</td>
</tr>
<tr>
<td>Force required from solenoid</td>
<td>335 N</td>
</tr>
<tr>
<td>0.0254m</td>
<td>75.3 lbf</td>
</tr>
</tbody>
</table>

The table shows that for an initial ball velocity of 11 m/s, a solenoid that will provide 75 lbf and 1 inch of travel would be required. Solenoids with these characteristics are not available, so the spring would have to be charged in a different way for this design to be feasible.

2.3 BALL LAUNCH TESTS

Tests were performed on the spinning disc and spring designs to confirm the results of the analysis and verify the feasibility of the designs.

2.3.1 SPRING DESIGN TESTING

A mouse trap and a rat trap were used to determine:
1. How much force / torque it takes to energize the springs
2. How far the tennis ball is thrown with that spring energy.

A spoon was attached to the spring loaded frame and the trap was clamped down. The trap was then set and the tennis ball placed in the spoon. The trap was tripped and the tennis ball was launched as the trap closed. In each case the clamping was not sufficient to hold the trap. This indicates that if the trap were more firmly clamped the ball would likely be launched even farther than these tests indicate. The actual distance would be expected to be larger since:
- More of the spring energy would go into launching the ball rather than into moving the trap
- The trap would be mounted to optimize the launch angle

**Mouse trap:**
- Force to energize spring: ≈ 2.5 lbs at 1.75” (4.38 ft-in or 70 oz-in or 0.36 ft-lb)
- Distance ball launched: ≈ 4’
- Ball moment arm: 5.5” and 9.5” (ball thrown same distance)

**Rat trap:**
- Force to energize spring: ≈ 10 lbs at 3.25” (32.5 ft-in or 520 oz-in or 2.71 ft-lb or 3.67 N-m)
- Distance ball launched: ≈ 20’ (and rolled another 6-8’)

9
Ball moment arm: 9.5”

The spreadsheet used for the spring design calculation was used to verify the numbers for the rat trap with some modifications due to the different geometry. The ball exit velocity was calculated based on the distance the ball was launched and was determined to be 7.8 m/s. Estimating the masses of the system and assuming the ball was in contact with the spoon for 45 degrees, a required torque of 4.0 N-m was calculated, which is reasonably close to the experimental value of 3.67 N-m. The values are shown below.

Table 3: Rat trap (spring test) calculation

<table>
<thead>
<tr>
<th>Rat Trap Calculation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Ball and Holder</td>
<td>0.1 kg</td>
</tr>
<tr>
<td>Mass Bar</td>
<td>0.01 kg</td>
</tr>
<tr>
<td>Length Bar</td>
<td>0.24 m</td>
</tr>
<tr>
<td>Initial Velocity of Ball</td>
<td>7.8 m/s</td>
</tr>
<tr>
<td>accelerate through this angle</td>
<td>45 deg</td>
</tr>
<tr>
<td>angular velocity</td>
<td>32.5 rad/s</td>
</tr>
<tr>
<td>angular acceleration</td>
<td>672 rad/s²</td>
</tr>
<tr>
<td>torque required</td>
<td>4.0 N-m</td>
</tr>
<tr>
<td>force required</td>
<td>48.5 N</td>
</tr>
</tbody>
</table>

This calculation verifies that the spreadsheet used in the spring design calculations gives a good approximation of the required forces. This result also confirms that the solenoid required to charge a spring to launch the tennis ball 40 ft would require a prohibitively large force.

2.3.2 SPINNING DISC PROTOTYPE 1

A 110 VAC, 3000 rpm, 1/3 hp washing machine pump motor was used in testing. An 8” die cast aluminum V-belt pulley was purchased as a disc with which to launch the ball. The purpose of the first trial was to determine if:
1. The pulley would be stable rotating at 3000 rpm
2. The pulley could be coupled securely to the motor shaft.

The testing was carried out and it was confirmed that the coupling was secure and that the pulley was stable at 3000 rpm.

In a second test, an off the shelf light dimmer switch was used to control the motor. The purpose of this test was to determine if the dimmer switch technology could be used to control the motor speed. This test was performed and it was confirmed that the dimmer switch can control the motor speed.
In further tests, a V-belt was cut and attached to the pulley using adhesive and pinning the ends, as shown below in Figure 10. The V-belt and pulley combination were not balanced causing excessive vibration when rotated at 3000 rpm by the motor. Attempts were made to balance the belt and pulley but the vibration could only be decreased slightly, still resulting in excessive vibration. It is postulated that the factors in the excessive vibration were:

- The flexibility in the shaft mounting in the motor (the shaft had some axial movement).
- The relatively small size and weight of the motor.
- The cantilever type loading of the pulley on the end of the long motor shaft.

![Figure 10: Prototype 1](image)

### 2.4 BALL LAUNCH DESIGN SELECTION

A pneumatic design was avoided because:

1. Controlling ball range is problematic, as you have to control the flow, and an electronically controlled flow control valve is likely expensive
2. Compressors are expensive and draw a lot of current (though a $10 compressor was purchased – it had a very low flow rate)
3. To launch the ball far, the ball would need to be somewhat sealed in the tube. It could be difficult to load the ball and then seal it to build pressure.
4. An accumulator tank is required and they are expensive (about $45).

The solenoid energized spring design was ruled out by the analysis. The spring tests also verified that a large spring force would be required to launch the ball. Analysis indicated that a typical solenoid with 3/8” travel would have to exert a very large force to energize
a spring sufficiently to launch the ball with an initial velocity of 11 m/s. Such large force solenoids are uncommon and would most likely be expensive and draw large amounts of current.

The rotating disc design was chosen as it appears to be the easiest to make and the least expensive since many of the components can be scavenged. This is the design that will be focused on, pending success in certain upcoming tests. A design using a single large pulley direct driven by an AC motor will be the preliminary design. The ball will be dropped onto (or under) the rotating pulley, pinched between the pulley and a solid surface, and launched through a short guide tube.

### 2.5 SPINNING DISC PROTOTYPE 2

Once the single direct driven disc design was chosen, a second prototype was built and tested (see Figure 11 below). The new prototype used a radial arm saw motor, rotating at 3450 rpm and providing an estimated ½ -¾ hp. This motor is bigger and heavier than the previous motor and has a more rigidly mounted shaft. The second motor has a shorter shaft than the first motor so the pulley is mounted much closer to the motor, reducing the cantilever loading. An undersize V-belt was used on a new pulley. The bottom part of the V profile on the belt was removed allowing the undersized belt to be mounted on the pulley without cutting the belt. In testing, the larger motor and better balanced pulley and belt eliminated the excessive vibration experienced with the first prototype.

![Prototype 2](image)

Figure 11: Prototype 2

PVC pipe and fittings were modified and assembled to create a path to feed the ball under the spinning disc and guide the ball as it is launched. The pipe assembly is configured to “pinch” the ball between the pulley and the tube wall at two points; where it is directly under the pulley and just before the ball exits the tube. The motor and PVC tubing
assembly is shown below in Figure 12. The ball is fed into the inlet tube on the right and exits through the outlet tube on the left.

![Motor and PVC tubing assembly](image)

**Figure 12: Motor and PVC tubing assembly**

This prototype was tested using different tennis balls. A new (hard to compress), regulation size ball could be launched almost 60 ft while a slightly undersize, “dead” ball (which could be easily compressed to half it’s diameter) could be launched almost 30 ft. These distances are significantly less than those predicted by the spinning disc spreadsheet because the spreadsheet doesn’t take into account deformation and resulting variation in the contact pressure of the ball. The testing of prototype 2 proved that ball deformation obviously plays a major role determining the ball range. The prototype was capable of launching balls with a wide variety of compressibilities a reasonable distance (30-60 ft). Differences in ball range due to varying ball compressibility are acceptable (even desirable) since variations in ball launch distance are desirable. The ball also has a high rate of top spin as it leaves the launcher which tends to reduce the height of its flight path, and thereby reducing the distance it travels through the air. Due to this top spin though, the ball will roll a considerable distance on the ground.

### 2.5.1 FURTHER DEVELOPMENT

Further testing will be done to determine if the new motor can be controlled using a light dimmer switch.

If required, some fine adjustment can be incorporated into the ball feed tubing to be able to vary the amount that the ball is squeezed between the pulley and the tube wall. The ball will enter the tubing from a funnel. The funnel will be fixed, but all the rest of the tubing would be mounted to a piece of plywood with a hinge at one end. This would
allow all the tubing to pivot for adjustable ball compression. Since the tubing is larger than a tennis ball and will be larger than the hole at the bottom of the funnel, small adjustments should still allow balls to drop from the funnel into the tubing. In the prototype stage the adjustments would be made with shims under the hinged plywood. Since the ball launcher needs to be able to launch a range of ball sizes, from 2.25” to 2.625” in diameter, and since over compression of the ball could jam the motor, it is not yet certain whether adjustability is required or even desired. Even though balls larger than tennis balls will be stopped in the funnel, if the tubing is pivoted too much a stiff ball may jam the motor.

For water drainage, holes will be drilled at or near the low point through the ball feeder tubing. Matching holes will be drilled through the base of the wood housing to allow the water to drain out of the ball launch unit.
3 BALL FEEDER, FOOD DISPENSER, PACKAGING AND ELECTRONICS

Loading the ball and dispensing the food both require some type of electronically activated mechanism. It was initially proposed to use the same mechanism for both functions, but this notion was later discarded because of the differences between the media being moved. Both the ball feeder and food dispenser mechanism are still under development. Packaging refers to the mounting for the other components and the housing for the entire unit. Electronics covers the microcontroller and other electronic components.

3.1 BALL FEEDER

The ball feeder needs to be able to release one ball at a time into the ball launch mechanism. There is some variation in size of tennis balls, plus balls that have been used by a dog are often deformed and may be smaller than usual. The ball feeder mechanism needs to be able to load a limited range of balls sizes, from 2.25” to 2.625”.

Different solenoid activated mechanisms were examined for the ball feeder including:

- Double gate with rising and lowering pins or plates
- Rotating gate on a lever
- Rotating wheel

Double gate:
The double gate concept used two solenoids directly attached to pins or plates (Figure 13). This concept was discarded by the limited travel of typical solenoids and the potential variety of sizes of tennis balls that could be used by the machine. The probable range of ball sizes was .375” (from smallest to largest), the same as typical longer solenoid travel, insufficient for the ball range. The solenoid stroke could be increased but at the expense of force. Another reason for not using this design is that, as noted below, solenoids are not intended to directly move a mechanism. A two solenoid design would also obviously be more expensive than a one solenoid mechanism.

Figure 13 - Double gate ball feeder

Lever:
The rotating gate on a lever used a solenoid at one end of a lever to activate a gate at the other end of the lever, thereby multiplying the travel of the solenoid (Figure 14). This
design will likely not be used as it uses a solenoid to directly move a mechanism. Solenoids are typically designed as a release or trigger so this design uses a solenoid in a way it is not designed for which may cause difficulties. This system also depends on timing (since the solenoid must be activated long enough for the ball to clear the lever), making it more complicated than using the solenoid as a trigger. A double lever system (similar to the double gate mechanism) could be used, but this would require the expense of two solenoids.

Rotating wheel:
The rotating wheel design is the design which is currently being worked on. The proposed ball feeder will use a solenoid activated, gravity feed paddle wheel (Figure 15).

The main advantage of this design is that it uses a single solenoid as a trigger, an intended use of a solenoid. Timing is not required since the spring return of the solenoid will stop the next wheel vane and the force for the ball feeder comes from gravity rather than the solenoid.

3.2 FOOD DISPENSER
While it was originally proposed to use the same mechanism for the ball feeder and food dispenser, it was decided that the solenoid designs for the ball feeder would not provide sufficient force to handle the loading of the feed. For the ball feeder the size of the tennis
balls causes a gap between the balls at the tube wall, allowing the paddles to rotate into the tubing without obstruction. Since the food is much smaller, there is no gap at the tube wall so the paddle would have to be forced across the food. It is doubtful that an affordable solenoid could provide this kind of force.

The food dispenser design that is currently being pursued uses a small stepper motor, salvaged from a printer, to rotate a slotted wheel. While the slots are rotating through the feed tube, feed will be allowed to be gravity fed through a tube.

The food will be stored in a hopper or funnel entirely inside the launcher, out of the rain and away from the dog. The food will be released by the food dispenser mechanism, passing through a small PVC pipe to a point outside the launcher.

3.3 PACKAGING
The prototype packaging will be made mostly of wood for the following reasons:
- It is inexpensive, available, and easy to build with
- The dog won’t eat the wood (at least not very much)
- Painting wood can make it relatively rain resistant.

The mounting and enclosure will be built as required by the various mechanism and electronics requirements. Where possible, stock brackets and mounts will be used to minimize cost and construction time.

3.4 ELECTRONICS
The electrical system for the ball throwing machine is split into three main sections: the microcontroller, the sensors, and the control circuitry. The system is built on a bread board for the prototype. For this project, no circuit boards will be made due to time and cost restrictions.

3.4.1 Microcontroller:
The main component of the circuitry is the TINI microcontroller. TINI is a JAVA enabled microcontroller that has a TCP/IP stack built into it. The controller is made by Dallas Semiconductor and is marketed through their iButton arm. Information can be found at www.ibutton.com. The microcontroller contains 4 external interrupt enables, 8 data lines, and 20 address lines. 4 MB of data can be externally addressed. In this project, D Latch CMOS drivers will be used to create output ports on the address/data bus. Figure 16 shows how the external ports are configured.
The input ports are connected directly to the sensors in the machine. Infrared LEDs and receivers will be used to create ball and dog food sensors. The LEDs will shine across the pipe to the receiver to complete the circuit. When there is a ball breaking the light beam, the sensor will turn off and provide a high input to the microcontroller port. The microcontroller will poll the sensors, and will display the results. It will also indicate a jam in the pipe in case any foreign objects find their way into the machine.

The motor will be driven using the circuit outputs and an opto-triac driven high current triac. If triac based speed control is possible, a sign wave cutting control system will be built. An external interrupt will be used to detect the incoming sign wave. The microcontroller will calculate when the triac can be turned on and output the on signal accordingly.

If solenoid actuators are used, either a triac (for AC) or a Mosfet (for DC) will be used to actuate the solenoid. These devices will be triggered by the output ports on the TINI microcontroller.

If a stepper motor is used, the stepper pulses will be created by the outputs from the microcontroller. The delay between pulses will be programmed into JAVA. Depending on the stepper motor, a multiple H-bridge controller will be made to drive it.
3.4.2 Programming

The control software will be written in JAVA and assembler for the TINI microcontroller. There is a large support community for the TINI microcontroller and there are several places where coding help can be found. The control system will be coded as a servlet for the free Tynamo web server created by Shawn Silverman of the University of Saskatchewan. This will allow for web based control of the system. There are several other possibilities for control on the TINI microcontroller; however, creating a servlet is the easiest way to create web controlled applications. Tynamo was used over a number of other web servers because of Shawn’s support for his product.
In the development of the ball launch mechanism, the Pro/Engineer model and prototype have been alternately developed. The current CAD model (Figure 17) is in the process of being updated to reflect the design of prototype 2. A Pro/Engineer model for the ball feeder is also being worked on but it is not sufficiently developed to be presented here.

Figure 17: Pro/Engineer ball launcher model
# 5 Project Status

Figure 18 below shows a revised project schedule.

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**ELEC SPECIFIC DEADLINES AND DETAILS**
- Friday, Jan. 17, deadline for submission of project specification and plan to supervisor
- Friday, Jan. 31, Progress Report #1 (to supervisors)
- Friday, Feb. 21, Midterm Review Meeting, EOW-430, 2:30pm-3:20pm
- Monday, Feb. 28, Progress Report #2 (to supervisors)
- Friday, Mar. 28, Poster Presentations (from 1:30 p.m.) at ELW Lobby
- Friday, Apr. 4, Last day of Classes
  1) Final Report submitted to supervisors
  2) Web presentations finalized.

**MECH SPECIFIC DEADLINES AND DETAILS**
- Monday, Feb 24, Mid-term Report (to supervisor)
- Friday, Apr 4, Final Report and Prototype (to supervisor)

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The project is generally on schedule. Pro/E modeling and Pro/Mechanica simulation have been pushed back as they are proceeding more slowly than expected. Assembly is ahead of schedule as the prototype has already been started. It is anticipated that the remainder of the project will follow the schedule as indicated.
6 REFERENCES

   and
   http://www.thejugscompany.com/support/diagrams/101_pitching_diagram.cfm

   and http://baseballbattingcages.com/pitchingmachines/ironmike.htm

