Trackball Mouse for Partially Handicapped Persons

by

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Abstract

Beechwood Home is a facility located in nearby Obryonville. There are many people that live there, including people suffering from the effects of stroke, multiple sclerosis, and arthritis. Most of the residents at Beechwood have access to a computer four out of seven days a week. For these people using a computer can be a hefty task, something most people take for granted. One of the biggest challenges the residents at Beechwood face when using a computer is how they are going to move the cursor on the screen.

There are several different types of mice used at Beechwood. The mouse that will be focused on in this report is the Microsoft Easy Ball. The Easy Ball was designed with children in mind, not handicapped adults. To click and drag with the Easy Ball, two hands are needed- one hand on the trackball, and one hand holding down the button. For someone that is partially paralyzed on one side of his or her body, this task is impossible. They would be forced to use a more cumbersome mouse, such as a mouth mouse.

This is where the Prototype Trackball comes in. The Prototype Trackball can be used with one hand, using one of two ways to lock the button. The Prototype Trackball has an additional button, for more features such as the cut and paste, or drag lock. The Prototype Trackball is ergonomically designed for the adult user with limited dexterity in his or her fingertips. It uses optical technology instead of analog technology to increase tracking resolution and reduce dirt problems associated with analog mice.

All the above, are good reasons to design and manufacture a trackball mouse for Beechwood Home.
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1. Introduction

Computers are an ever-growing tool that people use and depend on daily. Schools and businesses rely heavily on what the computer has to offer. Although most computer users are able-bodied humans, some are not.

There exist many products to aid the handicapped individuals in computer usage. Some of these products include a special mouth mouse, keyboards designed for the handicapped, and monitors that can track eye movement. However, the only product that exists for people with limited movement and dexterity in their fingers is the Microsoft Easy Ball (see figure 1).

![Microsoft Easy Ball](image)

(Figure 1- Microsoft Easy Ball, used at Beechwood)

1.1 Design Objectives

Beechwood is a home for handicapped individuals, and some of these people would like to use a computer on a regular basis, but due to unfortunate circumstances their motor skills hinder their ability to use a standard two or three button mouse—something that many of us take for granted every day. Such problems include paralysis from strokes, arthritis, and Multiple Sclerosis. Beechwood presently has an oversized
trackball mouse called the Microsoft Easy Ball. The Easy Ball was designed for children who have small hands, and to use with two hands (see figure 2), but the patients at Beechwood try to use the mouse with one hand, not the way it was designed for. The main problem with this mouse is there is only one button and it is located in a position in which patients accidentally press it many times and cannot easily click and drag a box (highlight text or drag a card in solitaire). This trackball also lacks a ‘right’ mouse button often used for secondary operations such as copy and pasting. Many of these patients write emails and cards to their loved ones and frequently use the copy and paste functions. The Microsoft Easy Ball also is not ergonomically proper for adult usage. This ball does not currently have any support for the wrist and forearm. Throughout prolonged usage patients may experience fatigue in their wrists and arms parts of the body.

1.2 Survey of Related Technical Sources

In order to design and produce a trackball mouse that the patients at Beechwood can use and gain enjoyment from, much research has been conducted in many different aspects of design and manufacturing.

The first aspect that needed to be addressed is the proper ergonomic positions for humans while using a computer. The conclusions of this study determined the overall look and feel of the mouse.

Patents were also searched for a similar design and contacted a mouse manufacturer to be sure the use of their electronics in the new trackball mouse is legal (See Appendix K).
After this introductory research was completed, research was done for design standards of prototype thermoplastic parts. Throughout the design process, Dave Snively (see References)- instructor of Engineering Plastics at OCAS- was a great wealth of information for design standards and possible manufacturing problems and solutions.

Another aspect that needed to be looked into was the possibility of using a laser (optical technology), in replacing the old analog technology. By doing so would eliminate some of problems mentioned above such as dirty interior parts to the mouse that would hinder the motion in analog mouses.

1.2.1 Ergonomics

Ergonomics is defined from Merriam-Webster’s dictionary as an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely – also called human engineering. Another definition of ergonomics comes from the Board of Certification for Professional Ergonomists, “is a body of knowledge about human abilities, human limitations and human characteristics that are relevant to design. Ergonomic design is the application of this body of knowledge to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable and effective human use” [2].

Ergonomics is derived from two Greek words, ergos and nomos. Ergos meaning “work” and nomos meaning the “natural laws of” or “study of”. Ergonomics has two branches, “industrial ergonomics” and “human factors”. This project will concentrate more on the “industrial ergonomics” of the product. Industrial Ergonomics focuses on the physical aspects of work and human factors such as force, posture, and repetition [1].
There are many work risk factors that go into designing a product with good ergonomic intentions, but this project will only focus on a select few:

- **Posture** - posture is the position the body is in while performing actions. It is considered that the more a joint moves away from the natural position, the higher the risk of injury. The wrist is a key component in using a computer mouse, bad wrist posture such as flexion/extension (bending up and down) and ulnar/radial deviation (side bending) can be causes for unnecessary stress and injury. (See Figure 3).

(Figure 3-Anatomy of the human hand)

- **Force** - force in this instance will be viewed as the exertion on tissue inside the body. The greater force, the greater the risk of injury. An example of this would be holding the neck at a 45-degree angle for one minute in comparison with holding the neck at a 45-degree angle for thirty minutes. Obviously there is a
much greater risk doing it for thirty minutes. The same example can be used for any other part of the body.

- **Contact Trauma**- the type of contact trauma that will be focused on is the mechanical stress that is caused by persistent contact between the body and an external object. For example, the forearm resting on the corner of the desk while using a computer mouse or keyboard. The force, duration of contact, and the sharpness of the object that is being rested on are all concerns for injury.

**Work Station Design**

Postural guidelines have been set for video display terminal workstations (computers). ANSI/HFS 100-1988, the American National Standard for Human Factors Engineering of Visual Display Terminal Workstations, acceptable engineering for video display terminal allows for:

- The angle between the upper arm and the forearm at 70-135 degrees
- The angle between the torso and the thigh at 90 to at least 100 degrees
- The angle between the upper and lower leg at 60-100 degrees

The feet flat on the floor
Optical Technology

The new trend and soon to be mainstay in mouse design is the implementation of optical technology to track movement versus the wheel mouses of old. This technology was developed by Agilent Technologies and introduced in the later part of 1999. The optical mouse is actually a very small camera that takes 1500 pictures a second- this is how the mouse tracks movement.
The Optical mouse can work on almost any surface and contains a small light emitting diode (LED) (see figure 5) that bounces light of the tracking surface (trackball in this case) onto a complimentary metal-oxide semiconductor sensor (CMOS). This sensor sends each picture to a digital sensor processor (DSP). A typical DSP operates at 18 million instructions per second (MIPS). The DSP detects pattern in movements and compare them the previous movements. Based on the changes the DSP detects it determines how far the mouse has moved and sends that message to the computer. This process happens hundreds of times per second.

(Figure 5 – left: new optical technology; right: old analog technology)

There are several advantages of using an optical mouse over an analog mouse:

- No moving parts mean less wear and a lower chance of failure.
- There's no way for dirt to get inside the mouse and interfere with the tracking sensors.
- Increased tracking resolution means smoother response.
- It doesn't require a special surface, such as a mouse pad. (and tracks curved surfaces too!)
1.2.2 Design Considerations

While designing the trackball mouse for Beechwood, manufacturing had to constantly be considered and taken into account. For instance: all plastic parts that are to be injection molded need to have at least 1-2° of draft in order for the part to come out of the mold without breaking the part or cracking the mold. It is even more sensitive in this case since the molds will be made of silicon rubber. These molds can be damaged much easier than steel or aluminum molds. Sharp corners should also be avoided. All corners need to have at minimum a .005” radius, but in most cases more [5].

Adding ribs and gussets are extremely important too, for these structures add stability, rigidity, and strength to the part. There are proper guidelines to follow when designing ribbing and gussets as seen in figures 6 and 7.

(Figure 6 – Proper rib design)
Screw bosses are another important aspect of product design. The figures show the proper way in which to design screw bosses near a wall and away from a wall. (See Figures 8–10)
(Figure 8 – Proper and improper screw hole designs)

(Figure 9 – Proper and improper boss designs against wall)
1.3 Patent Search

Searching patents did not yield much information. Product searching did yield a lot of information. There are many different models of trackballs on the market right now, but only one other trackball that I found that was comparatively close to the intended design of this trackball: the Microsoft Easy Ball- which is no longer sold.

1.4 Project Management

In order to meet the design requirements in the proper time, a detailed schedule needed to be designed and followed. The schedule appears in its entirety in Appendix I. Before the manufacturing began, an initial budget was estimated, and can be seen in its entirety in Appendix H.

1.5 Scope of Report

The following sections of the report will focus on the development of the Prototype Trackball. Each design stage will be discussed in great detail, from the initial
concept stages to the final completed prototype. Recommendations will also be given to correct any design flaws or to suggest changes for future prototype trackball models.
2. Technical Discussion of the Design Solution

The design that was finally decided upon has the characteristics that the project objectives lay out. The final design has been revised several times in order to comply with manufacturing and design guidelines, and customer input. The final design was selected over the existing alternative concepts because it scored higher in the Pugh Selection Method (see appendix D).

2.1 Needs to be Addressed

To find what the customer actually is interested in improving, surveys were handed out and analyzed. What was found out was that the ability to click and drag with one hand, as well as the locking function-, which are two objectives, that go hand in hand were very important. The position of the button is also very important so that the patients do not accidentally press the button while using the trackball. The ergonomic and aesthetics of the mouse are also somewhat important- people do not want to look at an eyesore while using the computer. The Microsoft Easy Ball also has a problem with dirt inside the mouse. In order to solve this problem, optical technology was used in place of analog technology. By doing so, this replaced the ‘X/Y’ bars (see figure 11) that often get dirty and cause the trackball to get stuck, preventing the cursor from moving along the screen. By using the laser, X/Y bars are no longer needed, thus reducing parts. The trackball remained approximately the same size, as the patients using the Easy Ball were extremely satisfied with the current size.
2.2 Project Objectives

There are several project objectives this Prototype Trackball for Beechwood have met. The project objectives needed to meet not only the end users needs but the manufacturers as well. To ensure the success of this Prototype Trackball, the following guidelines- or objectives- needed to be met:

- The Prototype Trackball that was designed will improve upon the current mouse of choice at Beechwood Care Facility, the Microsoft Easy Ball.
- The Prototype Trackball was designed for people with various disabilities including partial paralysis, multiple sclerosis, and arthritis.
- The addition of a mouse button on the Prototype Trackball for additional functions the current Microsoft Easy Ball does not have.
- Moved the current position of the button on the Prototype Trackball so the patients do not accidentally press the button.
• Made the left button “lockable” on the Prototype Trackball so the patients can highlight text.

• The Prototype Trackball withstood all forces applied to it under normal loading conditions

• The Prototype Trackball used optical technology instead of analog (x, y rollers) technology

• The Prototype Trackball has a more ergonomic aspect to it, as to keep the patients’ wrist more properly in line than that of the Microsoft Easy Ball, which reduces strain on the users’ wrist and arm over long periods of use.

2.3 Brainstorming

In order to solve the some of the problems presented by the customer, brainstorming became an important part of the design process.

One of the first things that needed to be discussed and determined was what kind of components would this mouse use? Analog or Digital? The bigger question remained as to whether or not a laser could track curved surfaces, and if it could, how sharp of a curved surface could it detect? When the Logitech Marble Mouse (see figure 12) was found, this problem was solved. This Prototype Trackball’s internal components are the components used inside the new trackball mouse for Beechwood (see figure 13).
The locking mechanism was the next thing that needed to be discussed. In order for the Prototype Trackball to be used completely with one hand, the left button needed to have a locking function in order for the patients’ hand to come off the button and direct the cursor where it needs to be. Lisa Smith [7] (the lab technician at beechwood) suggested an “environmental locking function” –as seen on television with the tap-lights. This was ruled out because of the necessary preciseness of the mechanism. The travel of the button on the circuit board is only approximately .030”. Another concept was explored that entailed bringing protrusions from the cover down to the top of the circuit, and making the button just a bit longer than these protrusions (see figure 15). The button would extend just below the protrusion and be able to twist, thus locking the button in the
down position

(Figure 14 – Looking up at the cover and buttons)

(Figure 15 – left: button in locked position; right: button in unlocked position)

Adding an additional button would just be a matter of manufacturing a second button and designing the base so that another circuit board can be placed beneath that
second button. The second button also has the ability to be drag locked, in case the users cannot push and twist the left mouse button. A drag lock is pushing the button down, which locks the button, the pushing it again to unlock it.

2.4 Quality Function Deployment (QFD)

The process of Quality Function Deployment is a tool that takes the customer input, and changes it into engineering characteristics. It is a graphical/mathematical arrangement that takes into consideration all aspects of the customers’ needs. By using a QFD form, it forces the designer to look at aspects of the design that might otherwise be overlooked without using the QFD.

The concept for the QFD was developed in Japan in the early 1970’s, with its first industrial application being in the Kobe Shipyard of Mitsubishi Heavy Industries. After this successful use of QFD, the automobile industry quickly latched onto this concept. By the mid 1980’s, many U.S. industries such as automotive, defense, and electronics were using QFD as an important step in their design processes. In a recent survey of 150 companies throughout the U.S., 71% have used QFD since 1990. Out of those companies 83% believed QFD had increased the customer satisfaction with the products designed, and 76% believed by using QFD the design team was more prone to make successful design decisions. Researching and completing the QFD process can be a painstakingly long and tedious one, but most companies feel that by putting the time in to the early part of the design produces less changes after the part is complete. The layout of the QFD form is shown in figure 16.
There are several different rooms of the “House of Quality” that are not used with this project. The rooms that are used and are explained in more detail include: the customer requirements (whats), engineering characteristics (hows), relationship matrix, competitive assessment, importance rating, and the technical importance.

The designer gathers the whats, or customer requirements, from the customer. This room is the foundation of the house of quality, it is the most important room, all other rooms depend on the customer input.

The engineering characteristics, or the hows, are listed in columns adjacent to the whats. These are not specific design details but special characteristics that can be measured and given target values. Some examples of these characteristics include force, weight, velocity, and density.
The relationship matrix is the tool that combines the engineering characteristics (hows) with the customer requirements (whats). For every matrix dimension, the designer will value how much the customer requirements match the engineering characteristics. A significant match earns a 9, a moderate match earns a 3, a slight match earns a 1, and no match earns a 0. An example of how the relationship matrix works: One of the customer requirements is weight of material. One of the engineering characteristics is density. This matrix dimension would earn a 9, because density and weight are strongly related to each other.

The competitive assessment compares the future product to one or two existing products. These are ranked from 1 to 5 with respect to the customer requirements. This room in the house of quality also considers future improvements and sales points.

The importance rating is a mathematical equation that multiplies the importance to end-user by the future satisfaction over the current satisfaction, which is then multiplied by the sales point. The highest value in this column is the most important characteristic to the customer.

The last room that was used in the QFD was the absolute importance or technical importance. This value is calculated by multiplying the engineering characteristic with the corresponding importance rating, and summing up the entire columns values. The highest technical importance value is the most important engineering characteristic [6].

In analyzing the QFD for this project it was determined that the locking function and the ability to drag with one hand were of equal importance to the customer. The most important engineering characteristic was the position of the buttons and the design time of the assembly.
2.5 Analysis of Alternative Designs

In the early stages of design, brainstorming was performed to try and “think outside the box.” This produced a few different and intriguing alternatives. The first alternative (see figure 17) was a device with two separate parts that worked together. In one hand was the trackball, moving the cursor along the screen, and the other hand held a handle with two or three buttons on it- acting like the left and right buttons on a typical mouse.

(Figure 17 – left: alternative design #3; right: alternative design #2)

Another interesting alternative included two separate parts as well (see figure 17). The base would be stationary containing an inverted laser. The inverted laser would track the movement of the second part that was an ergonomic ball that the patients would move over the base.

The last alternative that was discussed was a variation of the alternative that was selected for further development (see figure 18). The main difference of this concept and the selected was the locking mechanism. The locking mechanism that would be
implemented on this trackball mouse would be similar to that of a tap-light. In which the operator would press the button down, it would stay down until the operator pressed it again. This posed several different design problems. The first problem being that the locking mechanism needed to be very precise because the travel of the button on the circuit is only .030”. The second problem this type of locking mechanism presented is that an addition of a left mouse button would be needed, unless the patients would not mind pressing the button twice (once to press it down, another for the button to release) for simple one click operations.

(Figure 18 – Alternative design #1)

2.6 Selection of Preferred Design

The process in which a design is selected is called the Pugh’s Concept Selection Method. The Pugh’s Method compares the existing design alternatives to a datum, which should be one of the better design concepts. If one of the lesser concepts were chosen as a datum, most of the dimensions in the matrix would be a (+). The list of criterion on the left comes straight from the QFD’s whats portion of the QFD chart. The three other concepts are compared against the datum. If a given concept exceeds the
datum, that concept earns a (+) for that category. If a given concept fails to be equal to the datum in a given category, that concept earns a (-) for that category. If the concept matches the datum in a particular category, that concept earns an (S) for satisfactory.

After the process of ‘grading’ all the concepts with the categories is complete, the concept’s column is added up, the (+)s adding one, with the (-)s subtracting one, while the S’s neither add or subtract from the final score.

The process is repeated once more, but this time using the concept that scored the highest is used as the datum. This is done for several reasons, (1) to confirm the least desired concepts of the first round and (2) to possibly take characteristics from the lesser desired concepts and use them in the concept that is chosen (see Appendix D for selection process).

The process of Pugh’s concept selection method helps in determining the strongest and weakest concepts. It also magnifies the strongest and weakest elements inside each concept. This selection method is a valuable tool in the design process [6].

2.7 Analysis of Preferred Design

The stresses that are produced on the assembly of the trackball are minimum at best, but there are a few. The first stress that needed to be calculated is the stress that the wrist exerts on the ‘wrist landing’ (see figure 19). This needs to be calculated so that the plastic does not deform or break during typical use. The load on the wrist landing was treated as the worst possible case with point loading directly between the two reaction forces. The load that was applied was a 30lb load, which was the average force tested for five healthy males with ages ranging from 21-24. The result of this 30lb load produces
two resultant forces of 15 lbs (see appendix G).

(Figure 19 – Front view to visualize “wrist landing”)

The next stress analysis was conducted on the button of the mouse. The button was simulated as a column loaded member. The same thirty pounds from the above analysis was applied. The column acted like a long column and with a design factor of 3 the allowable stress would be 6 lbs. This would not be acceptable. In order to raise the allowable stress, a design factor of 1.5 is used since the part is not life threatening if it fails. Also the diameter of the column was changed from .25” to .35”. This produced much more allowable loading on the button.

The last stress analysis that was performed was the static and kinetic friction of the trackball and the surface that is in contact with it. Friction is a force that opposes motion. Static Friction is a force that opposes the necessary force to cause an object to move. The object moves when the force exceeds the maximum value for static friction of the given surfaces. This calculation surprisingly does not depend (critically) on the
Contact surface area. An example of static friction: It’s moving day and all the dishes and silverware are in a box on the tiled kitchen floor. This box is much too heavy to pick up with only one person, so one tries to push it along the floor. It takes quite a big push to get it going. This big push is the required force to exceed the static limit [4].

The force required to keep an object moving is called kinetic friction. This is less always less than static friction. An example of kinetic friction: When one pushes that box full of dishes and silverware, it is much easier to push after the motion starts.

The static friction of the trackball and surface is approximately 1.81 lbs of static force. The kinetic friction that the trackball must overcome to maintain movement is approximately .2715 lbs.

(Figure 20- picture of Prototype Trackball)
3. Fabrication of the Prototype Trackball

There were several aspects that were very much unknown going into the spring quarter of senior design. The biggest of these unknowns was what was going to be used for the trackball. In the early stages of researching the ball manufacturers, many companies wanted several hundred dollars for one (1) 4” diameter plastic ball. Some of these companies included Kaydon, Precision Plastics, Precision Plastic Balls, and Salem Specialty Balls. Thankfully I was referred to Euromatic, a company that manufacturers hollow plastic balls by the thousands for the playpens at McDonalds and Burger King. They also make larger hollow balls to cover bodies of water to retain a certain temperature or to keep an odor from escaping the water (See figure 21)

(Figure 21- Euromatic’s bierball on left, its use on right)

The next manufacturer that needed to be contacted was one that could make stereolitographies (SLAs) and prototype silicon molds. Several companies were contacted for quotes, they include quickparts.com, Morris Technologies, and Bastech. Bastech gave student discounts, so they were chosen to make the SLAs and the urethane prototype parts. (See appendix H for quote sheets)
3.1 The Trackball

Euromatic was gracious and donated 4 of their Birdballs (see figure 21), and they were converted into trackballs. Several steps needed to be taken to ensure the laser would track the movement of the ball. First, the ball needed to be sanded smooth, erasing all parting lines and imprinted writing. After the ball was smooth, a few coats of gray paint were applied. Once the paint was completely dry, small dots were placed on the ball with a Sharpie marker and hours of tedious time. The dots need to be on the ball because the laser must see a change in color in order to calculate a change in velocity and direction.

3.2 Stereolithographies (SLAs)

SLAs are the prototype before the prototype. They are very fragile pieces that simulate the geometry of a given part. The best way to describe an SLA is a 3D print. An SLA is layers upon layers of rigid epoxy resin, which is hardened when an ultraviolet laser passes over it. When the SLA is completed, it has rough edges and needs to be sanded. A big advantage in using the SLA is once they are finished; the designer can make sure the parts fit together before spending more money on the manufacturing of the silicon molds. (See figure 22 for an example of an SLA)
3.3 Silicon Molds and Prototype Urethane Parts

After the SLAs are completed and sanded smooth, the prototype silicon molds can be made. The SLAs are set inside a wooden box, and then the silicon is poured around the SLA. After about 20-30 minutes the silicon hardens, and the SLA is taken out of the mold. This creates the cavity that the urethane will flow into, creating the prototype plastic parts. (See figure 22 for a picture of a silicon mold)

Once the silicon mold is completed, the urethane can be shot into the mold. The urethane is shot from something similar to a glue gun. The urethane mixes with a catalyst, which is then injected into the mold. The urethane takes a few hours to harden, then needs to be placed into an oven to aid in the curing process.

(Figure 22 – Photograph of an SLA part left, and silicon mold on right)
4. Performance Testing

The main method in which the prototype was tested is by the completion of two surveys. The same survey that was given out six months ago to evaluate the Easy Ball was given out again to evaluate the Prototype Trackball. The results of that survey were compared to the results of the one completed six months ago. This is a clear indicator if the users liked the Prototype Trackball more or less than the Microsoft Easy Ball. In comparing the two surveys, the users were extremely pleased in the ability to be able to use the prototype with one hand. In most cases, accidental presses were reduced, with the biggest customer complaint being a lack of spring inside the buttons. One user mentioned that he likes the feeling of pressing down the button; the resistance the button provides is an indicator that the button is pressed. Overall, the users seemed pleased with the Prototype Trackball. (Surveys can be viewed in Appendix C)

Another survey was given out to strictly evaluate the performance of the prototype. Some of the questions on the surveys were similar, this is to ensure that the results were uniform on both surveys.

The answers that were given to these surveys were very helpful in determining what helps and hinders the computer user at Beechwood. The answers to question four-“To what extent do you feel fatigue in your wrist or hand during or after using the prototype trackball?”-yielded results that would indicate that the users pain while using the prototype decreased compared to the Microsoft Easy Ball. Since the pain is reduced, the time spent on the computer increased by a small amount in most cases, and by more than 30 minutes in one specific case.
Unfortunately 4 out of 6 users still press one of the buttons accidentally. This is due to the fact that some of the users are unsure if they have pressed the buttons down, not because of the position of the buttons. Although moving the buttons even further away would probably reduce accidental pressing even more.

The users say that the overall comfort in pressing the buttons is above average, but not completely comfortable.

Question 11 on the survey evaluating the performance of the Prototype is a very key question- “Would you agree that the current position of the buttons is better than the position of the Microsoft Easy Ball’s?” All six people surveyed agreed to this statement.

Question 12 which states, “You can click and drag with one hand,” also is a very important survey, of the six people that replied, all six strongly agreed. This was the main goal of the Prototype Trackball.

(Figure 23- Wrist resting on prototype on left, locking button function on right)

Questions 14-16, evaluating the ease of use for the prototype, received mixed responses. Four out of six users said the button is too difficult to press and twist to lock. Half of the responses said that the ball is hard to move, and the other half claimed it was
easy to move. When asked how easy the Prototype Trackball is to control, four out of six stated that it was easy to control.

The end of the survey asked an open ended question, “List your favorite things about the Prototype Trackball mouse, and circle your absolute favorite,” all responses wrote that the ability to use the trackball with one hand was the greatest characteristic of the Prototype Trackball.

The last question on the survey asked the user to identify the aspect of the Prototype Trackball that they did not particularly like, and two answers were given for this. The button is too easy to press and the trackball sometimes sticks. These are great recommendations for the next revision of the Prototype Trackball.

To stress test the Prototype Trackball, the prototype was taken to the north lab, where 30 lbs of force was applied by hand on a scale to the button and the wrist landing. The button withstood this test with minimal deflection, but the wrist landing started to deflect a little bit, but still remaining in the plastic region. During the senior design presentation, Professor Boronkay asked if the prototype was shock tested (as in dropping it on the floor), it had not and the cover was dropped, it did not break.

4.1 Cost Analysis

Manufacturing prototype plastic parts is not a cheap process. Prototype plastic parts are meant to be a very small cost compared to the big picture of hundreds of thousands of parts, but for a few prototypes, it is expensive.

The initial cost of (1) Logitech Marble Mouse was 29.95. This mouse was needed for the electronics inside. Euromatic was a generous sponsor in donating four of their
birdballs, so they could be transformed into trackballs. The large cost of this project came in the form of the SLAs and the silicon molds. Several companies provided quotes for both the SLAs and the molds, but Bastech in Vandalia, Ohio was chosen because of their student discount. Quote sheets can be seen in Appendix H.

Bastech made an SLA of the cover, base, and button for $472.00. This is a discounted price for students, this price includes very little labor. The cost of three (3) silicon molds, one for the base, cover, and button was approximately $950.00.

The cost per part breakdown can be viewed in Appendix H.
5. Recommendations

The Prototype Trackball is by no means a perfect product. As mentioned before there are several things that can be improved upon if done again. There are several things that can be done without making a new mold, which would cost several hundred more dollars.

One thing that can be done is adding a spring beneath both buttons. Introducing a spring would provide the necessary resistance the users feel for when depressing a mouse button. As it is now, the faint sound of a click is heard when the button is depressed.

Another problem the users stated is one that the trackball sometimes sticks in position and is sometimes hard to begin rolling. This is due to the fact that a coat of lacquer was placed on the trackball for a shiny finish, and also prevents the dots from being faded off the trackball. This also caused the trackball to stick a little to the plastic. Since Euromatic sent several birdballs to me, experimentation can be done to see what the best combination of coatings is to ensure superior rolling.

The last major recommendation would require new molds to be made and hundreds of dollars to be spent. Moving the buttons even further away from the centerline of the mouse would prevent the buttons to be pressed even more. This would require making a new cover. Also a bigger button would be made, because the users liked the feel of the big button of the Microsoft Easy Ball. But making a new button means making a new mold, therefore incurring more money.
6. Conclusion

The design process has been followed to design the best Prototype Trackball for the Beechwood Home in the given amount of time and resources. Surveys were given to the customers and results have been extracted. Customers’ needs were the primary concern in the design of this trackball. The Prototype Trackball includes several new aspects the Microsoft Easy Ball does not have. The new trackball has implemented optical technology for tracking motion, instead of analog X/Y bars. The left button on the prototype can be locked in order to highlight text and drag and drop a card while playing solitaire. Ergonomics were considered so that the users’ arm and wrist do not fatigue as quickly. A ‘right’ mouse button has been added for secondary functions such as cut and paste and a drag lock function. The positions of the buttons have been moved so that they are less prone to be accidentally pressed.
7. References


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  xslURL=/resins/techresearch/en/techniguides/xsl/techniguides1.xsl
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  URL=/resins/techresearch/en/techniguides/injectionMoldingDsgn/radii/radii.xml&
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Appendix B
Proof Of Design

Trackball Mouse For Beechwood Care Facility

The proof of design statement, or agreement by which our final product is judged, has been determined from the proposal stage to the preliminary stages of design. The following criterion will be met at the end of the manufacturing and testing process. To successfully design a trackball mouse that the patients will get much use out of, the following objectives must be met:

- The trackball mouse that will be designed will improve upon the current mouse of choice at Beechwood Care Facility, the Microsoft Easy Ball.
- The trackball mouse will be designed for people with various disabilities including partial paralysis.
- The addition of a mouse button on the trackball mouse for additional functions the current Microsoft Easy Ball does not have.
- Moving the current position of the button on the trackball mouse so the patients do not accidentally press the button.
- Make the left button “lockable” on the trackball mouse so the patients will be able highlight text.
- The trackball mouse will be able to withstand all forces applied to it under normal loading conditions
- The trackball mouse will use optical technology instead of analog (x,y rollers) technology.
- The mouse will have a more ergonomic aspect to it, as to keep the patients’ wrist more properly in line than that of the Microsoft Easy Ball, which will reduce strain on the users’ wrist and arm over long periods of use.

Professor Amir Salephour (Advisor)  Date:

J. Gordon Farley  Date:
Appendix C-1 Customer Research
C-2 Customer Survey Summary

In order to complete the QFD properly, customer input is needed to fill in the whats room of the QFD. The surveys were handed out to 6 people at Beechwood who currently use the mouse. A survey was also given to Lisa Smith - the lab technician at Beechwood. The survey covered questions ranging from how often they work on the computer to what they would prefer most on a new mouse.

Another survey was completed to strictly evaluate the performance of the prototype trackball.
C-3 Customer Survey

Oversized Trackball Mouse Survey Questionnaire.

1. How many times during a typical week do you use a computer?
   0-2  3-5  6-7  7 or more

2. How many minutes are you able to use the computer during a typical sitting?
   0-30  31-60  61-120  121 or more?

3. Do you feel fatigue in your wrist or hand during or after using the current trackball mouse?
   Yes  No
   If no please skip to question 7

4. Do you stop because your hand/wrist hurts or because your work is finished?
   Hurts  Finished

5. After how many minutes does your wrist or hand ache or fatigue?
   0-30  31-60  61-120  121 or more?

6. Where in your wrist/hand do you ache/fatigued (i.e. top of wrist, bottom of wrist, fingers)?

7. Have you ever pushed the mouse button on accident?
   Yes  No
   If no please skip to question 10.

8. How many times have you accidentally pressed the button?
   Once  A few times  Often

9. How comfortable is the current position of the mouse button to press?
   Very little  No Opinion  Comfortable  Extremely comfortable

10. You can highlight text with one hand.
    Yes  No
    If yes please skip next question

11. You would like to highlight text with one hand
    Yes  No

12. Would you agree that the current position of the button needs changed?
    Strongly Disagree  Disagree  No Opinion  Agree  Strongly Agree

13. A second or third mouse button would be useful.
    Strongly Disagree  Disagree  No Opinion  Agree  Strongly Agree

14. How difficult is it to depress the mouse button now?
    Extremely difficult  Somewhat difficult  Easy  Too Easy
Prototype Trackball Test Survey.

1. How long ago did you start to use a computer?
   - Present-1 month ago
   - 1 month ago- 6 months
   - more than 6 months

2. How many times during a typical week do you use a computer?
   - 0-2
   - 3-5
   - 6-7
   - 7 or more

3. How many minutes are you able to use the computer during a typical sitting?
   - 0-30
   - 31-60
   - 61-120
   - 121 or more?

4. To what extent do you feel fatigue in your wrist or hand during or after using the new trackball mouse?
   - 0
   - 1
   - 2
   - 3
   - 4
   - 5

   0 being no fatigue
   5 being much fatigue

   If no please skip to question 8

5. To what extent can you use the new trackball mouse any longer than you could use the Microsoft Easy Ball?
   - 0-10
   - 11-20
   - 21-30
   - more than 30

6. After how many minutes does your wrist or hand ache or fatigue?
   - 0-30
   - 31-60
   - 61-120
   - 121 or more?

7. Where in your wrist/hand do you ache/fatigued (i.e. top of wrist, bottom of wrist, fingers)?

8. Do you still press either one of the mouse buttons on accident?
   - Yes
   - No

   If no please skip to question 10.

9. How many times have you accidentally pressed the button?
   - Once
   - A few times
   - Often

10. What degree of comfort is the current position of the mouse buttons to press?
    - 0
    - 1
    - 2
    - 3
    - 4
    - 5

    0 being not any more comfortable
    5 being much more comfortable

11. Would you agree that the current position of the buttons is better than the Microsoft Easy Ball’s?
    - Strongly Disagree
    - Disagree
    - No Opinion
    - Agree
    - Strongly Agree

12. You can click and drag with one hand.
    - Strongly Disagree
    - Disagree
    - No Opinion
    - Agree
    - Strongly Agree

13. You can cut and paste without using the icons on the toolbar.
    - Strongly Disagree
    - Disagree
    - No Opinion
    - Agree
    - Strongly Agree

14. How difficult are the buttons to press and twist (to lock)?
    - Extremely difficult
    - Somewhat difficult
    - Easy
    - Too Easy
15. How easy is the ball to move?
   Extremely difficult    Somewhat difficult    Easy    Too Easy

16. How easy is the ball to control?
   Extremely difficult    Somewhat difficult    Easy    Too Easy

17. List your favorite things about the new trackball mouse, and circle your absolute favorite?

18. Please explain what you do not like about the new trackball mouse (if anything).
## C-4 Customer Survey Results

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</tr>
<tr>
<td>Question 8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Question 9</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Question 10</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Question 11</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Question 12</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Question 13</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

Question 7: top of wrist

Question 8: Yes 4, No 2

Question 9: Once 0, A few Times 1, Often 3

Question 10: Strongly Disagree 0, Disagree 0, No Opinion 0, Agree 2, Strongly Agree 4

Question 11: Strongly Disagree 0, Disagree 0, No Opinion 0, Agree 6, Strongly Agree 0

Question 12: Strongly Disagree 0, Disagree 0, No Opinion 0, Agree 0, Strongly Agree 6

Question 13: Strongly Disagree 0, Disagree 0, No Opinion 0, Agree 0, Strongly Agree 6
<table>
<thead>
<tr>
<th>Question</th>
<th>Extremely difficult</th>
<th>Somewhat Difficult</th>
<th>Easy</th>
<th>Too Easy</th>
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<td>Question 14</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<td>Question 15</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
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<td>Question 16</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
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<tr>
<td>Question 17</td>
<td>absolute favorite thing of all patients is ability to use mouse with one hand</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Question 18</td>
<td>Buttons too easy to depress, trackball sometimes sticks.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has locking button functions</td>
<td>Density of materials</td>
<td>Force applied to buttons</td>
<td>Time of manufacturing</td>
<td>tracking motion</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------</td>
<td>--------------------------</td>
<td>-----------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Has locking button functions</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Good Moveability on the screen</td>
<td></td>
<td></td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Ability to keep dirt out</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>ergonomic and aesthetic</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>manufacturing cost</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>ability to drag box with one hand</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>overall size of assembly</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>big buttons for easy use</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>big trackball for comfort</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>button are not in position to be accidentally pressed</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>9</td>
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</table>

Technical Importance 40.7 78 73 95.3 105 70 44 239 86 50.3

It appears that the position of the buttons on the mouse is the objective I need to concentrate the most on. With the time and the motion the trackball secondary objects of focus.
Appendix D  Design Alternatives
Concept #3
Appendix E
+/- .002 in. XXX

155.9° 2X

.5770 OAL

1.580 OAL

9.077 OAL

3.306

.500

SHEET 1

DRAWN BY: G. PARLEY
DATE: 2.27.02

TITLE: BASE

DWG NO: BASE-1

ABS
.XX = + /-.002
X.X DEG = + /-.5 DEG

1.300 CAL

1.380 CAL

.935 2X

.280 2X

DATE: 03.04.03

DRAWN BY: G. FARLEY

TITLE: CIRCUIT BOARD

DWG NO: 4-CIRCUIT BOARD
Appendix F Bill of Materials
Appendix G
Stress Calculations of Trackball Mouse

Stress Analysis of Wrist Rest

\[ \Sigma y = R_y1 + R_y2 - 30 \text{ lbs} \]
\[ \Sigma m_1 = (30 \times 3.5) - (R_y2 \times 7) \]
\[ = (105) - (7R_y2) \]
\[ R_y2 = 15 \text{ lbs} \]
\[ R_y1 = 15 \text{ lbs} \]

Stress Analysis of buttons on mouse (treated as a column)

\[ K = 2.1 \text{ (fixed-free end fixity)} \]
\[ L_e = K L \]
\[ = (2.1)(2.48) \]
\[ L_e = 5.208 \]
\[ R = 0.0625 \]

Slenderness Ratio = \( L_e / R \)
\[
\text{Slenderness Ratio} = 83.33
\]

Column Constant (\(C_c\)) = \([2\pi^2E/\text{Sy}]^{\frac{1}{5}}\)

\[
C_c = \frac{(2\pi^2(260000))/6000}{0.0491}/(5.208/.0625)^{\frac{1}{5}}
\]

\(C_c = 20.26\)

Column is long

\(P_{cr} = (\pi^2EA)/(KL/R)^2\)

\(P_{cr} = 18.15 \text{ lbs}\)

\(P_{al} = P_{cr}/N\)

\(P_{al} = 18.15/3\)

\(P_{al} = 6.05 \text{ lbs}\)

Made diameter = .35’’
Area of Contact = 4.670748 in²
Friction coefficient between ABS and Nylon = .15 = k
Volume of sphere = 33.51 in³

Static Friction (force to start moving ball)
Mass of sphere = .00313565 lb
Weight = 1.21 lbF
K = .15
Fs <= k*W
= (.15)(1.21064)
Fs= 1.81 lbs of Static Force

Kinetic Friction (force to keep ball moving)
Fk= k* Fs
\[
F_k = (0.15)(1.81)
\]
\[
F_k = 0.2715 \text{ lbs}
\]

Finite Element Analysis was attempted, but due to the nature of the surfaces involved, the mesh of the surface would freeze the computer. FEA will be further explored and hopefully included in further reports.
Appendix H Budget
# Quotes of SLAs and Urethane Parts

From Bastech for the SLAs

<table>
<thead>
<tr>
<th>Gordon Farley</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Cincinnati</td>
</tr>
</tbody>
</table>

**Date** | **Estimate #**  
04/03/2002 | BP2-322 |

**Terms** | Net 30

<table>
<thead>
<tr>
<th>P/N</th>
<th>Rep</th>
<th>FOB</th>
<th>Subject to accept</th>
</tr>
</thead>
<tbody>
<tr>
<td>See Below</td>
<td>CC</td>
<td>Dayton, OH</td>
<td>30 Days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qty</th>
<th>Description</th>
<th>Cost</th>
<th>Amount</th>
</tr>
</thead>
</table>
| 1  | Set of SLA Models  
|    | -Resin: Somos Waterclear  
|    | -Layer thickness: .006"  
|    | -Bench Level: Bastech level 2  
|    | -Delivery: 4 to 6 working days | 472.00 | 472.00 |
| 4  | Additional Sets of SLA Models  
|    | -Number of sets can be ordered up to specified quantity | 250.00 | 1,000.00 |

Thank you for your interest.

**Total** | $1,472.00
From Bastech for the Urethane Reproductions

Gordon Farley
University of Cincinnati

<table>
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<tr>
<th>P/N</th>
<th>Description</th>
<th>Qty</th>
<th>Cost</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover5</td>
<td>Single Cavity RTV Mold</td>
<td>1</td>
<td>408.00</td>
<td>408.00</td>
</tr>
<tr>
<td></td>
<td>-Estimated mold life = 25 reproductions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urethane Reproduction</td>
<td>10</td>
<td>65.00</td>
<td>650.00</td>
</tr>
<tr>
<td></td>
<td>-Mat'l: Rigid urethane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Color: To be determined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultbase</td>
<td>Single Cavity RTV Mold</td>
<td>1</td>
<td>380.00</td>
<td>380.00</td>
</tr>
<tr>
<td></td>
<td>-Estimated mold life = 25 reproductions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urethane Reproduction</td>
<td>10</td>
<td>60.00</td>
<td>600.00</td>
</tr>
<tr>
<td></td>
<td>-Mat'l: Rigid urethane</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Color: To be determined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Button Final</td>
<td>Single Cavity RTV Mold</td>
<td>1</td>
<td>120.00</td>
<td>120.00</td>
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<tr>
<td></td>
<td>-Estimated mold life = 25 reproductions</td>
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</tr>
<tr>
<td></td>
<td>Urethane Reproduction</td>
<td>10</td>
<td>25.00</td>
<td>250.00</td>
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<tr>
<td></td>
<td>-Mat'l: Rigid urethane</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>-Color: To be determined</td>
<td></td>
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</table>

Delivery: 2 weeks for reproductions

Thank you for your interest.

<table>
<thead>
<tr>
<th>Date</th>
<th>Estimate #</th>
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<tr>
<td>04/08/2002</td>
<td>BP2-323</td>
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</table>

Terms: Due on receipt

P/N: See Below

Rep: CC
FOB: Dayton, OH
Subject to accept: 30 Days

Total: $2,408.00
**Quote from Morris Technologies for several copies of SLAs, molds, and parts**

Gordon Farley  
2820 Digby Ave.  
Cincinnati, OH 45220  
Attn: Gordon Farley

<table>
<thead>
<tr>
<th>P.O. NO.</th>
<th>TERMS</th>
<th>DUE DATE</th>
<th>REP</th>
<th>FOB</th>
<th>PROJECT</th>
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<tr>
<td></td>
<td></td>
<td>04/03/2002</td>
<td>MH</td>
<td>Cincinnati</td>
<td>Gordon Farley-040302ESW</td>
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<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY</th>
<th>COST</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA-Part</td>
<td>A set of parts to include one of each of the following:</td>
<td>1</td>
<td>1,236.00</td>
<td>1,236.00</td>
</tr>
<tr>
<td></td>
<td>button_final</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cover5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>utlbase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material: rigid epoxy resin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Build Style: ACES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Layer Thickness: .006&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finish: RTV Mold ready</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTV Tooling</td>
<td>Single cavity RTV tooling for the three above parts.</td>
<td>1</td>
<td>866.00</td>
<td>866.00</td>
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<tr>
<td>Urethane</td>
<td>Urethane Reproductions of the above three parts. Price per set of parts.</td>
<td>1</td>
<td>140.00</td>
<td>140.00</td>
</tr>
<tr>
<td></td>
<td>Material: ABS-like polyurethane plastic. Some simple color matching may be available at no extra charge. Precise color matching is also available at additional charge.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The above set of single cavity RTV tooling has the capability to produce approximately twenty sets of parts.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery: six to seven working days A.R.O. for first articles. Three to four sets of parts per working day thereafter.</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>SLS Part</td>
<td>A set of SLS parts to include the following:</td>
<td>1</td>
<td>816.00</td>
<td>816.00</td>
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<tr>
<td></td>
<td>button_final Qty. 1</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>cover5 Qty. 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>utlbase Qty. 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLA-Part</td>
<td>Two sets of above parts.</td>
<td>1</td>
<td>1,346.00</td>
<td>1,346.00</td>
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<tr>
<td>SLS Part</td>
<td>Three sets of above parts.</td>
<td>1</td>
<td>1,843.00</td>
<td>1,843.00</td>
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<tr>
<td>SLS Part</td>
<td>Four sets of above parts.</td>
<td>1</td>
<td>2,324.00</td>
<td>2,324.00</td>
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<td>SLS Part</td>
<td>Five sets of above parts.</td>
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<td>2,789.00</td>
<td>2,789.00</td>
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<td>SLS Part</td>
<td>Six sets of above parts.</td>
<td>1</td>
<td>3,238.00</td>
<td>3,238.00</td>
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<td>SLS Part</td>
<td>Seven sets of above parts.</td>
<td>1</td>
<td>3,687.00</td>
<td>3,687.00</td>
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<tr>
<td>SLS Part</td>
<td>Eight sets of above parts.</td>
<td>1</td>
<td>4,136.00</td>
<td>4,136.00</td>
</tr>
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<td>SLS Part</td>
<td>Nine sets of above parts.</td>
<td>1</td>
<td>4,536.00</td>
<td>4,536.00</td>
</tr>
<tr>
<td>SLS Part</td>
<td>Ten sets of above parts.</td>
<td>1</td>
<td>4,937.00</td>
<td>4,937.00</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------</td>
<td>---</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td>Material: DuraForm polyamide.</td>
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<td></td>
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<tr>
<td></td>
<td>Finish: lightly sanded.</td>
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<tr>
<td></td>
<td>Delivery: four to seven working days A.R.O. depending on the number of parts ordered.</td>
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</table>

Payment Terms: 50% payment at time of beginning job. 50% payment due at completion of order.

Quote valid for 30 days from date above. Delv. subject to schedule at time of order placement.

**TOTAL** $31,894.00
### Budget

#### SLA Cost

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
<th>QTY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>200</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Cover</td>
<td>200</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Button</td>
<td>100</td>
<td>1</td>
<td>100</td>
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</table>

Approx $500.00 for

#### Estimated Mold Cost

<table>
<thead>
<tr>
<th>ITEM</th>
<th>COST</th>
<th>QTY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>200</td>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>Cover</td>
<td>200</td>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>Button</td>
<td>150</td>
<td>1</td>
<td>300</td>
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</table>

Approx $900.00 for 3 molds

#### Estimated Cost for Trackball

<table>
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<th>QTY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trackball</td>
<td>250</td>
<td>free</td>
<td>free</td>
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#### Cost for Logitech Marble Mouse That Contains Following Items

<table>
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<th>ITEM</th>
<th>COST</th>
<th>QTY</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuitboard</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Circuitlaser</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>rightcircuit</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>leftcircuit</td>
<td>1</td>
<td></td>
<td>1</td>
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30.00 FOR LOGITECH MARBLE MOUSE
Cost Per Part Analysis

Cost of three steel molds is about $100,000

Injection molding being used this is how the cost per part would break down.

<table>
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<th>Process</th>
<th>1000 Parts</th>
<th>10,000 Parts</th>
<th>100,000 Parts</th>
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</thead>
<tbody>
<tr>
<td>Injection Molding</td>
<td>100$/part</td>
<td>10$/part</td>
<td>1$/part</td>
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</table>

These results are just for the plastic pieces of the mouse, this does not take into consideration the electronics needed for the mouse to function properly. The $100,000 cost for three molds is strictly an estimate. This also does not take into consideration the cost of the material, which is relatively minimal.
Appendix I Schedule
<table>
<thead>
<tr>
<th>Task</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
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<tbody>
<tr>
<td>Product Research</td>
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<tr>
<td>Patent Research</td>
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<td>Preliminary Budget</td>
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<td>Design of Product</td>
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<td>Design Concepts</td>
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<td>Detailed Design</td>
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(Table 2-Schedule for Senior Design through graduation)
Appendix J Weekly Reports
Weekly Progress Reports for Senior Design II

Week 1

- Spoke with Eric Weinberg of Morris Technologies with regards to SLA products
- Waiting on a call back from Ben Staub of Bastech Inc, with regards to SLA products.
- Received 4” ball from Euromatic. Ball was donated by Euromatic. The ball needs some prep work to be made more glossy or reflective.
- Updated Beechwood on the project- they seemed very pleased.

For Next week

- Have ball prepped up for quality laser reflection
- Have the SLA’s in process
- Have a mold manufacturer lined up
Weekly Progress Reports for Senior Design II
Week 2

- Trackball is prepped to proper finish
- SLA’s are in process
- Bastech will most likely make the rubber molds
- Bastech (Vandalia, OH) will make the stereolithography parts at a reduced student rate.
- First draft of test methodology
- Survey complete for residents to complete in reference to new trackball

For Next week

- SLA’s should be finished, and prototype should be very close to completion
- Begin testing prototype
- Work on fabrication portion of final design report.
Weekly Progress Reports for Senior Design II
Week 3

- Stereolithography parts are complete, everything fits and works great.
- Bastech is currently working on urethane mold, will be completed middle of week 4.
- Took tour of Bastech

For Next week

- Prototype will be complete
- Begin testing with residents at Beechwood.
- Continue working on final report
Weekly Progress Reports for Senior Design II
Week 4

- Prototype still not complete
- Waiting on prototype to start testing
- Written test criteria

For Next week

- Prototype will be complete
- Begin testing with residents at Beechwood.
- Continue working on final report
Weekly Progress Reports for Senior Design II
Week 5

- Prototypes still not complete
- Waiting on prototypes
- Editing Test Criteria

For Next week

- Prototype will be complete
- Begin testing with residents at Beechwood.
- Continue working on final report
Weekly Progress Reports for Senior Design II
Week 6

- Prototypes still not complete
- Waiting on prototypes
- Editing Test Criteria

For Next week

- Prototype will be complete
- Begin testing with residents at Beechwood.

Continue working on final report
Weekly Progress Reports for Senior Design II
Week 7

- Prototypes complete
- Talked to Logitech about dots on trackball
- After talking to Logitech, placed hundreds of dots on trackball.
- Ordered 3 more birdballs from Euromatic
- Arranged meeting with Professor Everly to discuss circuit

For Next week

- Begin testing with residents at Beechwood.
- Meet with Professor Everly
- Continue working on final report
- Tech Expo presentation board
- Work on presentation
Weekly Progress Reports for Senior Design II
Week 8

- Met with Professor Everly about laser
- Testing began at Beechwood
- Tech Expo Board is finished
- Final report is coming slowly but surely

For Next week

- Presentation Complete
- Tech expo complete
- Testing complete
- Final report almost complete
Weekly Progress Reports for Senior Design II
Week 9

• Will have presented by the end of the week
• Expo was success…3rd Best of MET
• Testing complete
• Report nearing completion

For Next week

• FINISH REPORT
Weekly Progress Reports for Senior Design II
Week 10

• Report is finished!!!

For Next week

• NOTHING!!
Appendix K
Other Trackball Mouses on the Market

Microsoft D67-00001 Trackball Optical

Kensington K64226 Orbit USB/PS2 Combo Trackball

KENSINGTON expert mouse PRO
Appendix L- Purchased Parts and Material Specifications
Purchased Parts and Specs

Logitech Marble Mouse  $30.00

Chat Transcript With Quickparts.com (SLA manufacturer)

Mark: Welcome to Quickparts.com, how can I help you?
Mark: Mark is here live...
Visitor: I'm a student at the University of Cincinnati...I have to turn in a budget report for my senior project
Visitor: I'm designing an oversized trackball mouse
Visitor: Could you give me a ballpark of prices you charge for the housing, and a few small pieces?
Visitor: Something a bit larger than a standard mouse
Mark: Around $300 for one copy of the assembly
Visitor: OK...could you possible send an email to me, just for records so I can make the professors happy?
Mark: Sure, what address?
Visitor: farleyjg@hotmail.com
Visitor: Thanks a lot!!

Material Specs of ABS
Overview - Acrylonitrile Butadiene Styrene (ABS), Molded

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<thead>
<tr>
<th>Physical Properties</th>
<th>Metric</th>
<th>English</th>
<th>Comments</th>
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</thead>
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<tr>
<th>Property</th>
<th>Range</th>
<th>Units</th>
<th>Average</th>
<th>Grade Count</th>
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<tr>
<td>Density</td>
<td>1.02 - 1.21 g/cc</td>
<td>0.0368 - 0.0437 lb/in³</td>
<td>1.05 g/cc; Grade Count = 185</td>
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<td>Water Absorption</td>
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<td>Moisture Absorption at Equilibrium</td>
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### Mechanical Properties

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<th>Grade Count</th>
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<td>88 - 118</td>
<td>88 - 118</td>
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<td>Hardness, Shore D</td>
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<td>4320 - 9430 psi</td>
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<td>4290 - 9430 psi</td>
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<td>Elongation @ break</td>
<td>2 - 110 %</td>
<td>2 - 110 %</td>
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<td>Elongation @ Yield</td>
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<td>1.7 - 6 %</td>
<td>2.6%; Grade Count = 53</td>
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<td>Tensile Modulus</td>
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<td>260 - 464 ksi</td>
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<td>Flexural Modulus</td>
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<td>233 - 856 ksi</td>
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<td>Flexural Yield Strength</td>
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<td>6930 - 15500 psi</td>
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<td>Compressive Yield Strength</td>
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<td>7690 - 12500 psi</td>
<td>Average = 64 MPa; Grade Count=3</td>
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<td>1150 - 1900 MPa</td>
<td>167000 - 276000 psi</td>
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Appendix M
Abstract

There are many trackball mouses on the market today. There are none that aid people with disabilities in their wrists and hands. A new trackball mouse needs to be designed in order to assist the ease of motion of handicapped persons’ wrists and fingers. This proposal researches other trackball mouses on the market and the current trackball mouse that Beechwood uses. This prototype could reduce cost (although it is not a measurable objective), decrease user accidents of accidentally pushing a mouse button, and could let user press mouse button and scroll the ball at the same time as well as possibly being more comfortable to use.

The immediate target audience for this proposal is the patients at Beechwood that use the current trackball mouse provided. An extended target audience would be anyone with a disability that hinders them from moving their wrists or fingers well (i.e. from arthritis).
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Introduction

Beechwood care facility is a home for handicapped people, and some of these individuals would like to use a computer on a regular basis, but due to unfortunate circumstances their motor skills in their hands hinder their ability to use a standard mouse, such problems include
arthritis. Beechwood presently has an oversized trackball mouse called the Microsoft Easy Ball. The Easy Ball was designed for children with smaller hands, and to use with two hands (see figure 1), but the patients at Beechwood use the mouse with one hand, not the way it was designed for. The main problem with this mouse is there is only one button and it is located in a position in which patients accidentally press it many times.

(Figure 1-child use)

Several solutions to this problem include designing a larger or smaller trackball (the Microsoft Easy Ball has an approximate 4” diameter), and designing at least a two button mouse—that works hand in hand with many of today’s software programs— in which the buttons are in a place that they cannot be accidentally pressed.

The manner of which this will be achieved is by surveying and talking to many patients— including the lab technician at Beechwood. This mouse should be ergonomic in feel so that patients are not fatigued after an extended period of usage.

The mouse will be modeled in 3D CAD (IDEAS, PRO/E or SolidWorks), sending the file to a company to get an SLA (basically a 3D print of the model). Then use the SLA to make a silicon mold, then can proceed to shoot plastic parts. Existing electronic parts and drivers will be used from an existing Kensington trackball mouse (see email of permission from Kensington in appendix).

Introductory research has been done of existing models that appear to be related to the mouse that will be designed (see appendix for other trackball mouses). Nothing has been found that will be designed except for the Microsoft Easy Ball that remotely resembles the intended design. A few patents have been searched to be sure that designs and patents are not being infringed upon.

Background

Most of my information about product design and mechanical design came from a co-op at Fusion Product Design in Columbus, Ohio. Fusion designed prototype parts—mostly plastic—using the solid modeling software Pro/Engineer. There, we also molded many prototype plastic parts using small, simple silicon molds. There are many things that need to be taken into consideration when designing a product, such as, draft of the part so it can be removed from the mold, reduction in mass to cut costs, designing the part so it can be molded.
Technical Solution

Beechwood Care Facility currently uses the Microsoft Easy Ball, which is no longer available on the market, and the mice are starting to malfunction. The current mouse also has only one (1) button. In many years of using a computer, the second mouse button has become increasingly convenient in its usage to perform secondary operations. The current position of the only mouse button is in a bad position relative to wrist position. This causes patients to accidentally press the button. The Microsoft Trackball Mouse was originally designed for young children to use with two hands (see figure 1). (See Table 1-Measurable Objectives.)

My proposed plan for solution of the oversized trackball mouse is to get feedback from the users through the survey. The information gathered from the survey will influence the design as to make the customer as satisfied as possible. The product will be designed to meet the customer needs as far as their flexibility in their hands and wrists, while hopefully making the use of the mouse as comfortable as possible.

The steps that will be taken will include: taking drawings from industrial designer, designing a solid model using CAD software, getting an SLA of the parts of the mouse, making silicon molds of the SLAs, and finally shooting plastic parts. I will be using the electronics and driver from a Kensington trackball mouse (see attached email approval page 14).

In order to make the mouse as comfortable to use, I will be conducting some research and possibly some tests as far as the ergonomics are concerned.

When the mouse is finished, I will be taking it to Beechwood and have some of the patients use it to ensure that my improvements worked and they are satisfied with the new product.
Management

In order to make the product as best as possible for the patient, two surveys will be conducted. One survey will be conducted before the design of the product takes place (which has been an ongoing process), and one survey will be administered after the product is finished, to see how successful it was. Please see the budget for this project on page 18. Also see the schedule for this project on page 17.
Budget

WWW.QUICKPARTS.COM has an initial quote with regards to how much the assembly of SLA parts will cost. The preliminary estimate is around $300.00 for the assembly (see attached email from Mark Mackie in appendix, page 15).

Fisher Design in Cincinnati has been contacted with regards to making a few prototype silicon molds, which they have yet to reply. Fusion Product Design (my co-op employer) has also been contacted, to perhaps make arrangements to do the molding at their facility. They may also sponsor the product.

A Kensington mouse needs to be purchased, in order to use the electronics and software driver (see attached email permission in the appendix, page 14).

(Also see attached budget spreadsheet page 18).
Conclusion

The purpose of this proposal is to justify that designing, manufacturing and assembling an oversized trackball mouse will be a good Senior Design Project. The need for a trackball mouse of this variety comes from Beechwood Care Facility in which they expressed an interest in helping a student out in a way that would help Beechwood out.

One of the big problems that Beechwood is having is that the current trackball mouse is no longer available to purchase on the market. In designing a new mouse, it will improve the current one in that the button position will be changed, another button will be added, and the size of the trackball may be changed.

In doing this project, many new topics will be explored that haven’t been studied much at OCAS yet, such as the molding of plastics and the designing of plastics so they can be molded.
References

   (research of trackball mouses on market today)
   (research of trackball mouses on market today)
3.) Mackie, M. www.quickparts.com quote for SLA of assembly
4.) Kensington Technology Group, approval for use of their mouse electronics
Appendix
Oversized Trackball Mouse Survey Questionnaire.

3. How long ago did you start to use a computer?
   Present-1 month ago   1 month ago- 6 months   more than 6 months

4. How many times during a typical week do you use a computer?
   0-2   3-5   6-7   7 or more

3. How many minutes are you able to use the computer during a typical sitting?
   0-30   31-60   61-120   121 or more?

4. Do you feel fatigue in your wrist or hand during or after using the current trackball mouse?
   Yes   No
   If no please skip to question 8

5. Do you stop because your hand/wrist hurts or because your work is finished?
   Hurts   Finished

6. After how many minutes does your wrist or hand ache or fatigue?
   0-30   31-60   61-120   121 or more?

7. Where in your wrist/hand do you ache/fatigued (i.e. top of wrist, bottom of wrist, fingers)?

8. Have you ever pushed the mouse button on accident?   Yes   No
   If no please skip to question 10.

10. How many times have you accidentally pressed the button?
    Once   A few times   Often

10. How comfortable is the current position of the mouse button to press?
    Very little   No Opinion   Comfortable   Extremely comfortable

11. Would you agree that the current position of the button needs changed?
    Strongly Disagree   Disagree   No Opinion   Agree   Strongly Agree

12. A second or third mouse button would be useful.
    Strongly Disagree   Disagree   No Opinion   Agree   Strongly Agree

13. You like the current trackball mouse provided
    Strongly Disagree   Disagree   No Opinion   Agree   Strongly Agree

14. How difficult is it to depress the mouse button now?
    Extremely difficult   Somewhat difficult   Easy   Too Easy

15. How easy is the ball to move?
    Extremely difficult   Somewhat difficult   Easy   Too Easy

16. How easy is the ball to control?
    Extremely difficult   Somewhat difficult   Easy   Too Easy

17. List your favorite things about the current trackball mouse, and circle your absolute favorite?

18. What is your least favorite thing about the current trackball mouse?
19. How would you change it?
Email of Permission From Kensington

At 10/23/2001 02:10 PM we wrote -

Dear Gordon,

As long as you don't intend to reverse-engineer the product, there's no problem. Basically, once you've bought the unit you can do anything you like with it, as long as it's a non-commercial application.

And as an aside, you've chosen an elegant solution by deciding to focus on the ergonomic aspect and not re-inventing components that already exist.

I can offer you one more piece of information. If you finish your prototype and decide that a market may exist for it, you may wish to contact Kensington with your idea. You can email nellie_nourse@kensington.com for a submission form.

Question

---- 10/23/2001 01:37 PM  ---------------------------------------------
Hello,

My name is Gordon Farley and I'm a senior at the University of Cincinnati studying mechanical engineering. For our senior project we are to improve on an existing product, or design one that does not exist. I am designing an oversized trackball mouse (about 5" in diameter) for handicapped people that have poor motor skills in their wrists and hands.

If at all possible I would like to avoid programming a driver and assembling the electronics. My question to Kensington is would it be possible (legal) if I bought one of your mouses and used the driver and electronics for the mouse I am going to design? I do not want to infringe on any patents or do anything illegal here. I am not selling my mouse, I am giving it to the handicapped home that needs it. I only intent on making one prototype. Since I'm in mechanical engineering I would like to concentrate more on designing the casing and molding the prototype rather than the programming and electronic aspect.

Looking forward to your feedback.

Thanks!!

Gordon Farley

Question Reference #011023-000086

Product: Trackballs
Category: Technical Issues
Contact: farleyjg@hotmail.com
Date Created: 10/23/2001 01:37 PM
Last Updated: 10/23/2001 02:16 PM
Elapsed Time: 0 Minutes
Status: Pending
Model Number:
Serial Number:
Platform: N/A
Port: N/A
Email of Estimate from Quickparts.com

Mark: Welcome to Quickparts.com, how can I help you?

Mark: Mark is here live...

Visitor: I'm a student at the university of Cincinnati...I have to turn in a budget report for my senior project

Visitor: I'm designing an oversized trackball mouse

Visitor: Could you give me a ballpark of prices you charge for the housing, and a few small pieces?

Visitor: Something a bit larger than a standard mouse

Mark: around $300 for one copy of the assembly

Visitor: ok...could you possibly send an email to me for my records?

Mark: sure, what address?

Visitor: farleyjg@hotmail.com

Visitor: Thanks a lot!!

----------------------------------------
Mark Mackie
Quickparts.com Inc.
mackie@quickparts.com
404-303-6612 x250
Current Trackball Mouses on the Market

(Figure 2- Acco Fingertip Trackball)
ACCO ORBIT WITH FINGERTIP TRACKBALL
List Price: $109.99

(Figure 3- Kensington Turbo Mouse)
Kensington Turbo Mouse V5.0 Trackball MAC 4-BUTTON
Lowest Price: $94.26

(Figure 4- Trackball)
Two Additional Buttons for Easy Navigation
Ergonomic Mouse
Wheel for Scrolling and Zooming
IntelliEye Optical Technology
Microsoft Easy Ball

(No Price Available—no longer on sale)