Monkey Board

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Abstract

Over three million Americans are affected by glaucoma, yet only half of them know they actually have the disease (Glaucoma Research Foundation). It is for this reason that research on the topic of glaucoma has the potential to benefit humanity. Researchers at the University of Wisconsin-Madison hospital are currently using fluorophotometry to help understand how to treat glaucoma. Their test subjects are cynomolgus monkeys. The testing consists of dropping fluid into the anesthetized monkeys' eyes. Then, the florescence of the liquid is measured in order to analyze the condition of the eye. With the current procedure, the monkeys were simply placed on a metal board and the researcher would have to move the board manually in order to line up the monkeys' eyes with the stationary eyedropper. Since this is not the most efficient method, three potential designs were proposed. These three different designs were the gear mechanism, the foosball design, and the xy-table design. After computing the advantages and disadvantages of all three designs, the team decided that the design with the compound table best solved the problem. A misunderstanding of the coordinate system led to some initial design concepts that did not meet the client's specifications. Instead of having movement of the board in the x and y direction (flat plane) with 90 degrees of rotation, the device was to move the monkeys in the x (horizontal) and z (vertical) directions. Using various components of the past designs, such as the turntable, as well as new components—including a z-directional scissor jack—a final prototype was designed and produced according to the client's needs.

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Motivation

The client, Mr. Galen Heyne, has requested a table that moves in the xz-plane to help improve the efficiency of his glaucoma research. Currently, the client uses a monkey board that consists of a sheet of steel that has a headpiece attached to it, as shown in Figure 1. Because the current monkey board must be moved manually, this decreases the efficiency of the client's research. Consequently, the team's task is to design a device that connects the monkey board to an underlying table that is able to move in the xz-plane and rotate. This will allow Mr. Heyne to lock and position the monkey as needed. A significant amount of time is spent positioning the monkeys, so the motivation is to increase the efficiency of his research. It is hoped that the design created by the team assists Mr. Heyne and his team to spend more time focusing on their research instead of positioning the monkeys.

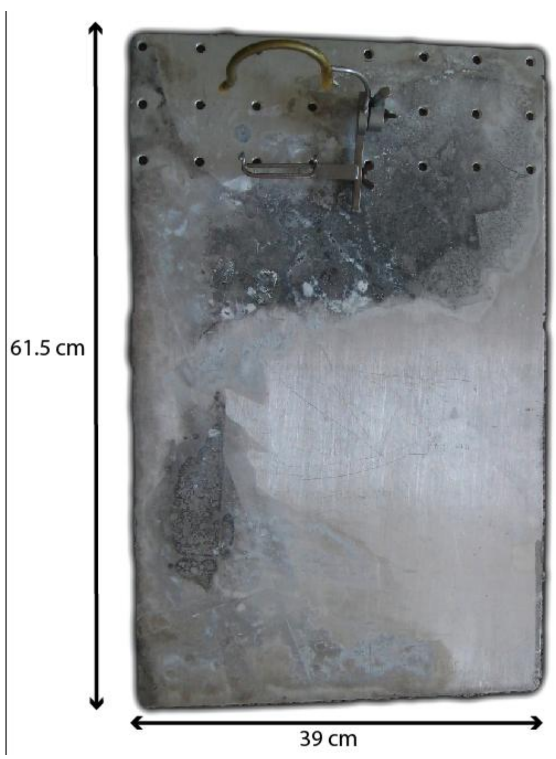


Figure 1: Current monkey board in use for glaucoma research at University of Wisconsin Hospital.

Client Information

The client, Mr. Galen Heyne, is a graduate student who researches glaucoma at the University of Wisconsin School of Public Health.

Problem Statement

Galen Heyne, the client, has requested a device to allow a monkey board to be positioned accurately in the xz-plane and be able to rotate at a minimum of 90 degrees. The device should also make his glaucoma research more efficient.

Background Information

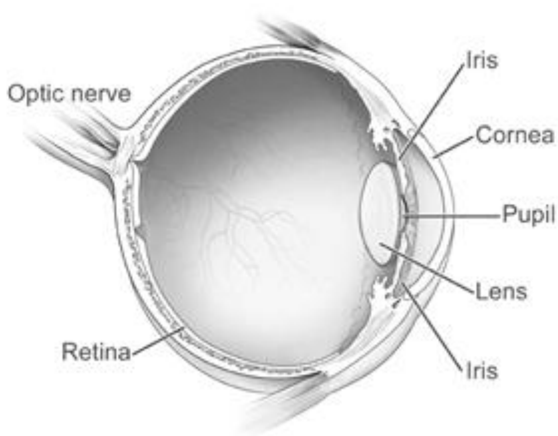
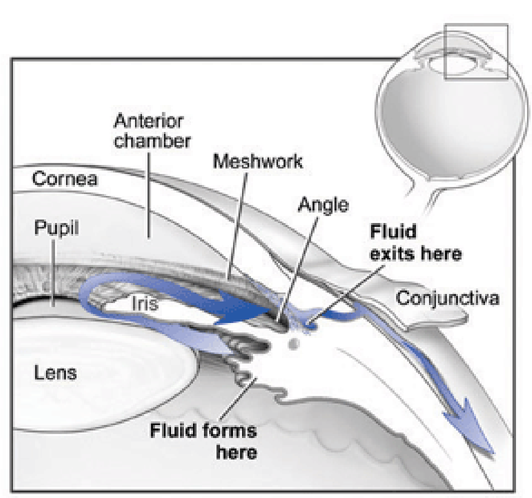


Figure 2: Diagram of eye showing optic nerve (Glaucoma Research, 2010).

Glaucoma is an eye condition where the optic nerve is damaged due to a steady increase in the intraocular pressure. The optic nerve has more than one million neurons that carry visual information from the retina to the brain. The eye anatomy relevant for glaucoma is shown in Figure 2, which includes the optic nerve, vitreous humour, and aqueous humour.

Several different types of of glaucoma exist, including open-angle glaucoma, angle closure glaucoma, and congenital glaucoma. Open angle glaucoma is the most common form of glaucoma and people generally have no symptoms until they begin to lose their vision (Glaucoma Research, 2010). Angle-closure glaucoma is a form of glaucoma where there is an increase in pressure in the anterior chamber of the eye. The anterior chamber can

Figure 3: Diagram of eye showing the pathology of glaucoma (Glaucoma Research, 2010).



be seen in Figure 3. The angle is a trabecular meshwork that allows fluid to exit the eye. The angle is blocked by a portion of the iris causing a sudden increase in eye pressure. Common symptoms include severe pain, nausea, cloudiness, and redness of the eye. Angle-closure glaucoma is considered a medical emergency and treatment usually involves laser surgery and/or medication to clear the blockage of the eye. The operation that doctors perform is called an iridotomy. An iridotomy uses a laser to open new channels in the iris, which relieves pressure and prevents more attacks (All About Vision, 2010).

Congenital glaucoma is an inherited disease. Congenital glaucoma is due to a defect in the angle of the eye that slows the drainage of the fluid out of the eye. Children with congenital glaucoma have eyes that are usually cloudy and very sensitive to light. Surgery is the typical treatment and is generally safe if done promptly. Typically, children that get surgery soon after diagnosis have a good chance of acquiring better vision.

Symptoms of glaucoma include the loss of vision. Initially, a patient's vision will be cloudy on the periphery, eventually clouding the entire field of vision. A picture of what a person would see with normal vision and a picture of what a person would see with glaucoma is presented in Figure 4.

Figure 4: Vision of person with no abnormalities (left) compared with vision of person with glaucoma (right) (Glaucoma Research, 2010).

Various treatments are used for the different types of glaucoma. Open-angle glaucoma is treated with eye drops. Laser treatment and surgery are also used to open new outflow channels in the eye. Some medications cause the eye to have less fluid, while others lower the pressure by enabling fluid to drain from the eye. Although there are drugs available for glaucoma, the exact cause of glaucoma is still unknown. As a result, many researchers are studying how glaucoma starts and how to prevent it.

One such area of glaucoma research uses a fluorophotometer to measures the amount of fluorescein, a dye injected into the eye that illuminates under the fluorophotometer. Mr. Heyne is interested in the level of fluorescein in the cornea and the anterior chamber segments of the monkeys' eye. Drops are given the evening before taking measurements with the device.

Mr. Heyne's research is trying to correlate glaucoma with high intraocular pressure (IOP), which may be due to many different things happening in the eye. This could include an increase in aqueous humor production, which is the fluid in the anterior chamber of the eye. By measuring the level of fluorescein in the eye over a period of time, he can observe how quickly the fluorescein is leaving the eye or being diluted by aqueous humor formation. By using a computer program, he can calculate the difference in outflow from the anterior chamber and the cornea. He can also compare the right and left eyes, as well as compare the baseline data to the data after administering a drug. Because there is such a low volume of eye fluid in the anterior chamber, the formation of aqueous humor must be very close, if not the same as aqueous flow. Therefore, he can assume that if a drug causes the fluorescein to be diluted more quickly, then it increases aqueous humor formation.

Competition

Since the client came to the team with an idea for a customized design, products that meet the requirements of the client do not currently exist. However, other monkey restraining devices have been examined. A past model used to restrain monkeys while studying ovulation is shown in Figure 5. This model is used on non-sedated monkeys and is fabricated using metal, leather, and wood. However, this model does not meet the requirements given by the client. The restraint chair can move in the z-

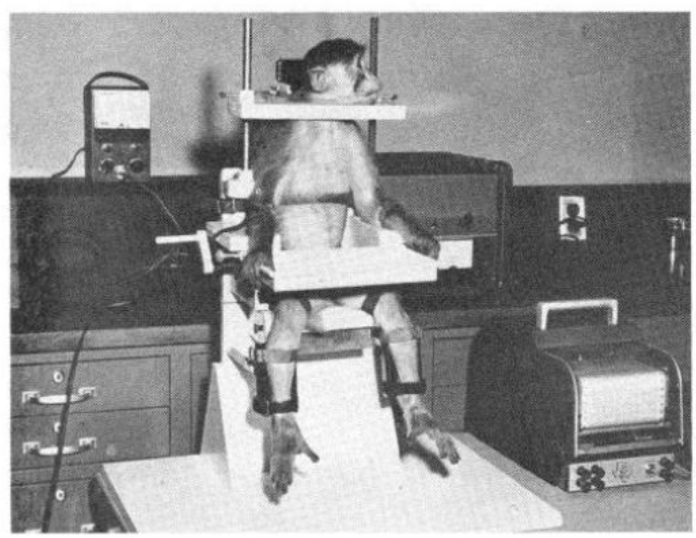


Figure 5: Past monkey restraining device used for studying ovulation (Balin & Israel, 1963).

direction, but it is unable to translate in the horizontal direction. In addition, the apparatus appears inhumane (Balin & Israel, 1963).

Proposed Designs

Due to a miscommunication with the client, there was confusion about the coordinate system, specifically the x- and y-axes. The team interpreted the x and y directions to be in the standard Cartesian coordinate system, as seen in Figure 6. However, the client uses a y-axis that points vertically creating a xy-plane that is perpendicular to the floor (Figure 7). Due to this miscommunication, the team spent the first half of the semester designing a device that moved in the xy-direction in the standard Cartesian coordinate system. The following proposed designs do not move in the correct planes, but they were incorporated in the final design.

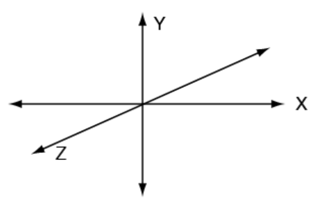


Figure 6: Cartesian coordinate system used by team.

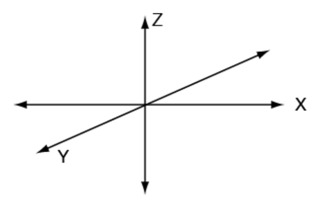


Figure 7: Coordinate system used by client.

Foosball Design

The foosball design implements rods that control the movement of the monkey board. The user manually controls the rods by pushing and pulling the rods through carved holes in

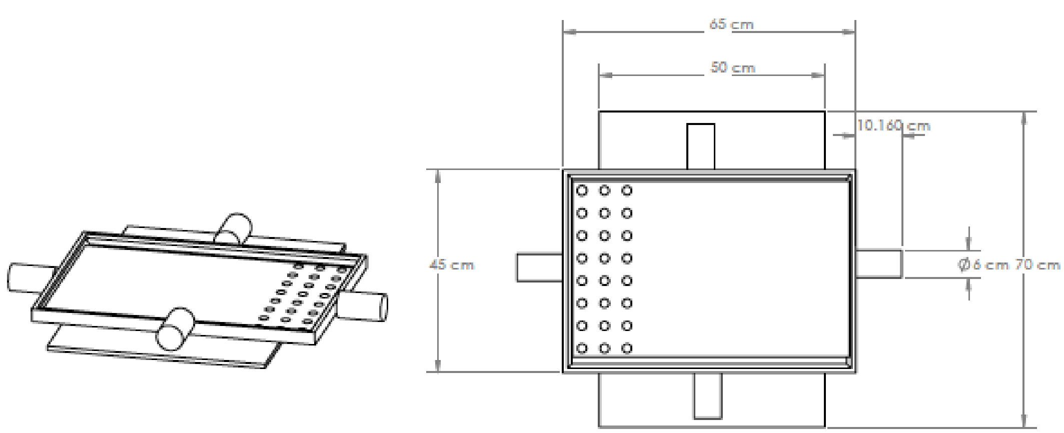


Figure 8: Foosball design with monkey board.

the base of the design. The table will have holes that extend along the entire base of the board allowing the table to move in both the Cartesian x and y directions. There will be a device that will allow the user to lock the rods into position. On the top of rods, there will be a board that the turntable attaches to in order to allow rotation of the board. The pan with the monkey board will be located on top of the turntable. The pan will protect the foosball design from any bodily fluids excreted by the monkey. Figure 8 shows the foosball design.

Gear Mechanism

The gear mechanism works with a geared drive train. The top portion of the gear mechanism consists of a sheet of non-oxidizing metal, such as aluminum. The top sheet that moves in the x-direction will have the dimensions of 16 by 12 inches and 0.25 inches thick. Underneath this sheet, a 16-inch rack gear will be centered between the sheets. Also, underneath the sheets there will be two parallel rods with an 8-inch separation between them that will have a diameter of 1 inch. Each parallel rod will have two linear motion adjustable ball bearings going though them with an outer radius of 0.75 inches. The distance between the center of the parallel rods and the sheet will be 4 inches. Each of the linear motion ball bearings will be welded to the sheet with a rod that is 5 inches in length and has a diameter of 1 inch. The separation between linear motions on each side will be 4 inches. The two parallel 16-inch rods will have their ends attached to a base of dimension similar to that of the sheet that will be located below them. The distance from the center of the parallel rods to the base will be 3 inches. This base will provide the structural support for this portion and allow it to move back and forth. In between the rods and the sheet will be a circular gear (A) (magenta) that will mesh with the rack gear. The radius of gear (A) will be 2 inches. The circular gear (A) will be pinned on both sides and attached to the base. Another gear of radius of 2 inches (B) (blue) will be meshed with gear (A). Gear (B) will also be secured to the base, but will have a long handle of 12 inches through its center. This will provide the coarse adjustment of the back and forth movement. Another gear (C) (yellow) will be meshed with gear (B) and will have radius of 0.75 inches. This too will have a handle going through it of 12 inches in length and will be secured to the base. Gear (C) will provide the fine adjustment.

The previously mentioned design will also be used to translate in the y-direction. This segment will be rotated 90 degrees and welded to the bottom of the base. This now will move in the xy-plane. On top of the sheet on frame 1 will have latches to attach the monkey board/pan piece. This will provide a mechanism to detach the money board/pan piece so that it can be sterilized. A turntable with the locking mechanism as explained previously will be attached below frame 2 to provide 360 degrees of rotation. Additionally, a pan will be attached onto the top of the gear mechanism via 4 latches. The current monkey board would be placed inside the pan. The pan will protect the foosball design from any bodily fluids excreted by the monkey.

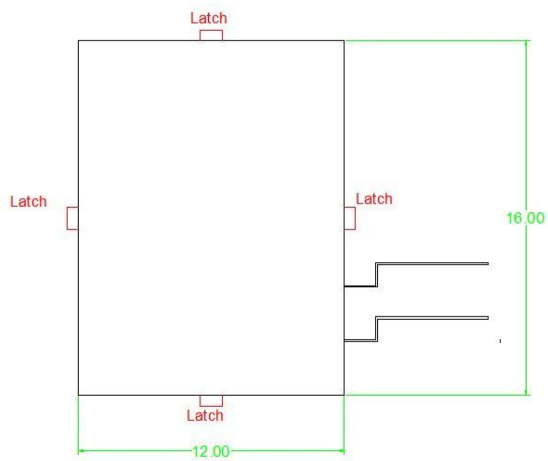


Figure 9: Top view of gear mechanism.

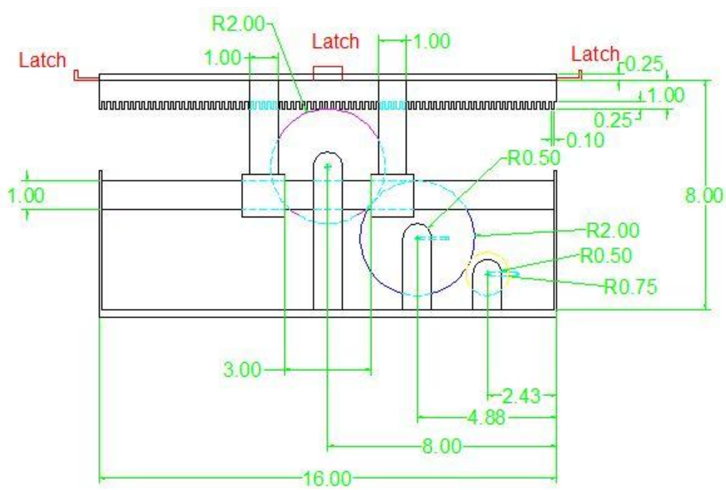


Figure 10: Side view from left to right of gear mechanism.

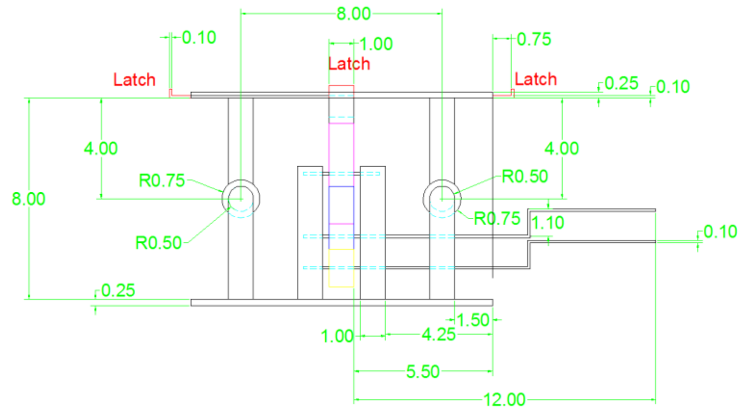


Figure 11: Side view from top to bottom of gear mechanism.

XY-Table

A xy-compound stage will be utilized to move the board in the x-y plane. The team has chosen the Grizzly X-Y table. A turntable will be used to rotate the monkey board 180 degrees to make the positioning easier for the client.

To lock the position of the monkey board during the procedure, a small rod will be placed in a circular metal plate. The bar will also go through another piece of sheet metal, which will prevent further rotation. Holes will be made at 90 degree increments, allowing the client maximum versatility in positioning the monkey. Above the turntable, there will be a stainless steel pan. This enables the researchers to keep the mechanism sanitary for the

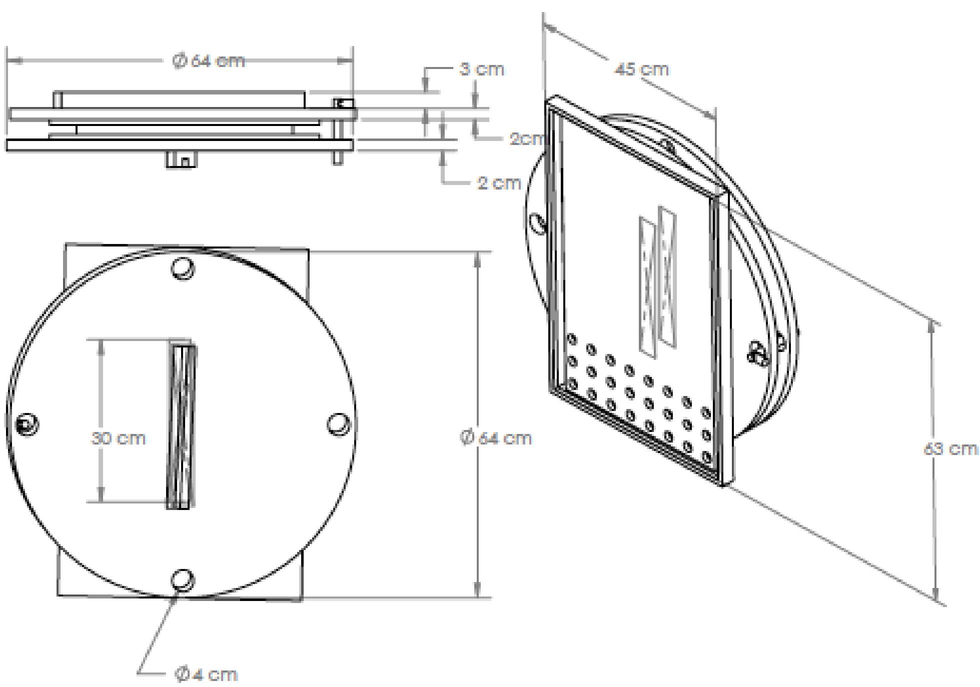


Figure 12: XY-table design with monkey board and locking mechanism.

monkeys, as bodily fluids will be caught in pan, and not in the xy-compound stage. The pan will be removable to keep it as clean as possible. The existing monkey board will be utilized as well. The current monkey board will be placed in the pan, as it will be removable to maintain a sanitary environment for the monkeys. The headgear and current hardware will remain, as the client still finds this helpful. The rotational assembly is shown in Figure 12.

Design Matrix

In order to compare the advantages and disadvantages of the three design ideas, the team developed a design matrix. The design matrix evaluates three different types of designs: the xy-table, the foosball idea, and the gear mechanism idea. The categories that the team used to evaluate the materials were determined from our client's specifications.

	Weight	XY-Table	Foosball	Gear Mechanism
Feasibility	1	4	2	2
Cost	1	2	2	1
Durability	0.7	4	3	4
Safety	0.75	3	3	3
Ergonomics	0.9	3	1	2
Accuracy	0.8	4	1	3
TOTAL		**16.95**	**10.05**	**12.25**

Table 1: Design Matrix.

The design matrix is shown in Table 1. The categories chosen to evaluate the materials include feasibility, cost, durability, safety, ergonomics, and accuracy. The team weighted these categories by ranking them on a scale from 0 to 1, with 1 being the most important. Each design was given a score from 1 to 4 relative to each other, with 0 being the worst and 4 being the best.

Some categories were considered more important than others. The feasibility category was weighted 1 out of 1 because the more difficult the product is to make, the more room there will be for making errors. Given the task at hand, the most important aspect of the final product is that it has to work.. The cost category was also weighted 1 out of 1 because at a budget of $200, the team is limited in the materials that it can acquire. The durability category was weighed 0.7 out of 1. Even though the team's intentions are to create a long-lasting piece of equipment, the main reason for this project to assist the client in his research. Consequently, the final product has to last as long as the research does, which is not forever. The safety category was weighted at 0.75 out of 1. The team is not at all dismissing the importance of safety; however, given the mechanical nature of the project, a life-threatening malfunction such as electrical shock or overdose of radiation is not likely to occur. It is realized that pinching a finger, pinching the tail of the monkey, or the device becoming unlocked during a produce are possible safety hazards to occur. This is why the safety was weighted at a relatively high at 0.75. The ergonomics category was weighted at 0.9 out of 1 because, once again, due to the nature of the task at hand, the whole purpose of the project is to make the client's job easier and having a difficult machine to use defeats this purpose. This is why ergonomics was given a high weight. The accuracy category was weighted 0.8 out of 1. Since the required accuracy needed to be 1 cm or less, the team determined that a weight for the accuracy should be relatively high.

With the weights determined, the three designs were given scores. In the feasibility category, the xy-compound design was given a 4, the foosball was given a 2, and the gear mechanism was given a 2. Since the xy-compound design required no further labor, it was given 4. Since both the foosball and the gear mechanism would require more intensive labor, they received a 2. In the cost category, the xy-compound design was given a 2, the foosball design was given a 2, and the gear mechanism was given a 1. Because all three designs would require large portion of the budget, they all received low marks.

In the durability category, both the xy-compound and the gear mechanism received perfect scores of 4, while the foosball received a 3. All three designs were deemed durable, but since the foosball mechanism would require more moveable parts, the team determined that the design had a greater chance of failure so it got a lower score. In the safety category, all three designs tied with the score of 3 because none of the designs stood out as being more dangerous than the other. None received a perfect score because each design could still cause injury if mishandled. In the ergonomics category, the xy-compound received a 3, the foosball mechanism received a 1, and the gear mechanism received a 2. This score was based mostly on how much the final project would weigh, which would influence how easily it could be transported. The xy-compound was the lightest, followed by the gear mechanism and lastly the foosball mechanism being the heaviest.

In the accuracy category, the xy-compound received a 4, the foosball mechanism received a 1, and the gear mechanism received a 3. The foosball received the lowest score because locking and positioning would be a huge problem for this design. The gear mechanism received the second best because there was the possibility of backlash occurring if the team had to construct the mechanism .The xy-compound was given a perfect score because it would be shipped from a factory who had done testing on it and solved any problems with regards to backlash. Totaling up the weighted scores, the clear winner was the xy-compound with a score of 16.95, followed by the gear mechanism with 12.25 points, and followed by the foosball idea with a total of 10.05 points.

In order to meet the client's requirements after the team realized that a miscommunication occurred about what the true needs of the client were, which was to have the board move in the z-direction and only in one linear direction, another new design had to be implemented. The new design required movement in the horizontal direction. The team had two options in order to make this happen: using gears or using a ball screw mechanism that resembles the xy-table. The Foosball idea wasn't sought after because of the difficulty involved in assembling its many components. Since the xy-table won in the categories of feasibility, cost, ergonomics, and accuracy, the team determined that using a ball screw mechanism was the best option, which is what the new design incorporated. The new design also required a z-direction. Again from the previous arguments, the xy-table design was mimicked in order to make this occur. This lead to the idea in using a scissor jack that utilized a ball screw mechanism as a crank to raise the platform.

Final Design

The final design both utilized the proposed designs and new ideas to meet the client's requirements. The design was separated into three movements: rotational, vertical, and horizontal.

Purchases

A fiberglass pan with dimensions of 25-3/4" L X 17-7/8" W X 1-1/8" H, sets atop of the device as it holds the current monkey board. This would prevent contamination of the rest of the device if a fluid is spilled onto the monkey board. The fiberglass pan is shown in Figure 13.

Figure 13: Fiberglass pan used for holding monkey board.

To accomplish full rotation with a locking mechanism, a turntable made of galvanized steel was used. The purchased turntable had steel ball bearings that were housed in a large circular race. In addition, the turntable had detents, which stopped or slowed the rotation of the turntable at 90-degree intervals. This eliminated the need for a separate locking mechanism. The turntable purchased has a diameter of 12 inches and a height of 5/16 inch. A

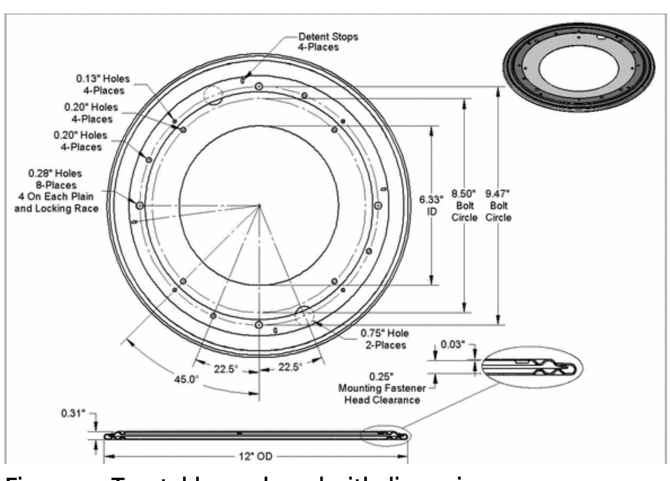


Figure 14: Turntable purchased with dimensions.

picture of it is shown in Figure 14.

To move the specified 12 inches in the z-direction, a jack was used. This scissor jack used a screw to raise and lower the board the specified range of 12 inches. This jack had a lift capacity of 1100 pounds, more than the amount required by the client. The purchased jack is shown in Figure 15.

Figure 15: Motorcycle scissor jack used for vertical translation (*1100LB Motorcycle Center Scissor Jack Lift Stand Plate*, 2010).

Movement in the x-direction was accomplished by using a bar clamp and drawer sliders. A Jorgensen Light-Duty Steel Bar Clamp Style 3700-LD (see Figure 16) was purchased as it provided 1.25 inch and 11 inch fine and coarse adjustments respectively for accurate positioning. Two drawer sliders, Figure 17, were used as an inexpensive, convenient way to provide smooth horizontal translation.

Figure 16: Bar clamp used in design for x-translation (adjustableclamps.com).

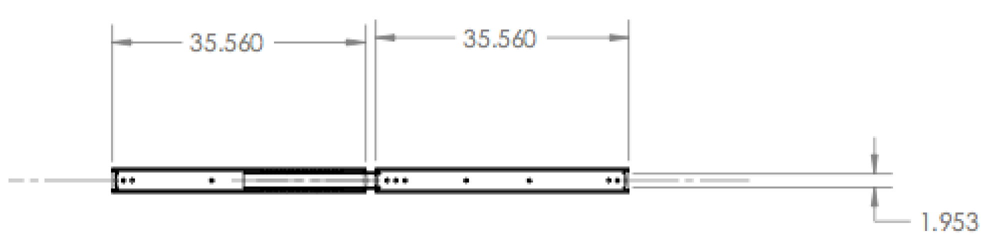


Figure 17: Drawer slide used in x-translation.

Three pieces of Formica-covered plywood were used as bases for attachment for many of the components. This provided a lightweight and sturdy surface that can be sanitized easily. Wood screws and an epoxy adhesive were used to attach components. Brackets and two small pieces of wood (2 in x 4 in) were used to align components properly.

Budget

Even with the relatively small budget, the team managed to stay under budget while still meeting the client's requirements. Unmentioned parts including the wood were donated.

Table 2: Budget table of final product.

Part	Price
Drawer Slide (2)	$15.00
Bar Clamp	$10.00
Turntable	$21.59
Fiberglass Pan	$25.31
Epoxy Adhesive	$10.11
Screws	$13.97
Scissor Jack	$84.95
TOTAL	**$180.93**

Fabrication

After receiving all parts, the assembly of the device began. The Formica-covered plywood was first cut into two pieces, with dimensions 60.8 cm x 47 cm x 1.5 cm and 38 cm x 47 cm x 1.5 cm respectively. Next, the 2"x4" was cut to 35.5 cm to align the clamp with the drawer sliders. The clamp could not be used in the purchased state, as the plastic ends did not work with the assembly. Thus, one end was cut off using a band saw. The ends were then drilled and tapped to fasten an angle bracket at each end. By using the angle brackets as an attachment point, the clamp was centered onto a piece of Formica-covered plywood and fastened using wood screws. The 2"x4"s were then fastened to the plywood using long wood screws, 37 cm apart with the clamp in the center. In order to attach the screw of the clamp onto the plywood to provide horizontal translation, a small angle iron was used to attach the stem of the clamp to the plywood. A notch was made to fit over the stem of the clamp. This was then attached to the top piece of plywood. The turntable was then centered onto the base plywood and fastened using wood screws. To fasten the top of the turntable onto the second piece of plywood, ¾ inch holes were drilled through the base plywood. Wood screws were used for attachment.

Epoxy adhesive was used to attach the base plywood to the scissor jack. This provided a solid attachment without drilling through the steel of the jack. The epoxy adhesive was also used to attach the fiberglass pan to the Formica-covered plywood. The final assembly is shown in Figure 18. The final assembly weighed 73 lbs and could move 11 inches in the x-direction for rough adjustment and 1.25 inches for fine adjustment. The device could move 12 inches in the z-direction and hold up to 1000 lbs.

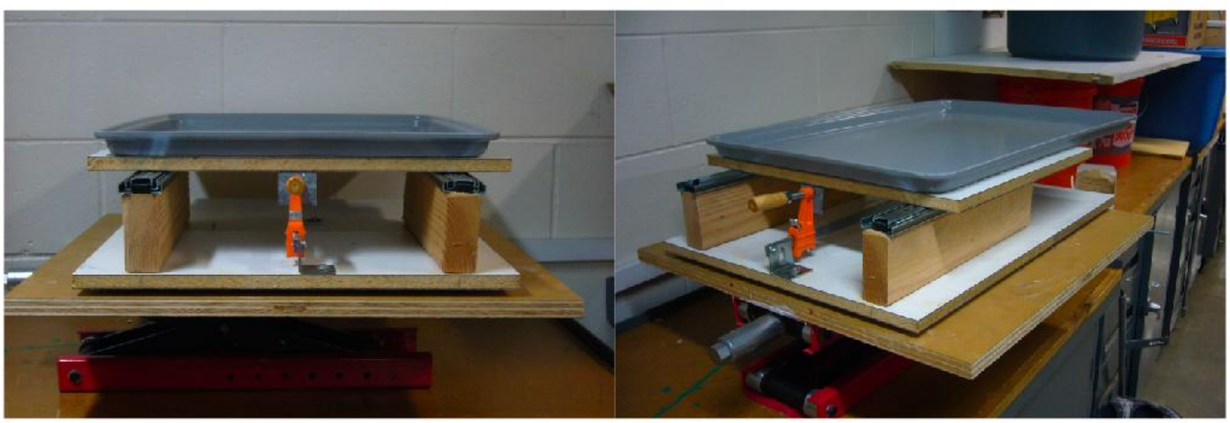


Figure 18: Final assembly of monkey board.

Ergonomics

This device can be used by any researcher familiar with the procedure carried out by the client's research team. The device rotates and locks in 90-degree increments, yet has the ability to rotate with a full range of 360 degrees if needed. The movements in the x and z directions are also easily carried out by the researcher, requiring minimum effort, yet it provides maximum efficiency. The fiberglass pan also makes it easier for the client to sterilize and clean after experiments since all bodily fluids and other unsanitary materials are contained inside the pan. The monkey board was designed with the monkey's comfort in mind. There will be no inhumane constraints that restrict the monkey in any way. This assures that forceful fastening cannot injure the monkey by the researchers performing the experiment.

Ethical Considerations

The main ethical consideration related to this project is the issue of animal safety. The design must treat the monkey humanely and make sure they are in as comfortable of an environment as possible. The lack of physical constraints will help achieve this goal. Also, the device was made to be used completely mechanically in order to avoid any electrical malfunction that could harm the animal. In addition to these considerations, the pan on which the monkey is placed ensures that the monkey could not get pinched by any of the hardware on the device while also making sure that the monkey's bodily fluids do not spread to, and potentially, defect the jack or any of the other device components.

Testing

Although the team was unable to perform live testing on the monkeys, the client helped very much in terms of getting an idea of how the device works in speeding up the process of the research. Since the research performed is kept confidential, the client, Mr. Heyne, was the only individual capable of testing the device. The previous method of lining up the monkey by hand took approximately ten minutes for each test subject. One thing that the device that the team built helps with is removing the need to reposition the board after each trial. This cuts down on the time of each successive trial on the test subject. Since the team was not allowed into the actual testing area, they conducted mock trials in which an imitation of a fluorophotometer was used along with a stuffed animal to simulate multiple trials on multiple test subjects.

The device ran smoothly in all areas of the test. The device easily moved in both the x and z-directions. It also swiveled back and forth as well as locked into place. The rough and fine adjustments in the x-direction were useful in both accuracy and precision. After the mock reading by the fluorophotometer was taken, the device was lowered and the monkey was removed. Successive trials were then performed after the first monkey. The procedure for the first monkey took on average, 2 minutes and 36 seconds. This number clearly speeds up the time it takes for the client to conduct his research. One thing the device also does is limit the amount of time it takes to perform each successive trial, because our client doesn't have to reposition in the x direction. The average time it took to position each successive trial was 1 minute and 3 seconds, proving that the team's locking x-directional system of movement is efficient. This testing provided the client with information on how his device would give him an easy and smooth way of situating test subjects for multiple trials.

Future Work

Though the final design meets the client's requirements, it still could be improved in the future. In order to improve the transportability of the design, the weight of the device needs to be reduced. This could be accomplished by using lighter materials. The only concern in using lighter materials is that the strength of the material would be compromised. The main reason why the team decided to opt for the heavier material was to maximize the durability of the device. Since the design will only be used in one lab and will not be moved around, weight was not given a high priority. However, if this device will be used for other clients, they may need it to be transportable and then weight of the design needs to be improved.

In addition, live testing of the device will need to be done in the future. Because the researchers use live monkeys, it was difficult for a team member to test on the monkeys. The safety requirements were extensive in getting into a lab where monkeys were held. Such requirements include having tuberculosis test. Only one of the members of the team had gotten this test done. In addition, the process of entering the lab is quite complex, as a large amount of paperwork had to be completed and approved. The team attempted to enter the monkey lab in order to view the current equipment that is used for research; however, a worker prevented the team from entering the lab. This is because the researchers are worried that outside individuals may mistakenly view the research being conducted on the monkeys as abuse. As a result, no one from the team was able to enter the lab.

Also, the team needs to determine how problematic it is to sterilize the board. Without any prior live testing, the team does not have any of the common spillages that would accumulate on the design that the monkeys discharge which include: fecal matter, urine, drool, and vital fluids. Consequently, in order for the team to determine how difficult these spillages are to remove, live testing needs to be conducted first.

Other areas of improvement can be conducted to enhance the product. While the current scissor jack adequately raises the monkey board, it does so at a rather slow rate. In order to improve the speed of the z-direction, hydraulics should be implemented in the future. However, it should be noted that improvements in the speed of the z-direction should not limit the accuracy that the current method allows. The scissor jack also needs a longer hand crank handle in order to increase the moment arm and the ease at which it is to raise the monkey board. Furthermore, the base of the design needs to be improved in order to increase stability. The current base rests on a smooth and rather small area. As a result, if the design is rested on an uneven surface, the design may have a tendency to wobble. In order to improve this, a larger surface area base should be designed and incorporated.

Another area of improvement is in strengthening the current design. Ways to accomplish this is to replace the epoxy used to attach objects with bolts. There are several reasons why the current model avoids bolts in certain situation. For example in attachment of the fiberglass pan to the horizontal movement mechanism, bolts were avoided in order to prevent cracking of the pan due to drilling. Another example is the attachment of the scissor jack to the horizontal movement. This was also glued with epoxy instead of bolted. The reason for this was the problems associated with placing a bolt through the top of the scissor jack. If an incorrectly placement of the bolt had occurred on top of the scissor jack, the jack would not be able to glide along the top and thus would prevent the vertical motion. Another way to strengthen the current design is to add more screws to the cabinet sliders.

In addition, improvements to the design can be made to enhance the comfort of the monkeys. Because the moneys are sedated while the experiment is being conducted, their body temperature falls and hyperthermia can set in. Problems associated with hypothermia include: reduction in respiration and cardiac function, slow metabolism, and death (Guidelines for the Use of Anesthetics, 2010). In order to prevent hypothermia, a pad/heating pad should be incorporated in the current design in the future.

Conclusion

Mr. Heyne and his team at the University of Wisconsin-Madison need a more convenient way to situate their test subjects in a position where they can be analyzed. Three initial designs were proposed: a model implementing gears, one using a foosball model with rods attached to the board, and finally a xy-compound table. The compound table design was deemed the best solution to the problem. However, due to miscommunication with the client about where the y-axis is pointing, a new design concept was researched and implemented. The new design incorporated a scissor jack to move in the z-direction and a ball screw type mechanism that has a release trigger for coarse and fine movement in the linear direction. It is hoped that this device will greatly improve the quality of client's research of glaucoma so that one day human suffering caused by glaucoma will be alleviated.

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Appendix

I. Project Design Specifications

Board for Glaucoma Research (PDS)

12/8/10

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Function: Mr. Galen Heyne, the client, has requested a device to allow a monkey board to adjust in the XZ-plane (move in the horizontal direction, move in the vertical direction, and be able to rotate at a minimum of 90 degrees) in order to make his research on glaucoma more efficient.

Client requirements:

- Must be able to move in the x-direction (rough and fine adjustments) (horizontal)
- Must be able to move in the z-direction (vertical)
- Rotate at least 90 degrees
- All rotations must be mechanical (no electronics for Animal safety)
- Has to be easily cleaned

Design requirements:

1. **Physical and Operational Characteristics**
    a. *Performance requirements:*
        i. Must move in XZ plane
        ii. Must be able to rotate 90 degrees
        iii. Must have a locking mechanism
    b. *Safety:*
        i. Must be mechanical
    c. *Accuracy and Reliability*
        i. Needs to have a mechanically controlled amount of precision (1 cm or less)
        ii. Needs to have consistency with positioning
        iii. Consistent initial securement for each monkey
    d. *Life in Service:*
        i. We want to design this board so that it will last for 10 years
    e. *Shelf Life:*
        i. Sterile before use

   ii. Easily storable
f. *Operating Environment:*
   i. Laboratory research
   ii. Room Temperature- 15-30 degrees Celsius
g. *Ergonomics:*
   i. Comfortable for the cynomolgus monkey
   ii. Increase efficiency of the research
   iii. Easy to use for the research
h. *Size:*
   i. Monkeys are 38 to 55 cm long
   ii. *Weight*
      1. Females are 7 - 13 lbs
      2. Males are 11-20 lbs
i. Weight:
   i. Females are 7 - 13 lbs
   ii. Males are 11-20 lbs

j. *Materials:*
   i. Steel
   ii. Epoxy
   iii. Fiberglass
   iv. Plastic
   v. Wood
k. *Aesthetics, appearance, and finish:*
   i. Function over aesthetics

2. Production Characteristics
a. *Quantity:*
   i. Only need to make one
b. *Target Product Cost:*
   i. $200.00

3. Miscellaneous
a. *Standards and Specifications:*
   i. Follow monkey handling ethical specifications
   ii. Must be safe and comfortable for monkeys
   iii. Must decrease stress of monkey
b. *Customer:*
   i. Customer m*ust be* able to move to the table
c. Patient-related concerns:
   i. Don't want the researcher or monkey to get pinched
   ii. Whole machine must be sterile
d. *Competition:*
   i. The competition is the preexisting board