
Kevin Taylor
Designing a Mini Golf Obstacle

Exploration of the Design Problem

Situation

- Minigolf Ltd, a manufacturer and distributor of resources necessary for the creation of a minigolf resort, presented us with the task of creating a quarter-sized prototype of a new mini golf obstacle which we must design

Brief

- The obstacle should be interactive and fun if it were to be installed in a mini golf course, it should have a popular theme and it must have an electrical input, a programmed process and a mechanical output

Design Specifications

- Must not exceed a budget of £50
- Interactive, fun and therefore appealing to the largest majority of customers possible. Can be done by following a popular theme e.g. of a new movie

Technological Requirements

- Electrical Input
- Programmed Process
- Mechanical Output

Target User/User Group

- Although mini golf courses which will house the mini golf obstacle can certainly be played and enjoyed by all age groups, an optimal approach to increasing the success of the design would be to design the obstacle so that it appeals to the largest audience possible by targeting a specific age group in order to maximise profits and success. This can be done by having the design follow a certain theme, e.g. LEGO, which would be appealing for young children, or of a recently released and popular action movie, which would appeal to teenagers and adults.

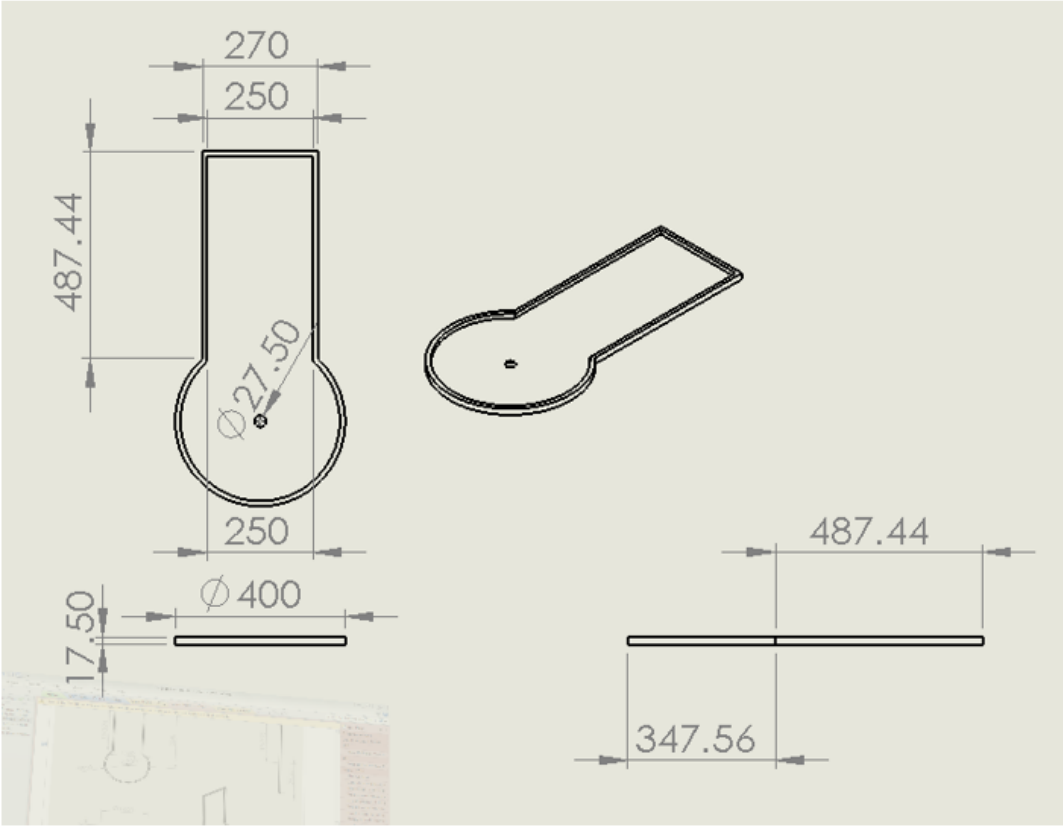
Exploration of the Design Problem

Design Parameters:

- The prototype must be built around the obstacle base, which should follow the dimensions of the illustration to the right.
- The reason behind this is to do with the laser cutter's capacity: All the parts required to build the base can be fitted onto two sheets, however if the dimension are modified or lengthened, then another sheet is required since the parts no longer fit on two sheets, which uses an excessive amount of material.
- On top of that, the fact that the obstacle base is built off three separate sheets means that the strength and sturdiness is compromised

Design Brief:

- Essentially, all the company wants from us is an appealing minigolf obstacle prototype which should be successful if it were to be fully created and shipped out to customers, to be played and enjoyed by minigolf players. This gives us the opportunity to design the minigolf obstacle as we please: the obstacle could be of all shapes and sizes, and the theme could range from Disney characters to space exploration. This makes sense too, since it does not limit creativity and variation of the minigolf obstacle, allowing for more unusual and interesting products to be made.



A quick overview of Minigolf Ltd.

- They create minigolf equipment and resources such as putters, low bounce balls and flags, but most importantly obstacles
- The obstacles' sales completely depend on what the customers decide to buy so the obstacle which is to be designed must be not only appealing put also affordable
- The company is run by a man by the name of Gary Jenkins who has been in the business for a number of years

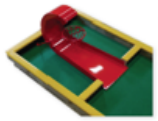
Crazy obstacles

for Mini Golf and Adventure Golf

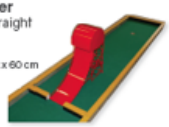
Red & stainless steel

Now our bestsellers are available in red paint too.
Buy all five of our stainless steel obstacles E01-P - E05-P for a special price!

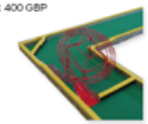
5 obstacles for 1 762 GBP



E03-P Mini basket
Suits plane, straight courses.
Measure: 65 x 25 x 32 cm
Price: 400 GBP



E04-P Tower
Suits plane, straight courses.
Measure: 85 x 22 x 60 cm
Price: 400 GBP



E01-P Saturn
Suits plane, straight courses.
Measure: 100 x 70 x 40 cm
Price: 400 GBP

E02-P Slalom
Suits plane, straight courses.
Measure: 220 x 22 x 26 cm
Price: 269 GBP

E05-P Loop RF
Suits plane, straight courses.
Measure: 45 x 32 x 44 cm
Price: 488 GBP

Clean & stainless steel

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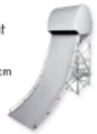
Price: 332 GBP



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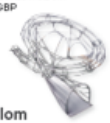
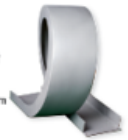


E01 Saturn
Suits plane, straight courses.
Measure: 100 x 70 x 40 cm
Price: 332 GBP

E02 Slalom
Suits plane, straight courses.
Measure: 220 x 22 x 26 cm
Price: 224 GBP



E05 Loop RF
Suits plane, straight courses.
Measure: 45 x 32 x 44 cm
Price: 423 GBP

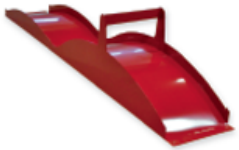
www.citygolf-uk.com

Their products range from 360 loops to pigs and elephants

Elephant
Suits plane courses. Ball is played through the trunk.
Measure: 183 x 30 x 90 cm
Item no. A01
Price: 612 GBP

Spiral
For left or right angled courses. Specify which angle when you order!
Measure small: 110 x 70 x 20 cm
Item no. A06-70
Pris: 303 GBP
Measure large: 120 x 90 x 30 cm
Item no. A06-90
Price: 418 GBP

Basket
Suits slope courses. The ball ends up in the basket.
Measure small: 70 x 25 x 90 cm
Artikelnr. A18-70
Pris: 634 GBP
Measure large: 100 x 25 x 98 cm
Item no. A18-90
Price: 770 GBP

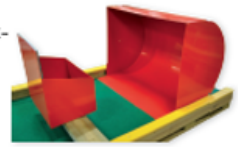


Double bridge
Suits plane, straight courses.
Measure small: 122 x 18 x 19 cm
Item no. A10-70
Price: 221 GBP
Measure large: 180 x 25 x 26 cm
Item no. A10-90
Price: 292 GBP

Snake
Suits slope courses. Preferably on a finishing course.
Measure: 245 x 50 x 7 cm
Item no. A07
Price: 147 GBP

Harvester
Suits plane courses.
Measure: 100 x 60 x 55 cm
Item no. F01
Price: 961 GBP

Lighthouse
Suits plane courses. The top gives a fine glow at night.
Measure: 60 x 60 x 110 cm
Item no. D01
Price: 810 GBP

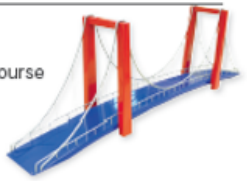


Snow catcher
Suits straight courses. The ball should make a loop backwards and end up in the box.
Measure: 60 x 45 x 30 cm and 30 x 21 x 21 cm
Item no. A19
Price: 251 GBP

Red loop
Suits plane, straight courses.
Measure: 65 x 40 x 60 cm
Item no. A15-90
Price: 368 GBP

Yellow loop
Suits plane, straight courses.
Measure: 55 x 30 x 40 cm
Item no. A15-70
Price: 306 GBP

Barn
Suits plane courses.
Measure small: 73 x 46 x 56 cm
Item no. A08-70
Price: 325 GBP
Measure large: 96 x 54 x 66 cm
Item no. A08-90
Price: 471 GBP



Suspended bridge
To beplaced on a straight course, or between two course sections.
Measure: 180 x 28 x 50 cm
Item no. A12
Price: 632 GBP

Pig
To beplaced on a plane course with an angle.
Measure: 65 x 50 x 30 cm
Item no. F03
Price: 789 GBP

Check out our website!
www.citygolf-uk.com

Find out your closest distributor! On our website you will also find more acessories, such as flags and repair material. You can also read more about how our Mini Golf & Adventure Golf projects been profitable for our customers.

Minigolf Ltd, Unit 8 Chiltern House, Waterside, Chesham. HP5 1PS | www.citygolf-uk.com

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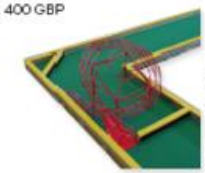

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Notice how all the obstacles allow for hole in ones. This is important as it improves the quality of the customer experience

This is a smart marketing technique which can lead to a customer buying a few more products than he/she would have, leading to a higher overall profit

These obstacles have more variation in theme – a more diverse product range increases the customer range

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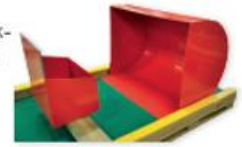

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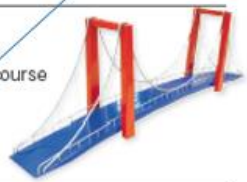

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Several of the obstacles appear to have a **rural** theme to them – this suggests that customers tend to like that theme

Strategies for Research and Data Collection:

Research Plan

- In order to create my minigolf obstacle to be as successful as possible I will need as much relevant information which could help me improve my design
    - This could range from what theme would be the most popular to what materials present the best balance between aesthetics and durability

- The most useful research to me is undoubtedly primary research as it allows me to evaluate minigolf obstacles myself instead of taking someone's word for it, however secondary research still remains important and useful, especially from an expert source such as Minigolf Ltd's CEO, Gary Jenkins, a man who has focused his career on these kinds of projects for a substantial amount of time.
    - On the 14th of September our class was able to secure an interview with him in order to ask certain questions about the matter. The answers he gave are vital to creating the most successful product possible and are the most significant form of secondary information.

Research Plan

Priority	Questions	Method of Research (primary/secondary, where, how)	Relevance
1	What themes would make the obstacle as enticing as possible for the target audience?	• Secondary research • OneNote • Using the information obtained from the interview with the CEO of Minigolf Ltd.	Knowing this could greatly improve the customer reception of the product
2	What player/customer range should the obstacle be aimed towards?	• Secondary research • OneNote • Using the information obtained from the interview with the CEO of Minigolf Ltd.	In order to maximise the product's success the it should be designed to appeal to the most optimal age group
3	What is an electrical input, a programmed process and a mechanical output?	• Primary and secondary research • Primary: Experimentation in class OneNote notes • Secondary: Google, Wikipedia	The design brief provided by Minigolf Ltd. states that the ¼ sized prototype must contain these three elements
4	What is the most enjoyable aspect of minigolf obstacles which can be improved on?	• Primary and secondary • Primary: Visiting a minigolf course • Secondary: Using the web to find what most makes minigolf fun to play	Ensuring that the product does not inhibit this can improve its success and customer reception
5	What is the worst/most frustrating aspect of minigolf obstacles which can be fixed/improved?	• Primary and secondary • Primary: Visiting a minigolf course • Secondary: Googling the most complained issues with minigolf	Finding this and fixing it will ensure that the customer/player experience is not worsened

Primary Research

- Luckily, I happen to have gone to several minigolf courses in the past, so I can use my experience to justify certain points as well as include certain ideas
- Among them are ‘Minigolf Goolfy’ at Villeneuve and ‘Mini-golf de Montreux’ (pictured), both in Switzerland.

Secondary Research

- Although the interview with Gary Jenkins lasted a while, several questions posed to him were unnecessary or redundant. Here is an outline of the answers he gave:

How many golf courses have you supplied?
36 in the UK the last 12 at golf centres. Rascal bay Manston is the closest to us.
Who is your average customer ?
Minigolf Ltd. sells to businesses on the higher end, generally golf related hotels/centres. But our clients tend to be family orientated: elders, teens aged 19-20 (university students) and notably, first dates.
Where are the courses located?
Seaside/holiday destinations
What themes would be popular and well-received by the target audience whilst fitting in with the other obstacles?
Themes including dinosaurs, pirates, Harry Potter content, a mystical atmosphere/style and dragons seem to do well.
What level of difficulty is most appropriate for a mini-golf obstacle?
Playable by all; not too difficult and with realistic holes, yet still with a decently long length. Always a hole in one possibility.
Are interactive obstacles common in the industry?
Obstacles special effects, usually smoke, light and sound do exist. For example, putting the ball into the hole and then having something done to move the ball, e.g. pin ball machine.
How has the market size changed over the past five years? Has it grown or decreased?
Minigolf course manufacture is an expanding industry and is becoming more competitive.
How do you structurally reinforce your obstacles to lengthen their product life?
2 Year guarantee. Articifical grass. Yearly contract to fix/repaint golf obstacles.
What is your go to material for obstacles, keeping in mind cost and durability?
Natural stone and timber are optimal. DO NOT USE FIBRE GLASS – it should be just for decoration.

Themes

- During the interview, Gary Jenkins stated that the most popular themes included dinosaurs, pirates, Harry Potter content, a mystical atmosphere/style and dragons.
    - This indicates that a product which is designed to fit the recommended themes is almost guaranteed to sell somewhat well, however an obstacle with a different and unique design can do just as well, if not better.
- He also mentioned that university students and elders commonly play on minigolf courses, and more notably that first dates often take place on minigolf courses. This could indicate further possibilities for theme ideas, including a romantic theme for couples.
- A theme, however, is not always required: As long as the product remains interesting and fun for users, it does its job. This is evident from my fun experience at 'Mini-golf de Montreux' in Switzerland, which as can be seen from the screenshot, does not have a distinct theme as the two images below present.

Player/Customer Range

- According to Gary Jenkins, “Minigolf Ltd. sells to businesses on the higher end, generally golf related hotels/centres. But [their] clients tend to be family orientated: elders, teens aged 19-20 (university students) and notably, first dates”
- This means that:
    1. The actual companies who buy their products in order to build a minigolf course work in the leisure and accommodation industry and are able to afford pricey products
    2. The clients who go to these places to use the products sold by Minigolf Ltd. are of all ages (family orientated) but the most common tend to be university students aged 19-20, elders looking to relax and couples on first dates.
- From this information we know that:
    1. Users who will play with the obstacles are looking to kill time and to relax as opposed to looking for a challenge and possibly getting frustrated, so the obstacle mustn’t be too difficult to overcome/complete
    2. The variety of obstacle themes is almost endless as the player range is very wide, however certain themes additional to Gary’s recommendations could do well (e.g. a romantic theme, as first dates tend to occur here).



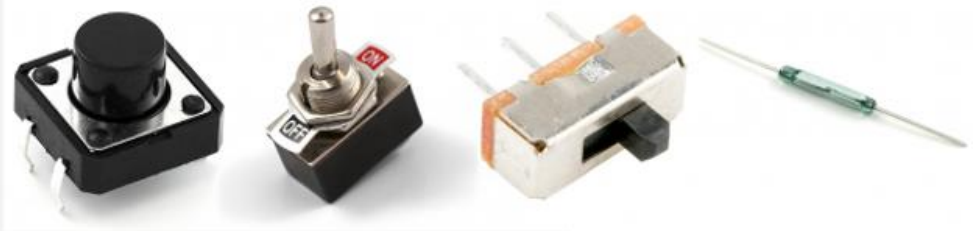

Research on Technological Requirements

1. Electrical Input

An electrical input is what activates a programmed process.

Electrical Input components could be:

- A switch (eg push-switch, microswitch)
- A key pad
- A Light Dependent Resistor (LDR)
- A thermistor
- A photodiode
- A phototransistor
- An opto-isolator
- A proximity switch or reed switch

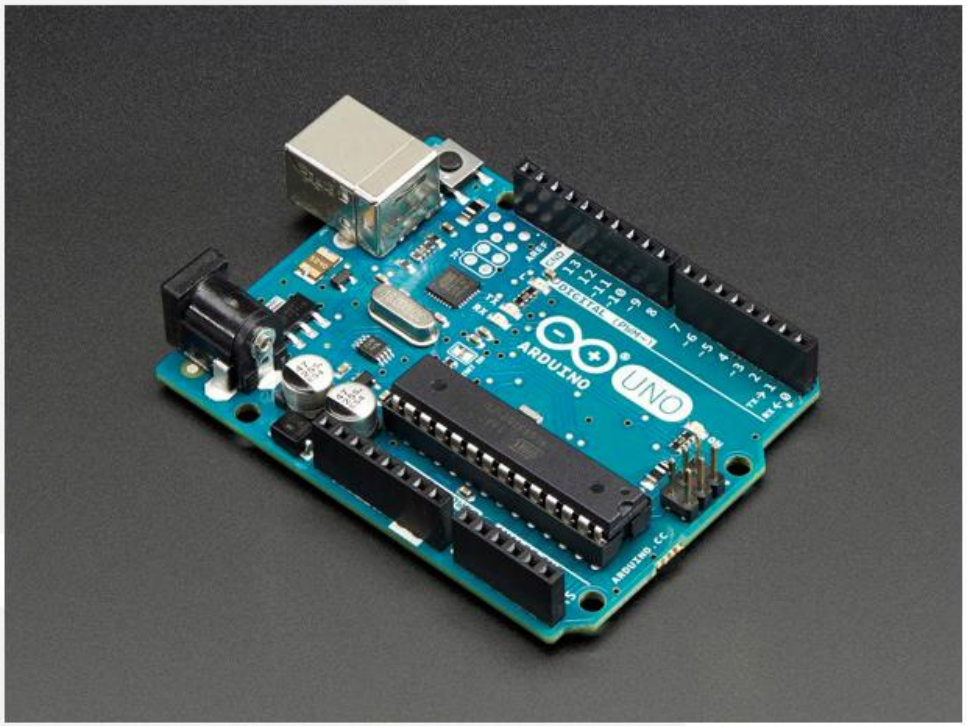


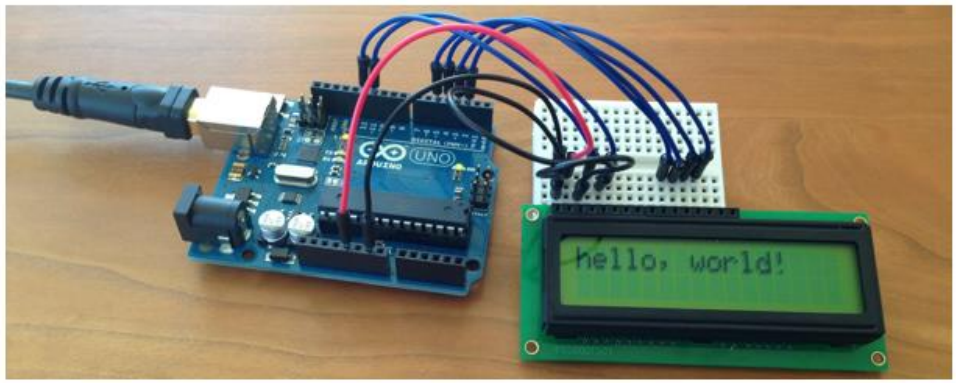
2. Programmed Process

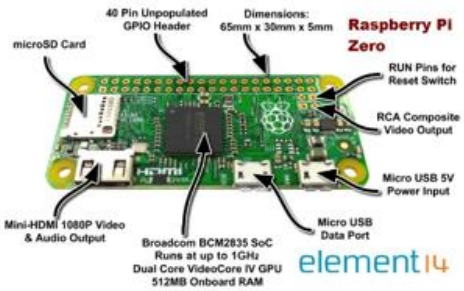
A programmed process is what controls the mechanical output after an electrical input is given.

- e.g. 1: The minigolf ball goes past a proximity sensor
  2: The programmed process, which tells a motor to activate, is sent to the motor
  3: The motor in question turns on, lifting a miniature portcullis

The programmed is generally stored and initiated by a microcontroller, such as an Arduino board.



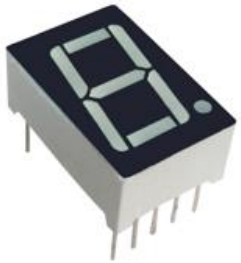


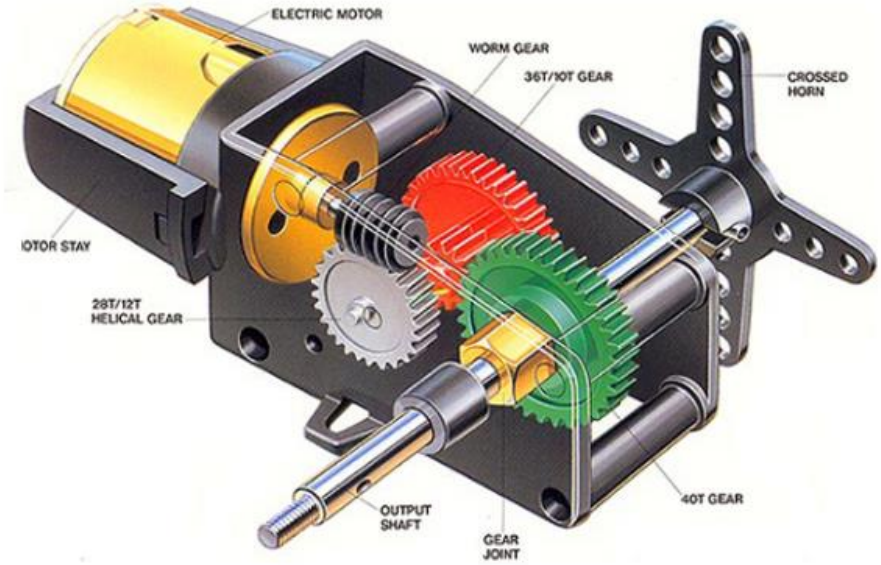


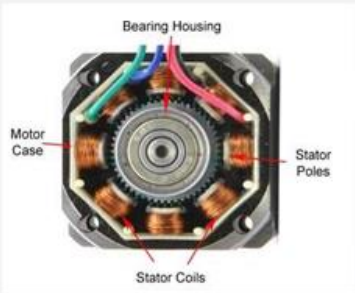
3. Mechanical Output

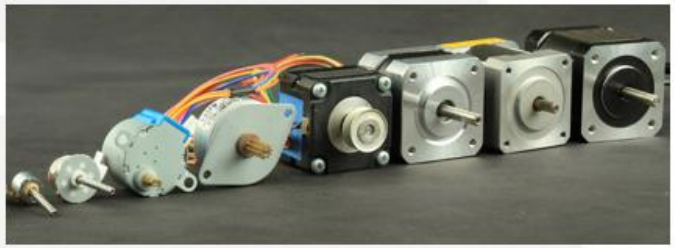
A mechanical output is the physical manifestation of a programmed process.
The minigolf obstacle which is to be designed will use a motor (servo and/or DC and/or stepper), but it could also use:

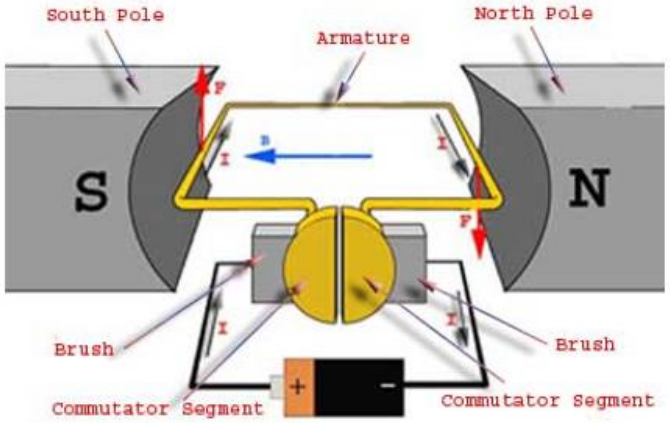
- An LED
- A lamp
- A buzzer
- A piezo
- A solenoid
- A relay
- A seven-segment display











Best Aspects

- Minigolf can be quite addicting and very enjoyable for players so long as they have a positive experience with it.

- The best aspects of obstacle design are:
  - There always being a hole-in-one possibility as this presents a higher level of difficulty for those who are up for the challenge without impairing the experience
  - When the outcome of the ball's trajectory is difficult to determine until the last moment, which presents suspense and makes the obstacle more exciting.

- Due to this knowledge, my obstacle will not require the user to hit the golf ball twice, and the outcome of the hit should be difficult to predict if possible.

Worst Aspects

- There can be, however, several overlooked mistakes and nuisances which can worsen or ruin the experience for the player
- From my experience playing minigolf, I have found that certain annoying aspects, such as unintended ridges and bumps in the ground and the ball getting unretrievably lost in a pond or river, can be cause for frustration and annoyance
- Also, if a certain obstacle/hole is extremely difficult to overcome/complete, the player can get frustrated with the course.
- These problems can be fixed though. For instance, providing a net will allow clients to retrieve stray minigolf balls without having to get wet, and ensuring that the minigolf course is overlooked for errors such as ridges, bumps, small edges and a hole which is ridiculously small.

Specification

What the product must do

Thanks to the research which has been carried out the initial primary specification can be elaborated and explained in more detail:

- The designed product must have an electrical input component which is compatible with the microprocessor in question (in this case, Arduino) which triggers the programmed process. This will most likely be an infrared sensor due to the automatic nature of minigolf courses (since the obstacles should not have to be manually triggered by the player by means of a switch)
- The designed product must have a programmed process which is compatible with the electrical input component and which effectively and correctly uses the mechanical output
- The designed product must have a mechanical output that fulfils the required task in order for the obstacle to work properly. It will most likely consist of a motor (servo, DC and/or stepper).
- The actual full sized obstacle mustn't be too expensive to manufacture. In order to ensure that the designed prototype won't result in that happening, it must cost less than £50 to make, that way the real obstacle won't end up costing a ridiculous amount of money to make.

What the product should do

Aside from the obligatory requirements of the product, certain aspects should be taken into consideration to improve the overall quality of the product.

- The product should have an appealing theme to target a certain audience, which according to Gary Jenkins consists of children, teenagers, the elderly and those going on dates. This would increase the player reception and improve the success of the product.
- As well as the mandatory mechanical output (which will be a motor), having different types of output could improve the product, notably having LEDs, buzzers, and even a seven-segment display.
- The minigolf obstacle should be of a reasonable difficulty, and thus playable by all; making it too difficult would frustrate the players, leading to a negative experience with the product, but making it too easy would not present a challenge and would not be fun for the player.
- Also, although not mandatory, the minigolf obstacle should allow for the possibility of a hole-in-one. This presents an extra challenge for those looking for it, and getting a hole-in-one is guaranteed to be fun for the player, leading to a positive experience with the product.

What the product could do

There are nearly endless possibilities for extensions and other additions to what the product could feature…

- Loops
- Elevators
- Large and elaborate obstacle designs
- etc.

…but many are unreasonable or too complicated to make.

Idea Generation and Exploration of Possibilities

Evaluated through clear, concise and specific annotation

- The following section will cover different possibilities and ideas for the prototype design
- Each idea and its features will be annotated and explained
- At the end, an idea evaluation matrix will cover the positive and negative aspects of each idea in order to determine which the best, after which is it further developed and eventually realised.

Design Ideas Outline

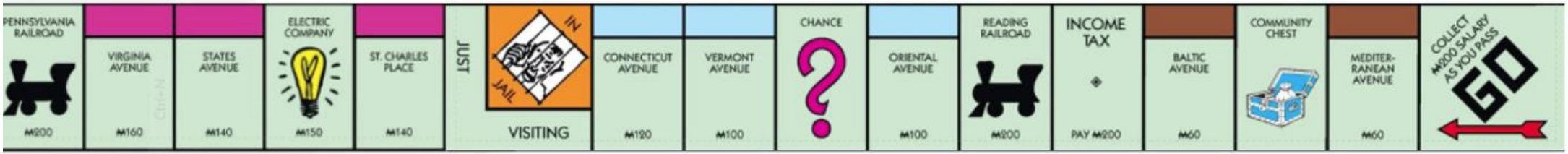
Theme Ideas	Inclusion of Technological Requirements	Notes
Monopoly	Electrical Input: • Push button Programmed Process: • Activate motor which moves cam and follower mechanism Mechanical Output: • Platform pushes ball up to hole	A theme idea which targets every age group and known internationally.
Minecraft: Redstone floor and wolf	Electrical Input: • Infrared sensor Programmed Process: • Presence of minigolf ball turns on light Mechanical Output: • Wolf's tail wagging back and forth. • Red LED turns on and fades off	This would be appealing for children, adolescents and possibly young adults. As well as a cute dog with a wagging tail, the course floor replicates the mechanic of 'redstone ore' in the game.

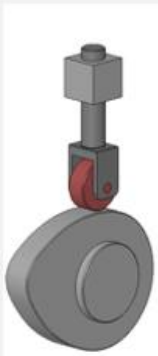
Design Ideas Outline

Theme Ideas	Inclusion of Technological Requirements	Notes
Pumpjack + Money	Electrical Input: • Push button Programmed Process: • Move motor slowly Mechanical Output: • Pumpjack is activated	This would be a theme that people would find especially interesting and relevant since it satirises the money-driven mindset driven by rich businessmen and politicians
Musical (notably piano)	Electrical Input: • Infrared sensors Programmed Process: • Activate buzzer to play different notes and cause the motor to rotate the arch Mechanical Output: • Speaker/Buzzer	This idea includes the use of a buzzer and should appeal to music enthusiasts. It should feature IR sensors which trigger buzzers, playing a melody as the ball rolls across the course.
BMX Course	Electrical Input: • Infrared sensor • Programmed Process: • Cause two servos to move the finish line flags up and down to imitate actual finish line flags Mechanical Output: • Finish line flags move as the ball approaches the hole	The premise of this idea is to incorporate slopes and inclines much like in a BMX course. This would obviously apply to those interested in BMX, but also skateboarders and scooter users.

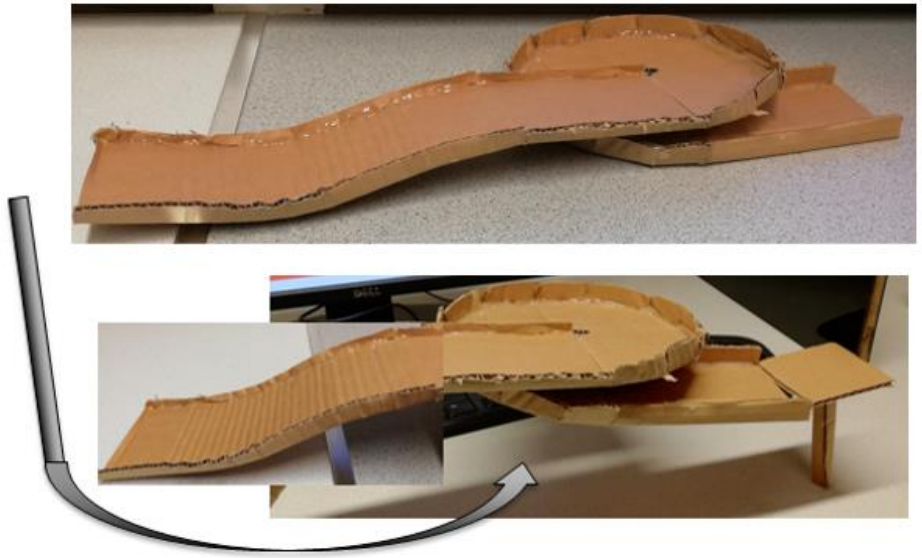
Monopoly

- This obstacle will be slightly different, in that the hole is off the ground and to win you have to time your hit correctly so that the cam and follower pushes your ball up.
- The texture of the floor will be the standard monopoly tiles, however there can be advertising on one of them.





1. The ball is hit up the slope in order to reach the desired height off the ground whereby there is space for the mechanical output (otherwise, a hole can be dug out and the obstacle can remain on the floor).
2. The ball rolls down the 360° loop, adding more variety to the course, as well as extending the length of tiles (and therefore possible advertisements).
3. The user must time the button press so that the cam and follower is activated by the motor at the right time. The mechanism then causes the platform to raise the ball into the hole, which should probably the monopoly man holding his hat out.



Minecraft

No.	Sales	Title	Developer(s)[a]	Publisher(s)[a]	Release date	Platform(s)	Ref.
1	170,000,000	*Tetris* † #	Elektronorgtechnica	Spectrum HoloByte[b]	June 6, 1984	Multi-platform	[2]
2	144,000,000	*Minecraft* † #	Mojang	Mojang	November 18, 2011	Multi-platform	[5]
3	90,000,000	*Grand Theft Auto V* †	Rockstar North	Rockstar Games	September 17, 2013	Multi-platform	[6]
4	82,830,000	*Wii Sports* †	Nintendo EAD	Nintendo	November 19, 2006	Wii	[7]
5	40,240,000	*Super Mario Bros.* †	Nintendo R&D4	Nintendo	September 13, 1985	NES	[9]

- Due to the extreme success of the game, making a golf obstacle using this theme is bound to receive a lot of attentions

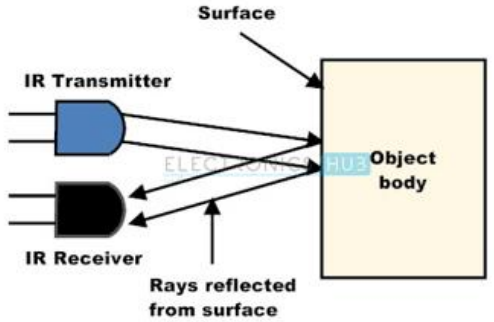
-Infogram from mid-2016

- The obstacle would have ‘redstone ore blocks’ instead of the usual ground surface
- As the ball passes over these the infrared sensor is activated, causing red LEDs in the ‘redstone ore blocks’ to turn on
- The programmed process, aside from turning the LED on, also makes the red LED fade out slowly
  (This is to simulate when a player in Minecraft causes a redstone ore block to emit light briefly and fade out after walking over it)
- Additionally, it would also feature a tamed wolf/dog in the middle of the course.
- The mechanical output would be the tamed wolf/dog’s tail wagging back and forth.

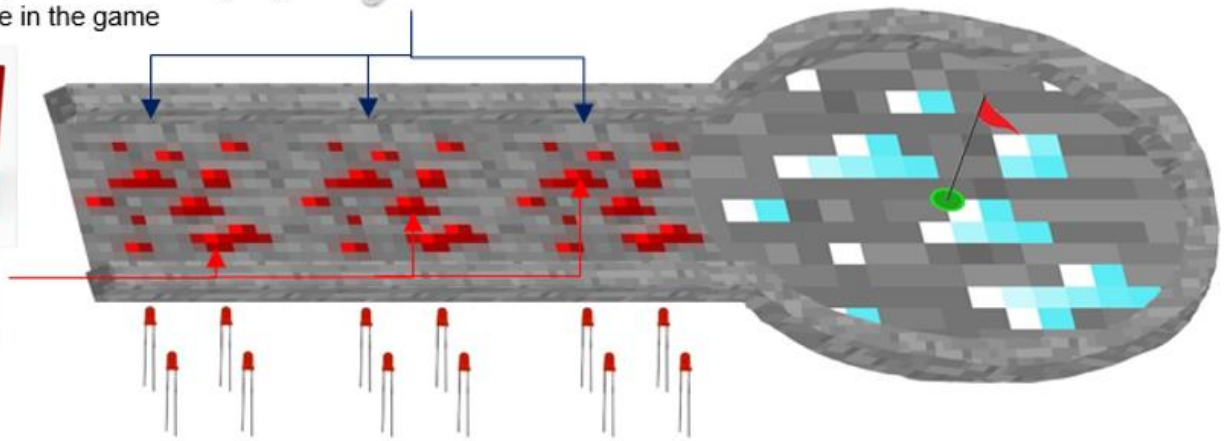
Minecraft: Redstone Floor

- The obstacle would have ‘redstone ore blocks’ instead of the usual ground surface
- As the ball passes over these the infrared sensor is activated, causing red LEDs in the ‘redstone ore blocks’ to turn on
- The programmed process, aside from turning the LED on, also makes the red LED fade out slowly
  (This is to simulate when a player in Minecraft causes a redstone ore block to emit light briefly and fade out after walking over it)

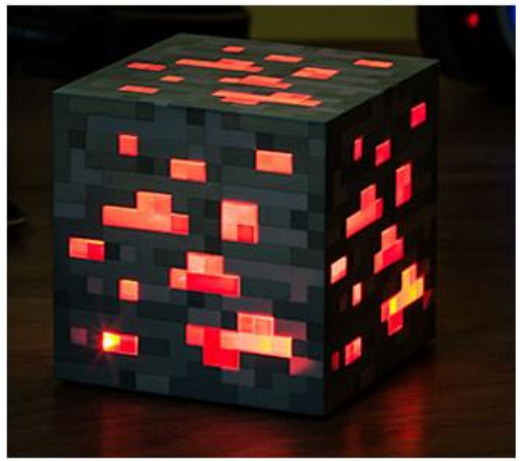
- IR Sensor
- Once minigolf ball cuts infrared ray, signal is sent to be dealt with programmed process



- Transparent red Plexiglass
- Combined with red LEDs, provides realistic lighting replicating the redstone ore in the game



- Red LEDs
  - Activated by programmed process
  - Fades out slowly to replicate in-game mechanic of redstone ore

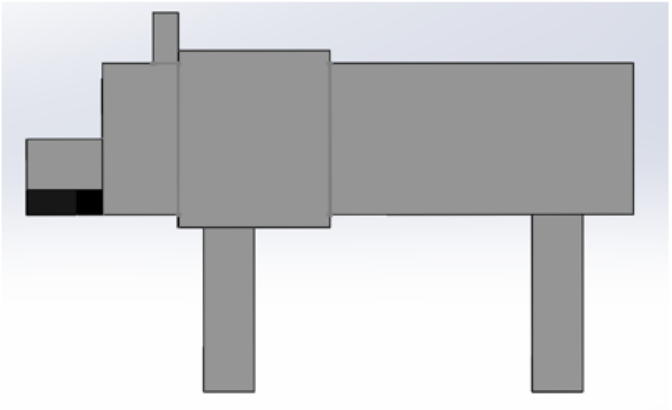


Minecraft: Tamed Wolf/Dog

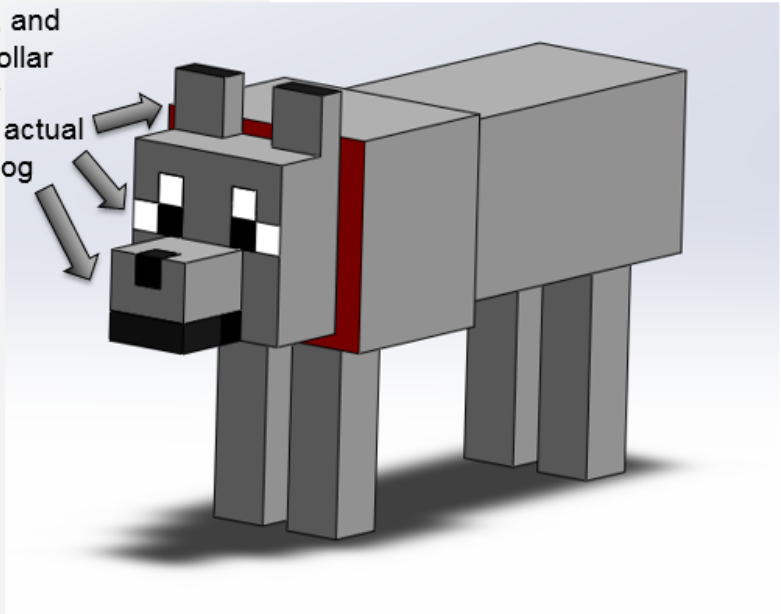
-Original

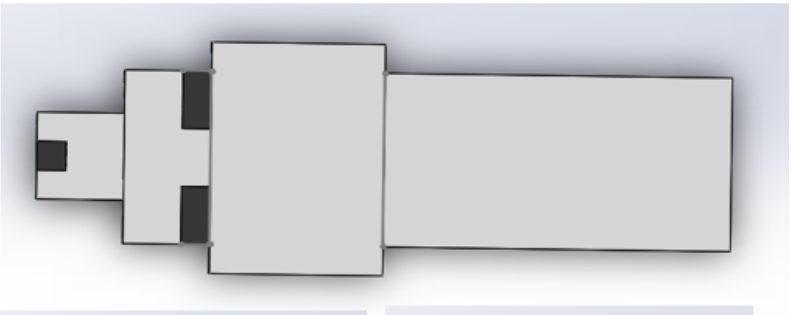
3D Solidworks model screenshots (without tail)

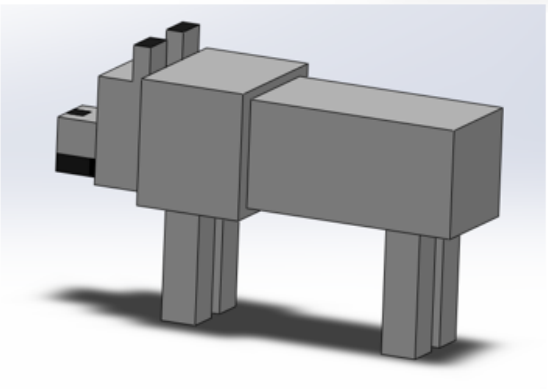
- The tail is to sway left and right much like in the game
- This is done using a servo motor, which is the mechanical output. The motor is to be activated by the same electrical input of the ‘redstone floor’: infrared sensors.

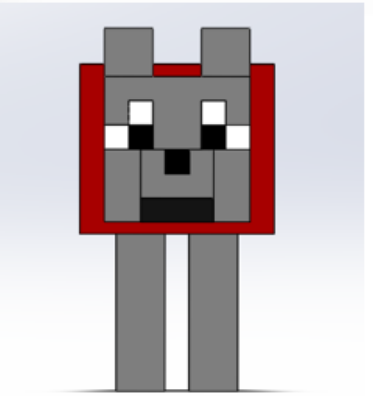


Eye design, ear and nose structure, and symbolic red collar represents key features of the actual design of the dog





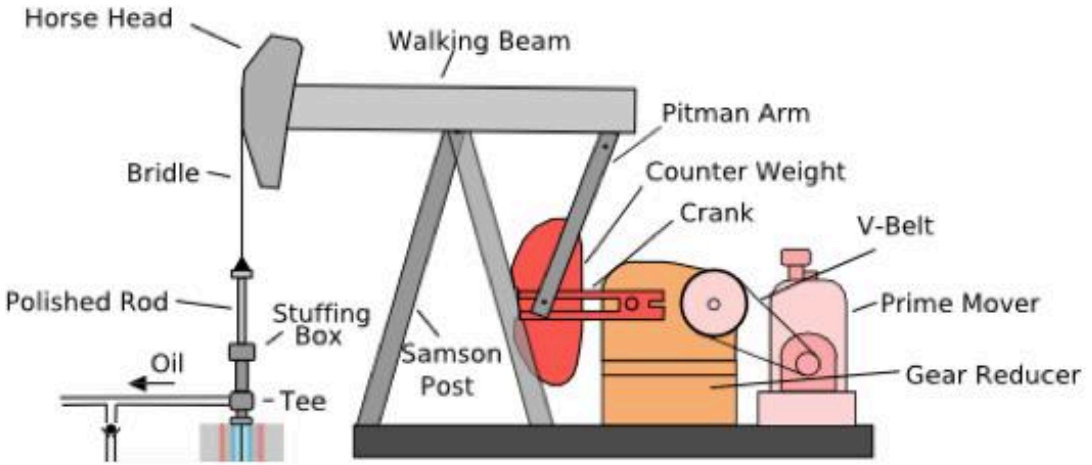




Pumpjack + Money

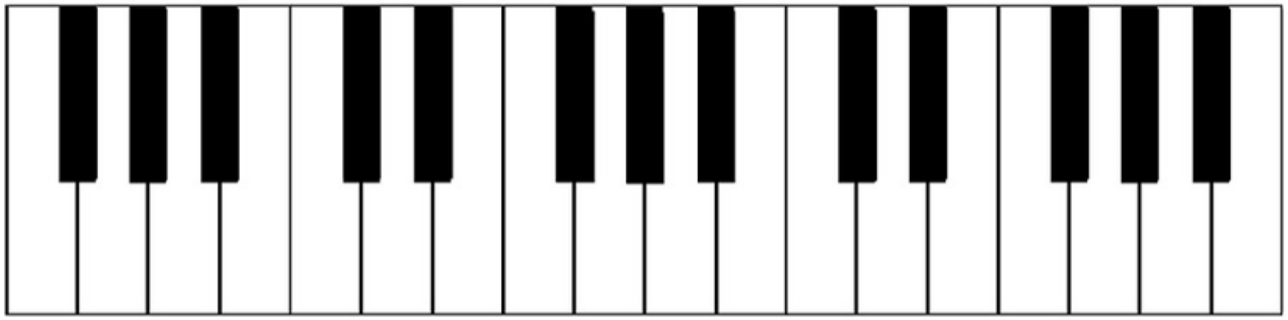
- This idea requires the player to time his shot accordingly in order for the ball to go under the ‘horse head’ of the pumpjack.
- The pumpjack is to keep working, which moves the ‘horse head’ up and down, in and out of the way of the ball.
- In order to conserve energy, the pumpjack stops moving after 3 minutes, after which it returns to its original position (which is in the way of the ball). The push button, it being the electrical input, activates the programmed process, which causes the pumpjack to work for another 3 minutes.

- Since the ‘horse head’ is relatively thin, it cannot obstruct the entire width of a normal minigolf course as it goes down. Because of this, the width of the initial part of the standard minigolf course design should be made to be slightly larger than the ’horse head’, preventing the ball from slipping past even when the ’horse head’ goes down.
- This presents a problem: Once the ball goes past the pumpjack, there wouldn’t be a challenge anymore since the ball would be guaranteed to be moving directly towards the hole since the walls of the course would have adjusted its course.
- To add difficulty to the course, as well as in order to continue the theme of capitalism, industry, business and **oili**garchy (**oil oli**garchy), the rest of the ground surface will be an uneven texture of American $100 bills, symbolic of excessive wealth. This would cause the ball to deviate of course, making the chance of getting a hole-in-one reasonably unlikely instead of probable.

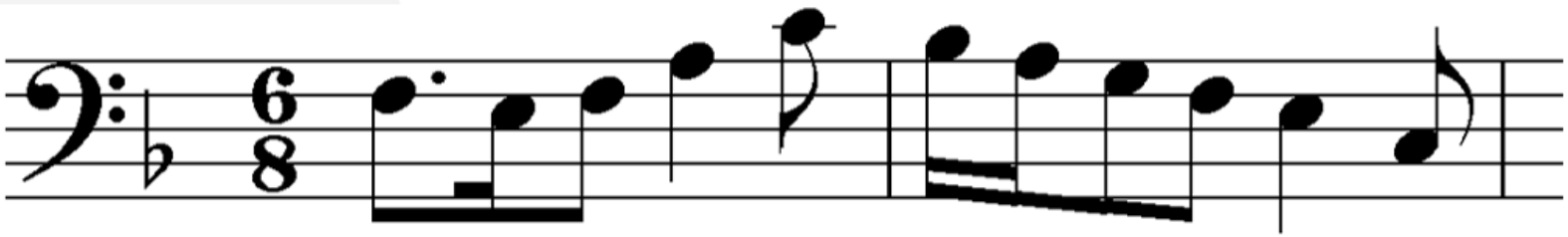


Musical

- This idea also uses infrared sensors to activate the programmed process, however instead of activating LEDs, the programmed process will activate a buzzer which is to emit different notes
- The floor will be designed like a piano keyboard, and there should be one infrared sensor aligned at every key



- Combining both the piano design and different notes being played by the buzzer as the ball goes by the infrared sensor, we are able to either create a realistic piano which plays ascending notes up to the last key (as if the ball was rolling across an actual piano keyboard), or just a set of keys, which together, play an actual tune/melody.
- This idea is practical as only one buzzer needs to be used, since it can be programmed to play different notes (according to which infrared sensor input is activated), however in order to portray the idea that the ball is rolling over individual keys, many infrared sensors are required. This probably isn't too expensive (as long as cheap IR sensors are purchased), however it will probably cause complications with the programming, and the short spacing between each infrared sensor could cause them to interfere with each other.
- As for the mechanical output, there should be a arch over the hole which is a musical bar. When the ball activates any of the IR sensors, a motor should cause the arch to rotate anti-clockwise (as if the notes from the buzzer are being read off the arch). Both the arch and the actual piano will give the player an more immersive/indulging experience, and they should especially enjoy it if they play the piano themselves.

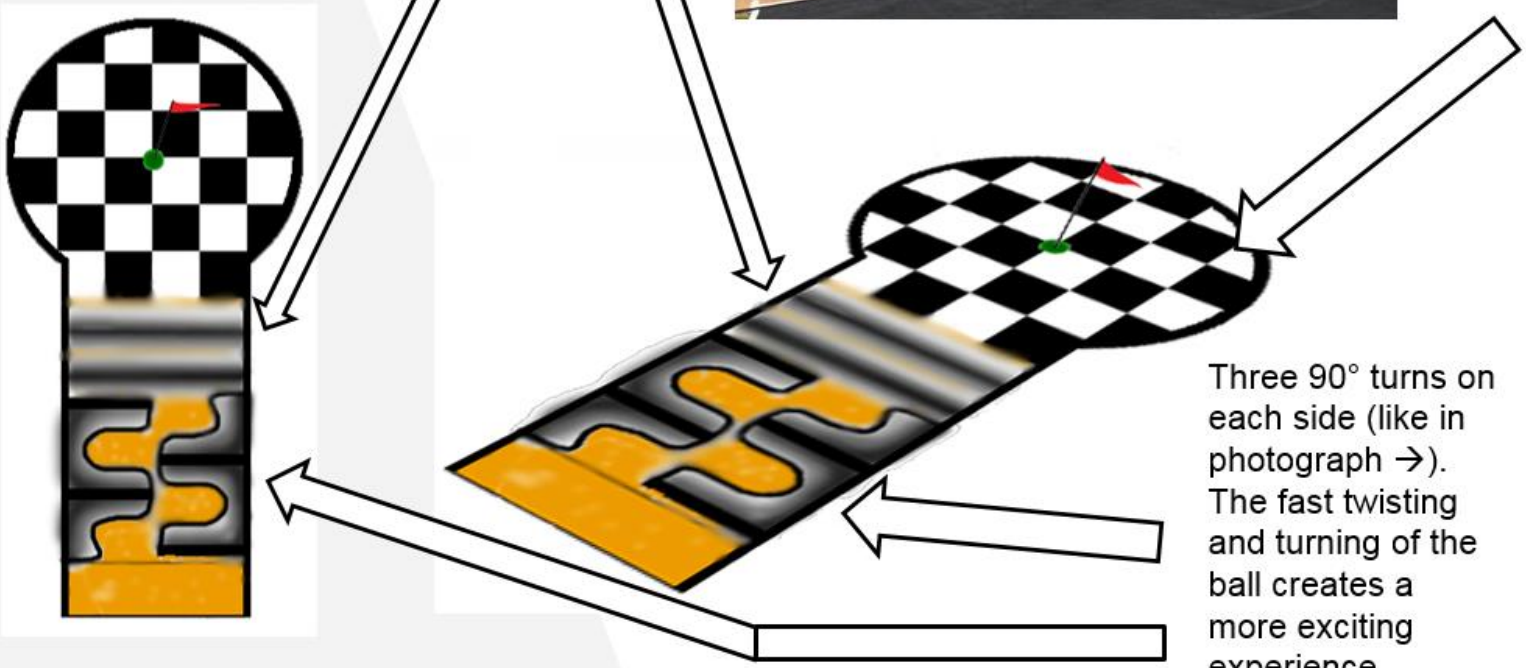


BMX Course

- The premise of this idea is to replicate the fast paced nature of the bumping and twisting involved in a BMX Course

Bumps (like in photograph). Creates suspense and tension when the ball reaches that point, making the obstacle more exciting

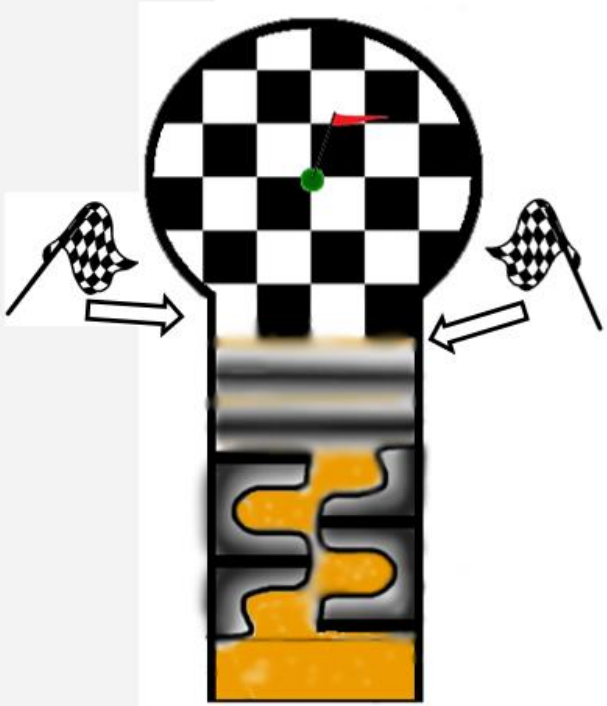
Finish line texture makes the course seem more like a BMX course



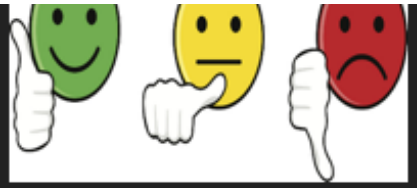
Three 90° turns on each side (like in photograph →). The fast twisting and turning of the ball creates a more exciting experience.

BMX Course

- As for the electrical input, programmed process and mechanical output, there will be two flags on the side which move back and forth at the finish line area, moved by two servos and activated by an infrared sensor between the two linear bumps.
- This replicates the feeling of accomplishment when finishing a race, increasing to what extent this obstacle replicates BMX courses and the atmosphere at the finishing line.



Idea Evaluation Matrix



Theme Ideas	Evaluation (out of 10 for each criteria)						Conclusion	Rating
	Visual appeal	Manufacturing cost	Target audience size	Appropriate difficulty	Hole-in-one chance + how fun it'd be	Accuracy of theme		
Monopoly	5	7	10	5 (harder than average)	3	5	Possibly too hard and is too generic, but still fun	35/60 5.8/10
Minecraft: Redstone floor and wolf	8	5	10	6 (slighty easy)	8	8	Slightly complicated to manufacture and could be made more challenging, but still an excellent idea	45/60 7.5/10
Pumpjack + Money	8	3	7	7 (slightly hard)	4	8	Appealing and fun, but very complicated and difficult to manufacture	37/60 6.2/10
Music	5	4	6	3 (far too easy)	8	6	Exciting and impressive, but component-costy and generic	33/60 5.5/10
BMX Course	7	5	3	4 (hard)	1	7	Small target audience, and no chance for hole-in-one thrill	27/60 4.4/10

Development of the Chosen Concept

Including reference to materials, manufacturing techniques, code, circuits, components, mechanisms and further details.

- After evaluating each idea under the specific criteria, I have chosen to further develop the idea concerning the Minecraft Redstone Floor and the Minecraft Dog
- The following slides will cover the following aspects of the obstacle and its development:
  - Materials: What is required for the actual building of the minigolf obstacle
  - Manufacturing Technique: Which method(s) is/are required to build the minigolf obstacle
  - Code: Which elements of code were combined together to enable full functionality of the outputs
  - Circuits: How the circuit was set up in order to carry out the code correctly
  - Components: Which components (input and output) were required in the creation of the
  - Mechanisms:
  - Further details: e.g. how certain problems were fixed

Materials

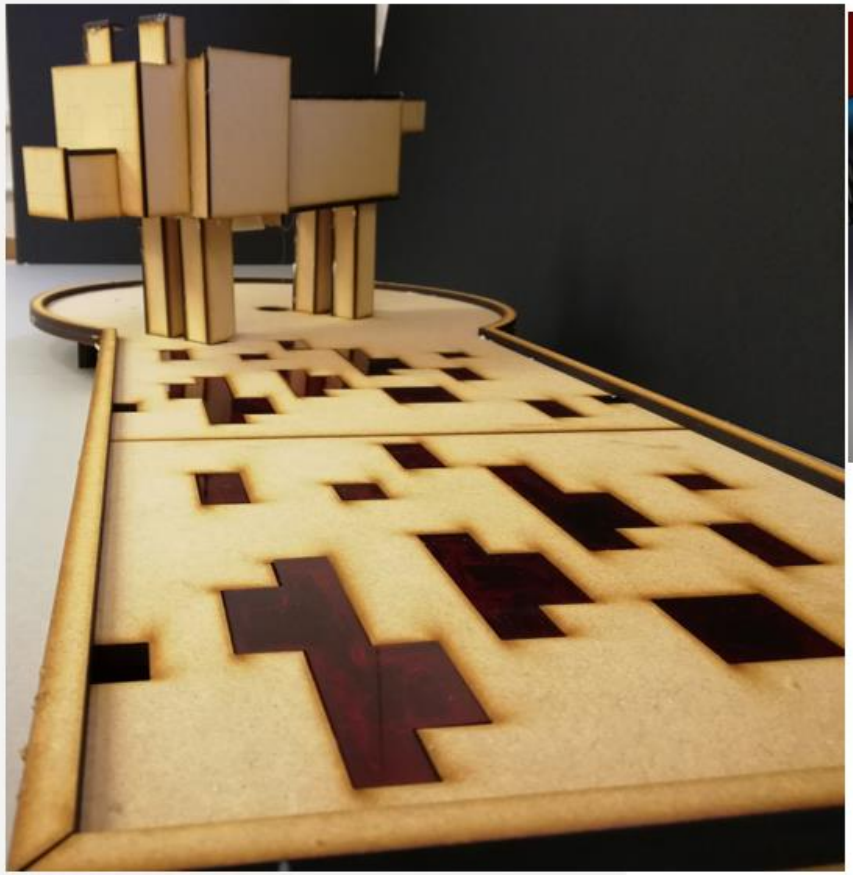
- The prototype consists of:
  - Two 6mm MDF (medium-density fibreboard) sheets
  - Transparent/translucent red 3mm plexiglass
    - In order to manufacture the obstacle base, and:
  - Two 3mm MDF sheets
    - In order to manufacture the prototype dog.

- The use of 6mm thick MDF for the obstacle base ensures that it is strong enough and sturdy enough.
- The red plexiglass is used to give the red LEDs under an even more red-tinted light, as well as making the beginning of the obstacle base surface look like the in-game ore, redstone.

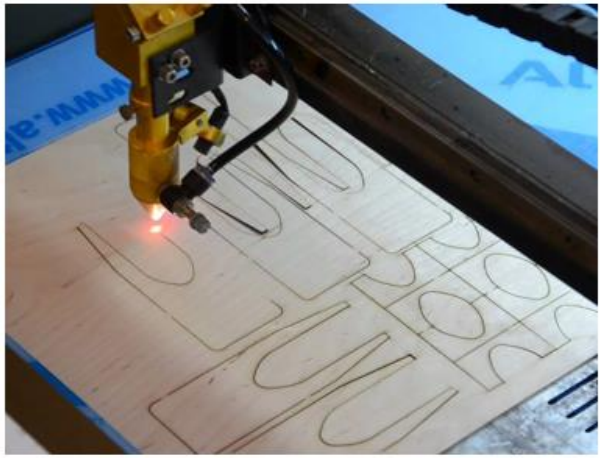
As for the dog, 6mm MDF was not required since it did not have to be very strong. Because of this, I used 3mm MDF instead.

Manufacturing Technique: CAM

- The only computer aided manufacturing technique used was laser cutting. This is because the obstacle base and the dog did not have complex angles and shapes which required 3D laser cutting, which is slower and more expensive.



As can be seen in the above picture, the dog consists mainly of squares and rectangles, since they are designed as such in the game, and the base of the obstacle does not have curves and edges on both the x and y axis, making laser cutting possible, which is more practical.



Although 3D printing could have been used to design the prototype, it would be slower, more expensive, less aesthetic since the material would not be flat, and less sturdy/strong. It would have been necessary to create objects such as the vase in the picture on the left due to the uneven and curved edges, however this was not required.

Manufacturing Technique: Assembly

- As for assembly, the choice is essentially between two techniques: Using PVA glue and/or a glue gun. There are other techniques too, such as using liquid cement, however these are not necessary since our prototype does not use any acrylic materials.

	Pros	Cons
PVA	• Gives a very sleek and neat look as long as glue is wiped off early • Glues wood to wood relatively well	• Takes an extremely long time to dry • Does not hold the assembly parts firmly in place until the glue has set in after at least 10 minutes, making assembly for certain parts slower • Requires excess glue to be wiped off, but added pressure from tissue often dislodges and separates parts from each other because of how long glue takes to dry
Glue gun	• Quick to dry, efficient to use • Transparent • Works well with almost all materials	• Can leave excess glue which is difficult to remove and considered unaesthetic • Solidifies slightly too quickly, which can make gluing of several different surfaces at once difficult

- What I have drawn from my experience with both as well as having analysed their pros and cons is that PVA glue is extremely frustrating and cumbersome to use since it takes so long to dry and requires excess glue to be wiped off which restarts the entire drying process since the tissue or cloth used always moves the parts slightly, but it is necessary to create a professional and neat look for the prototype. Meanwhile, using the glue gun is easy, practical and efficient, since it solidifies almost instantly, however it is almost guaranteed to leave traces here and there. If someone is short on time though, they really ought to use the glue gun, since its traces are far less noticeable and protruding than those left by the traces of PVA glue.
- Although PVA glue should be used most of the time, it is perfectly fine to use the glue gun when dealing with internal parts, or parts which's positions are not held firmly in place (such as the red Plexiglas parts which make up the 'redstone ore'), since having those glued in place with PVA glue is a nightmare.

Code

- Once activated by the electrical input (it being the two infrared break beam sensors), the code causes two sets of LEDs to turn on and fade out, as well as causing the servo to sweep back and forth for several seconds.

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo
// twelve servo objects can be created on most boards

int pos = 8;
int infrared1 = 6; // variable to store the servo position
int infrared2 = 7;
int led1 = 5;            // the PWM pin the LED is attached to
int led2 = 11;            // the PWM pin the LED is attached to
void setup() {
  myservo.attach(8);  // attaches the servo on pin 9 to the servo object
 pinMode(pos,OUTPUT);
 pinMode(infrared1,INPUT);
 pinMode(infrared2,INPUT);
digitalWrite (infrared1,HIGH);
digitalWrite (infrared2,HIGH);
}
```

1. The first section of the code, links the infrared break beam sensors and LEDs to different Arduino pins, as well as defining them as inputs or outputs.

```
void loop()
{
  if (digitalRead(infrared1) == LOW){
  analogWrite(led1,255);
  delay (2500);
    analogWrite(led1,250);
  delay (50);
  analogWrite(led1,245);
  delay (50);
      analogWrite(led1,240);
  delay (50);
  analogWrite(led1,235);
  delay (50);
      analogWrite(led1,230);
  delay (50);
  analogWrite(led1,225);
  delay (50);
```

2. Next is the void loop, which is the execution of commands made possible by the 'void setup' and the assignment of the pins. The screenshot on the right is how long the entire code for the fading out of the first group of LEDs, and the screenshot on the left is the beginning of it. The reason for its length is in order to obtain a smooth fading out effect, otherwise the changes in brightness can be seen (like watching a video with a low framerate).

```
if (digitalRead(infrared2) == LOW) {

  analogWrite(led2,255);
  delay (2500);
    analogWrite(led2,250);
  delay (50);
  analogWrite(led2,245);
  delay (50);
      analogWrite(led2,240);
  delay (50);
  analogWrite(led2,235);
  delay (50);
      analogWrite(led2,230);
  delay (50);
  analogWrite(led2,225);
  delay (50);
      analogWrite(led2,220);
  delay (50);
  analogWrite(led2,215);
  delay (50);
      analogWrite(led2,210);
  delay (50);
```

3. Next, the same thing is done for when the ball goes past the second infrared break beam sensor. This causes the LEDs under the second 'redstone ore' square to turn on and fade out.

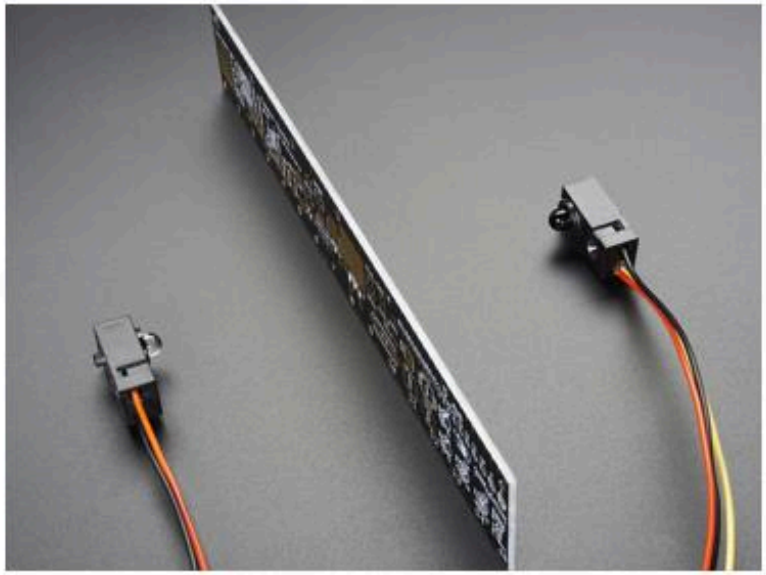
```
for (pos = 8; pos <= 85; pos += 3)
  // in steps of 1 degree
  myservo.write(pos);
  delay(15);
}
for (pos = 85; pos >= 8; pos -= 3)
  myservo.write(pos);
  delay(15);
}
for (pos = 8; pos <= 85; pos += 3)
  // in steps of 1 degree
  myservo.write(pos);
  delay(15);
}
for (pos = 85; pos >= 8; pos -= 3)
  myservo.write(pos);
  delay(15);
```

4. While #2 (for when the ball goes past the first infrared sensor) only causes the first set of LEDs to turn on and fade out, when the ball goes past the second infrared sensor, a servo motor is also activated. The code causes the servo to sweep back and forth for approximately 12 seconds. This section is very long because normally, the 'void loop' repeats the code over and over, which would only need two commands for the servo position, but since this isn't the only section of code, it wouldn't end up working.

Components

- The components required are:
  - Two infrared break beam sensor pairs
  - Eight red LEDs (4 for each redstone ore square)
  - One servo motor

- The infrared sensors are required to have the ball activate the programmed process without having its trajectory affected.
- The fact that they activate the programmed process once they reach a specific point is convenient, since it allows the LEDs to turn on as the ball is right over them. This gives the illusion that the ball's pressure caused the redstone ore to turn on, which creates a more immersive experience for the player.
- Eight LEDs are required, since there are four LEDs under each 'redstone ore' square. Although two could be used, this would not provide a strong enough light to replicate the mechanics of the in-game redstone ore, and combined with the fact that the minigolf obstacle would be outside in the sun, it would be barely visible.



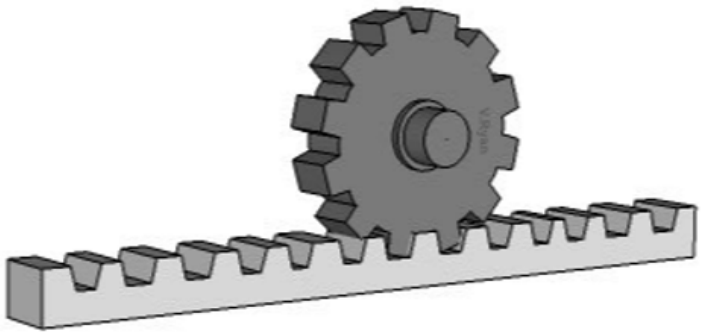
- The servo is required to carry out the mechanical output. I chose a servo over a stepper motor or a DC motor since:
  - A wide range of motion is not required
  - A specified range of motion was required, i.e. the movement had to be back and forth, and
  - The mechanical output required is far slower than what a DC motor offers.

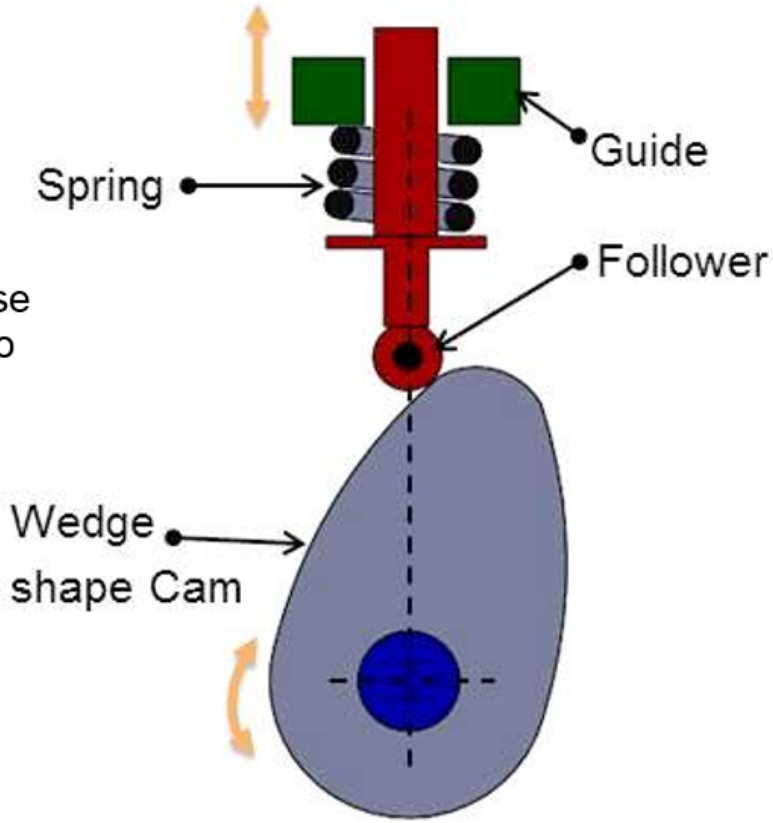
Mechanisms

- Due to the nature of the minigolf obstacle, a mechanism was not required. The mechanical output is the tail of the dog swaying back and forth, and servos are perfectly capable of carrying out this motion. Therefore, the tail is directly attached to the servo motor, and no extra mechanism is required to redirect the power of the servo motor. If different types of motion were required though, such as linear and reciprocating motion, then mechanisms transferring the rotary motion from the motor into those would be required.

Below: rack and pinion mechanism
Right: cam and follower mechanism

These may have been necessary if the required mechanical output could not be carried out by the servo, but since in this case it as the dog's tail swaying back and forth, no extra mechanisms are required.

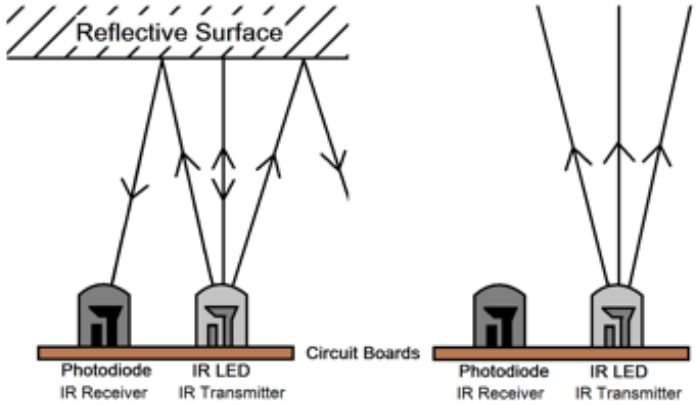




Further Details

- One issue encountered was how to effectively use two infrared sensors next to each other without setting each other off, and how to have the infrared sensor activate the programmed process once the ball is at an exact point instead of too early or too late, because this would destroy the illusion that the ball's presence is activating the 'redstone ore'.
- Although this could be dealt with while keeping the standard infrared components which have the transmitter and the receiver side by side by limiting to what extent the infrared cone of the standard infrared transmitters is allowed to diverge to the sides (preventing the neighbouring infrared receiver from being activated by it), using infrared break-beam sensors is a better solution, since it looks neater and more professional, as well as activating the programmed process when the ball is consistently at a certain point (when it breaks the infrared beam).

- In order to have the servo inside the dog while still being connected to the Arduino (which is under the obstacle base), two holes had to be made in the obstacle base. This allows for the wires to go from the servo, down through the dog's back legs and through the surface of the obstacle base
- I also considered having three 'redstone ore' squares, but I decided against it since it would create further complications with the code, as well as disrupting the standard obstacle base dimensions.



- There were also issues with the Arduino software and its limitations. The software only allows for one 'void loop', which means that two separate processes cannot occur simultaneously. This is a problem, because it means that when one task is being executed by the programmed process (for instance, when the ball goes past the first infrared break-beam sensor and the programmed process is causing the first set of LEDs to turn on and fade out), the second infrared break-beam sensor is no longer being 'listened to', since it can only be listed after the LED fade process. Because of this, if the ball goes past the second infrared sensor before the first group of LEDs have finished fading out, the second group of LEDs, as well as the servo motor, will not be activated. This would not be a problem if two 'void loops' could be set up, but unfortunately there is nothing that can be done apart from suing a different programming software, which is simply not an option.

Planning of production and sequence of operations

Risk assessment of product realisation, parts list, component specification, final code, circuit diagram, and detailed working drawings.

- This section elaborates on the development of the design idea, as well as preparing for it manufacturing.
- It covers:
  - The possible risks which should be taken into consideration
  - A detailed parts list so that the idea can be manufactured by a third party
  - The final polished code with annotation which can be used and customised by a third party
  - A circuit diagram so that the input components and output components can be set up
  - Detailed working diagrams, such as those of 2D Design (the computer aided design software used for by the laser cutter, it being the computer aided manufacturing of the product)
- The point of this is that anyone should be able to read it and create the prototype without needing to ask any questions or needing additional help.

Production Plan and its Risk Assessment

Manufacturing Step	Materials needed	Manufacturing process	Identify Process's that have some risk. Y/N	What are the risks to you?	What control measures are you going to put in place?	Are you happy now to complete the manufacturing step with these control measures in place Y/N?
Laser cutting obstacle base	Two 6mm MDF sheets	Laser cutting	Y (minimal)	High voltage laser	Only use laser cutters which's covers/screens turn off the laser when lifted to prevent the user from burning themselves with the laser	Y
Laser cutting dog	Two 3mm MDF sheets	Laser cutting	Y	High voltage laser	"	Y
Laser cutting 'redstone ore'	Plexiglass sheet	Laser cutting	Y	High voltage laser	"	Y
Assembling base	PVA glue	Gluing	N	N/A	N/A	N/A
Assembling base with plexiglass	Glue gun	Gluing	Y	Heat of glue gun	Use gloves if you really want to, just be careful	Y
Assembling dog	PVA glue, minimal amounts of glue gun	Gluing	N	N/A	N/A	N/A
Assembling servo motor with tail, all inside dog	Glue gun	Gluing	Y	Heat of glue gun	Use gloves if you really want to, just be careful	Y
Assemble dog with obstacle base	PVA glue/Glue gun	Gluing	N	N/A	N/A	N/A
Combine Arduino board with LEDs and servo motor	Arduino board LEDs (specified later) Servo motor	Manual assembly	N	N/A	N/A	N/A

- There really isn't any risk involved, since all laser cutters should have safety precautions such as turning off the laser when the cover is lifted, and the glue gun will barely burn your skin if you come into contact with it. If you really want to precautious you can wear protective gloves. One possibly risky situation is when/if you want to remove excess glue with a knife, since it has already solidified. For this, you might want to wear gloves, although this will reduce your dexterity with the knife to a certain extent. Just keep in mind that you must always **cut away from yourself**.

Annotated Final Code

- The following screenshots display the Arduino code used to allow for the realisation for the prototype. They are annotated with the use of // text.

```
int pos = 8;     //sets the expression 'pos' to the value 8
int infrared1 = 6; // sets the word 'infrared1' to pin 6, effectively binding the first infrared break-beam sensor to pin 6
int infrared2 = 7; // does the same for pin 7
int led1 = 5;      // does the same for the LEDs, in this case to pin 5. At this point, it being an input or an output is irrelevant.
int led2 = 11;     // does the same for the second group of LEDs, binding them to pin 11.
void setup() {
  myservo.attach(8);  // attaches the servo on pin 8 to the servo object
 pinMode(pos,OUTPUT); //this marks the motor position as the mechanical output
 pinMode(infrared1,INPUT); // this marks infrared1, or pin 6, as an input. arduino will now await an input signal from this pin
 pinMode(infrared2,INPUT); // this does the same for infrared2, it being pin 7.
digitalWrite (infrared1,HIGH); // in order to avoid confusion, these two commands mark the infrared sensor status as not activated, so that the
digitalWrite (infrared2,HIGH);        // mechanical output isn't unwantedly activated as soon as the void loop starts
}

void loop() //this starts a neverending loop which continously plays the commands written within its brackets until the Arduino is turned off.
{
  if (digitalRead(infrared1) == LOW){ // because this is in a 'void loop', this means: once the first infrared beam is broken...
  analogWrite(led1,255);              //change the LEDs assigned to pin 5 to brightness 255...
  delay (2500);                       // then wait 2.5 seconds, after which...
    analogWrite(led1,250);            //change the brightness of those LEDs down to 250...
  delay (50);
  analogWrite(led1,245);                //and as the LED's brightness is quickly lower by '5' every 0.05 seconds, a smooth fading effect is created.
  delay (50);                           //this continues until the LED reaches a brightness of 0.
      analogWrite(led1,240);
  delay (50);
  analogWrite(led1,235);
  delay (50);
      analogWrite(led1,230);
  delay (50);
  analogWrite(led1,225);
  delay (50);
      analogWrite(led1,220);
  delay (50);
  analogWrite(led1,215);
  delay (50);
```

---[skipped repetive segment of code]---

```
if (digitalRead(infrared2) == LOW) { //the same thing is done for the second infrared break beam sensor: once the beam is broken by the ball...

analogWrite(led2,255);  // the LEDs assigned to pin 11 turn on and fade out according to the 'delay' and the 'analogWrite' (set brightness) command lines
delay (2500);           // ... until the LEDs reach the brightness of 0
  analogWrite(led2,250);
delay (50);
analogWrite(led2,245);
delay (50);
    analogWrite(led2,240);
delay (50);
analogWrite(led2,235);
delay (50);
```

Annotated Final Code

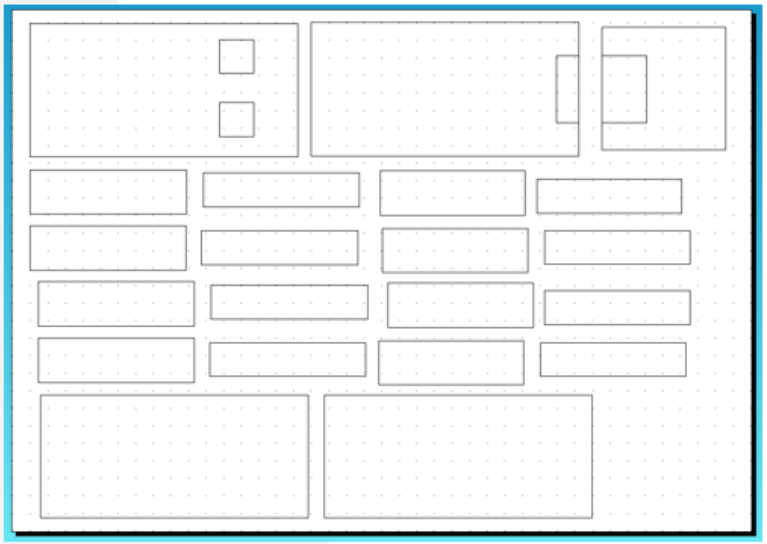
```
analogWrite(led2,15);
delay (50);
    analogWrite(led2,10);
delay (50);
analogWrite(led2,5);
delay (50);
analogWrite(led2,0);
for (pos = 8; pos <= 85; pos += 3) { // as soon as the second group of LEDs finished fading out, the servo motor assigned to pin 8 starts swaying back
                                     // and forth for approximately 12 seconds according the the following repeated lines of code:
  myservo.write(pos);
  delay(15);
}
for (pos = 85; pos >= 8; pos -= 3) {
  myservo.write(pos);
  delay(15);
}
for (pos = 8; pos <= 85; pos += 3) { //change the expression 'pos' from 8° to 85° in steps of 3 degrees
  myservo.write(pos);                // have the servo's angle follow this 'pos' value, causing the dog's tail to sway one way
  delay(15);                        //wait 15 milliseconds for this to finish
}
for (pos = 85; pos >= 8; pos -= 3) { // change the expression 'pos' from 85° to 8° in steps of 3 degrees
  myservo.write(pos);               // have the servo's angle follow the 'pos' value, causing the dog's tail to sway the other way
  delay(15);                           // wait 15 milliseconds for this to occur
}
for (pos = 8; pos <= 85; pos += 3) {

  myservo.write(pos);
  delay(15);
}
for (pos = 85; pos >= 8; pos -= 3) {
  myservo.write(pos);
  delay(15);
}
  for (pos = 8; pos <= 85; pos += 3) {
  // in steps of 1 degree
  myservo.write(pos);
  delay(15);
}
```

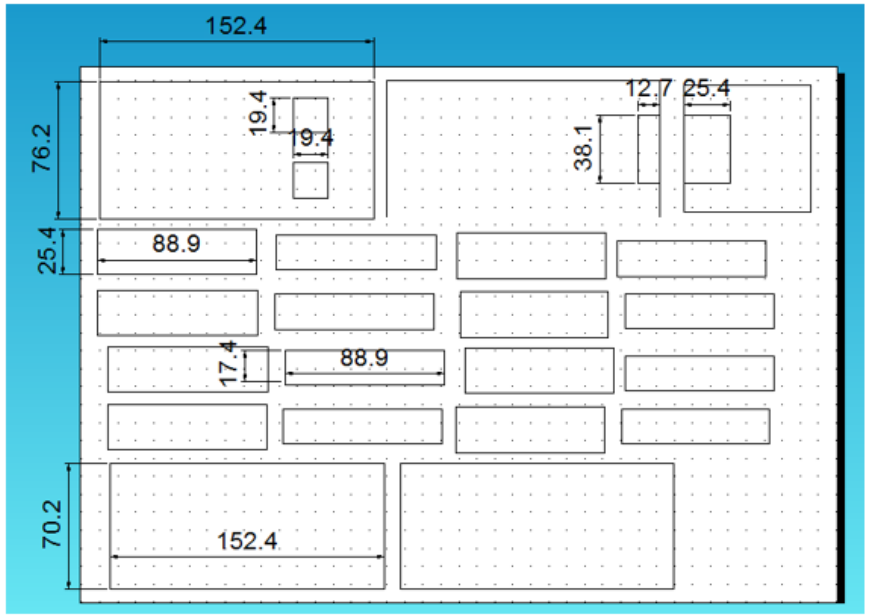
- The time that the servo sweeps back and forth can be changed by copy pasting or deleting the pair of code blocks accordingly
- The speed that the servo sweeps back and forth can also be adjusted by increasing or decreasing how many degrees each step is to make it faster or slower.

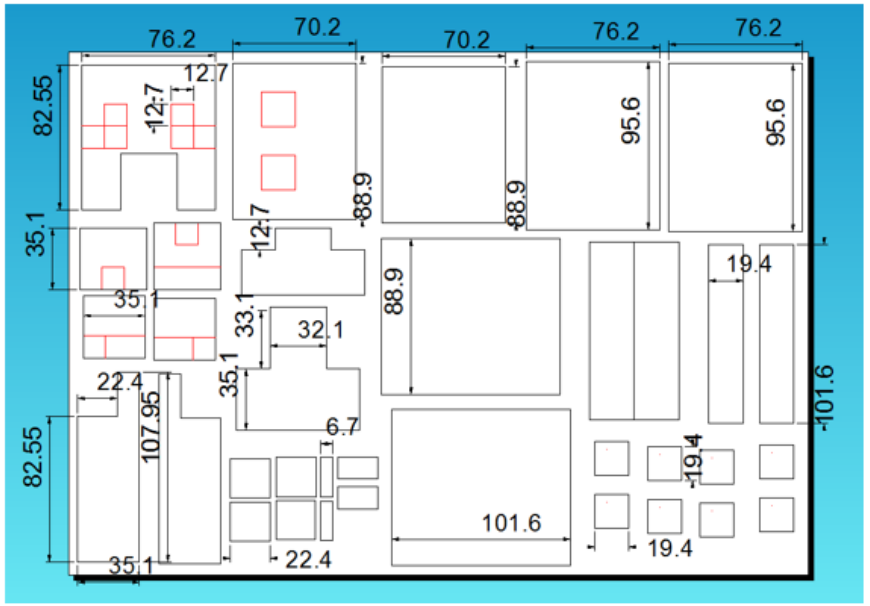
- Once the servo has stopped sweeping back and forth, the infrared sensors are once again ready to send an input signal, although this shouldn't even be necessary since the ball should've reached the ending area with the dog.

Detailed Working Drawings

- The following two designs, with and without measurements, are both laser cut out of 3mm thick MDF sheets. Once assembled, they make the dog, which's tail wags.

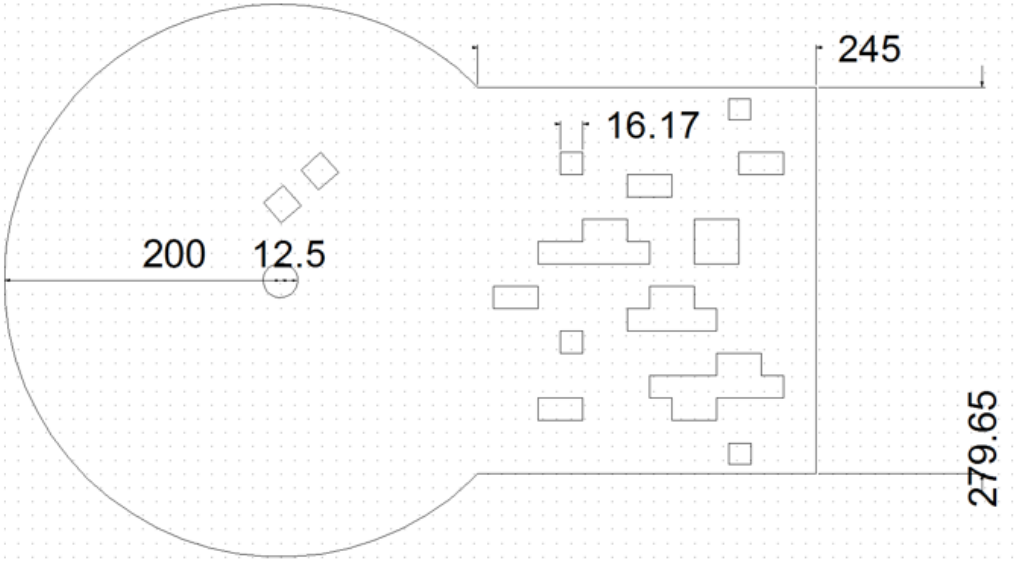


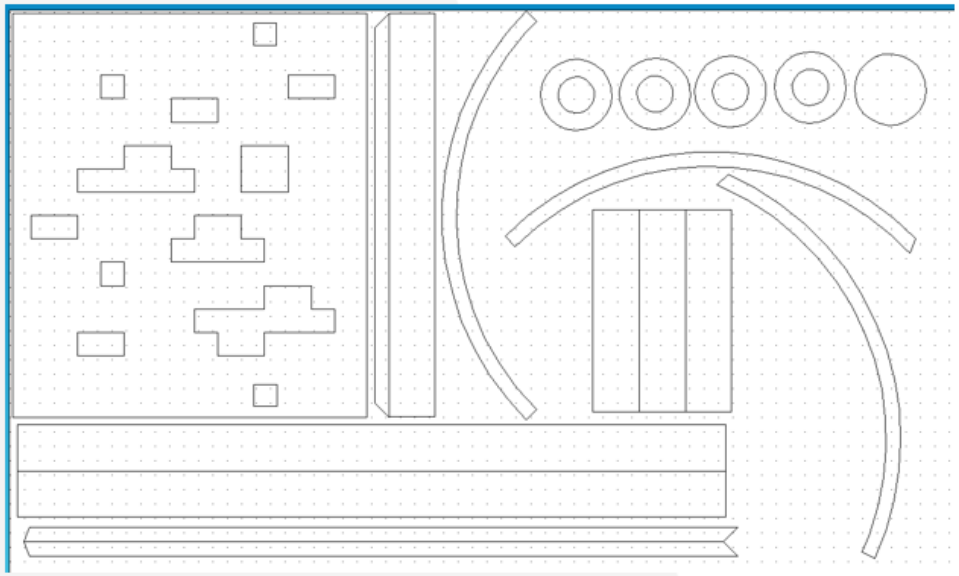


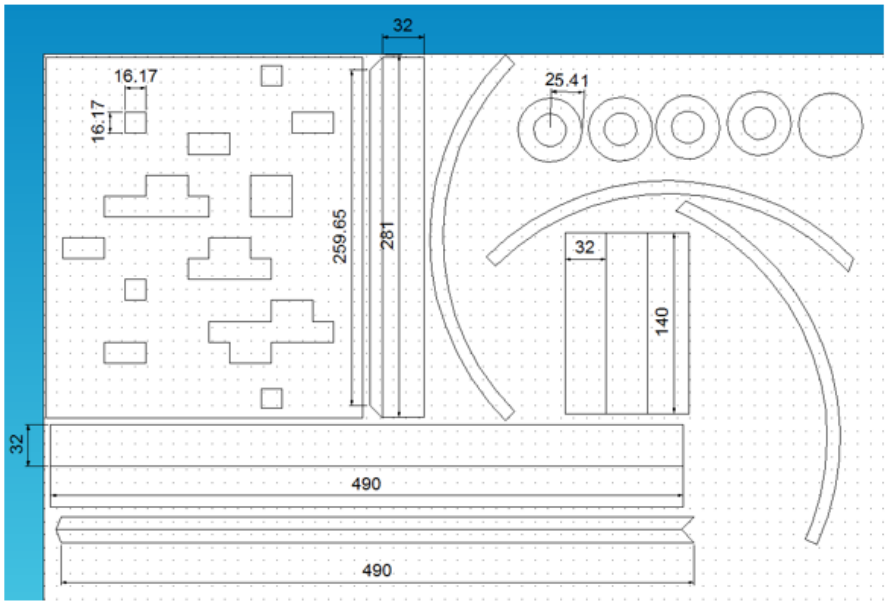


Detailed Working Drawings

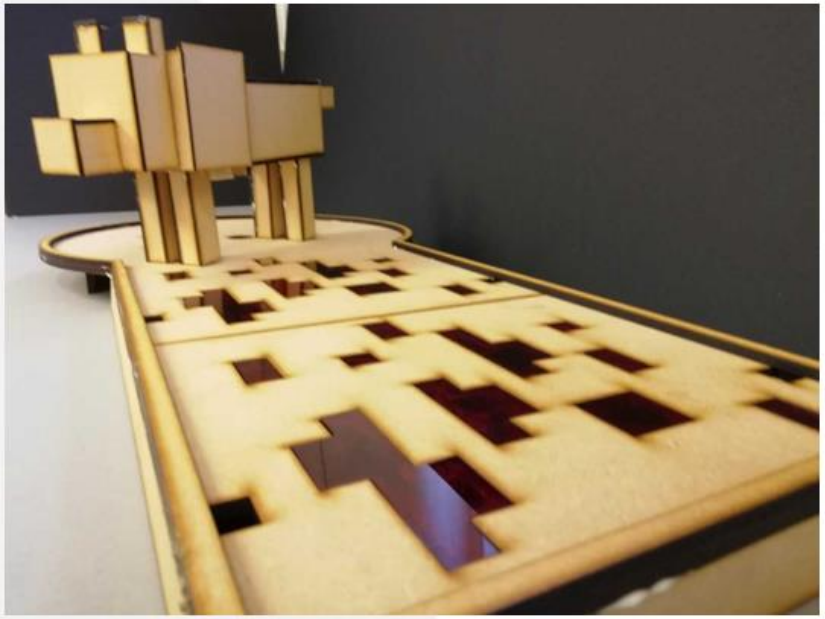
- These two designs, although also being laser cut, are cut out of 6mm thick MDF sheets instead. Once assembled, they make the obstacle base. The reason the obstacle base is split over two designs is due to limitation of the laser cutter's sheet capacity as well as the rarity of sheets large enough to fit the entire obstacle base, however if you have both at your disposal, feel free to combine them together, as that will make it, and as such the entire prototype, stronger and more sturdy.

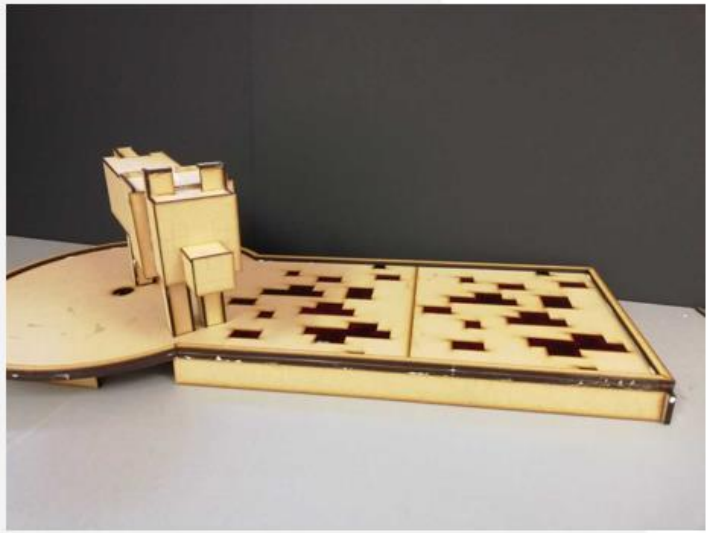


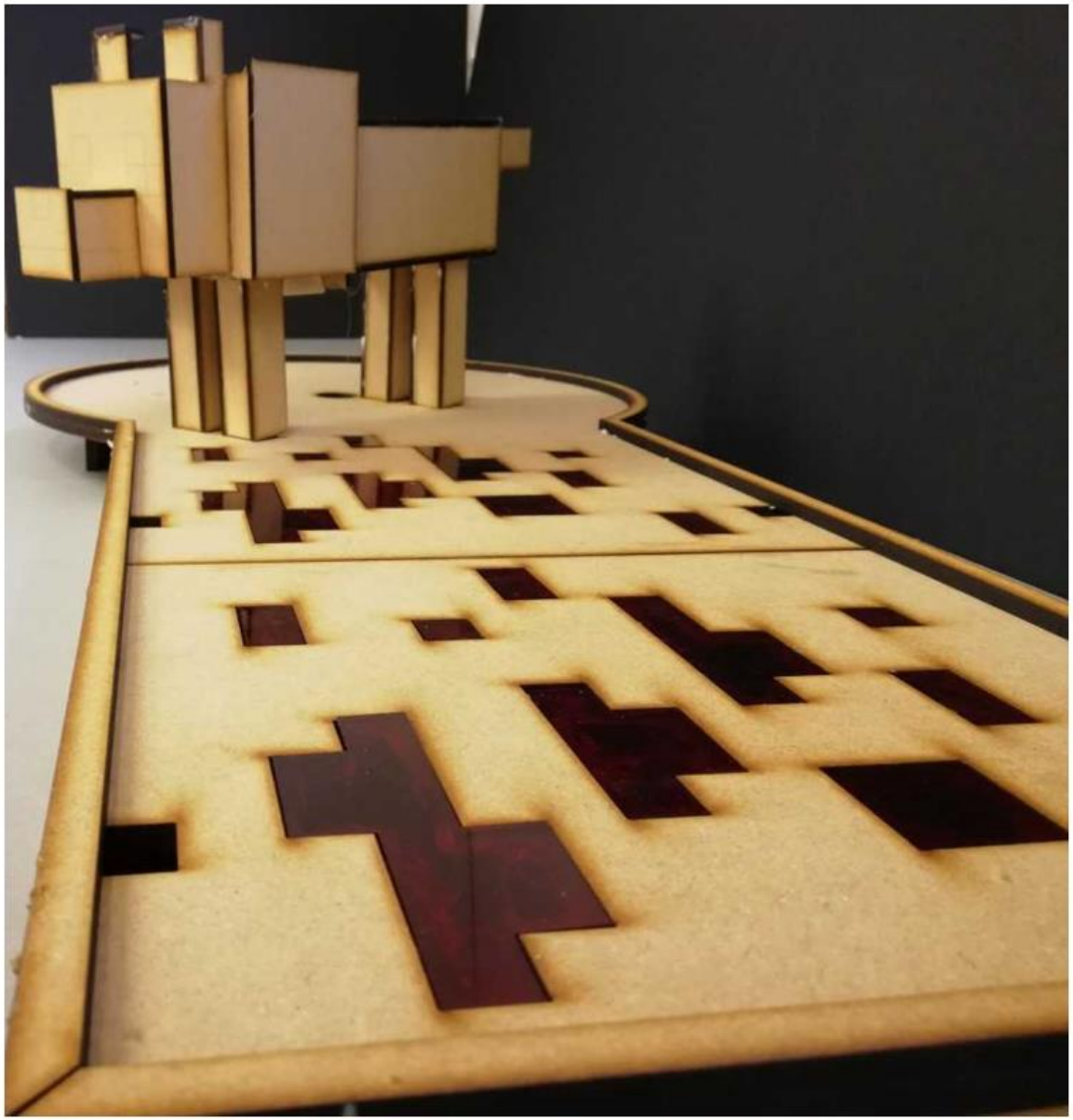




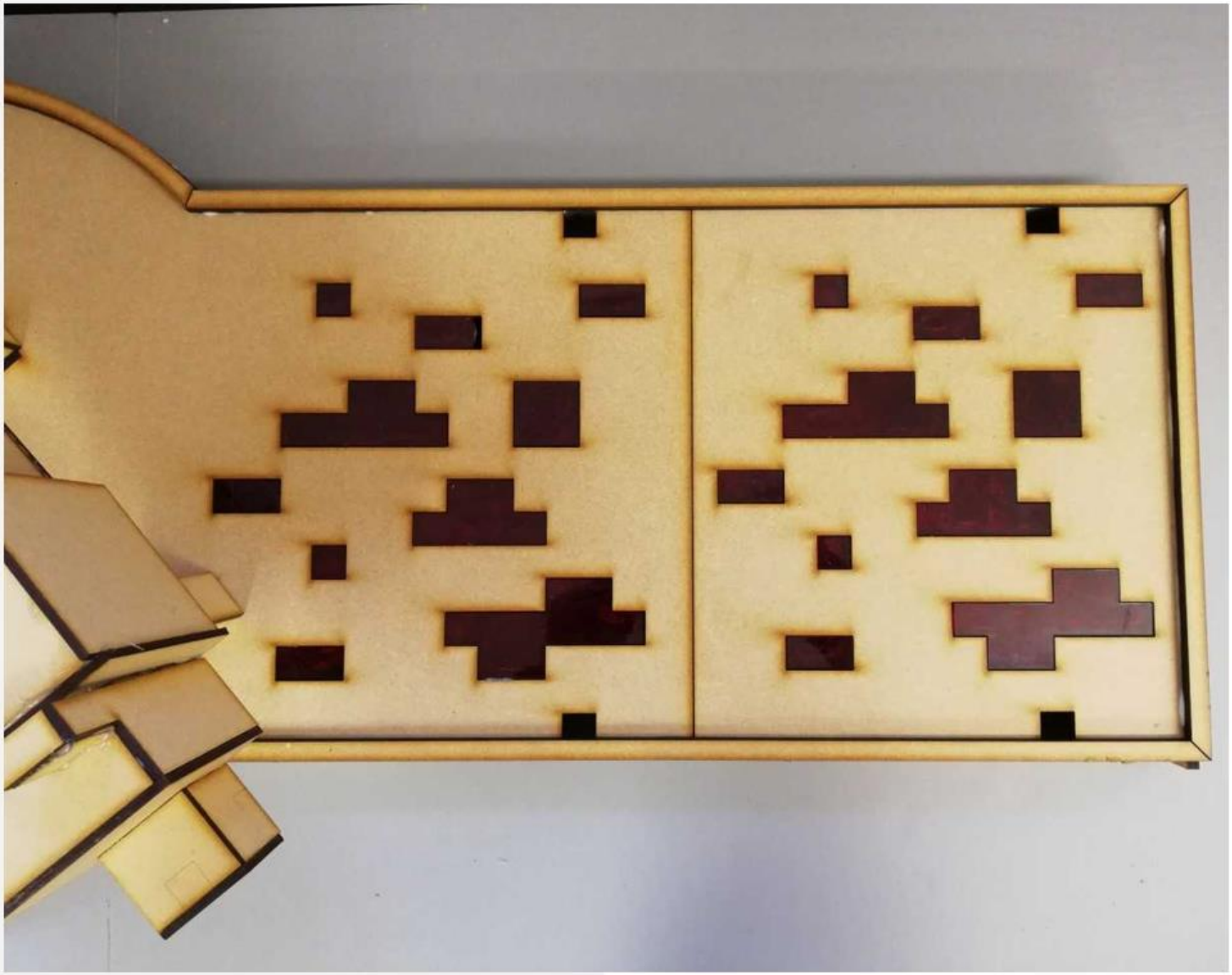
Product Realisation







Product Realisation



External Evaluation

- **Adam Kelly (1st place in several minigolf tournaments):**

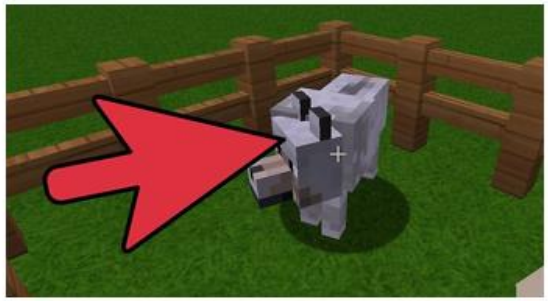
"I like where you're going with this prototype. The combination of the texture of redstone ore with red LEDs underneath which slowly fade out over time once the ball goes past the infrared sensors creates a more interesting and immersive experience for the player, and the dog which's tail wags once the ball gets close to it gives the mini golf obstacle a more Minecraft-esque feel. Some things I can suggest are that you make the obstacle slightly more challenging, and that, if possible, the dog's head moves subtly by means of a second servo and possibly a mechanism. This will help to further replicate way the dog behaves in the game, improving how exciting and fun the obstacle is for the user. Lastly, I also noticed that the second set of LEDs is cannot be activated by the second infrared sensor while the programmed process of the first infrared sensor is being carried out, and vice-versa. As such, an additional modification would be to use a different coding software entirely in order to have the two run side by side"

Possible modifications

- From information gathered by evaluation and the review submitted by Ryan Cherian, these possible modifications have come into consideration:

- A different programming software, or two Arduino boards, could be used in order to allow both infrared sensors to function simultaneously in order to create a more fluid and engaging experience with the player.
- An extra mechanical output be added to enhance the accuracy of the behaviour dog to the one in the game. This could be the dog's head tilting to the side, the dog's head moving subtly up and down/left and right, and maybe even have it open its mouth and pant occasionally, by having a motor accurately replicate the breathing of the in-game dog.




- Lastly, the obstacle could be made more challenging to allow the player to feel a greater sense of pride and accomplishment when he overcomes the obstacle. This could be done by adding an uneven surface, like hills of different biomes. Trees could also be added if is it still too easy.


End of Portfolio