Oliver Wilkes

Nottingham College

Computer Science

Programming Project

# Crazy Golf

2023/24

# Contents

# Analysis

## Problem Identification

In exam time, students can get stressed from revising for exams. Many students use video games as a way to escape from revision from time to time, but many games require too much of a time investment to be able to play for short periods of time. Multiplayer games can help during exam time as it can be a time to socialise during breaks while revising. Many recent games also require powerful computers to run the graphics requirements they meet, so I propose a game which has simpler graphics, shorter round times, and is multiplayer.

### Clients

My users are a group of 16-19 year old students which sometimes play video games. Many of them prefer smaller games where you do not have to worry if you have time to finish the game/round. Many of them also have low powered laptops, so a game that is easier on the graphics is more enjoyable due to less lag.

### Computational Methods

#### Problem Recognition

The first part of the problem is taking user input and translating it into in-game movement. This movement needs to be calculated on the course, and the ball has to interact with any obstacles in the way. Once this is done as single player, multiplayer would need to be implemented. This involves connecting other players to the game, and synchronising the game state between all players, while using minimal bandwidth. Players can also interact with each other via items, which involves player to player interactions.

#### Problem Decomposition

The different components the game involves are:

1. Connecting to the network to play multiplayer
2. Take user input and and serialise it to send to the server
3. Process multiple players' movements on the server
4. Synchronise state to the client, which shows the ball(s) moving

### Divide and Conquer

These steps can be solved on their own for the most part, as each component can be designed separately, and implemented modularly.

### Abstraction

Many different abstractions can be done between these components. When movements are sent to the server, the server is not concerned with what buttons the user pressed, but what direction the ball will move in. This abstraction allows the server to process movement without having to worry about the input method.

Similarly, the client should not have to process collisions with obstacles, but just show the ball moving via instructions from the server. This abstraction allows all players to have synchronised states easily, reduces processing on the client, and makes cheating harder.

# Interview

## First Interview

### Questions

The clients I have chosen to interview have played arcade-style games before. The aim of my first interview is to gather a general idea of mechanics and play styles that my clients enjoy. I will ask them questions about similar games they have played, and what they liked and disliked about them.

1. Have you played a multiplayer arcade-style game before?
2. If so, how many different games in this genre have you played?
3. What were your favourite parts of these games?
4. What were your least favourite parts of these games?
5. What would you like to see in a game like this?

### Responses

### Milan

**1. Have you played a multiplayer arcade-style game before?**

Yes, I have.

**2. If so, how many different games in this genre have you played?**

Probably something around 20. The new Discord activities, Golf With Your Friends, Ultimate Chicken Horse, etc.

**3. What were your favourite parts of these games?**
I particularly enjoy how these games facilitate a competitive environment while not being particularly frustrating to lose. Compared to real competitive games, it's easy to jump into a game like this with a group of friends and just have a good time trying to win, even if you end up doing poorly.

**4. What were your least favourite parts of these games?**
Generally, there's a very simple premise behind this type of game. After a couple hours of play it can feel like I've seen everything the game has to offer, which leads to me growing tired of such a game particularly quickly.

**5. What would you like to see in a game like this?**
5. This mostly relates to my answer to (4.), where I think some extra thought into replayability can go a long way. Something like impactful power-ups can drastically change the flow of a game, which can go a long way towards keeping it interesting.

**Extra Comments**
Another pretty cool example of this is Ultimate Chicken Horse, where the whole premise of the game is to have the players "create" the levels on the fly in a match. Each player gets to pick one of a few random items at the beginning of each round which they then place. Levels generally start off impossible to clear so players need to cooperate to make it winnable, and from there they start placing stuff to make it hard to clear. The goal of the game is to clear the stage while making others unable to clear it.

**Alex**

**1. Have you played a multiplayer arcade-style game before?**
Yes

**2. If so, how many different games in this genre have you played?**
At least 10

**3. What were your favourite parts of these games?**
Playing against/with friends –> competition / teamwork

**4. What were your least favourite parts of these games?**
When someone is a lot better than the rest of the group (skill gap)

**5. What would you like to see in a game like this?**
Skill levelling (chess.com has this when playing with friends, making it harder for one of the players)

**Gwen**

**1. Have you played a multiplayer arcade-style game before?**
Yes

**2. If so, how many different games in this genre have you played?**
About 5

**3. What were your favourite parts of these games?**
I like it when the rules are pretty simple but the game can be played in different ways based on the player

**4. What were your least favourite parts of these games?**
I don't like it when seemingly benign aspects of a game (i.e. character selection or locations on a map) give a player an unfair advantage over their competitors

**5. What would you like to see in a game like this?**
More collaboration between teammates

**Extra Comments**
I like Pico Park where several players (2+) have to learn and use the physics system of the game to their advantage, reach certain checkpoints, and use teamwork in order to complete a level. I want more of that in arcade-style games.

**Enoki**

**1. Have you played a multiplayer arcade-style game before?**
Yes

**2. If so, how many different games in this genre have you played?**
10-15

**3. What were your favourite parts of these games?**
The multiplayer aspect of it with different player interacting with each other in meaningful ways

**4. What were your least favourite parts of these games?**
The meta progression that some games have that give players unfair advantages over others

**5. What would you like to see in a game like this?**
Players being able to hijack other players' controls

**Analysis**
From those questions, I have gathered a general idea of what my clients would like to see in a game like this. They would like to see a game that is simple to understand, but has a lot of replayability. They would also like to see a game that has a competitive aspect, but is not frustrating to lose. They would also like to see a game that has a multiplayer aspect, but is not unfair to players that are new to the game. Every game should act almost ephemeral in a way, where the previous game does not affect the next game. This keeps it to the arcade style as standard arcade games do not have progression between games.

A co-operative aspect is something that Milan, Alex and Gwen mentioned in their responses. This could be something implemented as an extra game-mode in the game, but it would not be the main focus of the game. It would be something that could be played if the players wanted to, but it would not be forced upon them.

## Second Interview
In this second interview, I asked my clients more specific questions about the mechanics of the game. I asked about the controls, the camera, the items and the co-op aspect of the game. This allows me to curate success criteria for my game, and a set of requirements that I can use to make my game.

**Questions**
1. How would you like to control your ball and camera?
2. Should there be items/power-ups, and if so, what should they do?
3. How should the co-op part of the game work?
4. What kind of music would you like in the background?
5. How should you be able to join a multiplayer game (invite code, add via in-game friend, etc.)?

**Responses**

**Milan**

**1. How would you like to control your ball and camera?**

I think the most intuitive camera setup would be

- The camera is centred onto the ball.
- You can zoom in and out using the scroll wheel,
- You can click and drag with middle mouse/right click to rotate the camera around the ball,
- You can click and drag with left click to shoot the ball at different levels of power.

(Essentially the same as Golf With Your Friends/Putt Party) It could be interesting to experiment with some control fine-tuning like gear effect (think Wii Sports where you can shoot the ball along different trajectories by introducing effect), though that probably only makes any real amount of sense in sufficiently large courses. Lastly, it may be nice to have a way to detach the camera from the ball to scout ahead and discover the course.

**2. Should there be items/power-ups, and if so, what should they do?**

Given the focus of a "multiplayer arcade-style" game, I do believe there should be power-ups. I feel like the main focus for these power-ups should be affecting every player in the game. Essentially, anything that isn't downright frustrating but is still sufficient to put a wrench in the works for the "victims" should be good. An example of this could be a wind effect that can influence every player's next shot(s).

**3. How should the co-op part of the game work?**

As far as co-op is concerned, I feel like it's important that players get to play on the same hole simultaneously, especially so when taking power-ups into account. You could then make a decision between whether you want there to be distinct turns (i.e. each player gets to do one swing, then waits for all other players to have finished their swing, until the hole is cleared). Introducing turns in this fashion could make power-ups more impactful as you could have them stay active for a number of turns, making players unable to just wait it out.

**4. What kind of music would you like in the background?**

You could lean into the arcade side of things and make peppy music you would hear in actual arcade games. Something chiptune-like could also work depending on the graphical style of the game. Overall, as long as the music matches the creative direction of the game, I think a lot of different styles could work. An interesting example here is Golf With Your Friends. This game

heavily leans into creative map design with an exploration element, and this is reflected well in the music. The bgm for that game could actually fit pretty well into an RPG-style game.

**5. How should you be able to join a multiplayer game (invite code, add via in-game friend, etc.)?**
I think at a base level, using invite codes is fine, as long as groups aren't disbanded after each game. Entering an invite code once for a session of play with friends is more than acceptable. If the game were to be launched on a platform such as Steam, integrating with the platform's built-in friends system would be a nice addition. For a standalone game, however, I don't think a friends system is really a hard requirement.

**Alex**

**1. How would you like to control your ball and camera?**
I would like to control the ball with the mouse, and the camera with the keyboard.

**2. Should there be items/power-ups, and if so, what should they do?**
Yes, not sure.

**3. How should the co-op part of the game work?**
A few ideas:
1. One person can edit the course, other one shoots the ball.
2. One player moves the camera, one controls the ball
3. One player has a camera locked onto the ball but can't see where it's going to hit, other player only has a top down view but can see where the ball hits

**4. What kind of music would you like in the background?**
Tetr.io battle music

**5. How should you be able to join a multiplayer game (invite code, add via in-game friend, etc.)?**
Invite code / link and friends seem reasonable (so you can play with "strangers" and friends)

**Gwen**

**1. How would you like to control your ball and camera?**
The camera should loosely follow the ball, if 3d the ball should have a 'forward' direction that the camera should follow behind

**2. Should there be items/power-ups, and if so, what should they do?**
Items/power ups should be available but not necessary to complete a level, they should essentially give the player ability modify the game difficultly

**3. How should the co-op part of the game work?**
There should be sections of the game that require multiple players to be in different places to achieve a goal

**4. What kind of music would you like in the background?**
There should be a quiet ambient music at all/most times and louder music based on events that happen in-game

**5. How should you be able to join a multiplayer game (invite code, add via in-game friend, etc.)?**
Players should be able to send invitations from in a game to other players they want to play with, for the receiver to accept or deny

**Enoki**

**1. How would you like to control your ball and camera?**
Similar to putt party

**2. Should there be items/power-ups, and if so, what should they do?**
Yes, ideally more focused on affecting others rather than yourself, more extreme stuff is always more fun

**3. How should the co-op part of the game work?**
Potentially either have them take turns controlling the ball or have one ball that's not controlled by anyone but everyone has to hit it (like in pool) until it gets in the hole

**4. What kind of music would you like in the background?**
Anything works

**5. How should you be able to join a multiplayer game (invite code, add via in-game friend, etc.)?**
In game friend is more steps, a code / url is easier, more transient and more accessible

### Analysis

From these questions, I now have a more specific set of requirements for my game. I will use these requirements to create a set of success criteria below.

Question 1 has shown that putt party provides an ideal control scheme, but a possible keyboard control as suggested by Alex could be more accessible too.

Question 2's results explain how items provide a different experience for every run of the game, and Enoki suggested that power ups that affect others more than yourself are more fun.

Question 3 is still a bit undecided, but Milan suggested that players should be able to play on the same hole simultaneously, and Gwen suggested that there should be sections of the game that require multiple players to be in different places to achieve a goal.

Question 4's results can be combined into one idea. Arcade-like ambient music, with more intense music for events such as when time is running out.

Question 5 demonstrates a simple URL/code is good enough to join a multiplayer game, and Enoki suggested that an in-game friend system is not necessary but a nice to have.

## Existing Solutions

### Putt Party

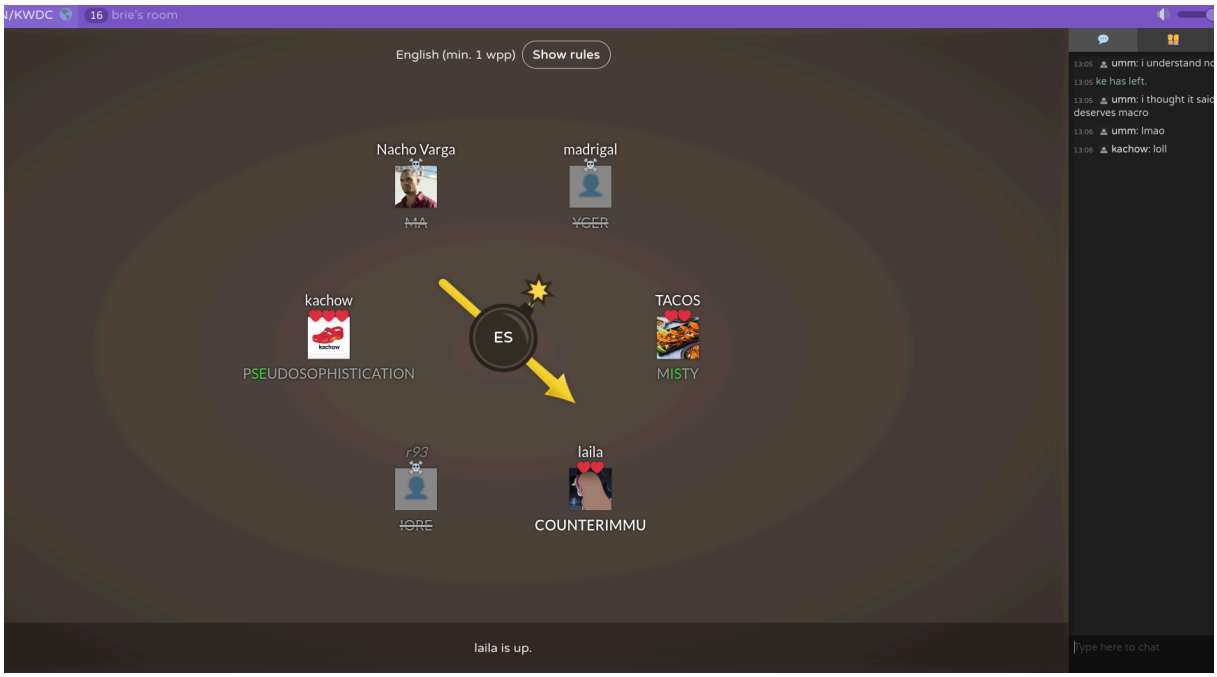

Putt party is a Discord “activity” built in to voice channels. This is an example of what my game will be like, as it is arcade-style and multiplayer. It can be played many times with different results as there are items in the many courses, and it is not frustrating to lose at. It implements multiplayer very well as you just join the same voice channel as your friends. It is simple to understand as the controls are just drag and point with the mouse, and it is not too graphically intensive. It is also not too long, as each hole has a time limit.

One of the downsides though is that you all have to have Discord to be able to play together. The window is quite small as it is a small section of the voice channel overview, so is difficult to see sometimes, especially on smaller screens like laptops.

### Parts of Putt Party I Can Apply

Multiple of my interviewees have mentioned the controls of putt party, or similar controls. I will take inspiration from this as a way to control the ball.

### Bomb Party

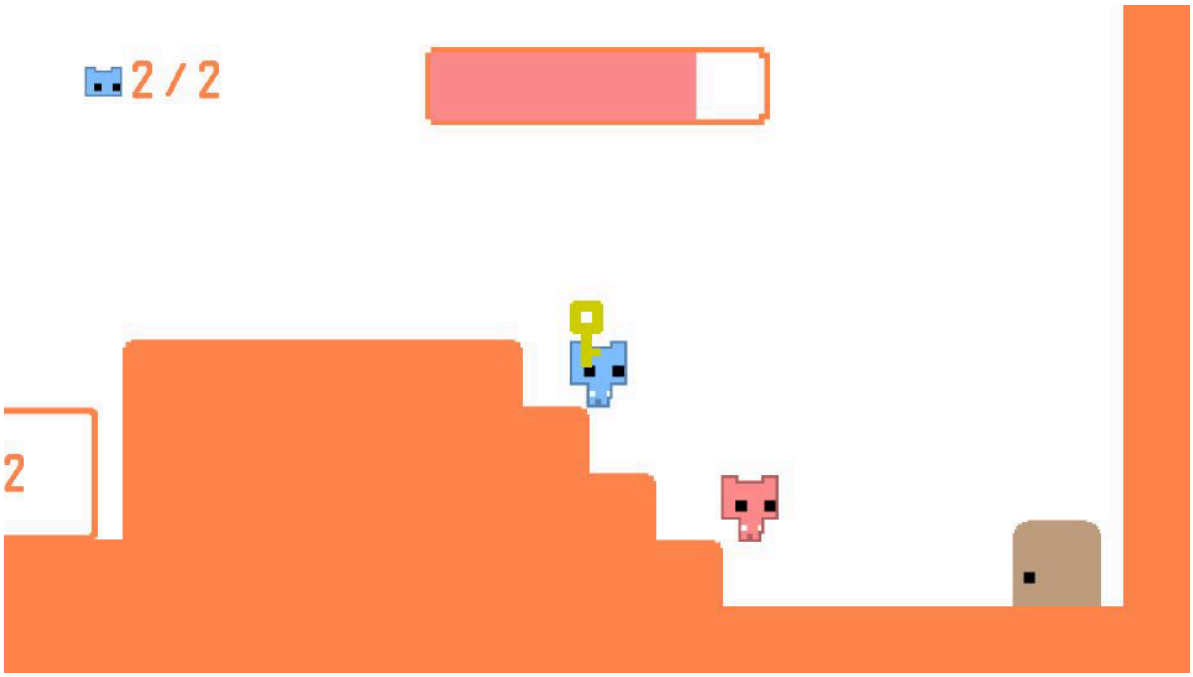



Bomb Party is a small party game where you have to type words based on a prompt. It is fast-paced, multiplayer, and has a competitive aspect. It is simple to understand as the controls are just typing, and it is not too graphically intensive. It is also usually not too long as you can configure turn limits and difficulty. The multiplayer aspect is implemented with a 4 letter code that can be entered or used via a link (`domain.tld/CODE`).

### Parts of Bomb Party I Can Apply

The multiplayer aspect of Bomb Party is something I can apply to my game. It is simple to understand and easy to use, so I will use a similar system in my game. This system was supported by Enoki, Alex and Milan in their responses.

### Pico Park




Pico Park is a co-operative multiplayer game where you have to work together to complete levels. It also has simple graphics and has short levels, which can get quite difficult as it requires co-ordination of multiple people. It is simple to understand as the controls are just arrow keys and space.

### Parts of Pico Park I Can Apply

I will consider the ways they make players work together and see how they can fit in a golf-style game. Gwen suggested to look at this game as it has a co-operative aspect.

### Golf With Your Friends


Golf With Your Friends is a 3D multiplayer golf game. It has a bit more complex graphics compared to the other games, but still simple to understand. It has a lot of different courses, and a lot of different game modes. It has a lot of replayability as there are many different ways to play the game. It is also not too long as each hole has a time limit. It has both online and local multiplayer support. There are no items but it has the concept of choosing where to hit your ball, and the power of the shot which makes the controls more complex.

### Parts of Golf With Your Friends I Can Apply

As this is a 3D game, I can take into consideration how the camera follows the ball on this, which was mentioned by Milan and Gwen in their responses. I can also look at how local multiplayer works too to consider adding.

## Features of the Proposed Solution

My solution will be a game with a main menu to select whether to host a room, join a room or change settings. When entering a round, there will be a heads-up display with information about the game such as the time left, scoreboard, and the current hole. The controls will be drag and point, the camera will follow the ball but still be possible to rotate with the mouse or keyboard, and the power of the shot will be controlled by how far you drag the mouse. There will be items that affect other players, and there will be a co-operative aspect to the game as a separate game mode. There will be a simple URL/code to join a multiplayer game, and there will be arcade-style ambient music.

## Limitations of the Proposed Solution

My game would require a Wi-Fi connection. It could use a LAN for local play, but not bluetooth. This is a limitation as school/college Wi-Fi can be unreliable or not accessible at times, and some students may not have access to Wi-Fi at home.

Some visual impairments may be a limitation too. As the game will be 3D, it may be difficult to interpret with a visual impairment. I will try to make the game as accessible as possible with changes such as a high contrast interface, but it may not be possible to make it accessible for all visual impairments.

The game will be controlled with a keyboard and mouse. This is a limitation as some students may not have access to a mouse, or may not be able to use a mouse due to a physical impairment. This would not be something I can solve completely initially, but a low amount of keyboard inputs would mean they can be remapped to a controller or an accessible input device.

The game could also act as a distraction from revision or school work. This is a limitation as it is not the intended purpose of the game. This could be solved by having a setting to lock the game at certain times of the day, but this could be bypassed by changing the system time.

# Requirements

## Stakeholder Requirements

### Design

| Requirement | Explanation |
|---|---|
| Main menu | The game should have a main menu so the player can choose what to do. |
| Full screen and windowed | The option of full screen is useful for smaller screens like laptops, but windowed is useful for large screens like desktops. |
| Simple to understand | The game should be simple to understand so it is easy to pick up and play. |

| | |
|---|---|
| Simple graphics | The game should have simple graphics so it is not too graphically intensive. |
| Simple controls | The game should have minimal controls so it can be learned straight away. |
| Following camera | The camera should follow the ball so the player can see where they are going. |

**Functionality**

| **Requirement** | **Explanation** |
|---|---|
| High Contrast Colour Palette | The game should have a high contrast colour palette so it is accessible to people with visual impairments, whilst also looking playful too. |
| Drag and point controls | The controls should be drag and point so it is simple to understand. |
| Power of shot controlled by drag | The power of the shot should be controlled by how far the player drags the mouse. |
| Items that affect other players | There should be items that affect other players so the game is more interesting. |
| Co-operative aspect | There should be a co-operative aspect to the game so players can work together if they wish. |
| Simple URL/code to join a multiplayer game | There should be a simple URL/code to join a multiplayer game so it is easy to join. |
| Arcade-style ambient music | There should be arcade-style ambient music so it is not too distracting. |

**Hardware and Software**

| **Requirement** | **Explanation** |
|---|---|
| Keyboard and mouse | The game should be playable with a keyboard and mouse. |

| | |
|---|---|
| Minimum … | The game should be playable on a minimum of … (pc specs, todo, no realistic target right now). |
| Windows >=10, macOS >=13.1, Linux x86_64 | These are the operating system versions that the game should be at minimum playable on. |

## Measurable Success Criteria for the Proposed Solution

| **Criteria** | **How to get evidence** |
|---|---|
| Clear main menu | Screenshot of the main menu and user feedback. |
| Full-screen and windowed options | Screenshot of the application being full-screen and windowed + code to switch between modes. |
| Simple to understand controls | Screenshot of the controls menu and user feedback of the controls. |
| In-game camera follows the ball | Screenshot which shows the ball is visible at all times + code to support. |
| High contrast colour palette | Screenshot of the game interface with user feedback. |
| Drag and point controls | Screenshot of the ball being controlled + code to support. |
| Power of shot controlled via dragging the ball | Screenshot of the ball being controlled + code to support. |
| Items that affect other players | Screenshot of the items in effect during gameplay + code to support. |
| Multiplayer functionality | Screenshot of game with multiple players + code to support. |
| Co-operative aspect | Screenshot and explanation of the co-operative aspect. |
| Simple URL/code to join a multiplayer game | Screenshot of the URL/code being used + code of code being handled. |
| Arcade-style ambient music | The code for the music, and where it came from. |

| | |
|---|---|
| Keyboard and mouse controls | Screenshot of the controls menu + code showing custom keyboard controls. |
| Support for controllers | Screenshot of the controls menu supporting controller inputs along with code that support controller inputs. |
| Includes a settings menu | Screenshot of the settings menu. |
| Simple graphics | Screenshot of the game, and framerate/GPU usage statistics with user feedback. |
| Scoreboard | Screenshot of the scoreboard + code to support. |
| Time limit | Screenshot of the time limit + code to support. |
| Configurable controls | Screenshot of the controls menu + code to support. |
| Quit button in the main menu | Screenshot of the main menu with the quit button + code to support. |
| Pause menu | Screenshot of the pause menu + code to support. |
| Start game button | Screenshot of the menus with the start game button + code to support. |
| Adjustable volume | Screenshot of the settings menu with the volume sliders + code to support. |
| Ball rolls naturally | Screenshot of the ball rolling + code to support. |
| Ball collides with obstacles | Screenshot of the ball colliding with obstacles + code to support. |

# Design

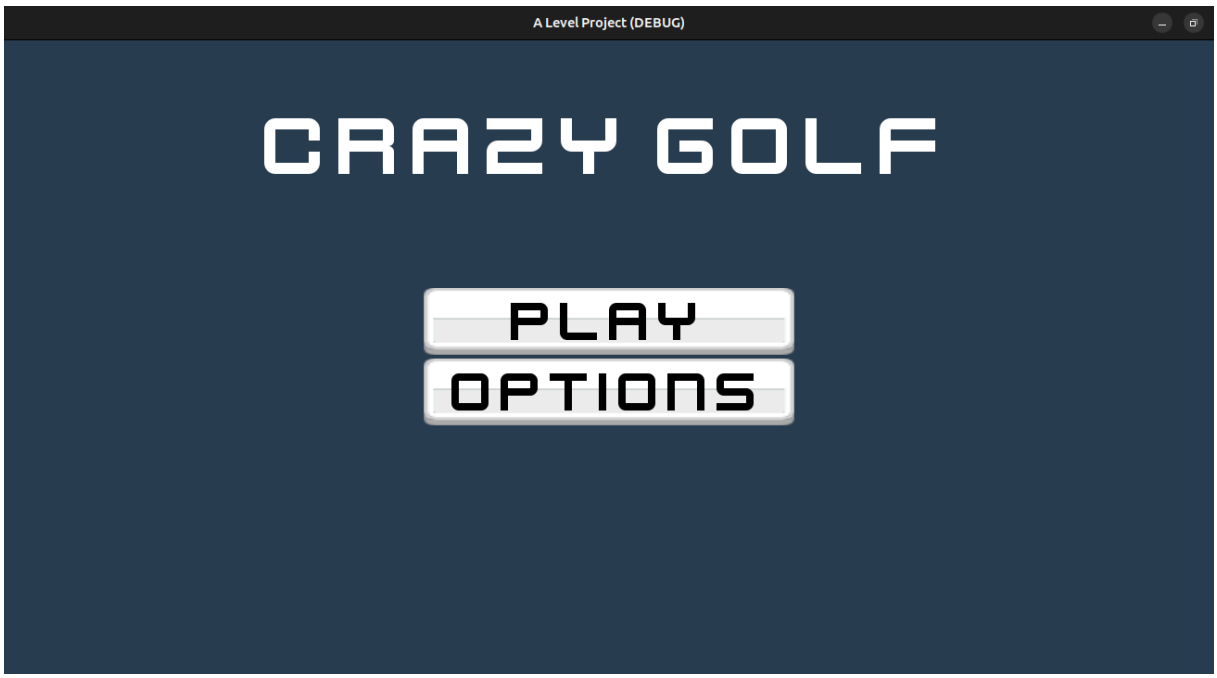
Key points:

- Interface design
- Program structure
- Algorithms - validation
- Features
- Key variables/data structures/classes

- Testing approach

# User Interface

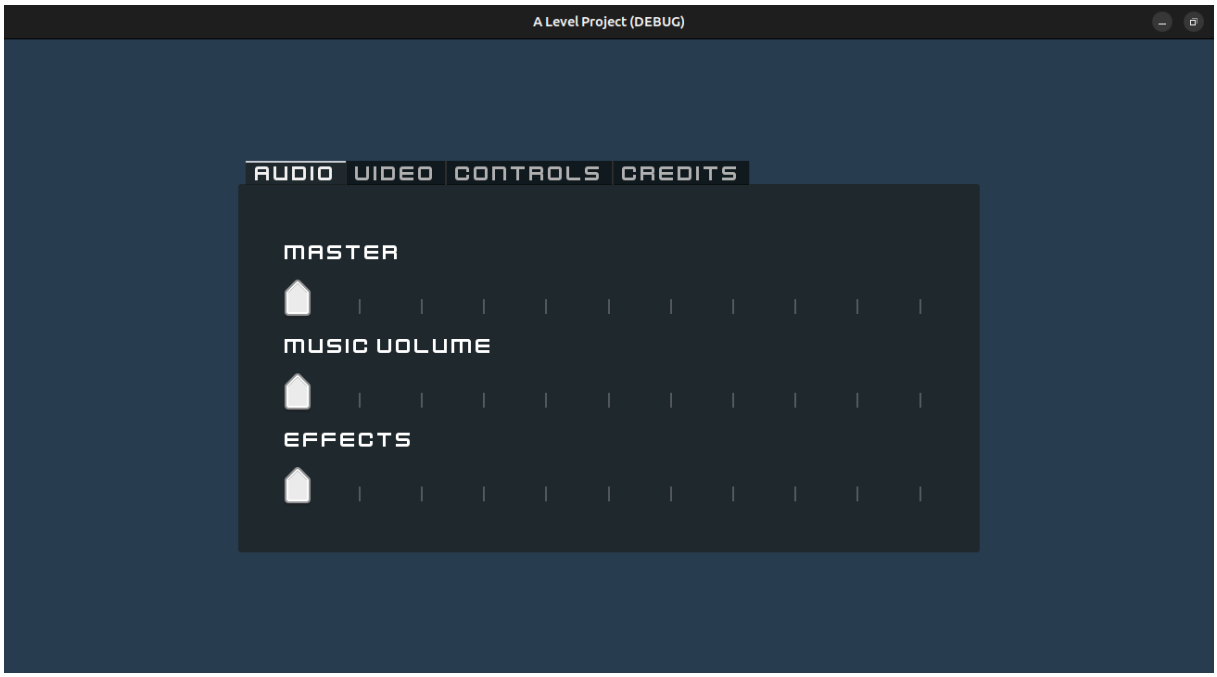
## Main Menu




This is the main menu the user sees when starting the game. There are only two main clear options on if the user is ready to play or if they want to change any settings. The background is a placeholder and may be replaced with a preview of one of the levels, to show the player what the game is like before they play. The options button will give the player a list of settings they can change for their own experience, such as graphics settings and controls. The buttons are in the center of the screen, with clear and large labels to let the player know what these buttons do.

Links to success criteria:
- Clear main menu
- Simple graphics

## Options Menu

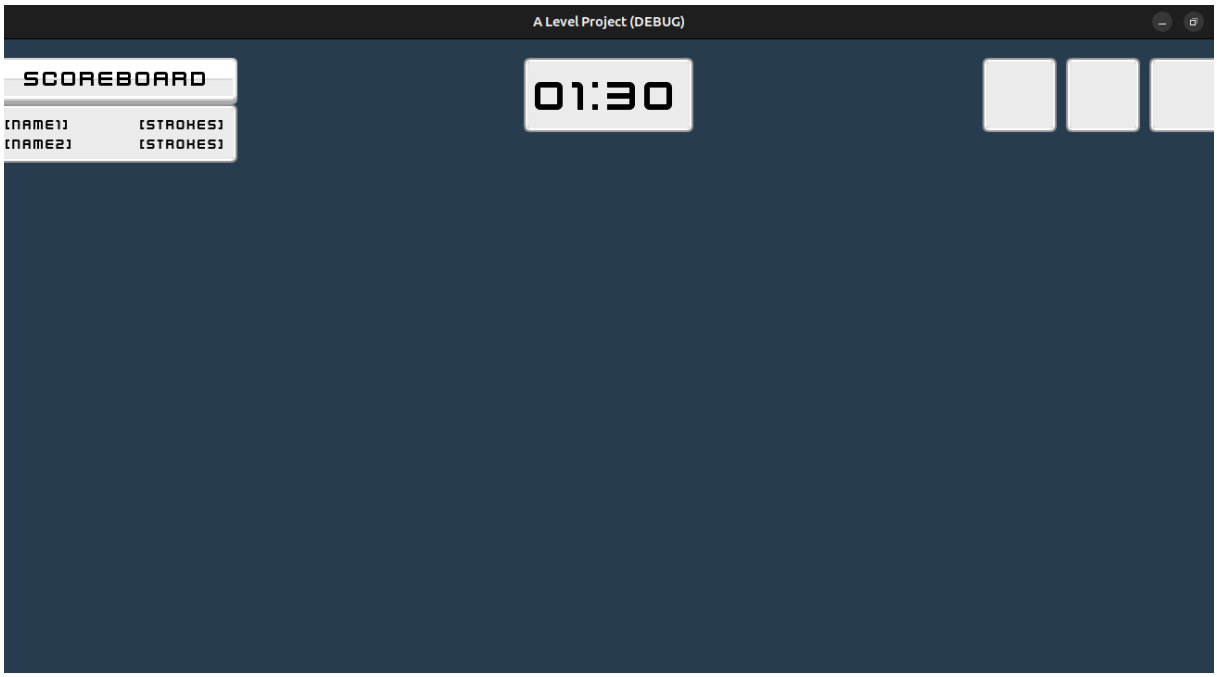



This is the menu which is shown after selecting the options button on the main menu or pause menu. This is where the player can change settings such as graphics settings, controls, and audio settings. There are tabs at the top for each category of setting, with clear and concise labels.

Links to success criteria:

- Full-screen and windowed options
- Simple to understand controls
- Keyboard and mouse controls
- Includes a settings menu

## Main HUD




This is the heads up display that will display in the main game. It shows the scoreboard of all the players (which can be collapsed as it could get big with many players). It also shows the time left on the hole, and the player's inventory of items.

Links to success criteria:
- Scoreboard
- Time limit

## Stakeholder Input

I sent the following message to my stakeholders for feedback on the user interface designs.

"Hi,

Attached are some screenshots of the designed layout of the menus for the game. These demonstrate the layout and roughly what they will look like in the game. They are the main menu, the options menu, and the main HUD in the game. The buttons are large to easily understand and read, with clear labels. The options menu has tabs at the top to easily navigate between different settings. The HUD is simple with everything at the top, with a collapsible scoreboard for if it gets in the way.

I would love to hear your feedback on these or any other comments you have.

Thanks,

Oliver"

## Responses

### Enoki

IMO the buttons look a bit weird on the corners due to the rounding of the inner sprite, and the font doesn't differentiate between H and K. I personally prefer the slider to be a bit higher, but that is not necessary. Besides that there isn't much I'd comment on.

### Gwen

The scoreboard could have the label "toggle scoreboard" to demonstrate it is toggleable, but that is the only thing I could find after some deliberation. It looks really good and you don't have to implement that change but that's my bit of feedback.

### Alex

- The individual slider markers are a bit hard to see for me, they need a bit more contrast / need to be more bright
- Scoreboard content text seems a bit small to parse at a glance, especially because it is collapsible I would make the text bigger
- Nitpick: Why is it "MUSIC VOLUME" but not "MASTER VOLUME"

I like the big buttons and large text and the very central timer

### Milan

The overall placement of HUD elements looks fine to me, though it would be nice to have some clear indication of how to access settings while in-game, perhaps through a "pause" menu.

I feel like a button to quit the game is missing from the main menu. While it isn't strictly necessary, it can be convenient for certain users, for example those playing with a gamepad. ( controller support is cool‼! [video referring to accessibility advantages of controller support] )

For the options menu, I like the layout with navigable menus at the top and the actual options laid out underneath. I think the sliders specifically would be improved a little if the actual slider bar was visible too, instead of only the ticks.

The overall styling seems fine, if a bit plain, which is to be expected for a draft version. As long as this is updated when the overall style of the game is

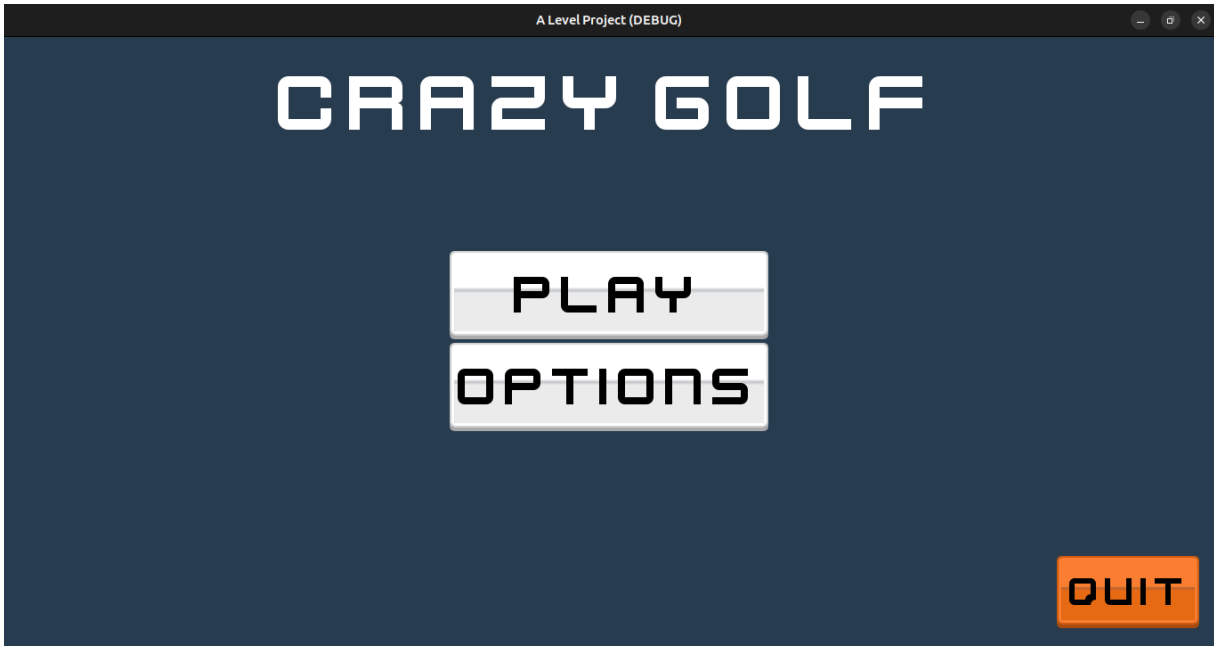
decided upon, I think the UI should work well. Lastly, I think the font could do with some modification, as the V looks a lot like a U. In context this isn't an issue (e.g. it's obviously "Video" and not "Uideo"), but I do personally find it a bit awkward to read.

## Analysis

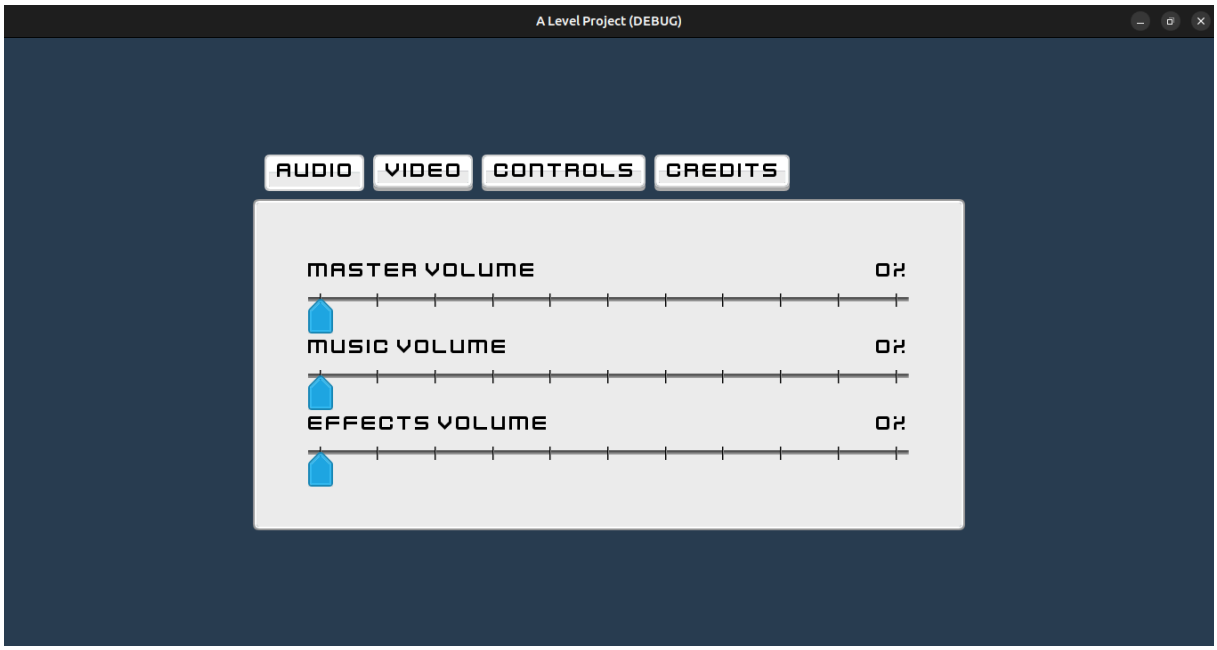
The feedback I received was generally positive, with some minor changes suggested. The following changes will be made to the designs based on the feedback:

- The inner corner of the buttons will be made more square to make the buttons look less weird.
- The font will be modified to differentiate between H and K, U and V.
- The slider markers will be made more bright to be easier to see.
- The scoreboard content text will be made bigger.
- The settings will be accessible through a pause menu with a physical button in the corner (as well as the escape button).
- A button to quit the game will be added to the main menu.

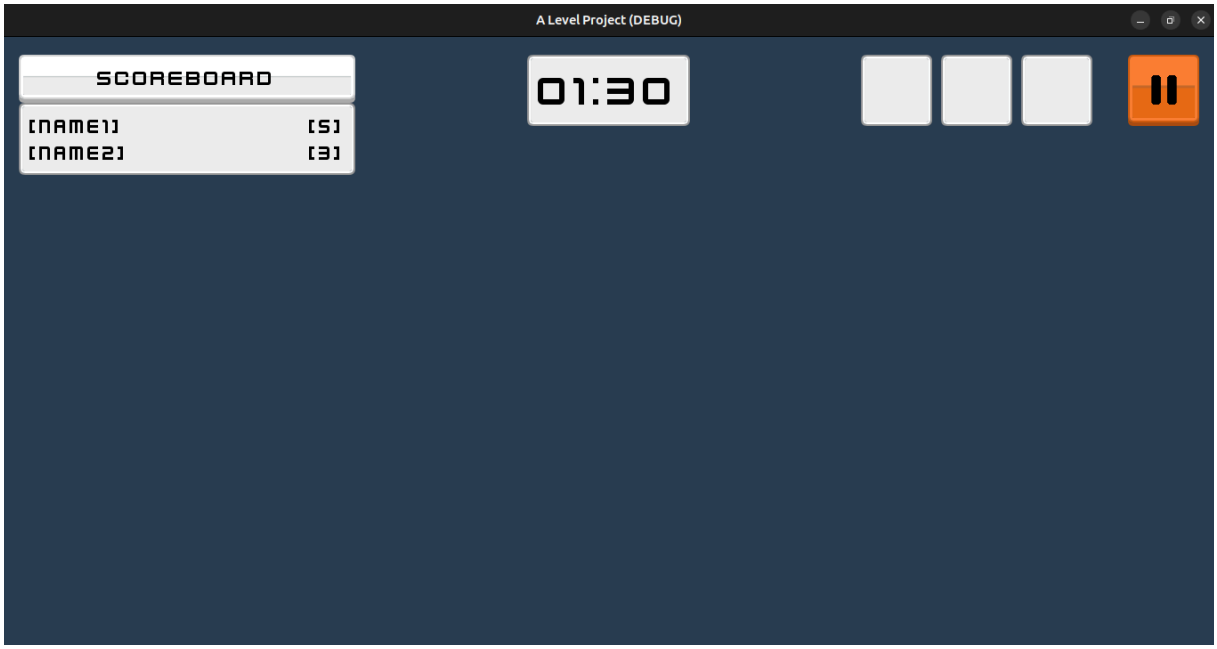
## Improvements




There is now a button to quit the game in the main menu.



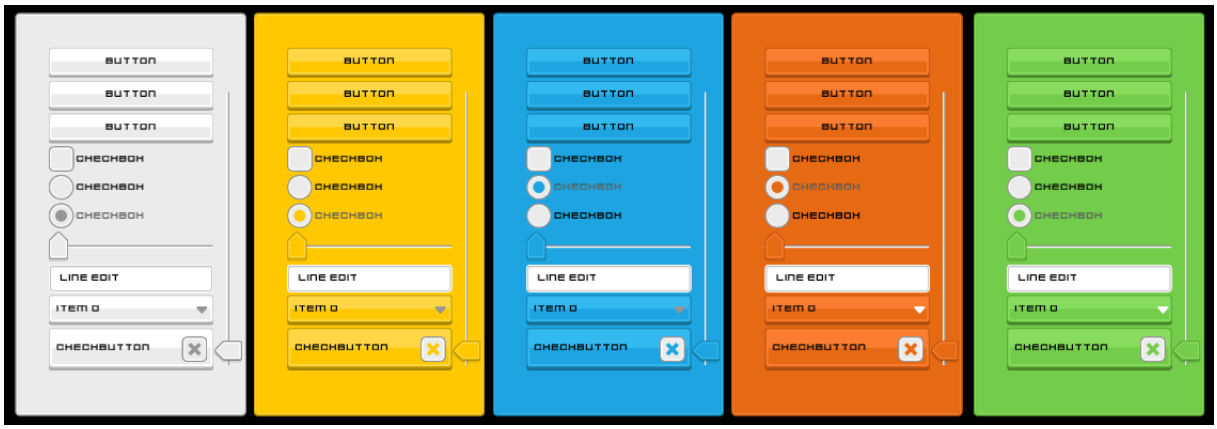

The sliders are now more visible, and the font has been changed to differentiate between H and K, U and V.




The scoreboard content text is now bigger, and there is a physical button to access the pause menu.

# Assets

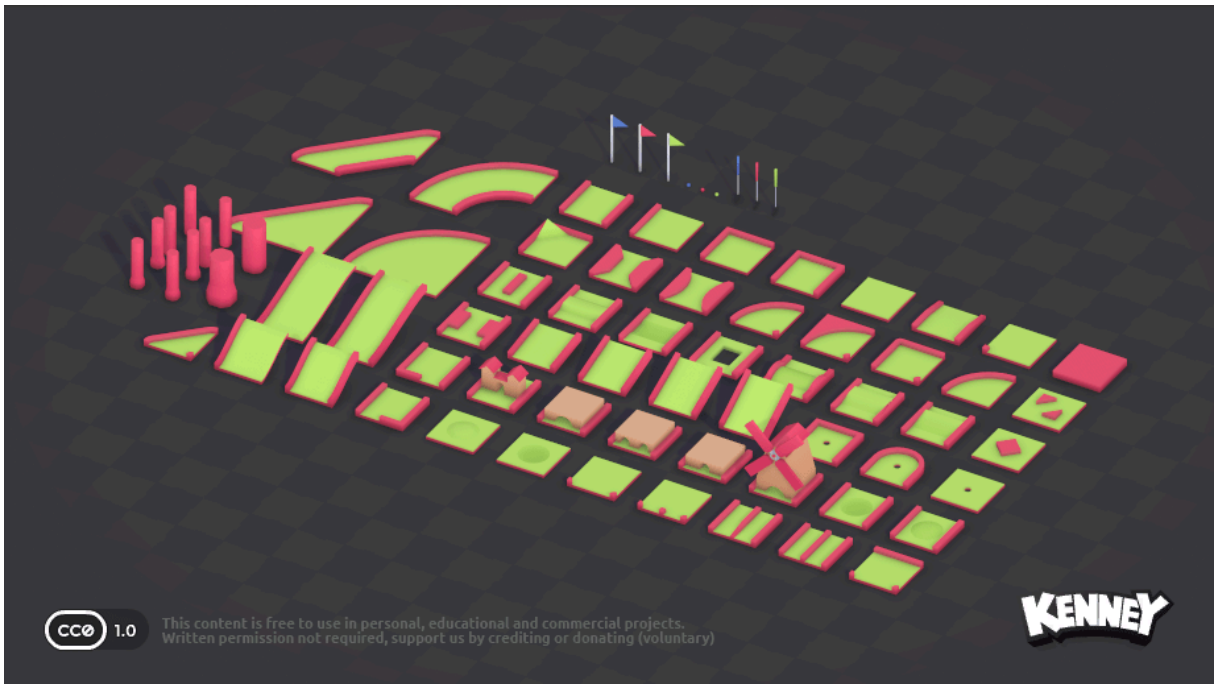
## UI Theme




This Godot UI theme is based off of Kenney's UI Pack. It is a simple and clean UI with large buttons and high contrast colours. This is useful for the game as it is simple to understand and looks playful. It is also free to use and modify, which I will be doing to update it from Godot 3 to Godot 4.2.

https://azagaya.itch.io/kenneys-ui-theme

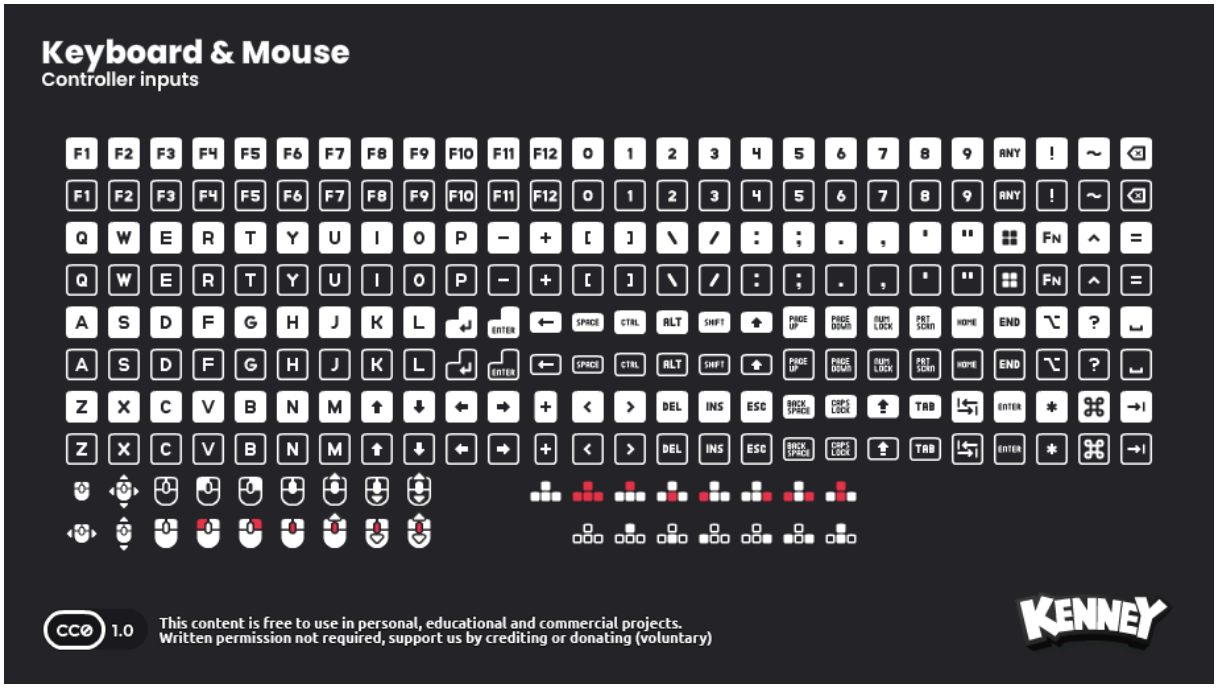
## 3D Models




These 3D models for the golf course are from the same creator as the UI theme base. There are many separate modular sections to choose from, and they are simple and clean. They also are CC0 licensed like the UI pack, so I can use and modify them for free.

https://www.kenney.nl/assets/minigolf-kit

## Control Inputs




I will be using these images as the content of the controls menu. They follow the same theme as the UI pack. There are many different supported setups such as Xbox, PlayStation, and keyboard and mouse.

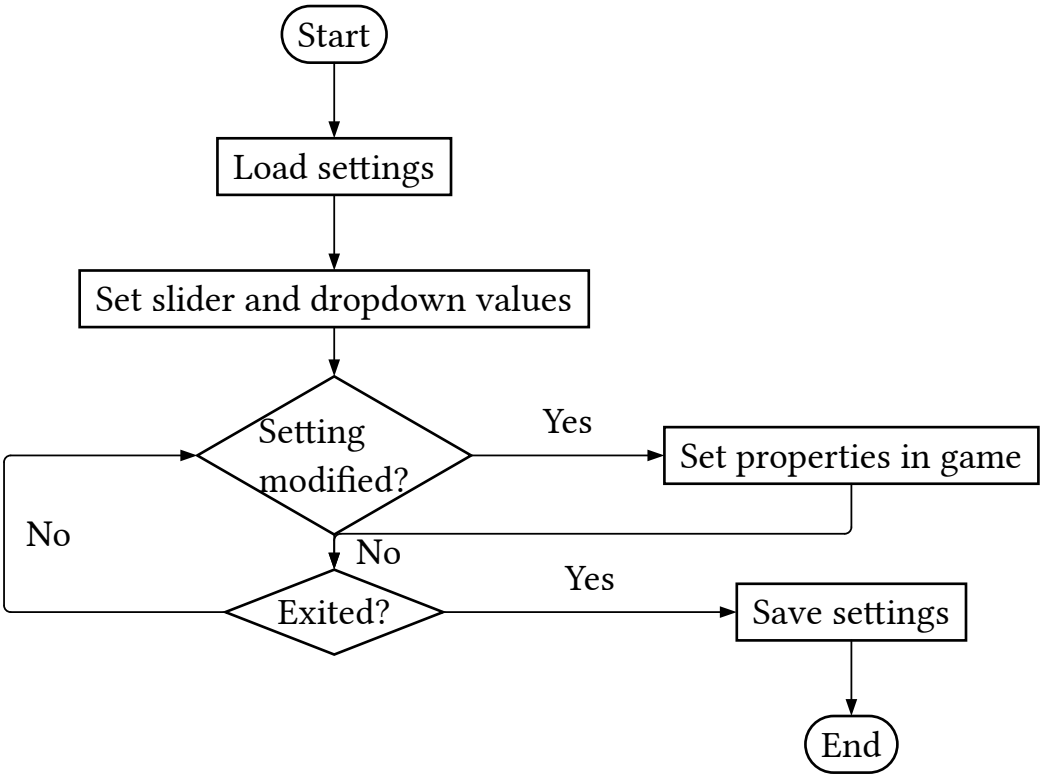
https://www.kenney.nl/assets/input-prompts

# Algorithms

## User Interface

### Options

The options menu does not take much complex scripting to implement. The most complex element is saving the settings to a file, and loading them when the game starts. Set properties refers to using Godot singletons to set the settings in game, which can also be retrieved later to save to a file.

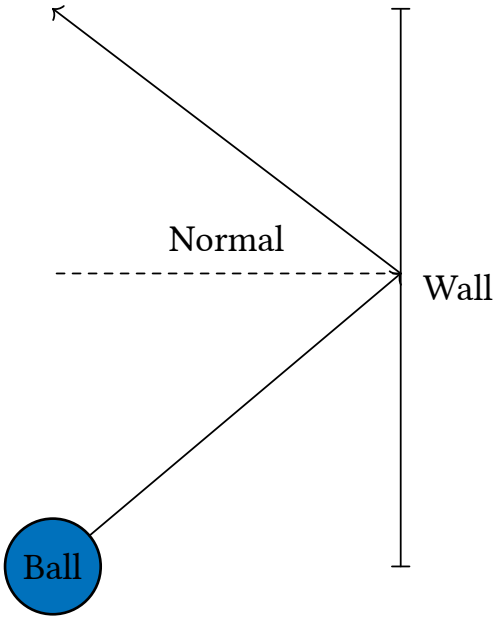



## Physics

### Collisions

Ball collisions should bounce off the walls. Godot `move_and_collide` moves the ball at the existing velocity and returns collisions if any.

The collision object provides a vector referring to the "normal" of the collision, represented in the following diagram:



The colliding vector can be reflected along the normal vector to get the resulting vector. Godot provides `Vector3.bounce(Vector3)` to do this for me.

# Development

The first stage of development is about creating the user interfaces. This includes linking the buttons to the different interfaces, and adding the relevant settings to the options menu.

## Stage 1: Setup & Menus

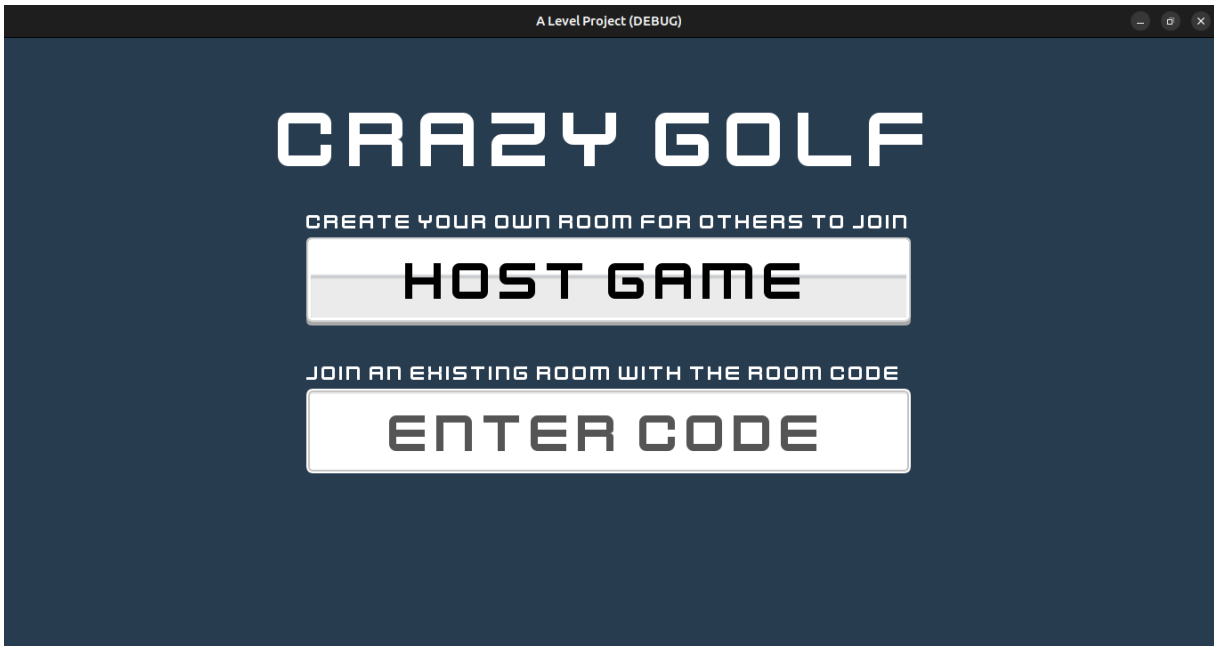
### Main Menu

In the main menu, the buttons are added via Godot's 2D editor, and each button is linked to a central script via signals. These signals are responded to below. Clicking the quit button sends a request to the `SceneTree` to quit.

The `play_scene` and `options_scene` are exported properties, so they can be set in the editor. This reduces coupling of the scenes and means the path of those scenes can change without issue. These `PackedScenes` are used to change the current scene to the play or options scene.

```
# main_menu.gd
extends MarginContainer

# Take in scenes as an exported property, to reduce coupling.
@export var play_scene: PackedScene
@export var options_scene: PackedScene


func _on_quit_button_pressed() -> void:
    # `get_tree()` gets the `SceneTree` which manages the game loop.
    get_tree().quit()


func _on_options_button_pressed() -> void:
    get_tree().change_scene_to_packed(options_scene)


func _on_play_button_pressed() -> void:
    get_tree().change_scene_to_packed(play_scene)
```

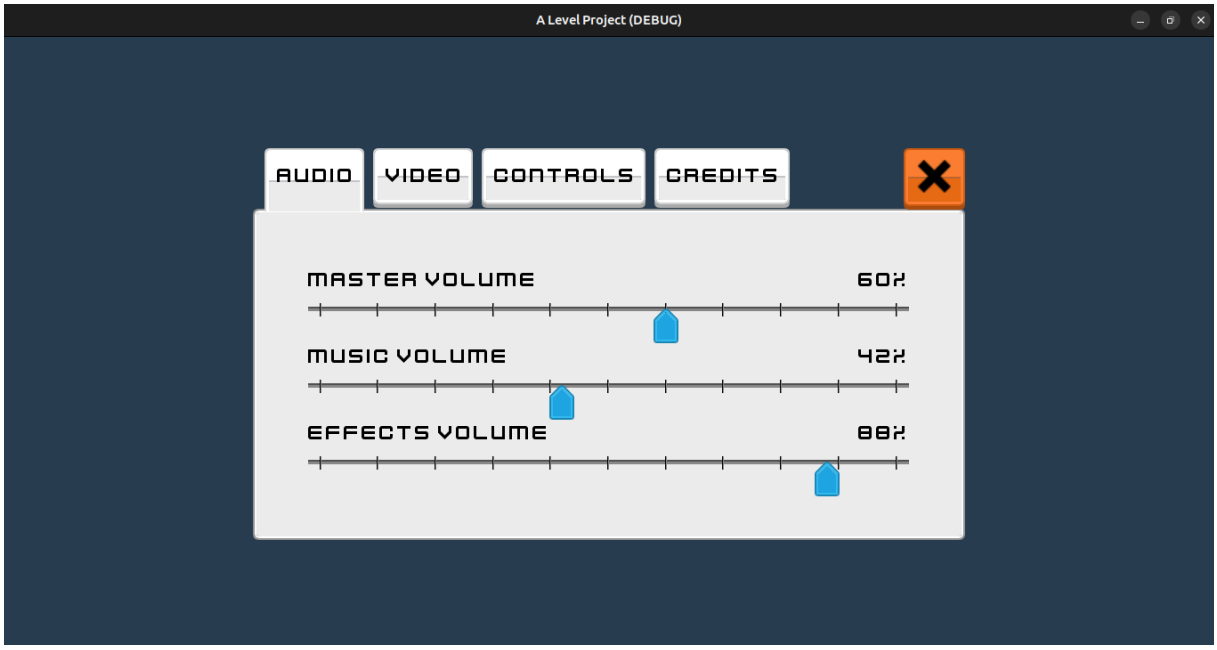
The `play_scene` looks like this:




## Options Menu

The options menu is also designed with the Godot 2D editor. The tabs are nodes underneath a `TabContainer` which handles switching the tabs. I added an exit button on the top right to go back to the previous scene - which can be either the main menu or pause menu. As the scene to switch back to depends on the previous scene, this is handled via a global script.

The tabs have also been extended downwards when selected so it is clearer as to if they are selected.



The following script is a global autoload 'singleton' script which holds the previous scene. This is used to determine which scene to switch back to when the exit button is pressed.

```
# global.gd
extends Node

## The scene before switching, used for back/close menu buttons.
var previous_scene: String
```

This is used in `main_menu.gd` (and soon to be used in `pause_menu.gd` too) to set the previous scene before switching to the options scene. This is so the options scene knows which scene to switch back to when the exit button is pressed.

```
# main_menu.gd
func _on_options_button_pressed() -> void:
    var tree := get_tree()
    Global.previous_scene = tree.current_scene.scene_file_path
    tree.change_scene_to_packed(options_scene)
```

In the options menu, the close button retrieves the previous scene from the global script and switches back to it.

```
extends Control


func _on_close_button_pressed() -> void:
    # Global.previous_scene could be either options or pause, this is set
    # before switching to options.
    get_tree().change_scene_to_file(Global.previous_scene)
```

### Audio Settings

Each volume slider is a child of a parent volume slider scene, which contains the slider, the label which contains the volume, and the script to handle the volume.

`audio_bus_name` is different per slider, so it is set per slider in the editor via an exported property. `audio_bus_index` is a unique number relating to this audio bus, used in the `AudioServer` API.

`_ready` is ran whenever the script is loaded. It retrieves the current bus volume from the `AudioServer` and sets the slider and label to that value. The `value_changed` signal is emitted whenever the slider is moved, and the `set_bus_volume_db` function is called to set the volume of the bus.

Both of these require converting to/from decibels, as the `AudioServer` API uses decibels for volume and that is a logarithmic scale.

```
extends VBoxContainer
```

```
@export var audio_bus_name: StringName
# The index of the audio bus in all buses.
@onready var audio_bus_index := AudioServer.get_bus_index(audio_bus_name)
@onready var value_node: Label = %Value
@onready var slider: HSlider = %Slider


func _ready() -> void:
    # Retrieve existing volume and set that on the slider and label.
    var db := AudioServer.get_bus_volume_db(audio_bus_index)
    var percentage := db_to_linear(db)
    var value := roundi(percentage * 100)
    value_node.text = str(value) + "%"
    slider.value = value


func _on_slider_value_changed(value: float) -> void:
    # Godot uses decibels, which is logarithmic. This function converts a number
    # from 0-1 into decibels (-80 to 24dB)
    var db := linear_to_db(value / 100)
    AudioServer.set_bus_volume_db(audio_bus_index, db)
    value_node.text = str(value) + "%"
```

### Video Settings

The video settings I have decided to implement, to keep it simple, are:

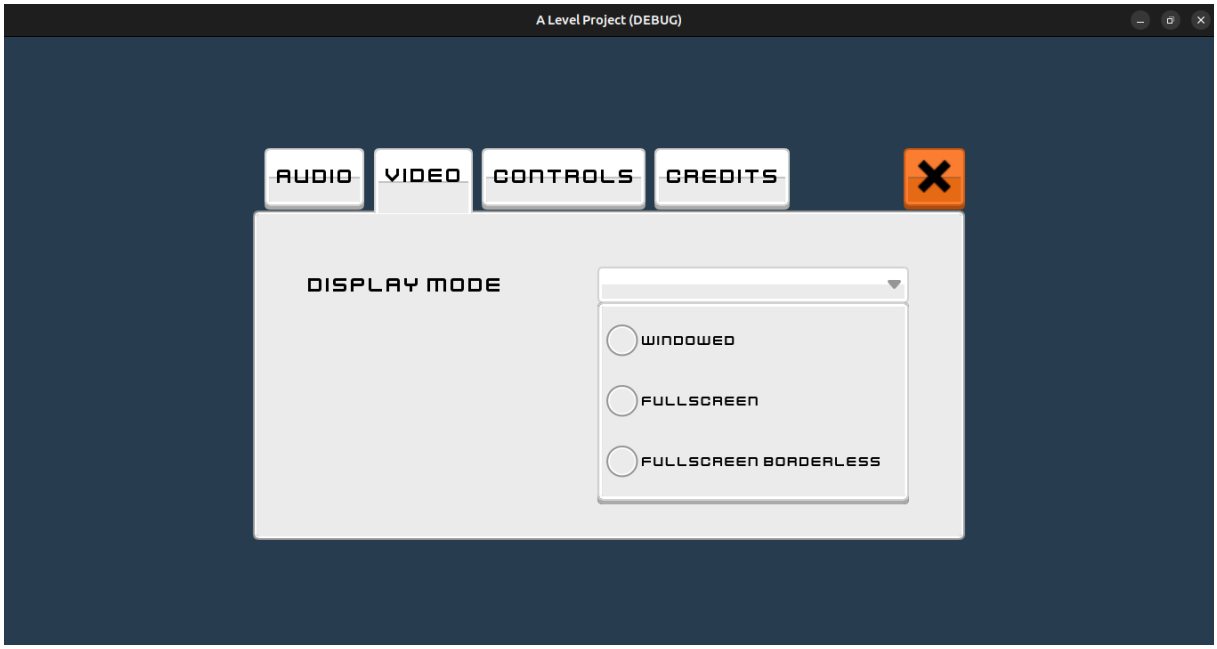
- Window mode (windowed/fullscreen)
- Anti-aliasing (MSAA)
- Vertical-sync (VSync)

### Window Mode

The first setting to implement is the window mode - whether the window is windowed or fullscreen. For this I asked one of my stakeholders which I know uses multiple (virtual) monitors on Windows 10 **and** Linux. I asked if they would like a borderless windowed fullscreen option, and they said they would like it. This is because it is more consistent across multiple monitors and is generally better for alt+tabbing especially in Windows.

```
# video.gd
extends MarginContainer

@onready var display_mode: OptionButton = %DisplayMode


func _on_display_mode_item_selected(index: int) -> void:
    # 0: Windowed
    # 1: Fullscreen
    # 2: Fullscreen Borderless
    if index == 0:
        # Windowed windows have a border and this sets it to maximised for a
        # consistent size when switching away from fullscreen.
        DisplayServer.window_set_flag(DisplayServer.WINDOW_FLAG_BORDERLESS, false)
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_MAXIMIZED)
    elif index == 1:
```

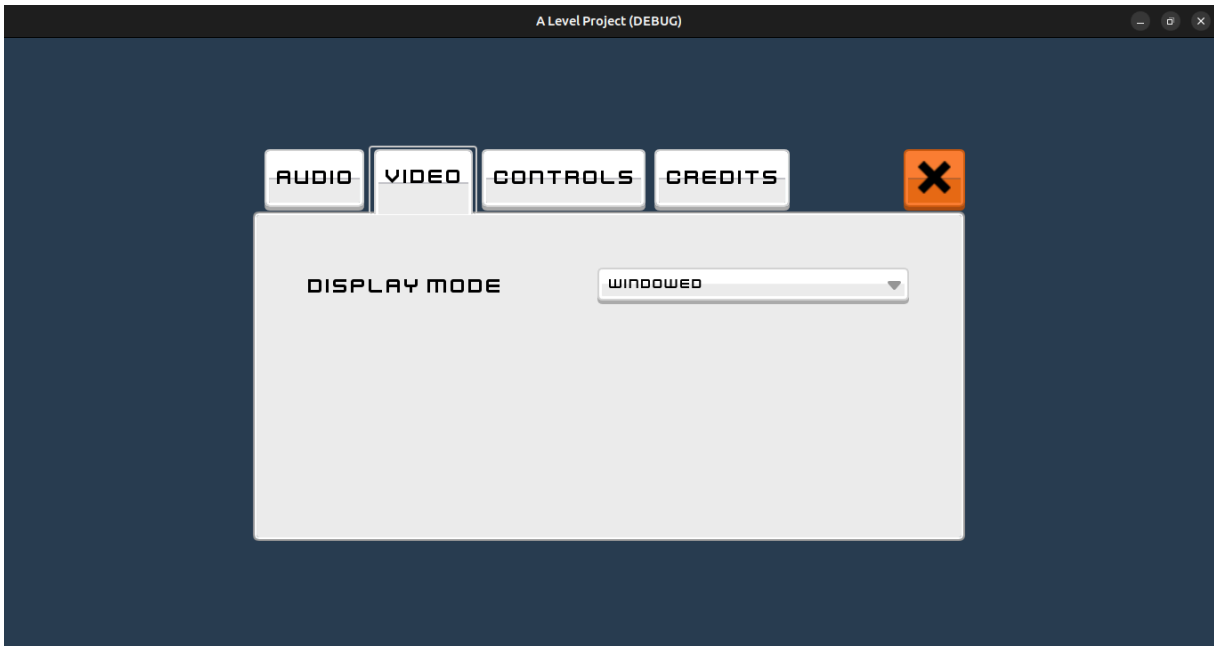
```
        DisplayServer.window_set_position(Vector2i(0, 0))
        # Exclusive fullscreen has a lower overhead as it usually avoids
        # the display compositor.
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_EXCLUSIVE_FULLSCREEN)
    elif index == 2:
        # Fullscreen borderless is a full screen sized window without a border.
        # It usually works better with multiple monitor setups when alt+tab/esc
        # in windows.
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_MAXIMIZED)
        DisplayServer.window_set_size(DisplayServer.screen_get_size())
        DisplayServer.window_set_flag(DisplayServer.WINDOW_FLAG_BORDERLESS, true)
        DisplayServer.window_set_position(Vector2i(0, 0))
```




This only shows the dropdown, where selecting each option will change the window mode. The next thing to do is setting the initial value of this dropdown so it shows the currently selected mode.

This defaults to assuming the window mode is windowed. If it finds that it is fullscreen, then sets it to fullscreen. If it finds that the window is borderless and windowed (maximised), then it sets it to fullscreen borderless.

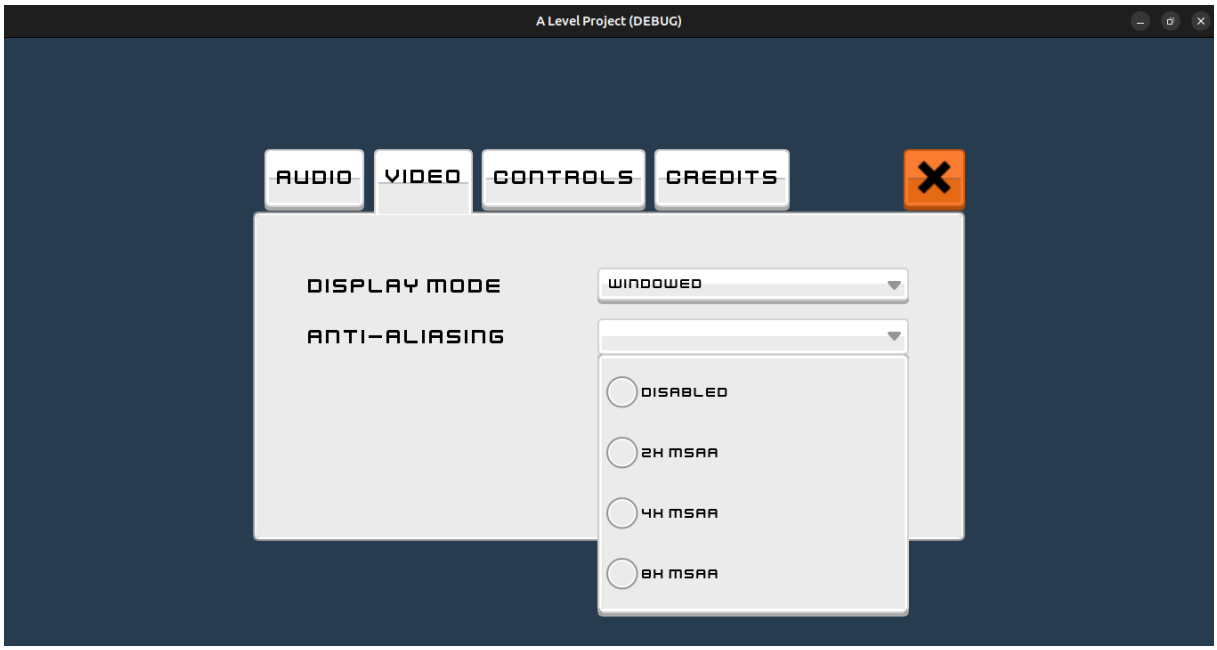
```
# video.gd
func _ready() -> void:
    # 0: Windowed
    # 1: Fullscreen
    # 2: Fullscreen Borderless
    var mode := DisplayServer.window_get_mode()
    var borderless := DisplayServer.window_get_flag(DisplayServer.WINDOW_FLAG_BORDERLESS)
    var id := 0
    if mode == DisplayServer.WINDOW_MODE_EXCLUSIVE_FULLSCREEN:
        id = 1
    elif mode == DisplayServer.WINDOW_MODE_MAXIMIZED and borderless:
        id = 2
    display_mode.select(id)
```




## Anti-Aliasing

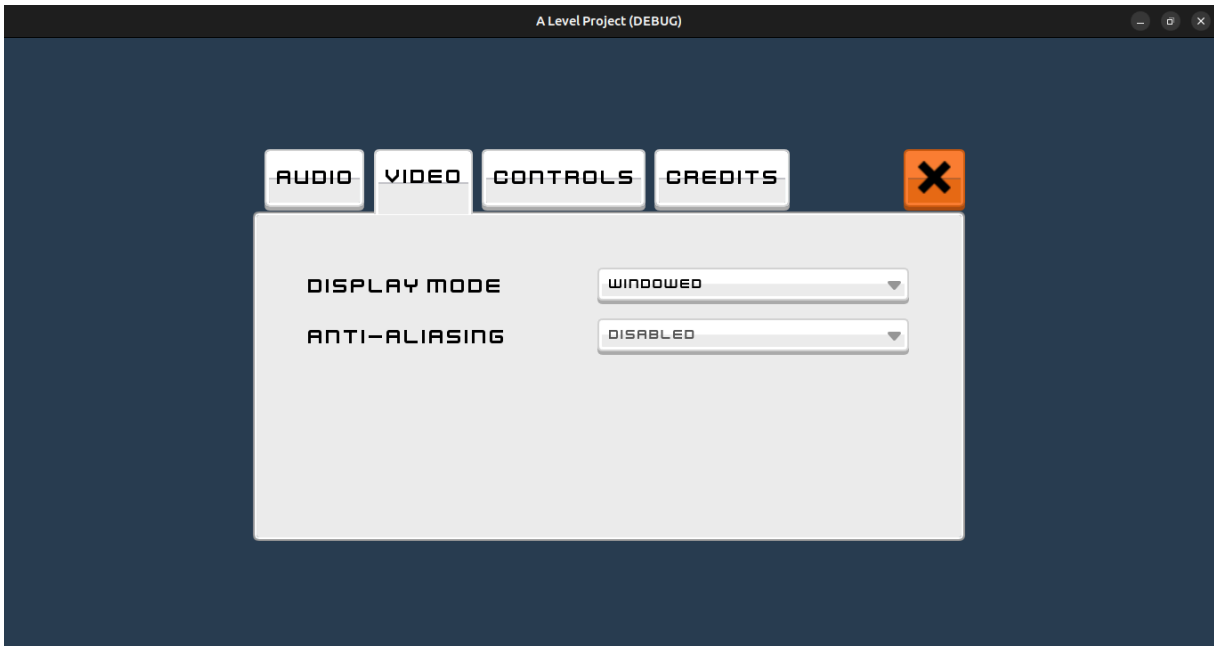
The next setting to implement is anti-aliasing. This keeps the 2D MSAA and 3D MSAA settings equal, as users are only going to enable anti-aliasing if their graphics card can handle it. The script is fairly simple, it sets the anti-aliasing quality in the project settings to the selected value.

```
# video.gd
# settings paths for anti-aliasing.
const ANTIALIASING_2D = &"rendering/anti_aliasing/quality/msaa_2d"
const ANTIALIASING_3D = &"rendering/anti_aliasing/quality/msaa_3d"

@onready var anti_aliasing: OptionButton = %AntiAliasing

# ...

func _on_anti_aliasing_item_selected(index: int) -> void:
    # 0: Disabled
    # 1: MSAA 2x
    # 2: MSAA 4x
    # 3: MSAA 8x
    if index == 0:
        ProjectSettings.set_setting(ANTIALIASING_2D, Viewport.MSAA_DISABLED)
        ProjectSettings.set_setting(ANTIALIASING_3D, Viewport.MSAA_DISABLED)
    elif index == 1:
        ProjectSettings.set_setting(ANTIALIASING_2D, Viewport.MSAA_2X)
        ProjectSettings.set_setting(ANTIALIASING_3D, Viewport.MSAA_2X)
    elif index == 2:
        ProjectSettings.set_setting(ANTIALIASING_2D, Viewport.MSAA_4X)
        ProjectSettings.set_setting(ANTIALIASING_3D, Viewport.MSAA_4X)
    elif index == 3:
        ProjectSettings.set_setting(ANTIALIASING_2D, Viewport.MSAA_8X)
        ProjectSettings.set_setting(ANTIALIASING_3D, Viewport.MSAA_8X)
```




The dropdown also needs to set the initial value of the dropdown to the currently selected anti-aliasing setting. This is done by checking the project settings and setting the dropdown to the correct value.

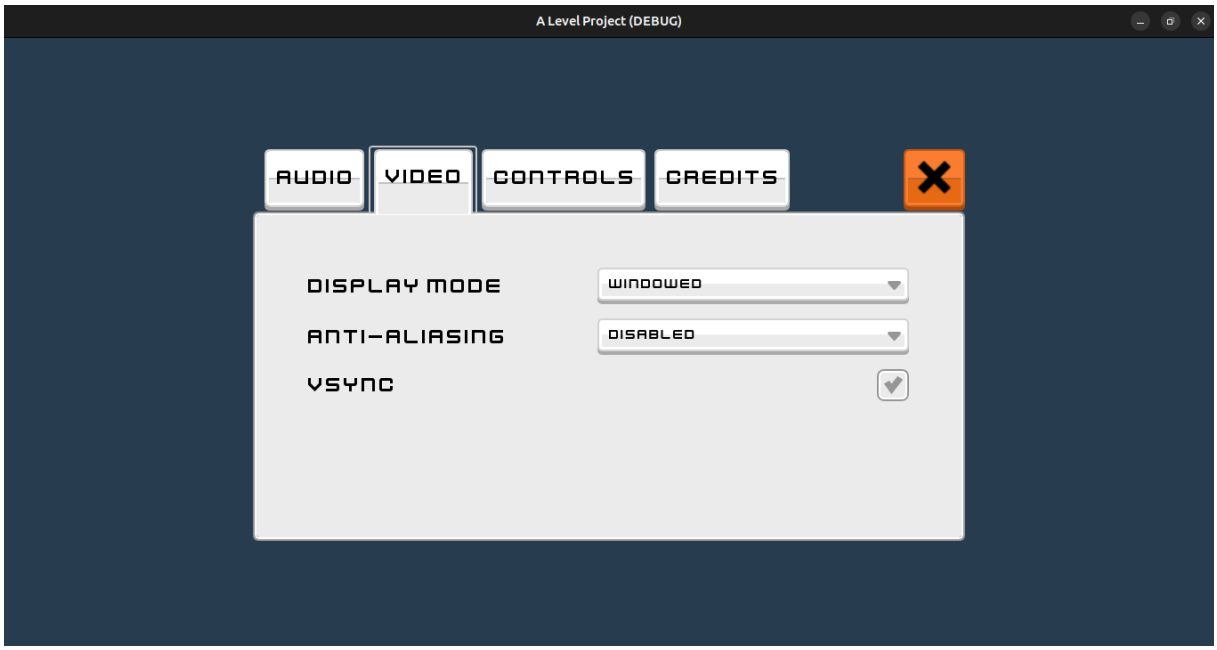
```
# video.gd
func _ready() -> void:
    # ...

    # msaa_2d and msaa_3d are the same here
    var antialiasing := get_viewport().msaa_2d
    id = 0
    if antialiasing == Viewport.MSAA_2X:
        id = 1
    elif antialiasing == Viewport.MSAA_4X:
        id = 2
    elif antialiasing == Viewport.MSAA_8X:
        id = 3
    anti_aliasing.select(id)
```




## Vertical Sync

The final setting to implement is vertical sync. This is a simple setting, as it only has two options - on or off. This is set in the project settings, and the dropdown sets the initial value to the currently selected setting.

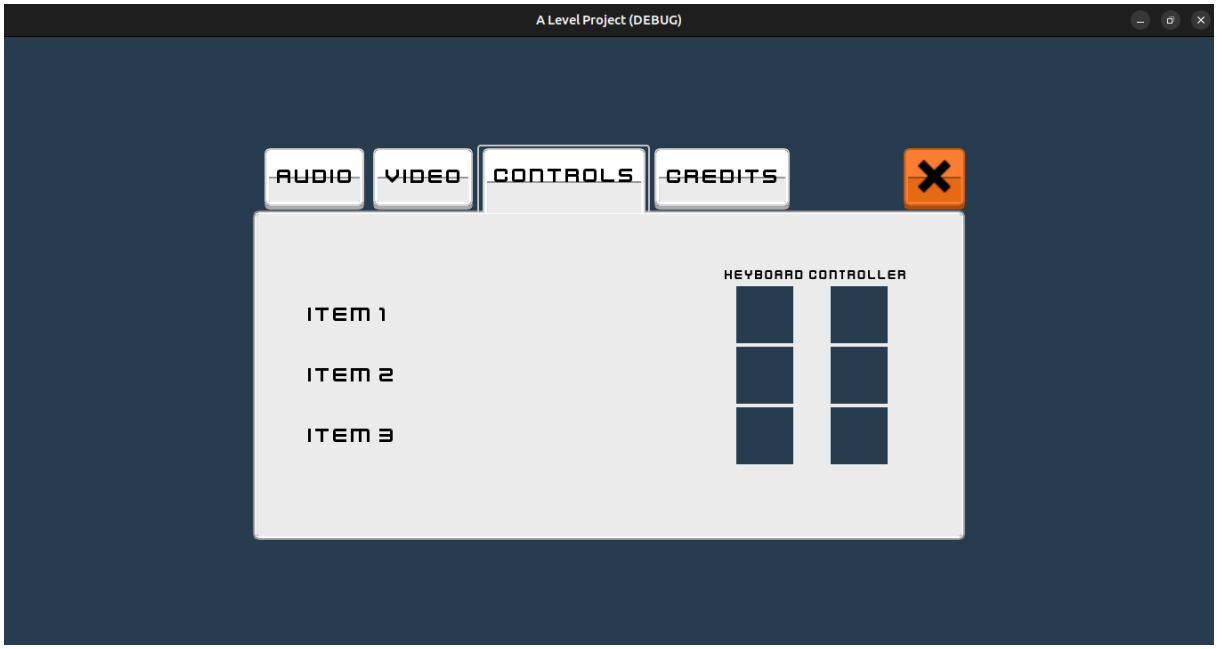
```
# video.gd
@onready var v_sync: CheckBox = %VSync


func _ready() -> void:
    # ...

    var vsync := DisplayServer.window_get_vsync_mode()
    if vsync == DisplayServer.VSYNC_ENABLED:
        v_sync.set_pressed_no_signal(true)
    else:
        v_sync.set_pressed_no_signal(false)


func _on_vsync_toggled(toggled_on: bool) -> void:
    if toggled_on:
        DisplayServer.window_set_vsync_mode(DisplayServer.VSYNC_ENABLED)
    else:
        DisplayServer.window_set_vsync_mode(DisplayServer.VSYNC_DISABLED)
```




## Control Settings

### Control Inputs

### Textures




The controls menu contains separate controls for both keyboard and controller. This is so the user can set custom settings for both so they can play how they want to.

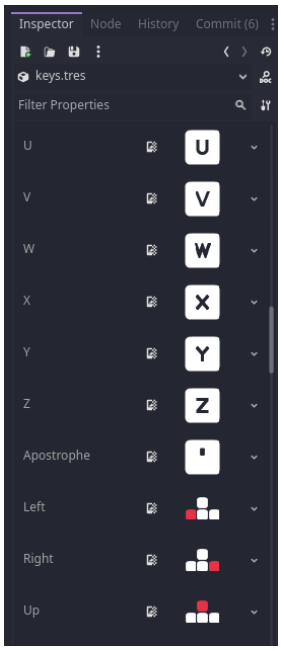
The textures for these buttons need to be stored in a resource to be used later. The following script provides properties that can be set in the editor with each

texture for all the supported keys. It also implements a `get_texture` method to retrieve the corresponding texture for an `InputEvent`.

```
# keys.gd
@tool
class_name KeyboardTextures
extends Resource

# All keys that can reasonably be used as custom controls.
# This means no modifier keys, no mouse buttons, no keys which do not usually
# pass through to programs such as numlock,
const _KEYS: Array[Key] = [
    KEY_0,
    KEY_1,
    KEY_2,
    KEY_3,
    KEY_4,
    KEY_5,
    KEY_6,
    KEY_7,
    KEY_8,
    KEY_9,
    KEY_A,
    KEY_B,
    KEY_C,
    KEY_D,
    KEY_E,
    KEY_F,
    KEY_G,
    KEY_H,
    KEY_I,
    KEY_J,
    KEY_K,
    KEY_L,
    KEY_M,
    KEY_N,
    KEY_O,
    KEY_P,
    KEY_Q,
    KEY_R,
    KEY_S,
    KEY_T,
    KEY_U,
    KEY_V,
    KEY_W,
    KEY_X,
    KEY_Y,
    KEY_Z,
    KEY_APOSTROPHE,
    KEY_LEFT,
    KEY_RIGHT,
    KEY_UP,
    KEY_DOWN,
    KEY_ASTERISK,
    KEY_BACKSPACE,
    KEY_BRACKETLEFT,
    KEY_BRACKETRIGHT,
    KEY_GREATER,
    KEY_LESS,
    KEY_CAPSLOCK,
    KEY_ASCIICIRCUM,
```

```
    KEY_COLON,
    KEY_COMMA,
    KEY_DELETE,
    KEY_END,
    KEY_ENTER,
    KEY_ESCAPE,
    KEY_EXCLAM,
    KEY_F1,
    KEY_F2,
    KEY_F3,
    KEY_F4,
    KEY_F5,
    KEY_F6,
    KEY_F7,
    KEY_F8,
    KEY_F9,
    KEY_F10,
    KEY_F11,
    KEY_F12,
    KEY_HOME,
    KEY_INSERT,
    KEY_MINUS,
    KEY_PAGEDOWN,
    KEY_PAGEUP,
    KEY_PERIOD,
    KEY_PLUS,
    KEY_PRINT,
    KEY_QUESTION,
    KEY_QUOTEDBL,
    KEY_SEMICOLON,
    KEY_SLASH,
    KEY_BACKSLASH,
    KEY_SPACE,
    KEY_ASCIITILDE,
    KEY_TAB,
]

var textures: Dictionary = {}


func _init() -> void:
    for k in _KEYS:
        textures[OS.get_keycode_string(k)] = null


# Make this Resource act like all of its properties are contained in `textures`.
func _get(property: StringName) -> Variant:
    if property in textures.keys():
        return textures[property]
    return null


func _set(property: StringName, value: Variant) -> bool:
    if property in textures.keys():
        textures[property] = value
        return true
    return false


# Fake the properties we have as all the supported keys.
func _get_property_list() -> Array[Dictionary]:
    var properties: Array[Dictionary] = []
```

```
    for k in _KEYS:
        properties.append(
            {
                name = OS.get_keycode_string(k),
                type = TYPE_OBJECT,
                hint = PROPERTY_HINT_RESOURCE_TYPE,
                hint_string = "Texture2D"
            }
        )
    return properties


func get_texture(event: InputEvent) -> Texture2D:
    if not event is InputEventKey:
        return
    var key_event := event as InputEventKey
    var scancode := key_event.keycode
    return textures.get(OS.get_keycode_string(scancode), null)
```

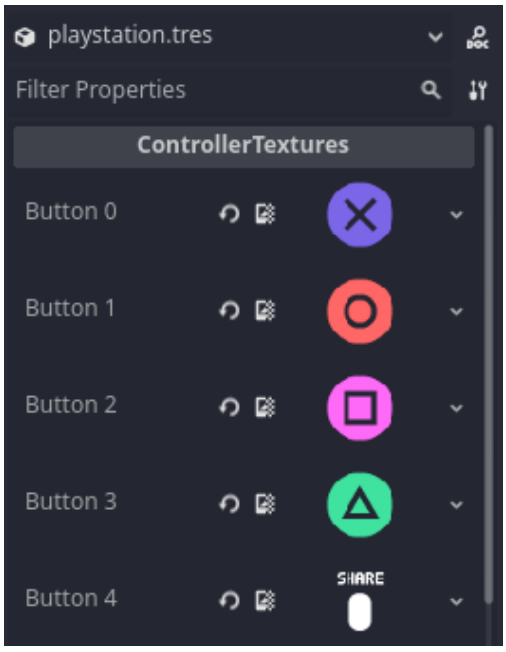



This allows me to insert the textures into a new resource file and use them in the controls menu.

And similar with the controller textures, but with the controller buttons instead of keyboard keys. There are much less controller buttons so the properties do not need to be created dynamically, and allows me to add docstrings for what each button corresponds to.

```
# controller.gd
@tool
class_name ControllerTextures
extends Resource

## Bottom action (PS X, Xbox/Steam A, Nintendo B)
@export var button_0: Texture2D = null
## Right action (PS O, Xbox/Steam B, Nintendo A)
@export var button_1: Texture2D = null
```

```
## Left action (PS □, Xbox/Steam X, Nintendo Y)
@export var button_2: Texture2D = null
## Top action (PS △, Xbox/Steam Y, Nintendo X)
@export var button_3: Texture2D = null
## Back (PS 1/2/3 Select, PS 4/5 Share, Xbox Back, Nintendo -)
@export var button_4: Texture2D = null
## Guide (PS PS button, Xbox home, Nintendo home)
@export var button_5: Texture2D = null
## Start (PS 1/2/3 Start, PS4/5 Options, Xbox menu, Nintendo +)
@export var button_6: Texture2D = null
## Left stick (PS L3, Xbox L/LS, Nintendo left stick)
@export var button_7: Texture2D = null
## Right stick (PS R3, Xbox R/RS, Nintendo right stick)
@export var button_8: Texture2D = null
## Left shoulder (PS L1, Xbox LB, Nintendo L)
@export var button_9: Texture2D = null
## Right shoulder (PS R1, Xbox RB, Nintendo R)
@export var button_10: Texture2D = null
## D-pad up
@export var button_11: Texture2D = null
## D-pad down
@export var button_12: Texture2D = null
## D-pad left
@export var button_13: Texture2D = null
## D-pad right
@export var button_14: Texture2D = null
## PS5 Microphone, Xbox Share, Nintendo capture
@export var button_15: Texture2D = null
## Paddle 1
@export var button_16: Texture2D = null
## Paddle 2
@export var button_17: Texture2D = null
## Paddle 3
@export var button_18: Texture2D = null
## Paddle 4
@export var button_19: Texture2D = null
## PS4/5 touchpad
@export var button_20: Texture2D = null


func get_texture(event: InputEvent) -> Texture2D:
    if not event is InputEventJoypadButton:
        return null

    var joypad_event := event as InputEventJoypadButton
    var button := joypad_event.button_index
    return get("button_" + str(button))
```




And this is similar with controllers, where I have created multiple resource files for different controller platforms.

To ensure only one button can be waiting for input, I have added a property to `global.gd` to share the currently listening prompt.

```
# global.gd
## The control input that is currently listening.
var listening_control: ControlInput
```

### Buttons

I then created a generic input prompt script which can be used for both keyboard and controller inputs. `get_texture` is left unimplemented as that is the part which differs depending on keyboard or controller inputs.

This uses the `global.gd` script to ensure only one input prompt can be waiting for input at a time. If a new input prompt is selected, the old one is unselected by calling `unlisten()` on it, and then setting the current prompt as the global property.

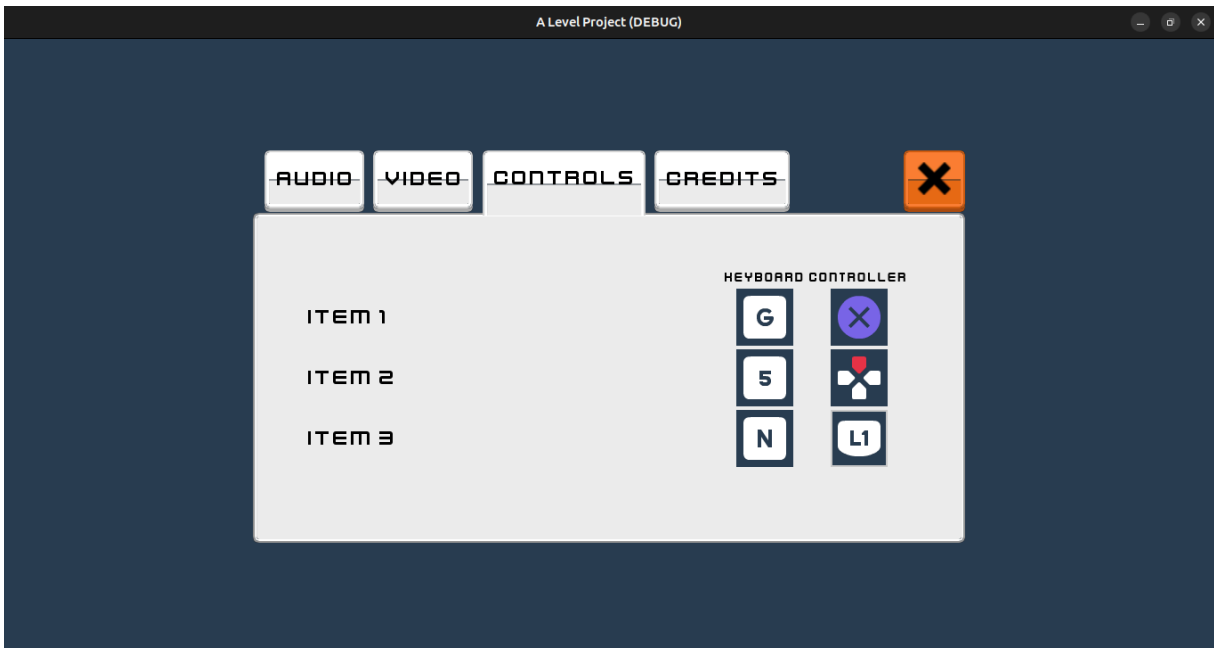
```
# control_input.gd
class_name ControlInput
extends Button

# Whether to act upon new `gui_input` events.
var listening: bool = false
# The texture to revert to if this input is unselected.
var previous_texture: Texture2D = null

@onready var texture_rect: TextureRect = %TextureRect
@onready var label: Label = %Label
```

```
func _on_pressed() -> void:
    # Don't redo the same process if we are already listening, as that will
    # call `unlisten` below.
    if listening:
        return
    # Store the previous texture to revert to later if needed.
    previous_texture = texture_rect.texture
    texture_rect.texture = null
    label.text = "Waiting for input..."

    listening = true
    if Global.listening_control != null:
        Global.listening_control.unlisten()
    Global.listening_control = self


func _on_gui_input(event: InputEvent) -> void:
    if not listening:
        return
    var texture := get_texture(event)
    if texture == null:
        return

    label.text = ""
    texture_rect.texture = texture

    listening = false
    Global.listening_control = null


func _on_tree_exited() -> void:
    unlisten()


# Called either when this node is not visible (`tree_exited`), or a different
# control input is selected (see above).
func unlisten() -> void:
    listening = false
    label.text = ""
    texture_rect.texture = previous_texture


# keep `get_texture` abstract, for separate key inputs and controller inputs.
func get_texture(_event: InputEvent) -> Texture2D:
    return null
```

And then the individual implementations for keyboard and controller inputs.

```
# key_input.gd
class_name KeyInput
extends ControlInput

const textures: KeyboardTextures = preload("./resources/keys.tres")


func get_texture(event: InputEvent) -> Texture2D:
    var texture := textures.get_texture(event)
    # If it is not null, this is a valid texture, store this event as action`.
    if texture != null:
        store_action(event)
    return texture
```

```gdscript
# controller_input.gd
class_name ControllerInput
extends ControlInput

const xb_textures: ControllerTextures = preload("./resources/xbox.tres")
const ps_textures: ControllerTextures = preload("./resources/playstation.tres")
const ni_textures: ControllerTextures = preload("./resources/nintendo.tres")
const st_textures: ControllerTextures = preload("./resources/steam.tres")


func get_texture(event: InputEvent) -> Texture2D:
    var device := event.device
    var joy_name := Input.get_joy_name(device)
    # The following conditions come from the public SDL controller database
    # https://github.com/mdqinc/SDL_GameControllerDB/
    var texture: Texture2D
    if joy_name.contains("Xbox"):
        texture = xb_textures.get_texture(event)
    elif (
        joy_name.contains("PlayStation")
        or joy_name.contains("PS")
        or joy_name.contains("DualShock")
    ):
        texture = ps_textures.get_texture(event)
    elif joy_name.contains("Nintendo") or joy_name.contains("Switch"):
        texture = ni_textures.get_texture(event)
    elif joy_name.contains("Steam"):
        texture = st_textures.get_texture(event)
    else:
        texture = xb_textures.get_texture(event)

    return texture
```




Only item 1, 2 and 3 are implemented as controls right now, as I am not sure what the other controls will be yet. This will be implemented later when I have a better idea of what the controls will be.

These settings do not apply to the game yet. The following code sets them in the global `InputMap` so they can be used in the game. Each control input takes in the `action` which is the name of the action in the `InputMap`.

```
# key_input.gd
@export var action: StringName


func _ready() -> void:
    var current_events := InputMap.action_get_events(action)
    for existing_event in current_events:
        if existing_event is InputEventKey:
            texture_rect.texture = get_texture(existing_event)
            break


func store_action(event: InputEvent) -> void:
    var current_events := InputMap.action_get_events(action)
    # Clear any existing key events for this current action and replace it with
    # the new one.

    for existing_event in current_events:
        if existing_event is InputEventKey:
            InputMap.action_erase_event(action, existing_event)

    InputMap.action_add_event(action, event)



# controller_input.gd
@export var action: StringName


func _ready() -> void:
    var current_events := InputMap.action_get_events(action)
    for existing_event in current_events:
        if existing_event is InputEventJoypadButton:
            texture_rect.texture = get_texture(existing_event)
            break


func get_texture(event: InputEvent) -> Texture2D:
    # ...

    if texture != null:
        store_action(event)

    return texture


func store_action(event: InputEvent) -> void:
    var current_events := InputMap.action_get_events(action)
    # Clear any existing key events for this current action and replace it with
    # the new one.
    for existing_event in current_events:
        if existing_event is InputEventJoypadButton:
            InputMap.action_erase_event(action, existing_event)

    InputMap.action_add_event(action, event)
```

## Ongoing Testing

### Controller Input Passthrough

During testing of the controller inputs, I found that when assigning a D-pad button, the GUI would also accept that input and move the focus to the next button. This is not what I want, as I want the GUI to ignore the input and only use it for the control input. I found that this can be prevented with a simple `Control.accept_event()` when handling an `InputEvent` in a specific `Control`.

```
# control_input.gd
func _on_gui_input(event: InputEvent) -> void:
    # ...
    if texture == null:
        return

    accept_event()

    label.text = ""
    texture_rect.texture = texture

    # ...
```

### Keyboard Input Loading

During testing of the keyboard inputs, I found that the existing keys from the `InputMap` are not properly loaded. There seems to be an inconsistency with `InputEvents` from real input, and those stored in `InputMap`, where `InputEventKey.keycode` is `0`. Thankfully the Godot docs provide another property - `InputEventKey.physical_keycode` - which correlates to a US QUERTY keyboard layout. This can be converted back to a `Key` enum for the current keyboard layout.

```
func get_texture(event: InputEvent) -> Texture2D:
    if not event is InputEventKey:
        return
    var key_event := event as InputEventKey
    var scancode := key_event.keycode
    # When accessing InputMap, this is 0
    if scancode == 0:
        var physical := key_event.physical_keycode
        scancode = DisplayServer.keyboard_get_keycode_from_physical(physical)

    return textures.get(OS.get_keycode_string(scancode), null)
```

### Controller Input Initial Focus

I also found that for controller input to work in menus, one `Control` should grab the focus initially so the controller focus knows where to start.

```
# main_menu.gd
func _ready() -> void:
    play_button.grab_focus()
```

```
# options.gd
func _ready() -> void:
    tab_container.get_tab_bar().grab_focus()
```

### Saving Settings

The settings need to be saved between sessions, so the user does not have to set them every time they play the game. This is done by saving the settings to a file in the user's home directory. This is done in the `global.gd` script, which is autoloaded so `save_settings` can always be accessed.

### Restructuring

Since the video mode will be retrieved here, I have moved that logic to `global.gd`, which is used in `video.gd` to set the initial value of the dropdown.

```
# global.gd
enum {WINDOW_WINDOWED, WINDOW_FULLSCREEN, WINDOW_BORDERLESS}
enum {ANTIALIASING_DISABLED, ANTIALIASING_2X, ANTIALIASING_4X, ANTIALIASING_8X}

# ...


func get_window_mode() -> int:
    var mode := DisplayServer.window_get_mode()
    var borderless := DisplayServer.window_get_flag(DisplayServer.WINDOW_FLAG_BORDERLESS)
    var id := WINDOW_WINDOWED
    if mode == DisplayServer.WINDOW_MODE_EXCLUSIVE_FULLSCREEN:
        id = WINDOW_FULLSCREEN
    elif mode == DisplayServer.WINDOW_MODE_WINDOWED and borderless:
        id = WINDOW_BORDERLESS

    return id


func get_antialiasing() -> int:
    # msaa_2d and msaa_3d are the same here
    var antialiasing := get_viewport().msaa_2d
    var id = ANTIALIASING_DISABLED
    if antialiasing == Viewport.MSAA_2X:
        id = ANTIALIASING_2X
    elif antialiasing == Viewport.MSAA_4X:
        id = ANTIALIASING_4X
    elif antialiasing == Viewport.MSAA_8X:
        id = ANTIALIASING_8X

    return id



# video.gd
func _ready() -> void:
    var id: int = Global.get_window_mode()
    display_mode.select(id)

    var antialiasing: int = Global.get_antialiasing()
    anti_aliasing.select(id)

    # ...
```

## File Saving

### Video Settings

The settings are saved using a `ConfigFile`. This is a key-value store which maps to an "ini" (non-standard) file format. This is saved in the user's home directory.

```
# global.gd
## Config file for holding modified settings.
var settings := ConfigFile.new()


func save_settings() -> void:
    var vsync := DisplayServer.window_get_vsync_mode()
    var video_mode := get_window_mode()
    var video_antialiasing := get_antialiasing()
    var video_vsync_enabled := vsync == DisplayServer.VSYNC_ENABLED

    settings.set_value("video", "mode", video_mode)
    settings.set_value("video", "antialiasing", video_antialiasing)
    settings.set_value("video", "vsync", video_vsync_enabled)

    settings.save("user://settings.ini")
```

This is then called in `options.gd` when the options are being exited.

```
# options.gd
func _on_tree_exiting() -> void:
    Global.save_settings()
```

```
oliver in ~/.local/share/godot/app_userdata/A Level Project λ cat settings.ini
       File: settings.ini
   1   [video]
   2
   3   mode=0
   4   antialiasing=1
   5   vsync=true
```

### Audio Settings

The audio settings saving is similar to the video settings. The settings are saved as a mapping of bus index to volume in decibels.

```
# global.gd
func save_settings() -> void:
    var bus_count := AudioServer.bus_count
    for bus in range(bus_count):
        var db := AudioServer.get_bus_volume_db(bus)
        settings.set_value("audio", str(bus), db)

    # ...
```

```
File: /home/oliver/.local/share/godot/app_userdata/A Level Project/settings.ini
[audio]

0=0.0
1=0.0
2=0.0

[video]

mode=0
antialiasing=0
vsync=true
```

## Control Settings

The control settings need to store a key event and a joypad button event for each action. `store_event` is a separate function to reduce the size of `save_settings` as there were too many indents for it to be easily readable.

```gdscript
# global.gd
func save_settings() -> void:
    # ...

    var actions := InputMap.get_actions()
    for action in actions:
        # ui_* are default UI traversal controls.
        if not action.begins_with("ui_"):
            var events := InputMap.action_get_events(action)
            for event in events:
                store_event(action, event)

    # ...


func store_event(action: StringName, event: InputEvent) -> void:
    if event is InputEventKey:
        # Similar to prompts/resources/keys.gd#get_texture
        var key_event := event as InputEventKey
        var keycode := key_event.keycode
        if keycode == 0:
            var physical := key_event.physical_keycode
            keycode = DisplayServer.keyboard_get_keycode_from_physical(physical)

        settings.set_value("controls", action + "_key", keycode)
    elif event is InputEventJoypadButton:
        var joypad_event := event as InputEventJoypadButton
        var button := joypad_event.button_index

        settings.set_value("controls", action + "_control", button)
```

File: /home/oliver/.local/share/godot/app_userdata/A Level Project/settings.ini

```
[audio]

0=0.0
1=0.0
2=0.0

[video]

mode=0
antialiasing=0
vsync=true

[controls]

use_item_1_key=54
use_item_1_control=13
use_item_2_key=50
use_item_2_control=11
use_item_3_key=51
use_item_3_control=14
```

## Ongoing Testing

### Anti-Aliasing Loading

During testing of saving video settings, I found that antialiasing was always disabled. I found out that `ProjectSettings` is not needed for this, and it can be set directly as `Viewport.msaa_2d` and `Viewport.msaa_3d` in `video.gd`.

```
# video.gd
func _on_anti_aliasing_item_selected(index: int) -> void:
    var viewport := get_viewport()
    if index == 0:
        viewport.msaa_2d = Viewport.MSAA_DISABLED
        viewport.msaa_3d = Viewport.MSAA_DISABLED
    elif index == 1:
        viewport.msaa_2d = Viewport.MSAA_2X
        viewport.msaa_3d = Viewport.MSAA_2X
    elif index == 2:
        viewport.msaa_2d = Viewport.MSAA_4X
        viewport.msaa_3d = Viewport.MSAA_4X
    elif index == 3:
        viewport.msaa_2d = Viewport.MSAA_8X
        viewport.msaa_3d = Viewport.MSAA_8X
```

## File Loading

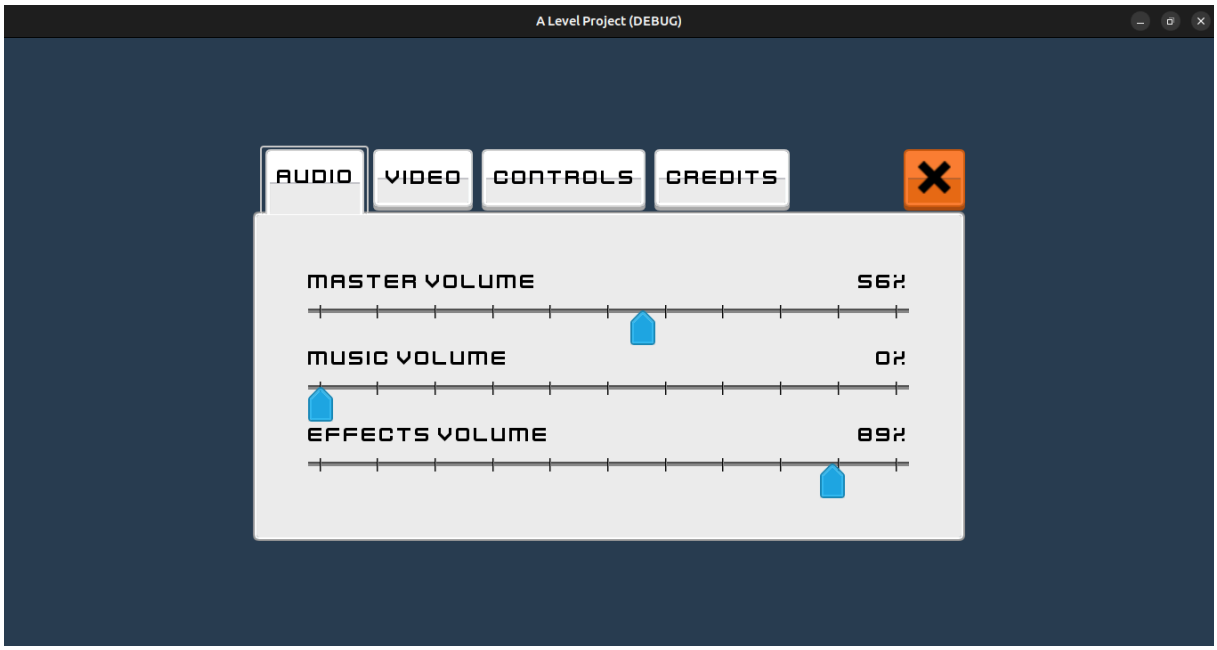
### Audio Settings

The settings are now saved to `settings.ini`. They need to be loaded when the game is ran. This can be done in `Global._ready` by loading the settings from the file and setting the values in the game in the global singletons `DisplayServer`, `AudioServer` and `InputMap`.

`SETTINGS_PATH` is moved to a constant as it is used in both `save_settings` and `load_settings`.

```
# global.gd
const SETTINGS_PATH = "user://settings.ini"
```

```
# ...


func _ready() -> void:
    load_settings()


func load_settings() -> void:
    var err := settings.load(SETTINGS_PATH)
    if err == ERR_FILE_CANT_OPEN:
        return

    # Audio
    var buses := settings.get_section_keys("audio")
    for bus in buses:
        var db: int = settings.get_value("audio", bus)
        var index := int(bus)
        AudioServer.set_bus_volume_db(index, db)
```




The options shown above in the screenshots are being loaded as decibels and stored in `AudioServer`.

### Video Settings

For video settings, I moved the logic of setting window mode and antialiasing out from `video.gd` and into `global.gd` so they can be used by both.

```
# global.gd
func set_window_mode(mode: int) -> void:
    if mode == 0:
        # Windowed windows have a border and this sets it to maximised for a
        # consistent size when switching away from fullscreen.
        DisplayServer.window_set_flag(DisplayServer.WINDOW_FLAG_BORDERLESS, false)
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_MAXIMIZED)
    elif mode == 1:
        DisplayServer.window_set_position(Vector2i(0, 0))
        # Exclusive fullscreen has a lower overhead as it usually avoids
```

```
        # the display compositor.
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_EXCLUSIVE_FULLSCREEN)
    elif mode == 2:
        # Fullscreen borderless is a full screen sized window without a border.
        # It usually works better with multiple monitor setups when alt+tab/esc
        # in windows.
        DisplayServer.window_set_mode(DisplayServer.WINDOW_MODE_MAXIMIZED)
        DisplayServer.window_set_size(DisplayServer.screen_get_size())
        DisplayServer.window_set_flag(DisplayServer.WINDOW_FLAG_BORDERLESS, true)
        DisplayServer.window_set_position(Vector2i(0, 0))


func set_antialiasing(mode: int) -> void:
    var viewport := get_viewport()

    if mode == 0:
        viewport.msaa_2d = Viewport.MSAA_DISABLED
        viewport.msaa_3d = Viewport.MSAA_DISABLED
    elif mode == 1:
        viewport.msaa_2d = Viewport.MSAA_2X
        viewport.msaa_3d = Viewport.MSAA_2X
    elif mode == 2:
        viewport.msaa_2d = Viewport.MSAA_4X
        viewport.msaa_3d = Viewport.MSAA_4X
    elif mode == 3:
        viewport.msaa_2d = Viewport.MSAA_8X
        viewport.msaa_3d = Viewport.MSAA_8X


func load_settings() -> void:
    # ...

    # Video
    var mode: int = settings.get_value("video", "mode")
    set_window_mode(mode)

    var antialiasing: int = settings.get_value("video", "antialiasing")
    set_antialiasing(antialiasing)

    var vsync: bool = settings.get_value("video", "vsync")
    if vsync:
        DisplayServer.window_set_vsync_mode(DisplayServer.VSYNC_ENABLED)
    else:
        DisplayServer.window_set_vsync_mode(DisplayServer.VSYNC_DISABLED)
```

### Control Settings

The control settings are loaded in a similar way to the video settings. The settings are loaded from the file and set in the game in the global singleton `InputMap`. Each setting is either a `*_key` or a `*_control` so they have to be handled differently.

```
func load_settings() -> void:
    # ...

    # Controls
    var controls := settings.get_section_keys("controls")
    for stored_control in controls:
        if stored_control.ends_with("_key"):
            var control := stored_control.trim_suffix("_key")
```

```
        for existing_event in InputMap.action_get_events(control):
            if existing_event is InputEventKey:
                InputMap.action_erase_event(control, existing_event)

        var new_event := InputEventKey.new()
        new_event.keycode = settings.get_value("controls", stored_control)
        InputMap.action_add_event(control, new_event)

    elif stored_control.ends_with("_control"):
        var control := stored_control.trim_suffix("_control")
        for existing_event in InputMap.action_get_events(control):
            if existing_event is InputEventJoypadButton:
                InputMap.action_erase_event(control, existing_event)

        var new_event := InputEventJoypadButton.new()
        new_event.button_index = settings.get_value("controls", stored_control)
        InputMap.action_add_event(control, new_event)
```

## Review: Setup & Menus

### Progress Made

The program runs, and the options menu is fully functional. The settings are saved and loaded from a file in the user's home directory. The settings are also applied to the game when it is loaded. Extra key-binds can be added later when necessary.

This means that I now have a program with the main menu and options menu fully functional, providing the base for a game to be built on top of.

### Testing Done

| Aspect Tested | Input | Expected Output | Actual Output | Comments/ Resolution |
|---|---|---|---|---|
| Quit button | Run game -> press quit | Game closes | Game closes | |
| Options exit | Open options -> press close | Options close and return to main menu | Options close and return to main menu | |
| Video settings | Change window mode | Window mode changes | Window mode changes | The difference between fullscreen and windowed fullscreen was verified using the X11 `xprops` program (via `xwayland`). |
| Video settings | Change video settings -> close | Settings are as they were set | Antialiasing was always "disabled" | This was resolved in Anti-Aliasing Loading |

| | | | | |
|---|---|---|---|---|
| | game -> reopen options | | | |
| Audio settings | Modify audio sliders | Audio played with different buses changes volume | Audio played with different buses changes volume | This was tested by adding a new `AudioStreamPlayer` to the UI and changing what audio bus it uses. |
| Audio settings | Change audio settings -> close game -> reopen options | Settings are as they were set | Settings are as they were set | |
| Control settings | Using a controller -> change control settings | Controller textures change depending on the device used | Controller textures change depending on the device used | This was tested by using a PS5 controller and a Nintendo Switch Pro controller. |
| Control settings | Change control settings -> close game -> reopen options | Settings are as they were set | Settings were blank, not even the default setting | This was solved in Keyboard Input Loading before file loading was implemented, this was to do with `InputMap` and not storing settings. |
| Controller support | Using a controller -> navigate menus | Controller navigates menus | D-pad and left stick have no effect | This was solved in Controller Input Initial Focus, and then was tested using a PS5 controller and a Nintendo Switch Pro controller once solved. |

### Links to Success Criteria

- Clear main menu
- Full-screen and windowed options
- Simple to understand controls
- Keyboard and mouse controls
- Support for controllers
- Includes a settings menu
- Quit button in the main menu
- Configurable controls

- Adjustable volume

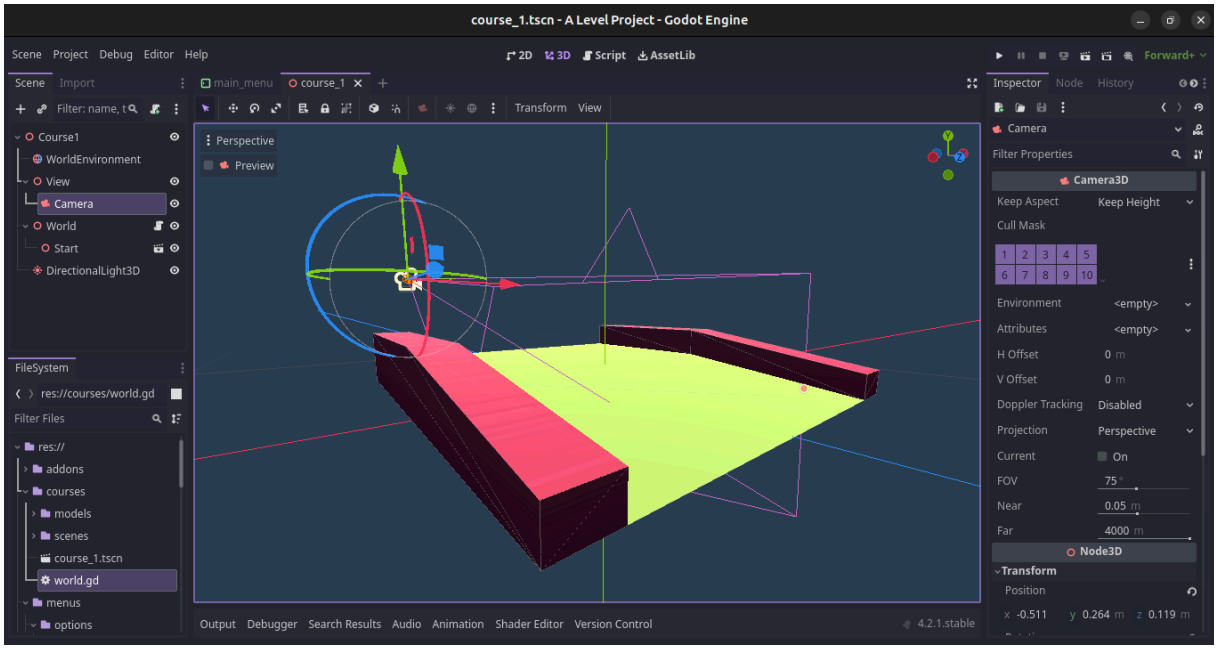
# Stage 2: Course Creation & Initial Physics

## Ball Placement

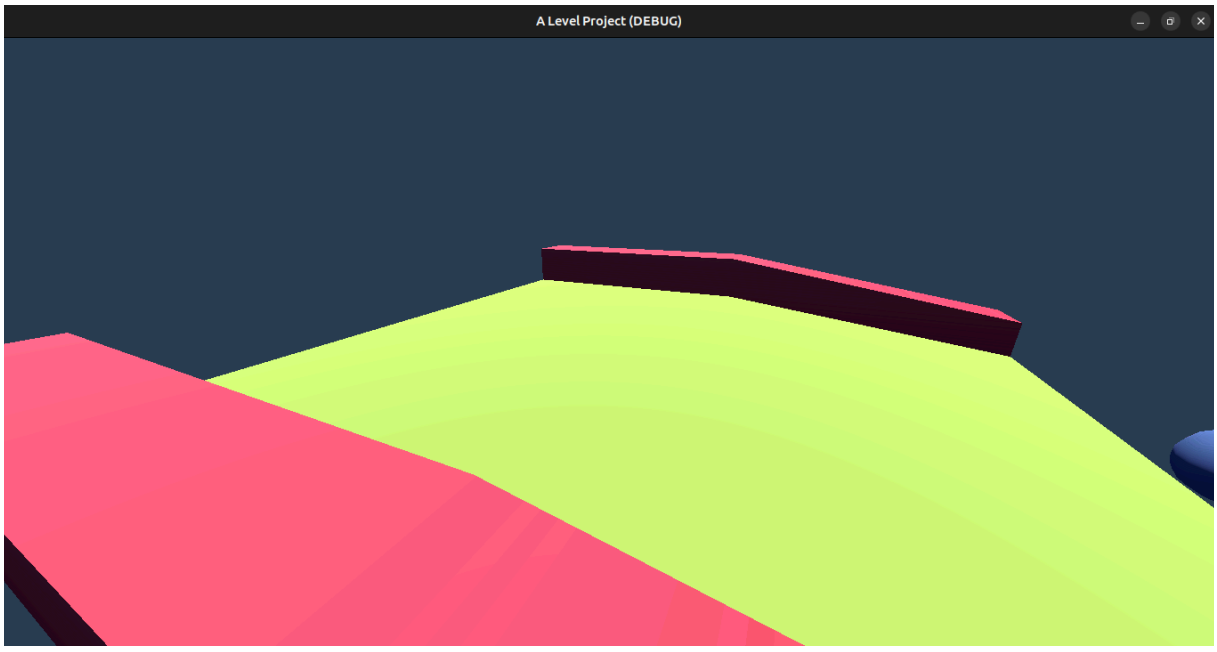
Firstly, I wanted to test to make sure my models of the course and ball work okay with Godot.

I created a scene with a `Camera3D`, and programatically added a ball just above a `Start` platform.

```
# world.gd
extends Node3D

const BALL_BLUE = preload("res://courses/scenes/ball_blue.tscn")


func _ready() -> void:
    var ball: Node3D = BALL_BLUE.instantiate()
    add_child(ball)
    ball.position = Vector3(0, 0.09, 0.1)
```



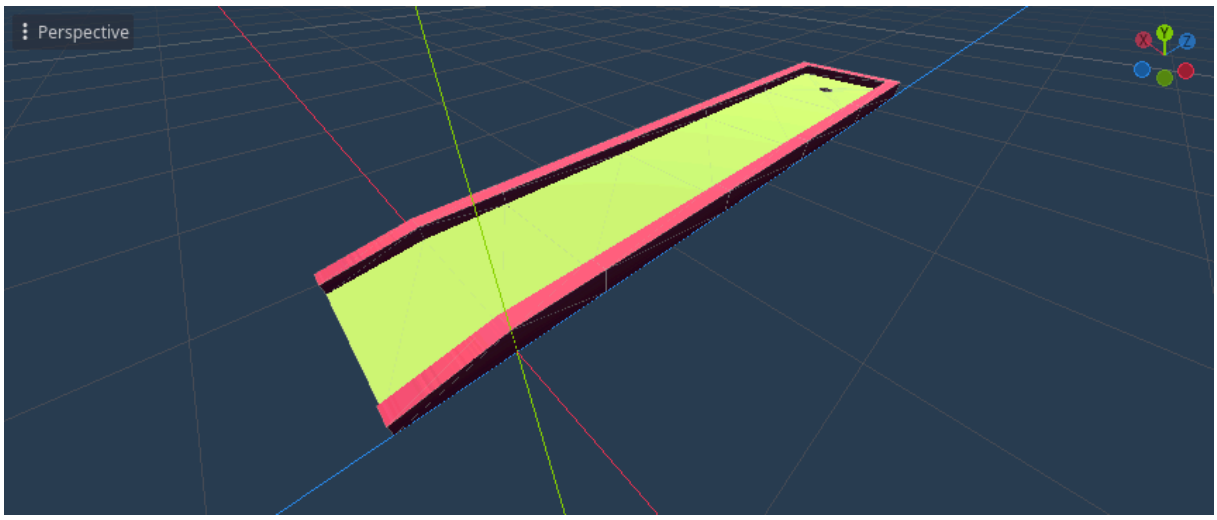

This worked, the ball went down the slope and off the edge (as there is no ground). This is a good start, this means that my `RigidBody3D` ball and `StaticBody3D` platforms have the correct collision meshes/boxes.




## First Course Design

### Hole 1

The first hole will just be like a practice hole, a simple straight towards an open hole. This also makes it easy for me to test the physics of the ball and the course with only perpendicular surfaces.




### Wall Collisions

The ball needed to bounce off the horizontal walls of this hole. I overrode the `_physics_process` method of the ball as the default is to `move_and_slide` along the walls. The correction for `linear_velocity.y` to be `0` is because I would find the ball fall through and collide with the intersections of the floor collision mesh.

```gdscript
# ball.gd
extends RigidBody3D


func _physics_process(delta: float) -> void:
    var collision := move_and_collide(linear_velocity * delta)
    if collision:
        var normal := collision.get_normal()

        # Keep the ball on the ground, not fall through.
        if normal.y != 0:
            linear_velocity.y = 0

        # Bounce off walls.
        if normal.x != 0 or normal.z != 0:
            var new_velocity := linear_velocity.bounce(normal)
            linear_velocity.x = new_velocity.x
            linear_velocity.z = new_velocity.z
```

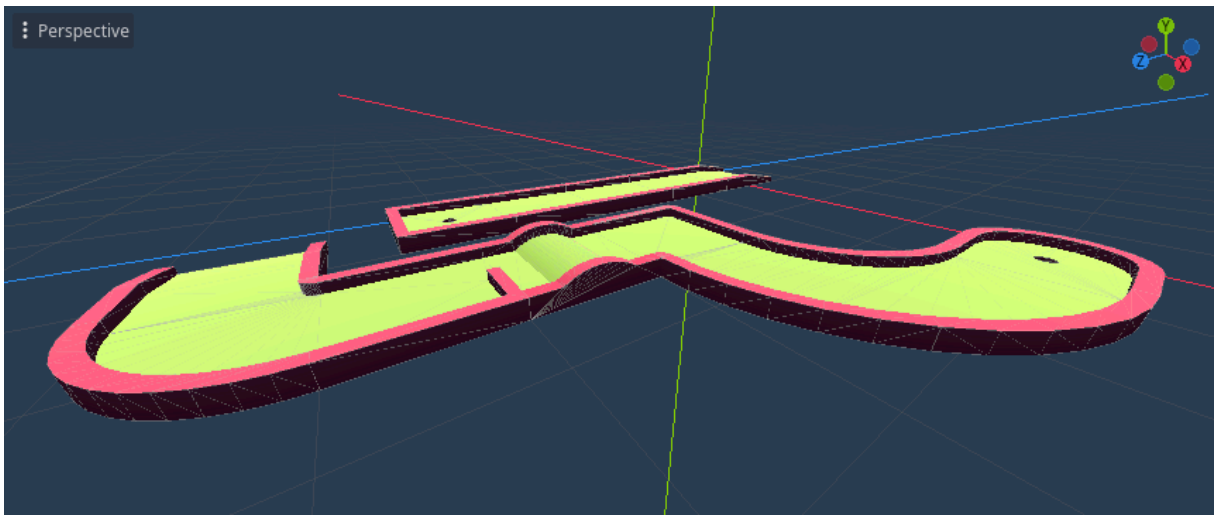
### Stop Rolling

The ball would continue moving, slowing down due to angular and linear velocity dampening but not slowing down enough to stop completely. I added an exported variable to the ball to set the minimum velocity, and if the ball's velocity is below this, it is set to `Vector3.ZERO`.

```gdscript
@export var MIN_VELOCITY: float = 0.3


func _physics_process(delta: float) -> void:
    # ...

    # Stop the ball rolling forever.
    if linear_velocity.length() < MIN_VELOCITY:
        linear_velocity = Vector3.ZERO
```

### Hole 2

The second hole will be a bit more complex, with a bend and a hill. This will test the ball's ability to go up and down slopes, and around corners.



### Slope Collisions

As the ball goes up and down slopes, `move_and_collide` does not work as expected as sometimes it may collide with the slope itself. I found that simply detecting if the collision is not horizontal and ignoring it if so, works well.

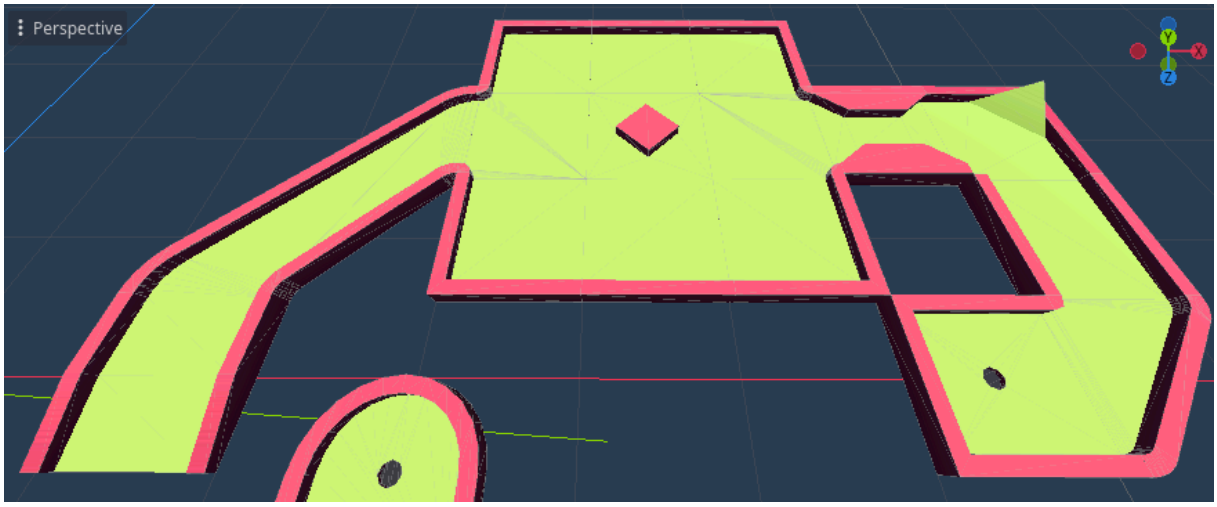
```
func _physics_process(delta: float) -> void:
    # ...

        if normal.y != 0 and normal.y != 1:
            return
```

### Inelastic Collisions

Collisions with a wall should not bounce back with the same velocity, as this is not realistic. I added a `elasticity` property to the ball to control how much it bounces off walls.

```
@export var ELASTICITY: float = 0.9


func _physics_process(delta: float) -> void:
    # ...

        # Bounce off walls.
        if normal.x != 0 or normal.z != 0:
            var new_velocity := linear_velocity.bounce(normal) * ELASTICITY
            linear_velocity.x = new_velocity.x
            linear_velocity.z = new_velocity.z

    # ...
```

### Hole 3

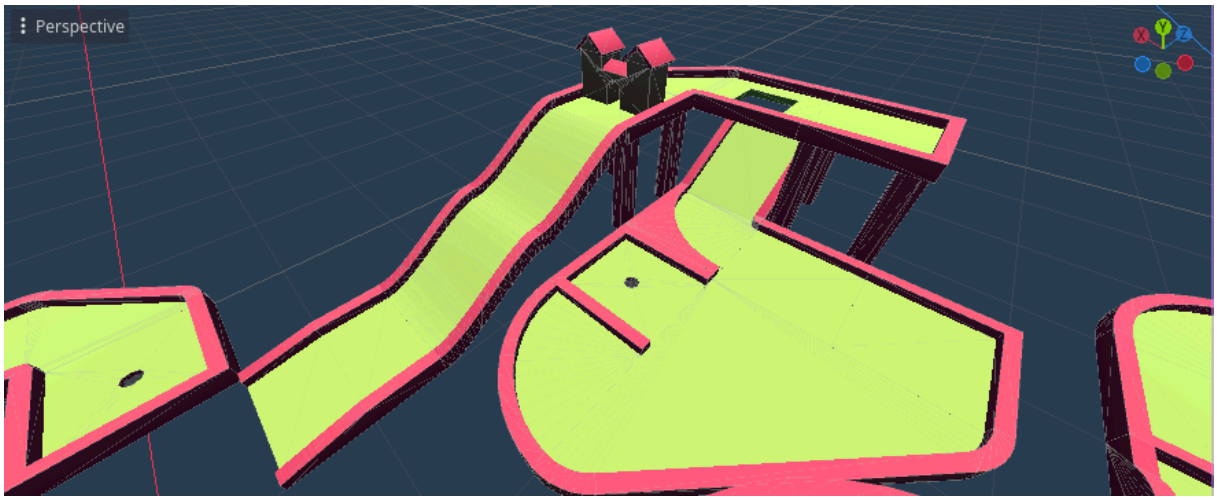



This hole has nothing different in terms of physics, as the slope is handled fine just like the previous hole's hill.

### Hole 4

### Slope Climbing

Hole 3 has nothing extra interesting, but hole 4 has a ramp up to the main part of the hole.

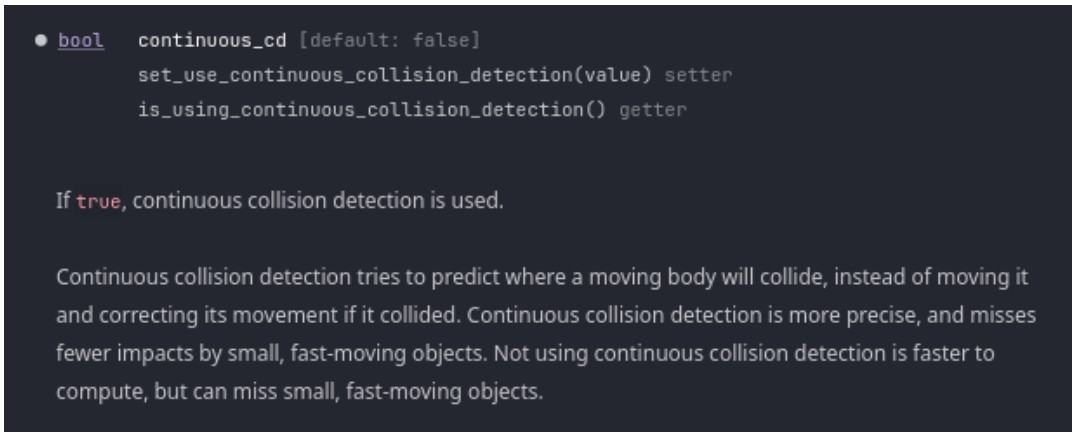



During testing of the ball rolling up the slope, at a high enough velocity the ball would clip through the ground. I found that this is because when it collides with the ground, `normal.y` is not `0` so `linear_velocity.y` would be set to `0` and disallow the ball to climb the slope.

To solve this I only compensate for falling through the floor when `normal.y == 0`, otherwise all components of `linear_velocity` would be bounced on a collision.

```
extends RigidBody3D

@export var MIN_VELOCITY: float = 0.03
@export var ELASTICITY: float = 0.9


func _physics_process(delta: float) -> void:
    var collision := move_and_collide(linear_velocity * delta)
    if collision:
        var normal := collision.get_normal()

        # Don't fall through the floor.
        if normal.y == 1:
            linear_velocity.y = 0
            return

        # Bounce off walls.
        if normal.x != 0 or normal.z != 0:
            linear_velocity = linear_velocity.bounce(normal) * ELASTICITY

    # ...
```

### Continuous Collision Detection




I found the "Continuous CD" setting in the `RigidBody3D` node, which is used to prevent the ball from clipping through collision boxes. It does this by predicting collisions before they happen, which works well for small, fast moving objects. This allowed me to remove the following code:

```
if normal.y == 1:
    linear_velocity.y = 0
    return
```

## Review: Course Creation & Initial Physics

### Progress Made

I now have the course and ball working well together. The ball can roll around the course, bounce off walls and slopes, and stop when it reaches a low enough velocity. The course has a few holes to test the ball's physics, and the ball can climb slopes and go around corners.

### Testing Done

| Aspect Tested | Input | Expected Output | Actual Output | Comments/ Resolution |
|---|---|---|---|---|
| Wall collisions | Ball hits wall | Ball bounces off wall | Ball bounces off wall | |
| Roll ball at low velocity | Ball stops moving | Ball stops moving | Ball stops moving | |
| Slope collisions | Send ball rolling up slope | Ball goes up slope | Ball stops and rolls back down when going too fast | This was solved in Slope Climbing |
| Ball stays on course | Send ball rolling around course | Ball stays on course | Ball falls through floor or | This was solved in Continuous Collision Detection |

| | | | | |
|---|---|---|---|---|
| | | | clips through walls | |
| Ball loses more velocity when colliding | Send ball rolling into wall | Ball loses velocity when colliding | Ball loses velocity when colliding | |

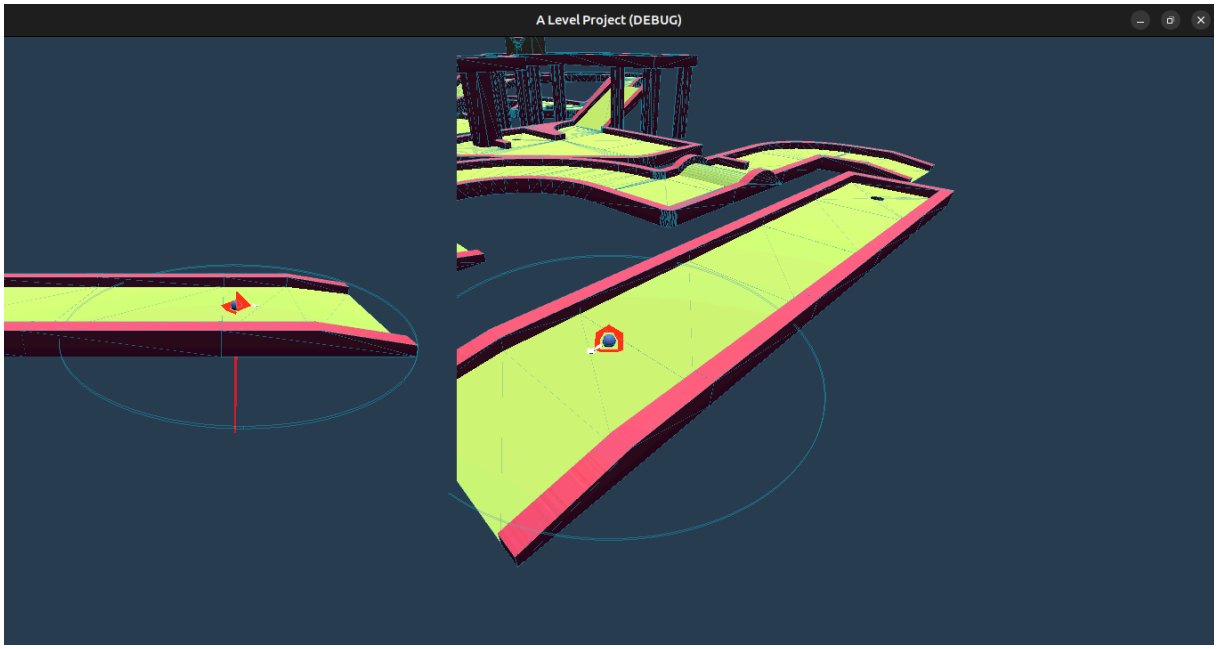
### Links to Success Criteria

- Simple graphics
- Ball rolls naturally
- Ball collides with obstacles

## Stage 3: Controls & Camera

### Point Controls

First off is drafting out the point and drag controls for the ball. This requires finding where the mouse is "in 3D space" relative to the ball. This can be done via drawing an invisible circle around the ball and finding the point where a ray cast from the camera to the mouse intersects the circle.

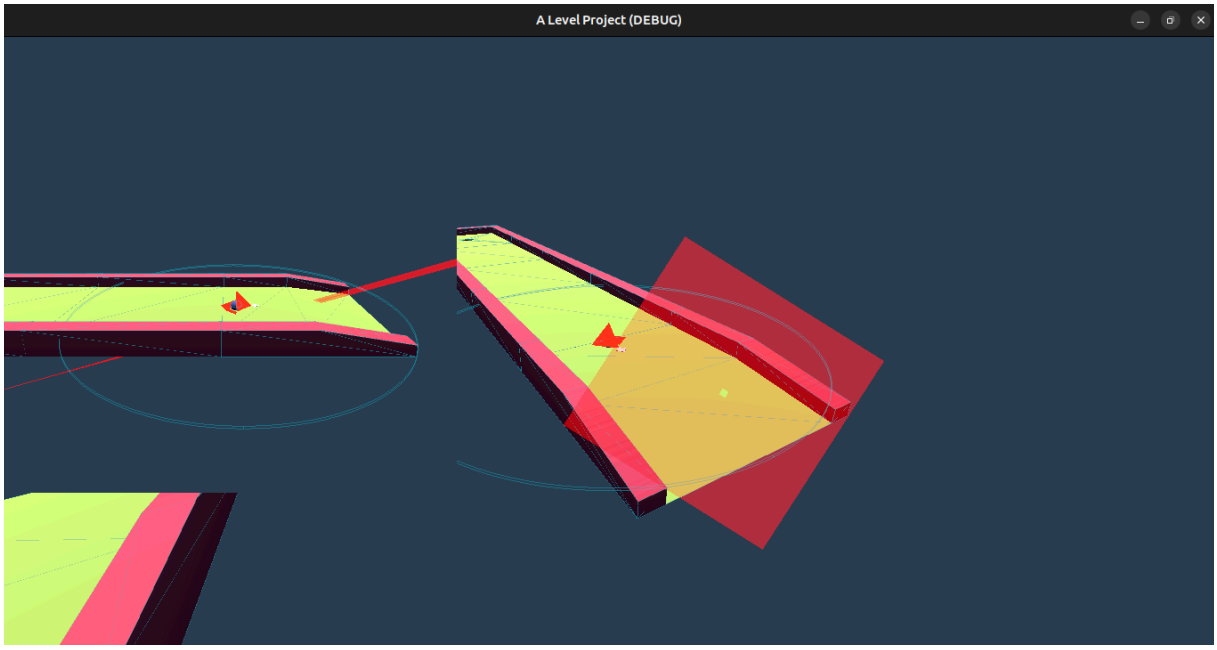


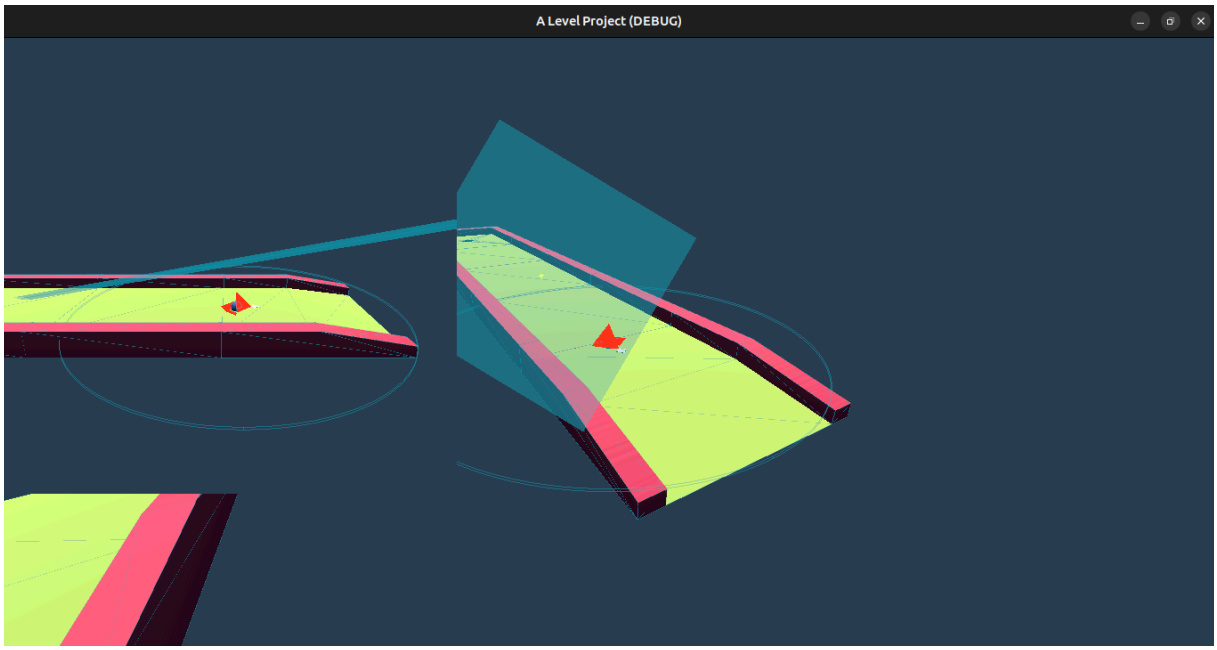

```
# player.gd
extends Node3D

@onready var ray_cast: RayCast3D = %RayCast
@onready var camera: Camera3D = %Camera
```

```
func get_control_position(mouse_position: Vector2) -> Vector3:
    # Draw a ray cast from the camera, to the mouse position far away.
    # The ray is configured to only collide with the ball control plane,
    # so the collision is the mouse position in the same plane as the ball.
    var origin := camera.project_ray_origin(mouse_position)
    var direction := camera.project_ray_normal(mouse_position)
    var ray_length := camera.far
    var end := direction * ray_length
    ray_cast.global_position = origin
    ray_cast.target_position = end

    return ray_cast.get_collision_point()


func _input(event: InputEvent) -> void:
    # Temporary code to test the use of the ray cast.
    if event is InputEventMouseMotion:
        var mouse_event := event as InputEventMouseMotion
        var mouse_position := mouse_event.position

        var mouse_position_3d = get_control_position(mouse_position)
```

This results in correct detection by the ray, showing as red in this debug mode when colliding, and blue otherwise.

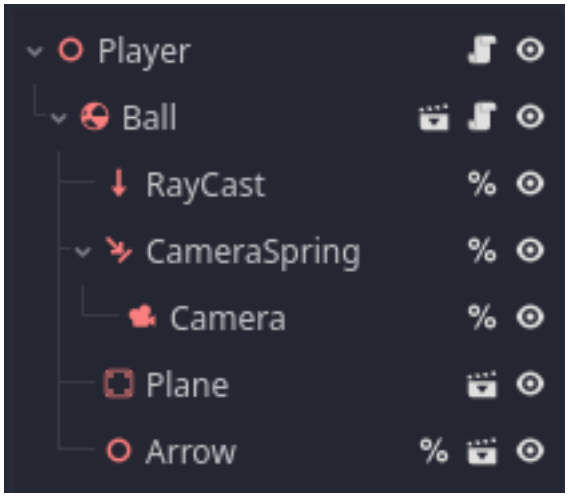
The ray can be seen in the debugging sub-viewport in the top left, and by the centre of the box in the main camera.






## Pivot Camera

To be able to properly use these controls, the camera must be able to pivot around the ball. This is done by attaching the camera to a spring arm that can pivot around the ball.




The pivoting is operated by click and dragging the right mouse button. Joystick controls can be added later.

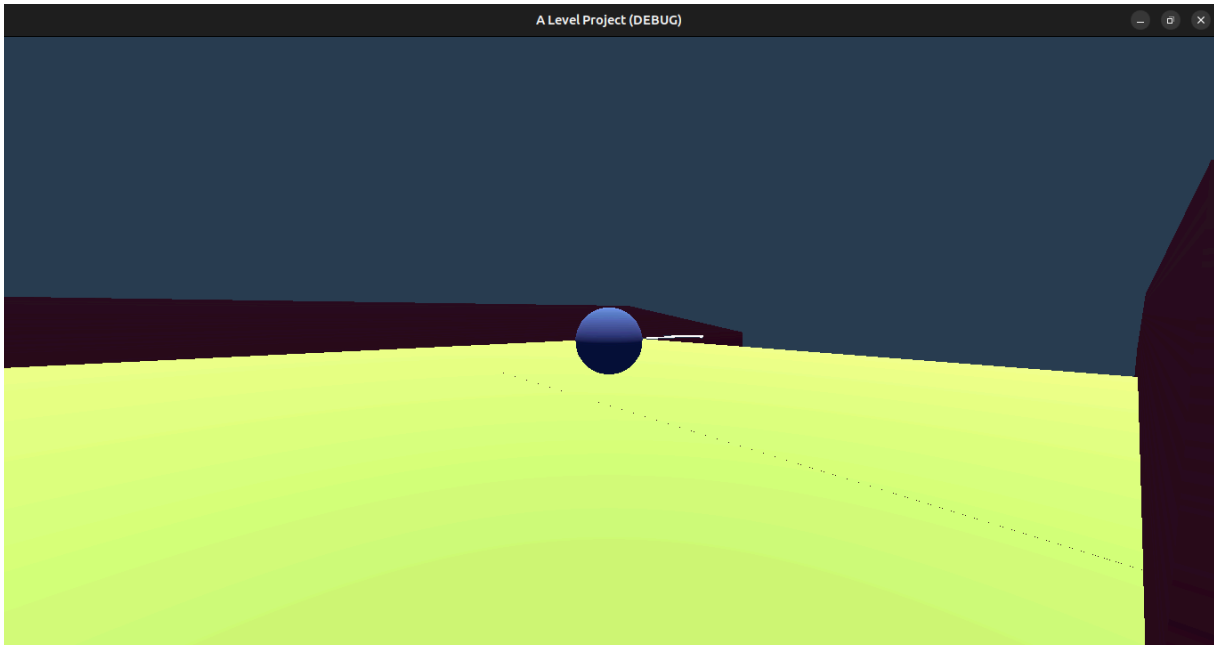
```
# player.gd
var mouse_sensitivity: int = 1

# ...

func _input(event: InputEvent) -> void:
    if event is InputEventMouseButton:
        var mouse_event := event as InputEventMouseButton
        # Pivot camera on right click drag.
        if mouse_event.button_index == MOUSE_BUTTON_RIGHT:
```

```
            if mouse_event.pressed:
                if Input.get_mouse_mode() == Input.MOUSE_MODE_VISIBLE:
                    Input.set_mouse_mode(Input.MOUSE_MODE_CAPTURED)
            else:
                if Input.get_mouse_mode() == Input.MOUSE_MODE_CAPTURED:
                    Input.set_mouse_mode(Input.MOUSE_MODE_VISIBLE)
    elif event is InputEventMouseMotion:
        var mouse_event := event as InputEventMouseMotion
        # Rotate camera spring arm when pivot button is down.
        if Input.get_mouse_mode() == Input.MOUSE_MODE_CAPTURED:
            # Invert mouse movements as the coordinate origin is different.
            var rotation_y := deg_to_rad(-mouse_event.relative.x * mouse_sensitivity)
            var rotation_x := deg_to_rad(-mouse_event.relative.y * mouse_sensitivity)

            camera_spring.rotation.x += rotation_x
            camera_spring.rotation.y += rotation_y
```

`mouse_sensitivity` should be added to the options menu later.

The camera has no reason to go lower than 45° below horizontal, so that is restricted by clamping the rotation values after they are changed.

```
# ...

camera_spring.rotation.x += rotation_x
# Restrict camera from rotating more than 45° from horizontal downwards.
camera_spring.rotation.x = clampf(camera_spring.rotation.x, -PI/2, PI/4)
camera_spring.rotation.y += rotation_y
```




## Ongoing Testing

### Ball Idle Bouncing

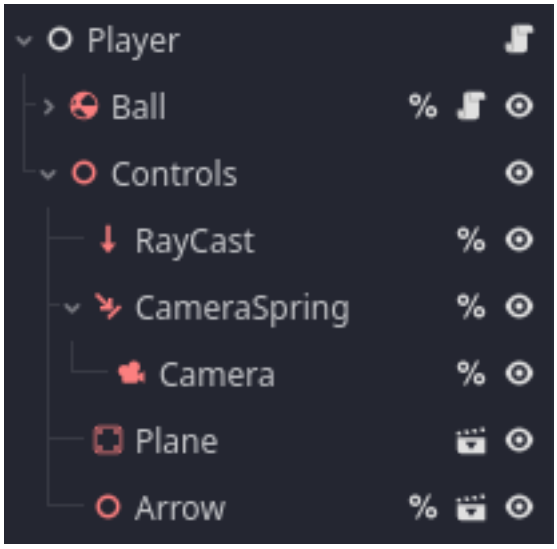
I found when the ball is idle, it would bounce up and down slightly. This is because the ball is a `RigidBody3D` and has gravity applied to it, which would

try to pull the ball through the ground. I found the easiest way to solve this at least for now is to just set the ball's `linear_velocity.y` to `0` when it is idle.

```
# ball.gd
func _physics_process(delta: float) -> void:
    # ...
    if collision:
        var normal := collision.get_normal()

        # Prevent ball from bouncing off the ground when stationary.
        if normal == Vector3(0, 1, 0):
            if linear_velocity.x == 0 and linear_velocity.z == 0:
                linear_velocity = Vector3.ZERO

        # ...
```

### Camera Rotation

When testing if the camera follows the ball correctly, I found that the camera also rotated with the ball as it was a child of the ball node. I solved this by restructuring the player scene so that the ball and everything else were siblings.




This also meant that the whole of the `Controls` node needed to be repositioned as the `Ball` moved. This was a simple fix by updating the position every tick like so:

```
# player.gd
func _process(_delta: float) -> void:
    # Keep controls centred on the ball.
    controls.position = ball.position
```

## Drag Controls

### Left Click Handling

To continue with the point and drag controls, there needs to be a way to differentiate between when a mouse drag is for pivoting the camera or dragging the arrow. This can be done with an enum like so:

```
enum Action { PIVOTING, DRAGGING, NONE }

var action: Action = Action.NONE

# ...

func _input(event: InputEvent) -> void:
    if event is InputEventMouseButton:
        var mouse_event := event as InputEventMouseButton
        # Pivot camera on right click drag.
        if mouse_event.button_index == MOUSE_BUTTON_RIGHT:
            if mouse_event.pressed:
                if action == Action.NONE:
                    Input.set_mouse_mode(Input.MOUSE_MODE_CAPTURED)
                    action = Action.PIVOTING
            else:
                if action == Action.PIVOTING:
                    Input.set_mouse_mode(Input.MOUSE_MODE_VISIBLE)
                    action = Action.NONE
    elif event is InputEventMouseMotion:
        var mouse_event := event as InputEventMouseMotion
        # Rotate camera spring arm when pivot button is down.
        if action == Action.PIVOTING:
            # ...
```

I only want left click to work when the mouse cursor is close enough to the ball, otherwise it should pivot the camera instead.

This means I need to make sure `get_control_position` is relative to the ball's position to be able to get the distance away.

This can be done simply by subtracting the ball's global position vector from the ray cast.

```
func get_control_position(mouse_position: Vector2) -> Vector3:
    # ...

    return ray_cast.get_collision_point() - ball.position
```

This correctly results in values close to 0.5 (radius of the plane) on the cardinal directions.

```
(0.008965, 0.005, 0.499812)
(0.008965, 0.005, 0.499812)
(-0.493089, 0.005, -0.006724)
(-0.493089, 0.005, -0.006724)
(-0.008965, 0.005, -0.481883)
(-0.008965, 0.005, -0.481883)
(-0.008965, 0.005, -0.481883)
(-0.008965, 0.005, -0.481883)
(0.497572, 0.005, 0.002241)
```

Now left click can be handled just like right click, starting with the if condition:

```
# player.gd
func _input(event: InputEvent) -> void:
    if event is InputEventMouseButton:
        var mouse_event := event as InputEventMouseButton
        # Pivot camera on right click drag.
        if mouse_event.button_index == MOUSE_BUTTON_RIGHT:
            # ...
        # Drag ball controls with left click, but only if close enough, else
        # pivot camera.
        elif mouse_event.button_index == MOUSE_BUTTON_LEFT:
```

When the left mouse button is pressed down, there needs to be a condition deciding whether this is a drag of the controls or a pivot of the camera. This requires the mouse position, to get the distance from the ball.

```
if mouse_event.pressed:
    var mouse_position := get_viewport().get_mouse_position()
    var control_position := get_control_position(mouse_position)
```

There should be a maximum distance away from the ball that the mouse can be to drag the controls. This means that the distance between the mouse and the ball needs to be calculated. This can be done by getting the length of the vector like so:

```
var ball_distance := control_position.length()
```

The maximum distance can be set as a constant in the `player,gd` file.

```
## Distance from ball to consider a gesture a drag.
@export var DRAG_THRESHOLD: float = 0.2
```

Which can then be used to decide what action is happening, and capture the mouse only when pivoting:

```
if ball_distance < DRAG_THRESHOLD:
    action = Action.DRAGGING
else:
    Input.set_mouse_mode(Input.MOUSE_MODE_CAPTURED)
    action = Action.PIVOTING
```

If the left mouse button is released, this is when the ball should be "fired" in the direction and power of the drag, which comes later, so for now I will just cancel the current action.

```
if action != Action.NONE:
    Input.set_mouse_mode(Input.MOUSE_MODE_VISIBLE)
    action = Action.NONE
```

This all results in the following code:

```
## Distance from ball to consider a gesture a drag.
@export var DRAG_THRESHOLD: float = 0.2

# ...

func _input(event: InputEvent) -> void:
    if event is InputEventMouseButton:
        var mouse_event := event as InputEventMouseButton

        # ...

        # Drag ball controls with left click, but only if close enough, else
        # pivot camera.
        elif mouse_event.button_index == MOUSE_BUTTON_LEFT:
            if mouse_event.pressed:
                var mouse_position := get_viewport().get_mouse_position()
                var control_position := get_control_position(mouse_position)
                var ball_distance := control_position.length()
                if ball_distance < DRAG_THRESHOLD:
                    action = Action.DRAGGING
                else:
                    Input.set_mouse_mode(Input.MOUSE_MODE_CAPTURED)
                    action = Action.PIVOTING
            else:
                if action != Action.NONE:
                    Input.set_mouse_mode(Input.MOUSE_MODE_VISIBLE)
                    action = Action.NONE
```

### Drag Motion Handling

When the mouse is moved while the left mouse button is down, the control arrow should rotate and scale in the opposite direction and magnitude of the mouse movement to show the direction and power of the ball.

At the current scale, the arrow is at around 0.15 away from the ball, which seems like a good minimum power as the arrow is still easily visible. The maximum scale to get to 0.5 away from the ball is 4.5, so the scale can be clamped between these values.

Not only should the z direction be scaled for length, but the x direction should balance out the shape slightly so the arrow isn't so thin long and thick when short. The following values I found were best for this:

| z scale | x scale |
|---|---|

| | |
|---|---|
| 1 | 0.5 |
| 2 | 0.75 |
| 3 | 1 |
| 4 | 1.25 |
| 5 | 1.5 |

This gives the following mathematical function for the scale:

$S_x = 1 + (S_z - 3) * 0.25$

When $S_z$ is 1, $S_x$ results in $1 + (-2 * 0.25)$ which is correctly $0.5$.

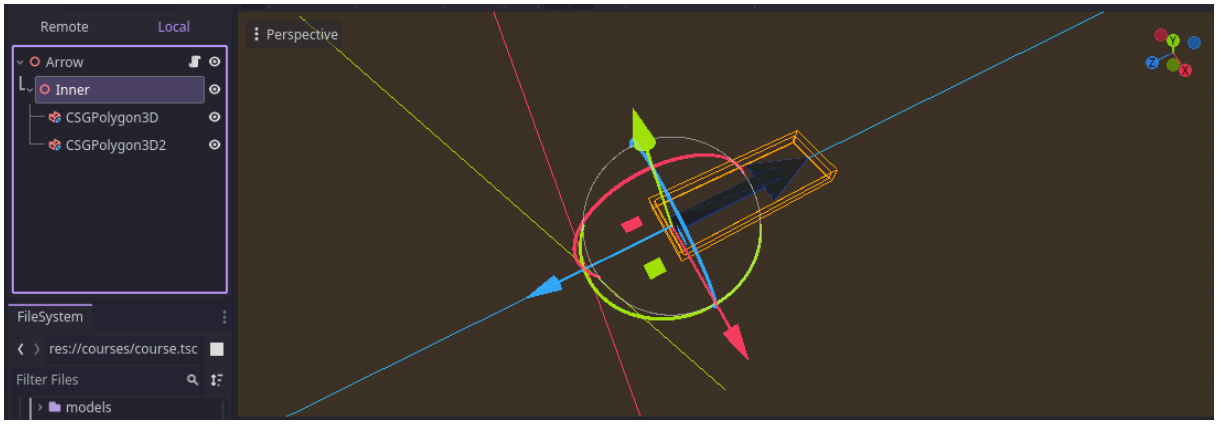
$S_z$ needs to also be calculated from the distance from the ball, ranging from $0.15 \to 1$ to $0.55 \to 4.5$. This ends up with the following linear function:

$S_z = 10 * d - 0.5$

Both of these equations can be easily implemented:

```
## Convert a distance to an approximately appropriate scale.
func _distance_to_z_scale(distance: float) -> float:
    distance = clampf(distance, 0.15, 5)
    return 10 * distance - 0.5


## Map a z scale to an appropriate x scale.
func _z_scale_to_x(z_scale: float) -> float:
    return 1 + (z_scale - 3) * 0.25
```

We can then create a function to resize and rotate the arrow based off a 3D position. First here is the structure of the arrow scene:




`$Inner` contains the arrow shapes and is offset. This is the part which should be scaled to retain the same offset from the ball.

This means we need to get the `Inner` node in our script

```
# arrow.gd
class_name Arrow
```

```
extends Node3D

@onready var inner: Node3D = $Inner
```

The previous functions can then be used to get the x and z scale for the inner node.

```
## Rotate and scale the arrow opposite to the given `position`.
func move_to(mouse_position: Vector3) -> void:
    var z_scale := _distance_to_z_scale(mouse_position.length())
    var x_scale := _z_scale_to_x(z_scale)
```

The angle is needed for the rotation, this can be done by getting the angle between the mouse vector and the vector at angle 0.
`Vector3.signed_angle_to` uses the current vector it is called on, and the first parameter to calculate an angle, through the reference of the axis provided in the second parameter. So I use mouse vector, the opposite of the forward vector, and the down axis to get the angle - between $-\pi$ and $\pi$.

```
var angle := mouse_position.signed_angle_to(-Vector3.FORWARD, Vector3.DOWN)
```

### Arrow Rotation

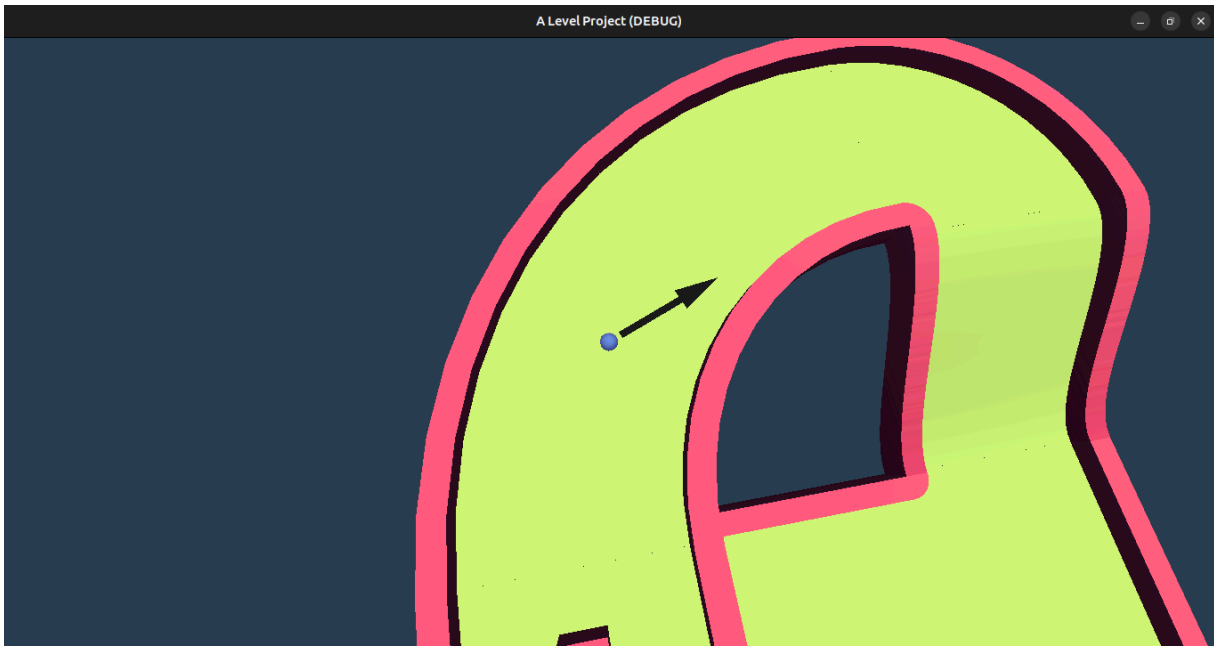
When the cursor is dragged out of the circle, the arrow should rotate to point in the direction of the cursor. This means that the `$Plane` needs to be large, with code to detect distance for if the cursor is out of bounds. This is because it feels unnatural for rotation to stop when the cursor is too far away but rotating around the ball. The code currently already handles this by using `clampf` on the scale.

### Ongoing Testing

### Arrow Scaling

When testing the arrow scaling, I found that the arrow would scale even when the cursor is "0.5m away" from the ball. This is because `clampf` was passed min 0.15 and max 5 instead of a maximum of 0.5.

```
-distance = clampf(distance, 0.15, 5)
+distance = clampf(distance, 0.15, 0.5)
```




The arrow now correctly scales to a maximum size (power).

## Moving The Ball

Now the arrow can be used to control the ball. When the left mouse button is released, the ball should be moved in the direction and power of the arrow.

This means that there should be a way to get the power from the arrow's scale, and the direction from the arrow's rotation. As the scale is stored in the `Inner` node, there needs to be a public function to get this out, to reduce coupling of external code on the arrow's structure:

```
# arrow.gd
## Get the power, between 1 and 4.5.
func get_power() -> float:
    return inner.scale.z
```

The dragging of the ball should be cancellable by moving the cursor back close to the ball. This can be done by checking the distance from the ball when the left mouse button is released.

```
# player.gd
## Distance from ball when letting go to cancel the action.
@export var CANCEL_DISTANCE: float = 0.05

# ...

if action == Action.DRAGGING:
    # ...

    if ball_distance > CANCEL_DISTANCE:
        pass
```

The power can be obtained via `arrow.get_power()` and the direction can be obtained via `arrow.rotation.y`. This can then be used to move the ball in the direction and power.

```
if ball_distance > CANCEL_DISTANCE:
    var rotation := arrow.rotation.y
    var power := arrow.get_power()
```

`rotation` is in radians, based off the forward vector, so the direction can be calculated by rotating the forward vector by the rotation angle. This can be done by using the `rotated` method on the unit vector.

```
var ahead := Vector3.FORWARD
var direction := ahead.rotated(Vector3.UP, rotation)
```

Finally, the `direction` vector can be scaled, and `RigidBody3D.apply_impulse` can be used to move the ball in the direction and power.

```
var result := direction * power
ball.apply_impulse(result)
```

## Ongoing Testing

### Pivoting and Dragging Multiple Times

When testing the controls, I found that the camera would pivot every first time you interact with the ball using left click. This is because the `RayCast` would not be updated immediately and always be one update behind. This was fine for when dragging, but in the check on if the cursor is close enough to the ball this was not acceptable. This was a simple fix by using `RayCast.force_raycast_update()` to update the ray cast immediately.

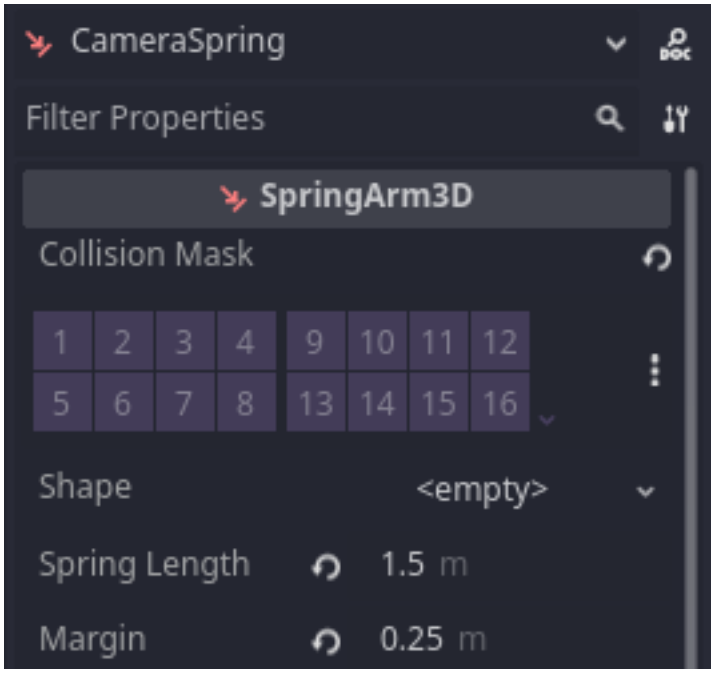
```
# arrow.gd
func get_control_position(mouse_position: Vector2) -> Vector3:
    # ...
    ray_cast.global_position = origin
    ray_cast.target_position = end

    ray_cast.force_raycast_update()
    return ray_cast.get_collision_point() - ball.position
```

### Camera Clipping Through Walls

When the ball would move so that the camera was behind a wall, the camera spring would adjust length to be in front of the wall. This is intended but would be annoying when it would happen briefly as the ball moved.

One solution would be to disable camera spring collisions so the camera can be behind walls. This can be done by setting the `collision_mask` of the camera

spring to ignore `0`. This would make the camera go above an underpass, but the camera can be rotated by the player anyway.




Another thing that can be changed is restricting the angle the camera can pivot to, as there is no reason to go below the ground. This can be done by clamping the rotation values in the `player.gd` script.

```
# player.gd
if action == Action.PIVOTING:
    # ...

    camera_spring.rotation.x += rotation_x
    # Restrict camera from rotating too far down.
    camera_spring.rotation.x = clampf(camera_spring.rotation.x, -PI/2, -PI/6)
```

## Adjusting Power

The current power range of 1-4.5 is not very useful. A power of 1 still moves the ball far, and 4.5 is not enough to get up some hills. I have adjusted the power with a scale, and an offset for lower values:

```
func get_power() -> float:
    return (inner.scale.z * 2) - 1.75
```

## Zooming

The camera should be able to zoom in and out. This can be done by changing the length of the camera spring. The camera spring has a property for this called `spring_length`. The mouse scroll wheel is a button action, with a `factor` as the amount/delta of each scroll - usually `1.0` but can vary depending on the mouse.

```
# player.gd
elif mouse_event.button_index == MOUSE_BUTTON_WHEEL_DOWN:
    camera_spring.spring_length += mouse_event.factor / 20
    camera_spring.spring_length = clampf(camera_spring.spring_length, 0.25, 5)
elif mouse_event.button_index == MOUSE_BUTTON_WHEEL_UP:
    camera_spring.spring_length -= mouse_event.factor / 20
    camera_spring.spring_length = clampf(camera_spring.spring_length, 0.25, 5)
```

`InputEventMouseMotion.factor` is scaled to get the distance in metres to change by. This is clamped to a minimum of 0.25 and 5 so the camera is not too close or far.