

CSE 566 Virtual Reality, Spring 2022

Assignment 4: Advanced VR

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Unity version : 2020.3.25f1

Theme of the park: Space/Alien planet

Hardware used: MacBook Air M1, Oneplus 7 pro(Android phone), Google Cardboard, VR Empire bluetooth game controller ([link](#))

Directory hierarchy

Directory hierarchy of the Assets folder looks like below. Please open the “SampleScene” scene in the scenes folder to see the created scene. Material, texture pngs and scripts are located in the Materials, Texture and Scripts folders respectively. Audio is in the Audio folder.

```
[Saahils-MacBook-Air:Texture saahil$ find .
./Scifi_pattern
./Scifi_pattern/Scifi_pattern_roughness.png
./Scifi_pattern/Scifi_pattern_emissive.png.meta
./Scifi_pattern/Scifi_pattern_ambientocclusion.png
./Scifi_pattern/Scifi_pattern_emissive.png
./Scifi_pattern/Scifi_pattern_normal.png.meta
./Scifi_pattern/Scifi_pattern_normal.png
./Scifi_pattern/Scifi_pattern_height.png
./Scifi_pattern/Scifi_pattern_basecolor.png.meta
./Scifi_pattern/Scifi_pattern_ambientocclusion.png.meta
./Scifi_pattern/Scifi_pattern_height.png.meta
./Scifi_pattern/Scifi_pattern_roughness.png.meta
./Scifi_pattern/Scifi_pattern_basecolor.png
./stripe_938f462ea5d6e968d9822ce2169a06f2.png
./30_leather_texture.jpeg
./.DS_Store
./moon-dif-512.png
./30_leather_texture.jpeg.meta
./moon-dif-512.png.meta
./stripe_938f462ea5d6e968d9822ce2169a06f2.png.meta
./muddy_ground.jpeg
./seamless-ge6714219f_640.png
./Soil-4.jpeg.meta
./Alien_fluid_metal_texture._(2).jpg.meta
./stripe_ffde85c8d8c176e43310d5752bb0658e.png
./stripe_ffde85c8d8c176e43310d5752bb0658e.png.meta
./mar0kuu2.jpg
./seamless-ge6714219f_640.png.meta
./scifi-pattern.zip
./Soil-4.jpeg
./muddy_ground.jpeg.meta
./Alien_fluid_metal_texture._(2).jpg
./mar0kuu2.jpg.meta
./461223182.jpg.meta
./461223182.jpg
./Scifi_pattern.meta
./stripe_9002785c34a08aa6fc84fb3343a464a.png
./scifi-pattern.zip.meta
./stripe_9002785c34a08aa6fc84fb3343a464a.png.meta

[Saahils-MacBook-Air:Materials saahil$ find .
./Glass.mat.meta
./New_Physic_Material.physicMaterial.meta
./scifi_high_tile.mat
./scifi_high_tile.mat.meta
./Cart.mat
./BlackSeat.mat
./New_Physic_Material.physicMaterial
./BlackSeat.mat.meta
./Moon.mat.meta
./Cart.mat.meta
./Tracks.mat
./Glass.mat
./UFO.mat
./Tracks.mat.meta
./Moon.mat
./UFO.mat.meta
./seamless-ge6714219f_640.png
./Soil-4.jpeg.meta
./Alien_fluid_metal_texture._(2).jpg.meta
./stripe_ffde85c8d8c176e43310d5752bb0658e.png
./stripe_ffde85c8d8c176e43310d5752bb0658e.png.meta
./mar0kuu2.jpg
./seamless-ge6714219f_640.png.meta
./scifi-pattern.zip
./Soil-4.jpeg
./muddy_ground.jpeg.meta
./Alien_fluid_metal_texture._(2).jpg
./mar0kuu2.jpg.meta
./461223182.jpg.meta
./461223182.jpg
./Scifi_pattern.meta
./stripe_9002785c34a08aa6fc84fb3343a464a.png
./scifi-pattern.zip.meta
./stripe_9002785c34a08aa6fc84fb3343a464a.png.meta
```

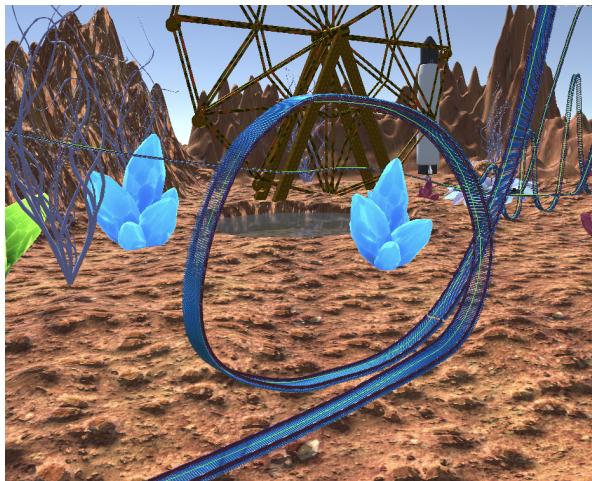
```
[Saahils-MacBook-Air:Scripts saahil$ find .
.
./EndCoasterRide.cs
./FPSControllerScript.cs.meta
./UFO.cs.meta
./Star.cs
./UFO.cs
./EndCoasterRide.cs.meta
./ChangeAcceleration.cs
./ChangeAcceleration.cs.meta
./RotateAlongY.cs
./GazeController.cs
./ChangeMode.cs.meta
./FerrisWheelRotate.cs.meta
./MoveCart.cs.meta
./MoveRocket.cs
./ChangeSpeed.cs
./MoveRocket.cs.meta
./MoveCart.cs
./ChangeSpeed.cs.meta
./GazeController.cs.meta
./RotateAlongY.cs.meta
./RotateAlongZ.cs
./CreatePath.cs
./FerrisWheelRotate.cs
./RotateGondola.cs
./FPSControllerScript.cs
./DayNightScript.cs.meta
./CreatePath.cs.meta
./DayNightScript.cs
./RotateGondola.cs.meta
./RotateAlongZ.cs.meta
./ChangeMode.cs
./Star.cs.meta
```

Below is the directory structure of the Assets folder.

```
[Saahils-MacBook-Air:Assets saahil$ ls -l
total 12504
-rw-r--r--@ 1 saahil staff 2145 Feb 16 11:58 128x128 white dot.png
-rw-r--r-- 1 saahil staff 2807 Feb 16 13:00 128x128 white dot.png.meta
drwxr-xr-x 10 saahil staff 320 May 5 02:47 Audio
-rw-r--r-- 1 saahil staff 172 Apr 30 23:52 Audio.meta
drwxr-xr-x 4 saahil staff 128 Apr 20 18:18 Cartoon arms
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 Cartoon arms.meta
drwxr-xr-x 6 saahil staff 192 Apr 20 18:18 JMO Assets
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 JMO Assets.meta
drwxr-xr-x 4 saahil staff 128 Apr 20 18:18 LowPoly Assets
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 LowPoly Assets.meta
drwxr-xr-x 8 saahil staff 256 Apr 29 11:27 Mars Landscape 3D
-rw-r--r-- 1 saahil staff 172 Apr 29 11:27 Mars Landscape 3D.meta
drwxr-xr-x 18 saahil staff 576 May 5 17:34 Materials
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 Materials.meta
drwxr-xr-x 9 saahil staff 288 Apr 20 17:21 MeshCombiner
-rw-r--r-- 1 saahil staff 172 Apr 20 17:10 MeshCombiner.meta
-rw-r--r-- 1 saahil staff 830 Feb 28 16:09 MinimapRenderedTexture.renderTexture
-rw-r--r-- 1 saahil staff 188 Feb 28 15:42 MinimapRenderedTexture.renderTexture.meta
-rw-r--r-- 1 saahil staff 557476 Apr 29 11:08 New Terrain 1.asset
-rw-r--r-- 1 saahil staff 189 Apr 19 22:05 New Terrain 1.asset.meta
-rw-r--r-- 1 saahil staff 1959048 May 3 20:03 New Terrain 2.asset
-rw-r--r-- 1 saahil staff 189 Apr 29 11:20 New Terrain 2.asset.meta
-rw-r--r-- 1 saahil staff 557472 Apr 19 22:02 New Terrain.asset
-rw-r--r-- 1 saahil staff 189 Apr 19 22:02 New Terrain.asset.meta
drwxr-xr-x 8 saahil staff 256 Apr 24 13:53 PathCreator
-rw-r--r-- 1 saahil staff 172 Apr 24 13:53 PathCreator.meta
drwxr-xr-x 4 saahil staff 128 May 2 16:39 Plugins
-rw-r--r-- 1 saahil staff 172 May 2 16:39 Plugins.meta
drwxr-xr-x 26 saahil staff 832 May 4 12:23 Prefabs
-rw-r--r-- 1 saahil staff 172 Apr 19 22:42 Prefabs.meta
drwxr-xr-x 4 saahil staff 128 May 5 20:17 Scenes
-rw-r--r-- 1 saahil staff 172 Apr 19 22:00 Scenes.meta
drwxr-xr-x 34 saahil staff 1088 May 5 03:52 Scripts
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 Scripts.meta
drwxr-xr-x 6 saahil staff 192 Apr 30 14:23 SineVFX
-rw-r--r-- 1 saahil staff 172 Apr 30 14:23 SineVFX.meta
drwxr-xr-x 10 saahil staff 320 Apr 19 23:19 SplineMesh
-rw-r--r-- 1 saahil staff 172 Apr 19 23:19 SplineMesh.meta
drwxr-xr-x 8 saahil staff 256 May 1 16:45 Standard Assets
-rw-r--r-- 1 saahil staff 172 Apr 20 18:18 Standard Assets.meta
drwxr-xr-x 20 saahil staff 640 Apr 29 20:29 StarterAssets
-rw-r--r-- 1 saahil staff 172 Apr 29 20:29 StarterAssets.meta
drwxr-xr-x 10 saahil staff 320 May 4 12:43 StreetLightsPack
-rw-r--r-- 1 saahil staff 172 May 4 12:43 StreetLightsPack.meta
-rw-r--r-- 1 saahil staff 557508 Apr 26 16:06 TerrainData_510cb43c-f148-48ca-a5a1-99c80d7eb5f8.asset
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-rw-r--r-- 1 saahil staff 557508 Apr 29 11:08 TerrainData_65d5c883-a7a0-4afa-bf7a-87868f17ae69.asset
-rw-r--r-- 1 saahil staff 189 Apr 26 16:36 TerrainData_65d5c883-a7a0-4afa-bf7a-87868f17ae69.asset.meta
-rw-r--r-- 1 saahil staff 1958984 Apr 29 11:27 TerrainData_c32e166f-6b50-4833-bb3c-709a77d33e9c.asset
-rw-r--r-- 1 saahil staff 189 Apr 29 11:20 TerrainData_c32e166f-6b50-4833-bb3c-709a77d33e9c.asset.meta
drwxr-xr-x 29 saahil staff 928 May 5 20:22 Texture
-rw-r--r-- 1 saahil staff 172 Apr 20 19:42 Texture.meta
drwxr-xr-x 16 saahil staff 512 Apr 29 11:09 Tom's Terrain Tools
-rw-r--r-- 1 saahil staff 107 Jul 28 2016 Tom's Terrain Tools.meta
drwxr-xr-x 4 saahil staff 128 May 4 12:23 VRSampleScenes
-rw-r--r-- 1 saahil staff 172 May 4 12:23 VRSampleScenes.meta
drwxr-xr-x 8 saahil staff 256 May 2 16:39 XR
-rw-r--r-- 1 saahil staff 172 May 2 16:26 XR.meta
drwxr-xr-x 12 saahil staff 384 May 3 20:03 _TerrainAutoUpgrade
-rw-r--r-- 1 saahil staff 172 Apr 29 11:10 _TerrainAutoUpgrade.meta
-rw-r--r--@ 1 saahil staff 96333 Feb 16 16:18 circular-loader.jpeg
-rw-r--r-- 1 saahil staff 2807 Feb 16 16:21 circular-loader.jpeg.meta
saahil$
```

Extra functionalities/Credit

- 360 circular loop in the roller coaster. The top of the circular track is inverted as well.



- Sound effects have been added to the game. There is an eerie background sound which plays constantly in the background taken from :
<https://freesound.org/people/Magmi.Soundtracks/sounds/425984/>
The roller coaster also has a sound effect of a cart moving on tracks taken from:
<https://freesound.org/people/BaDoink/sounds/538758/>
- Added walk animation from standard assets to the player. This is available only in third person mode.

Implementation details

I have implemented a virtual reality theme park application as per the specifications provided in the assignment. The settings and code have been modified so as to work best when deployed on an Android phone. I've chosen the theme : **Space/Alien planet**

1. **Realistic textures:** All the objects in the scene have high quality textures.
2. **Terrain:** I have created an uneven terrain to make it seem like a planet surface. The textures for the terrain have been taken from here:

Marble texture from : <https://opengameart.org/content/100-seamless-textures>

Mars texture from:

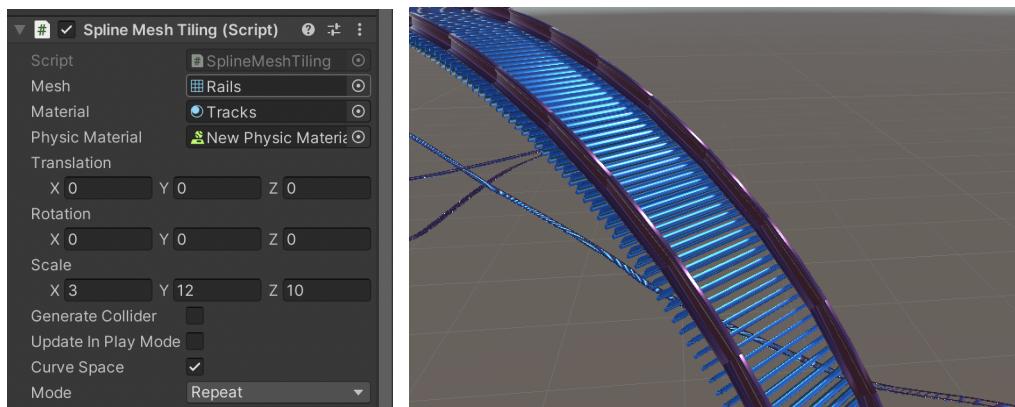
<https://assetstore.unity.com/packages/3d/environments/landscapes/mars-landscape-3d-175814>

3. **Roller Coaster Track:** The roller coaster track is constructed using the track object found here : <https://www.turbosquid.com/3d-models/free-3ds-model-tracks-street/727474>

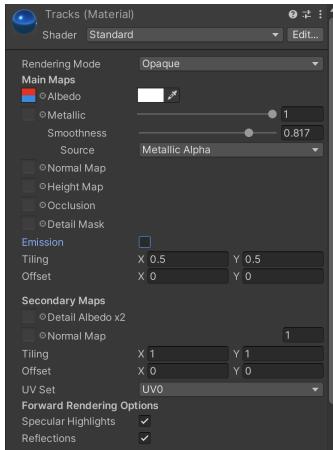
I have used a free Unity package from the asset store called SplineMesh:

<https://assetstore.unity.com/packages/tools/modeling/splinemesh-104989> .

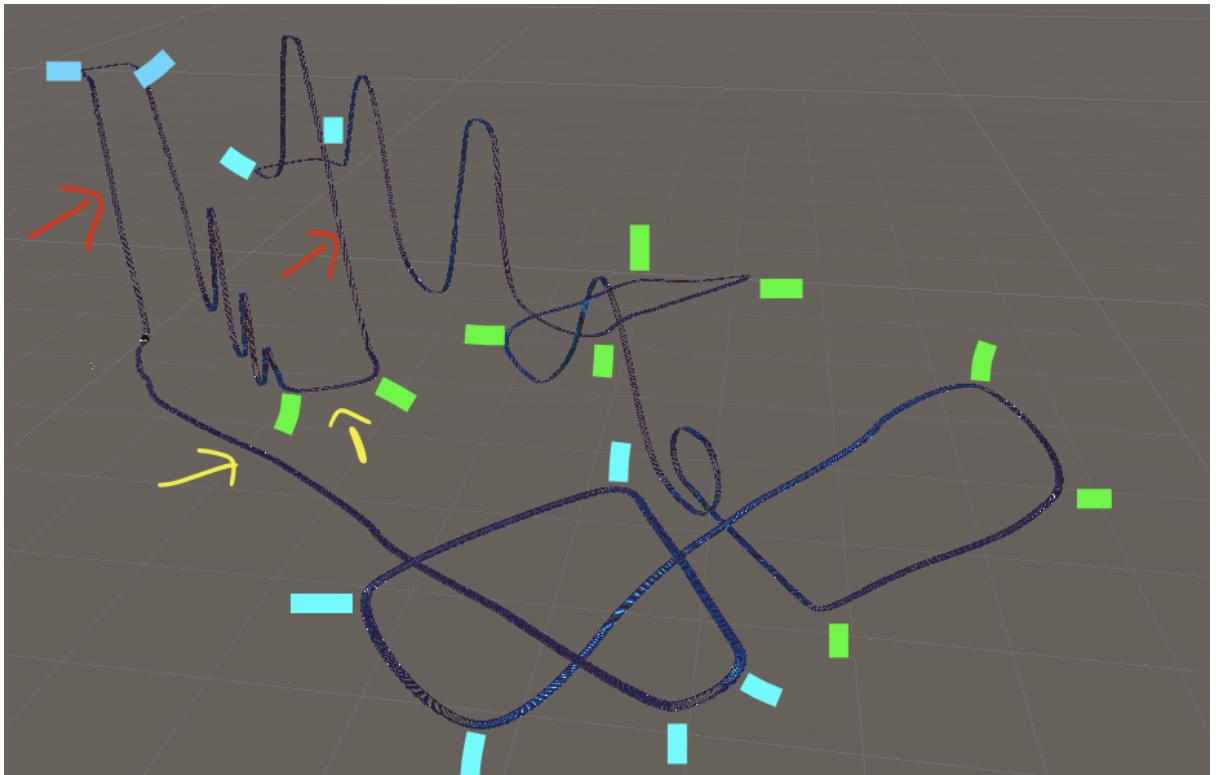
This tool lets you create a 3-d spline using bezier curves and generates a 3-d mesh along the spline by repeating the mesh that you provide. In our case the earlier rail model. You can then provide the material to render the mesh with. The tool has a limitation, it joins any submeshes into one single mesh.



As we can see from the above photo the track has a texture consisting of 2 colors and has a specular characteristic on the material. Texture is created using this tool: <http://www.stripgenerator.com/index.php?page=index#Zm9yZT1GRjAwMDA7aD0zMDt3PTUwO3A9NTA7YmFjazE9MDA1NUZGO2JhY2syPWZmMDAwMDtndD0wO2Q9MjzaGFkb3c9MDs=> I have created a standard metallic specular material since the specular shader has been deprecated and was causing performance issues. I have asked the TA regarding this as well and he said it was fine. Below is the material used:



Track requirements:



In the above photo I have marked the following:

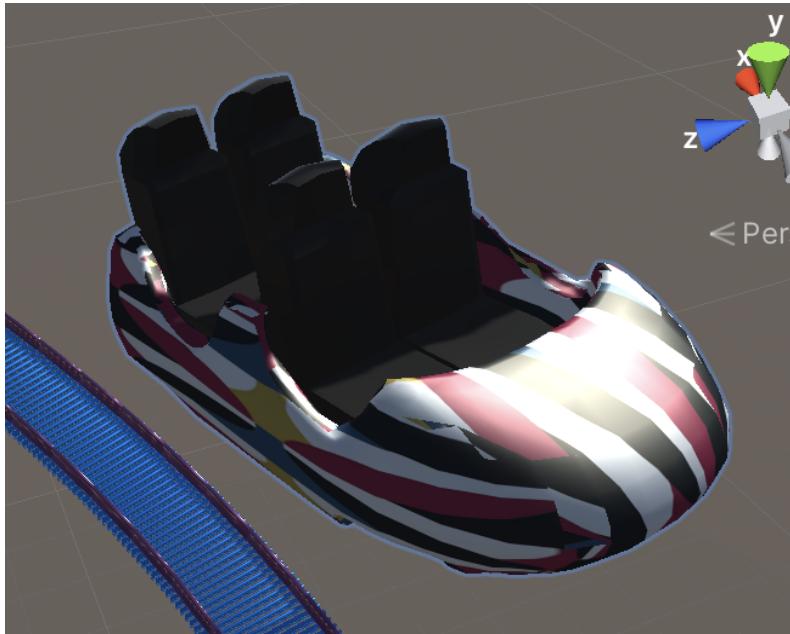
- 2 lift hills with **red arrow**
- 2 brake sections with **yellow arrow**
- 7+ left turns with **green markers**
- 7+ right turns with **cyan markers**
- There are also 7+ uphill and downhill sections as can be seen. The 360 loop can also be considered as consisting of uphill and a downhill section

4. **Roller coaster cart:** For the cart I have taken the model from here :

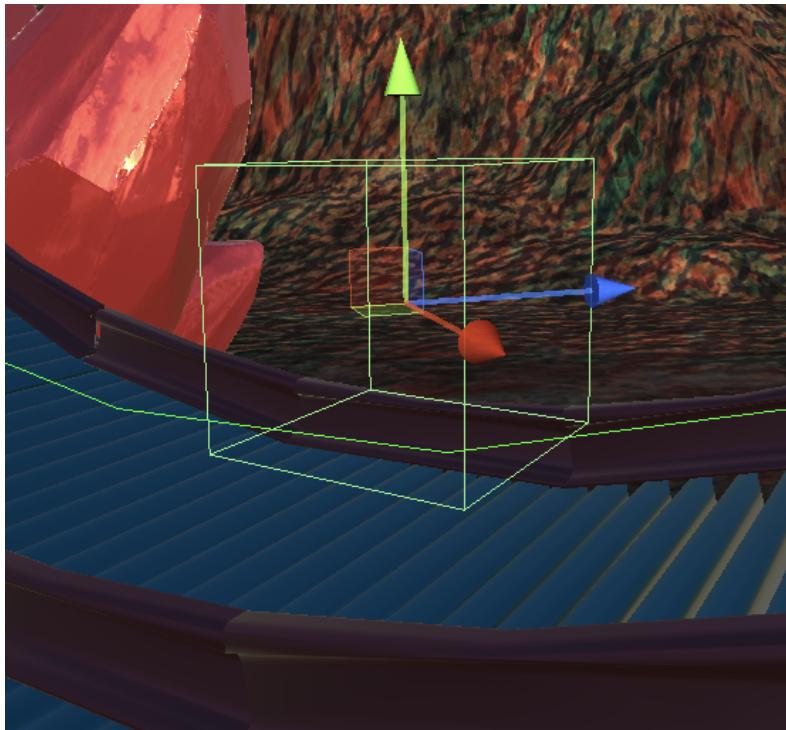
<https://sketchfab.com/3d-models/roller-coaster-06a750a284104d76ba6a05c2b0f5ccf3#download>

The cart too has a specular property set and consists of multicolor textured material. Texture has been taken from :

<https://pixabay.com/vectors/seamless-geometric-retro-pattern-1603109/>



5. **Roller coaster cart movement:** I have set cube collider triggers at various points on the track. When the cart collides with these triggers the acceleration of the cart changes. If the cart is going downhill the acceleration is positive. Value is higher when the downhill is steeper and. Value is negative when going uphill and it is low when going up steep uphill slopes. There is some amount of deceleration constantly to account for friction. The deceleration is higher on the brake tracks. These are present before the 2nd lift hill and before stopping.



6. **Park Decoration :** There are quite a few park decorations

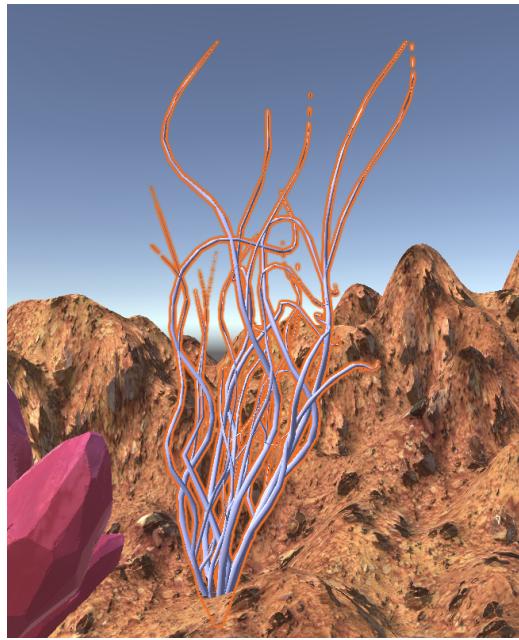
a. **Alien flower:** Taken from

<https://www.turbosquid.com/3d-models/pack-floral-alien-vegetation-3d-model-1470488>



b. **Alien bush:** Taken from

<https://www.turbosquid.com/3d-models/pack-floral-alien-vegetation-3d-model-1470488>



c. **Colorful Crystals:** From package

<https://assetstore.unity.com/packages/3d/environments/fantasy/translucent-crystals-106274>



d. **Alien :** Found at

<https://www.turbosquid.com/3d-models/free-3ds-mode-alien-green-argise/744537>



- e. **Rocket** : Found at
<https://free3d.com/3d-model/rocket-v1--735447.html>



7. **Script generated objects** : I have generated 2 objects using scripts. First is a star and second a UFO. I have used a rotation calculator to calculate the vertices of the objects and manually set them in the scripts.

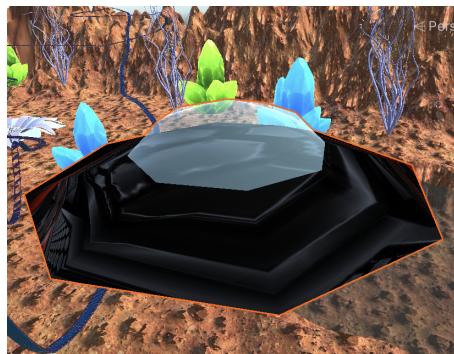
<https://www.emathhelp.net/en/calculators/algebra-2/rotation-calculator/?px=0&py=4&a=72&u=d&d=cw&qx=0&qy=0>

- a. Star : The Star.cs script generates this object.

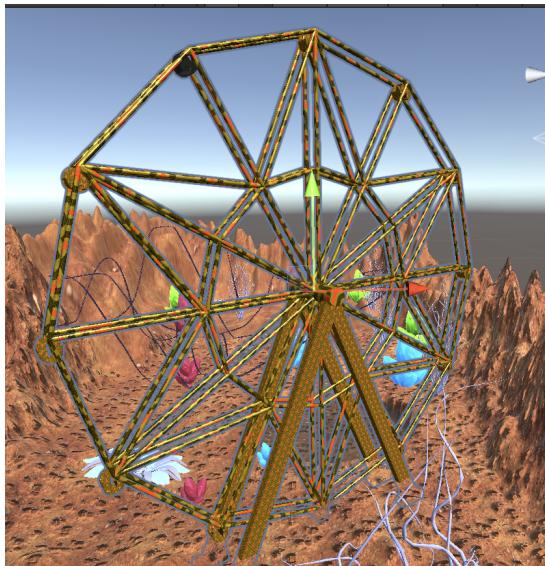


- b. UFO : The UFO has 2 submeshes, One for the body and the other for the cockpit. The UFO.cs script is responsible for generating this object. I used the texture from

[https://commons.wikimedia.org/wiki/File:Alien_fluid_metal_texture_\(2\).jpg](https://commons.wikimedia.org/wiki/File:Alien_fluid_metal_texture_(2).jpg) for the body and a transparent glass material for the cockpit.

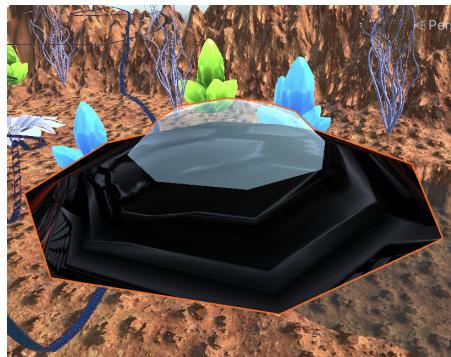


8. **Ferris wheel** : Ferris wheel model is taken from <https://www.cgtrader.com/free-3d-models/architectural/other/ferris-wheel-771b6f9d-816e-4cdc-bc15-6ec8456254f2> . The texture for the material has been taken from : <https://www.renderhub.com/valetovskaia/scifi-pattern#> . Similar to the roller coaster this too has a specular property set. The ferris wheel constantly-and-slowly rotates in one direction and is able to capture all the objects in the park from certain angles when the user is at a height.

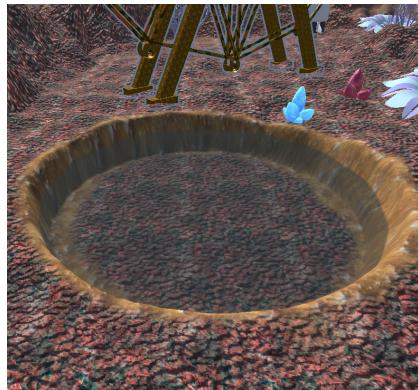


9. **Transparent objects** : There are 2 transparent objects in the scene.

- Cockpit of UFO - made of glass material created by me

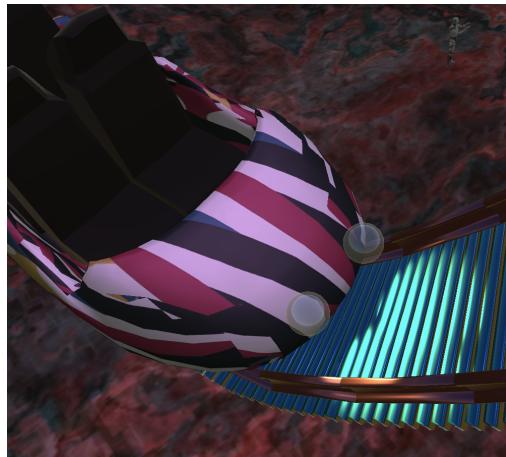


- Transparent water in the pond - unity standard asset

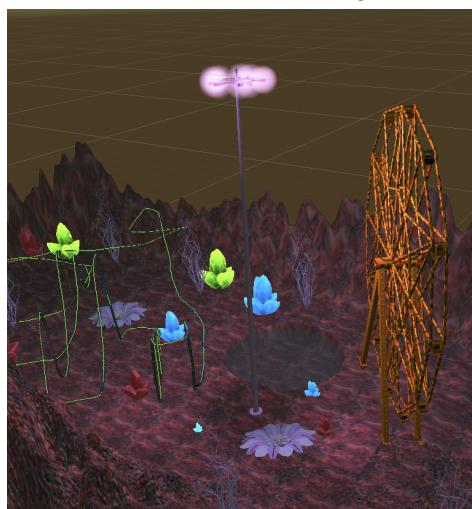


10. Spotlights: There are multiple spotlights in the scenes.

- a. There are 2 as headlights for the roller coaster cart



- b. There are 10 on the flood light in the middle of the park



11. VR Controller mapping: Let's see the control mapping. I'm using the bluetooth VR controller found here: [link](#). As we can see we have a joystick and 4 buttons to map our functionalities to. The 4 buttons have the below keycodes in unity's input system:

X - joystick 1 button 2
A - joystick 1 button 10
B - joystick 1 button 5
Y - joystick 1 button 3



In the assignment I have used the HMD(XR) to rotate my player(i.e- the player will always be facing the direction the user is looking at and will move in that direction) and the joystick to move the player just like the controls found in normal FPS games such as GTA. The controls are as below.

Controls:

Rotating - head movement of the user

Movement - joystick

Toggle modes - press X

Confirm - press A

Cancel - press B

12. Different Modes and movement: In FPS mode the user can move around using the joystick controls with up and down going forward and backward and left and right moving the player in that direction respectively. The direction in which the user is looking is controlled by the head movement of the user(HMD/XR plugin). Example to look and move towards the left the player would look to their left and then move the joystick up. In third person mode the camera moves behind and slightly above the user. Gaze interaction is disabled in this mode. User's head movement still rotates the player and camera and the user can navigate with the same controls. User can enter third person mode during the rides as well, as seen below.



13. Interaction with ride/Teleportation: Once the user gazes at a ride for 5 seconds they will see a dialog pop up. They can then press A to confirm or B to cancel. If the user chooses to confirm they are teleported to the respective ride and the ride starts. During

the ride the user stays in it and is teleported back to the original location they triggered gaze from once it's over.

14. **Interaction during the ride:** During the roller coaster ride the user can interact with 2 objects, the star and the UFO. On gazing at the objects for 5 seconds the star will rotate along the z axis and UFO will rotate along Y axis.
15. **Interaction in the park:** The user can interact with the alien. On gazing for 5 seconds the alien will talk in an alien language. The user can also interact with the rocket. On gazing for 5 seconds the rocket will bob up and down 5 times and then stop.

16. Scripts:

- a. ChangeAcceleration.cs - changes acceleration of the roller coaster cart.
- b. ChangeMode.cs - handles toggling of modes(first/third person) as well as input button mapping. Moves the camera behind and above in third person view.
- c. ChangeSpeed.cs - changes speed of the roller coaster cart. Used on lift track.
- d. CreatePath.cs - used to create path prefab to move cart along. Was created from points along the coaster track spline.
- e. DayNightScript.cs - handles sunrise and sunset. Toggles lights on and off based on day/night.
- f. EndCoasterRide - Ends the roller coaster ride. Set off by a collision trigger.
- g. FerrisWheelRotate.cs - Rotates Ferris wheel
- h. FPSControllerScript - Control movement of player
- i. GazeController.cs - Handles gaze control via raycating and triggers respective actions for the objects/rides
- j. MoveCart.cs - Moves coaster cart along path created using path creator
- k. MoveRocket.cs - moves rocket up and down
- l. RotateAlongY - Rotates object along Y axis. Used for the UFO
- m. RotateAlongZ - Rotates object along Z axis. Used for the star
- n. Star.cs - Generates Star object during runtime from vertices and faces
- o. UFO.cs - Generates UFO object during runtime from vertices and faces

References:

- https://www.youtube.com/watch?v=IJ9Tla_Q4gk&list=PL5KbKbJ6Gf9-d303Lk8TGKCW-t5JsBdtB&index=4
- <https://www.youtube.com/playlist?list=PL5KbKbJ6Gf9-d303Lk8TGKCW-t5JsBdtB>
- <https://www.emathhelp.net/en/calculators/algebra-2/rotation-calculator/?px=0&py=4&a=72&u=d&d=cw&qx=0&qy=0>
- <https://www.c-sharpcorner.com/article/how-to-apply-materials-shaders-and-textures-to-objects-in-unity2/>
- https://www.youtube.com/watch?v=_yf5vzZ2sYE
- <https://docs.unity3d.com/ScriptReference/Transform-position.html>
- <https://youtu.be/aQUJ9qMMhlQ>
- <https://www.youtube.com/watch?v=saAQNRSYU9k>
- <https://sharpcoderblog.com/blog/unity-3d-fps-controller>
- <https://www.youtube.com/watch?v=XkrJ-cwphlo>
- <https://www.youtube.com/watch?v=y6TCQfFB2xg>
- <https://www.youtube.com/watch?v=FSUIYTMXKNo>
- https://www.youtube.com/watch?v=Jbd0cx5GM_Q
- <https://learn.unity.com/tutorial/get-ready-for-unity-essentials?uv=2020.3&pathwayId=5f7bcab4edbc2a0023e9c38f&missionId=5f77cc6bedbc2a4a1dbddc46&projectId=612f9602edb2a1b588a3af3#>
- <https://answers.unity.com/questions/14770/creating-a-circular-progressbar-timer.html>
- <https://www.youtube.com/watch?v=0SzuPgFQO-8>
- <https://forum.unity.com/threads/raycast-coming-from-center-of-camera.321510/>
- <https://assetstore.unity.com/packages/tools/utilities/b-zier-path-creator-136082>
- <https://www.youtube.com/watch?v=saAQNRSYU9k>
- <https://github.com/sirgru/MeshCombineWizard>
- <https://answers.unity.com/questions/8003/how-can-i-know-if-a-gameobject-is-seen-by-a-partic.html>
- <https://docs.unity3d.com/ScriptReference/Transform-localScale.html>
- <https://www.youtube.com/watch?v=T6LVBPs0UdE>
- <https://forum.unity.com/threads/solved-move-camera-to-ray-hit-point-but-get-hit-object-center.876715/>