Orbital Mechanics Simulator

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Abstract

Orbital mechanics are an often misunderstood aspect of spaceflight, but one which can be explained through hands-on piloting of a simulated spacecraft which follow a few basic mathematical equations. In this project, I will focus on teaching how a few basic laws of Newtonian physics can result in many types of orbits around celestial bodies, and how to figure out the most efficient way to get from one planet or moon to another. Along the way, I may touch upon the Oberth effect, Hohmann transfers, gravity assists, patched conics, the rocket equation, and other spaceflight-related concepts. By turning it into a game to find the most efficient solution, learning becomes fun and accessible to everyone.

Tools

- Software
  - Unity 6 engine
  - Microsoft Visual Studio Community 2022
  - Autodesk Maya 2025
  - Adobe Photoshop 26
- Hardware
  - Development computers:
    - Windows PC with Intel Core i7-11700 & NVIDIA GTX 1080 Ti
    - Apple MacBook Air (M3, 2024)
  - Build targets which run on:
    - Windows
    - macOS
    - Web browsers (WebGL)

Diagram 1: Screen UX Flow

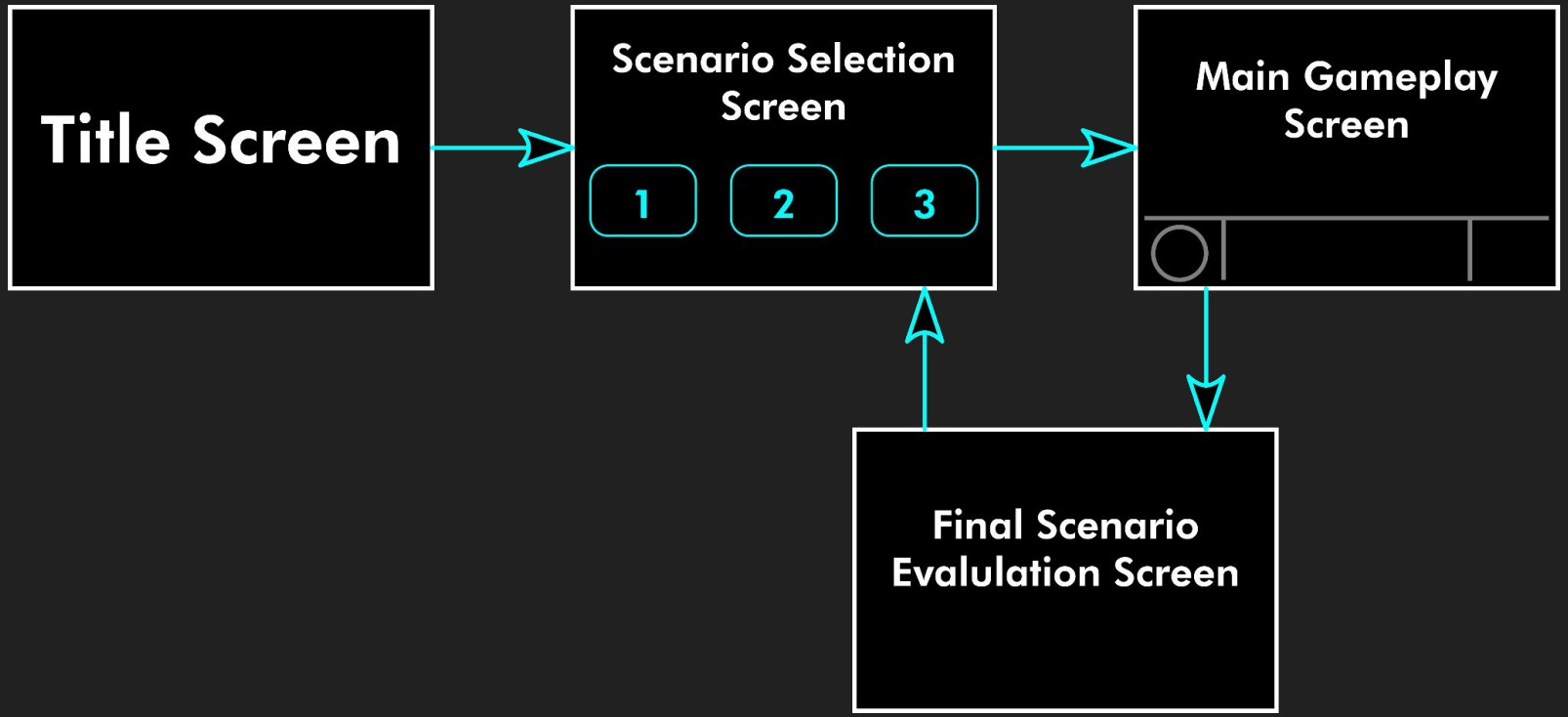
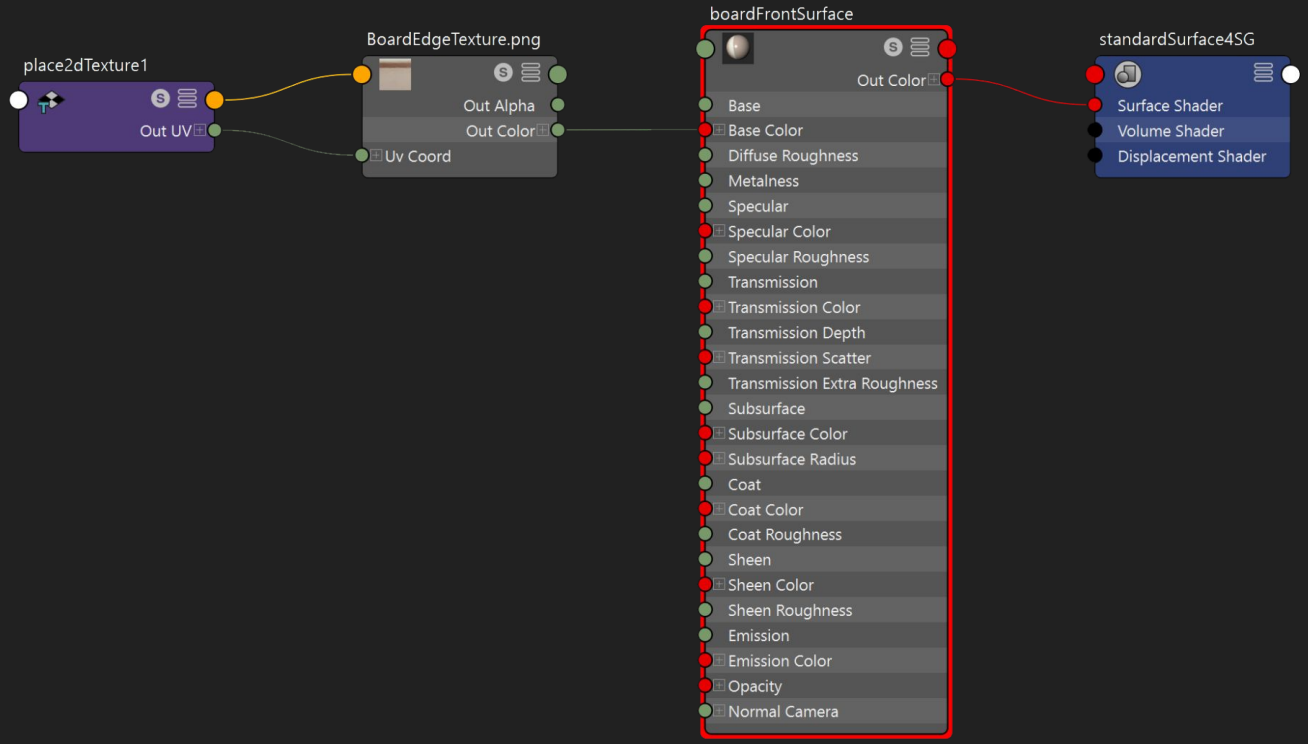


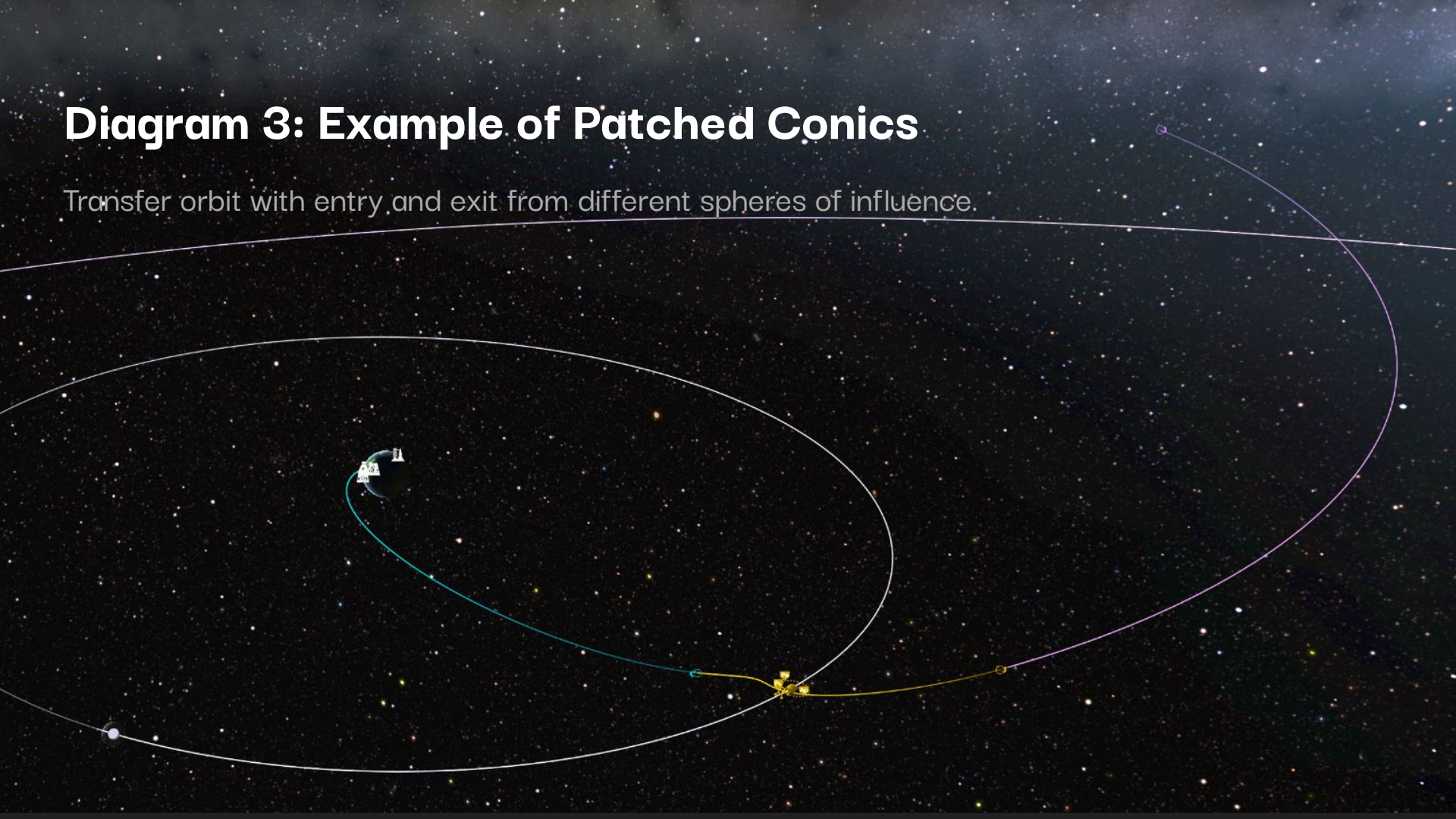
Diagram 2: Example Shader Network



Simple texture mapping shader for 3D rendering

Diagram 3: Example of Patched Conics

Transfer orbit with entry and exit from different spheres of influence.



Tentative Schedule

Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project planning & research. Set up project repo & issue tracker.															
		Identify users, use cases, and proposed solutions. Sketch UI/UX.													
				Develop prototype/demo. User testing, presentation.					Further testing			Final testing			
					Refine and build out UI and features based on user and presentation feedback.										
								Triage features and issues to decide on MVP							
											Feature lock & focus on fixing issues.				
													Prepare final presentation & submission		

Data Sources

Gravitational constants and other celestial data from NASA.

Use Cases

1. Astrophysics course to illustrate different kinds of orbits and how velocity varies with the distance.

2. Casual user who wants to play with spaceships in orbit and solve challenging scenarios such as finding the most efficient transfer from Earth orbit to Moon orbit.

3. Video maker (for YouTube, for example) who wants to generate animations to show the orbits of asteroids, satellites, and celestial bodies in their videos.