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COSC363 Assignment 1 Report – Pendulums and Yoyos

Scene Description

I am Bob. Bob only has three things that make him happy. Bob likes Pendulums, Yoyos, and oddly satisfying things to look at. Bob was always fascinated with yoyos, but Bob wondered why do Yoyos spin vertically? They would look a whole lot more interesting if they spun horizontally instead. Bob was sad one day and his friend decided to make him a scene that involved everything that made him happy. This scene had a horizontally spinning yoyo, with not one or two pendulums, but four cone pendulum that perfectly passing through the centre of the Yoyo. This extra satisfying set of motions made Bob very happy.

More formal scene description… There is yoyo like looking object in the centre of the scene that was generated using a sweep surface. This yoyo spins infinitely around its centre. While this is spinning there are four pendulums with cones attached to them that perfectly pass through the centre of the yoyo. These pendulum are separated by 45 degrees and are modelling off real life pendulums where gravity is 9.8m/s^2. However, these pendulums do not consider air resistance or friction and therefore will infinitely oscillate. Additionally, there is a spotlight that follows one of the pendulums are it oscillated. This screen takes place in the middle of the mountains where magic exists, and friction does not. Finally, this scene has a floor that the spinning yoyo rests on, with two support poles that hold up the pendulums. These poles are structurally supported by three spheres for horizontal support and to hold up the four pendulums.

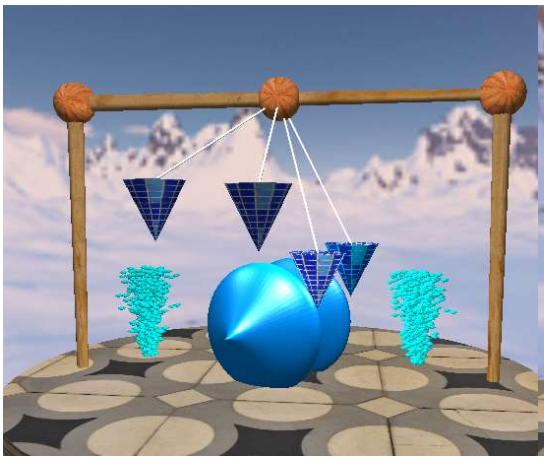


Figure 1: Scene View with Sun

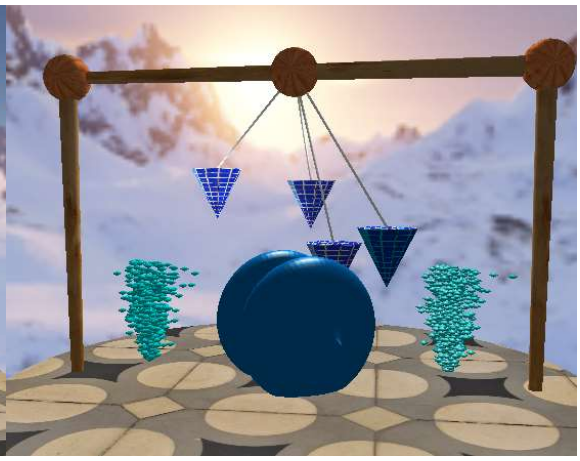


Figure 2: Scene View behind Sun

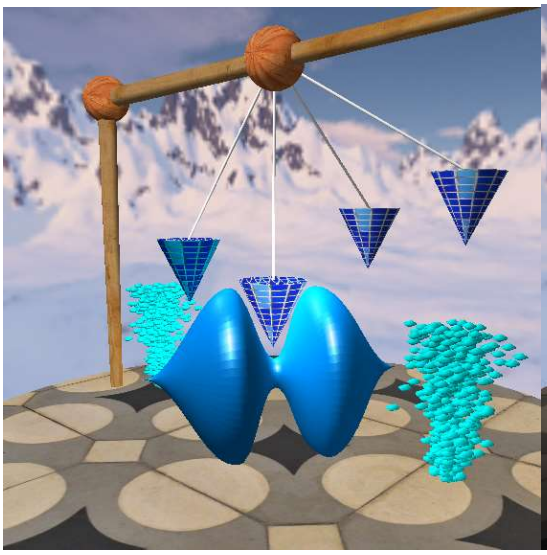


Figure 3: Close up without Sun

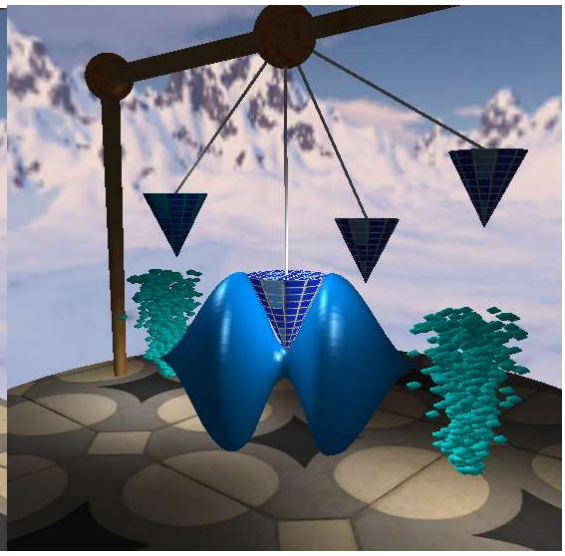
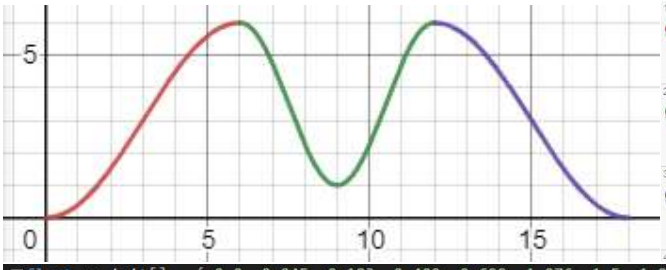


Figure 4: Close up with Sun

Extra Features

Custom Sweep Surface:

I combined three different cosine equations with certain limits to create a segment for a yoyo looking shape. I took three x and y coordinate pairs for every unit of length on the x-axis (e.g., 0.0, 0.33, 0.67, 1.0…). All these coordinated points combined to create 55 vertices. These were used to create the sweep surface of the yoyo shown in the scene.



$$3\cos\left(\frac{1}{6}\pi x+\pi\right)+3\ \{0<x<6\}$$

$$2.5\cos\left(\frac{1}{3}\pi x+2\pi\right)+3.5\ \{6<x<12\}$$

$$3\cos\left(\frac{1}{6}\pi x+2\pi\right)+3\ \{12<x<18\}$$

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float vx_init[] = { 0.0, 0.045, 0.183, 0.402, 0.699, 1.076, 1.5, 1.969, 2.484, 3.0, 3.516, 4.031, 4.5, 4.924, 5.301,
5.598, 5.817, 5.955, 6.0, 5.852, 5.409, 4.75, 3.943, 3.057, 2.25, 1.591, 1.148, 1.0, 1.148, 1.591, 2.25, 3.057,
3.943, 4.75, 5.409, 5.852, 6.0, 5.955, 5.817, 5.598, 5.301, 4.924, 4.5, 4.031, 3.516, 3.0, 2.484, 1.969, 1.5,
1.076, 0.709, 0.402, 0.183, 0.045, 0.0 };
float vy_init[] = { 0.0, 0.33, 0.67, 1.0, 1.33, 1.67, 2.0, 2.33, 2.67, 3.0, 3.33,  3.67, 4.0, 4.33, 4.67, 5.0, 5.33,
5.67, 6.0, 6.33, 6.67, 7.0, 7.33, 7.67, 8.0, 8.33, 8.67, 9.0, 9.33, 9.67, 10.0, 10.33, 10.67, 11.0, 11.33, 11.67,
12.0, 12.33, 12.67, 13.0, 13.33, 13.67, 14.0, 14.33, 14.67, 15.0, 15.33, 15.67, 16.0, 16.33, 16.67, 17.0,
17.33, 17.67, 18.0 };
```

Physics based animation:

The pendulums' move based on x and y offsets that calculated through the:

- Length (L) | the length of the pendulum's tether
- Mass (m) | the mass of the pendulum's object at the end of the tether
- Gravity (g) | a physics constant here on earth of 9.8m/s^2.
- Angle (θ) | the angle of the pendulum in radians.
- Angular Velocity (ω) | the angular velocity of the pendulum in rad/s.
- Angular Acceleration (α) | the angular acceleration of the pendulum in rad/s^2.
- Force (F) | the force one the pendulum in newton meters.

Every time the program updates the location of the pendulum the following calculations are performed:

$$F = \frac{g \times \sin\left(\frac{\theta\pi}{180}\right)}{L}$$

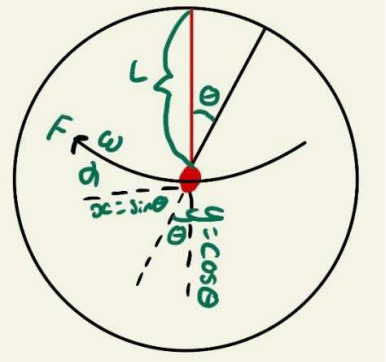
$$\alpha = \frac{\mathrm{F}}{m}$$

$$\omega = \omega + \alpha \times m$$

$$\theta = \theta + \omega$$

$$x = L \times \sin(\frac{\theta\pi}{180})$$

$$y = L \times \cos(\frac{\theta\pi}{180})$$



Assumptions:
- Friction and air resistance does not exist
- The pendulum's tether has no mass

Skybox:
The entirety of the scene is textured by a set of six skybox textures to create the illusion that the scene takes place in some scenic mountainous location.

Moving Spotlight:
There are two moving spotlight that tracks one of the moving pendulums as it oscillates back and forth. These spotlights are inside the two spheres inside the support struts. However, these spotlights are hard to notice when the sun in turned on. Therefore, the sun is turned off by default.

Particle Effects:
Particle effects in the form of spheres shoot up from the floor to emphasise how great the scene is. This is created by a structure/class the define the various properties of the particle such as its lifespan and coordinates. There are two helper functions, the first is 'particles_init()' that set the initial velocity of the particles and a random speed at which the particles fade away. The second helper function 'update_particles()' draws the actual particles and updates there positions and other parameters such as if the particle is no longer alive.

Control Features

• ← | Rotates the angle of the camera by one degree in the negative direction. The camera position is then changed to be pointing directly at the centre of the scene.
• → | Rotates the angle of the camera by one degree in the positive direction. The camera position is then changed to be pointing directly at the centre of the scene.

- ↑ | Increases the distance from the centre of the scene by one unit (metre).
- ↓ | Decreases the distance from the centre of the scene by one unit (metre).
- S | Toggles the light coming from the sun on and off.

Build and Run Instructions

The program includes a cmake file. Therefore, after extracting the files, within programs source directory run these three commands in a terminal:

1. cmake.
2. make
3. ./Source.out

References

All textures not provided by the lecturer came from an open-source texture library website

- Skybox | Provided by the lecturer
- Pendulum Cone Texture | Blue Tile Texture Lib
- Floor Texture | Tile Texture Lib
- Wood Struts Texture | Plywood Texture Lib
- Support Structure Spheres | Wood Plank Texture Lib

The pendulum equations were derived from this document detailing the motion of a pendulum. Additionally, F is the equivalent to I in the document. The document is titled the Oscillation of a Simple Pendulum.