Faculty of Science

Course:	CSCI 4110U: Advanced Computer Graphics
Lab Assignment:	6
Topic:	Animation - Dynamics

Overview

In this lab, you will animate two spheres, one representing the moon and one representing the Earth, using the dynamics model discussed in the lectures. The code to render a single sphere, from the in-class example, is provided. You are expected to make modifications to this program to make it render two spheres, and update the force, acceleration, velocity, and position of each sphere in a loop using Euler integration, as discussed in the lectures.

Instructions

First, you should download the base project from the repository is given, below:

- https://github.com/randyfortier/CSCI4110U_Labs

Both celestial bodies will have a gravitational impact on each other. For each body, determine the gravitational force by the other body. Use the resulting acceleration equation, and derived velocity and position equations to find the change in acceleration, velocity, and position after a time step (`dt`). These will be 3D vectors (using `glm::vec3`).

The time step value (`dt`) chosen should be small, but small is a relative concept. Small for an Earth-Moon system might be an hour. You may need to experiment with different values to find the right balance of low error (small `dt`) and performance (larger `dt`).

Gravitational Force

The force of gravity can be determined using the following formula. The values for the various constants is given in the table, below. Initially, use the r value provided to position to two spheres (e.g. Earth at 0,0,0 and the Moon at r,0,0), but then determine the r value from the new separation of the two bodies (measured from their centre).

$$F = \frac{G m_e m_m}{r^2}$$

Constant	*Description*	*Value*
G	The gravitational constant	*6.674×10^{-11} N·kg^{-2}·m^{2}*
m_e	The mass of the Earth	*5.972×10^{24} kg*
m_m	The mass of the Moon	*7.34767309×10^{22} kg*
r	The distance between the Earth and the Moon	*384,400,000 m*

Note: Due to the large separation, you may need to adjust the camera position (and the clipping values) so that you can still see the scene. An alternative would be to scale these values down to a more reasonable size, but do so carefully so that the proportionality is preserved. The former is the easier approach.

Acceleration

Calculating the acceleration of a body is extremely simple, according to Newton's laws:

$$F = \text{ma}$$

Velocity

Velocity (v) can be thought of as the first derivative of position (s) with respect to time. Therefore, you can use the following ordinary differential equation to approximate it using Euler integration:

$$v = ds = a \cdot dt$$

Position

Position (s) can be approximated using the following ordinary differential equation, via Euler integration:

$$s = v \cdot dt$$

Need an Extra Challenge?

If you feel like this is too easy for you (e.g. you have some background with OpenGL), you are welcome to try one of these variations (presented in order of difficulty):

1. Use Runge-Kutta to reduce the error in the system
2. Include a sun element to produce a three body system

Lab Report

To demonstrate to the lab instructor your completion of this laboratory assignment, merely show them the modified OpenGL program.