

Project 02 – Flight Sim

Due: Friday Nov 7

Total: 100 pts

You will be creating a flight simulator with randomly generated, and infinite, terrain.

LIGHTING

The lighting for the simulator will be fairly complex, and consist of:

- General ambient lighting
- A background [sky](#) including a sun
- Sun light from the sun that casts shadows on everything
- The world will go through a day-night cycle every minute: at 0 seconds it is midnight, 15 seconds it is sunrise, at 30 seconds it is noon, and at 45 seconds it is sunset. The following must change with the “time of day”:
 - sun must change position
 - shadows must change with the sun position
 - light intensities and colors must change appropriately
- Shadows must be fairly good (minimal banding/acne) and must be visible even as the plane moves across the infinite terrain
- It should be a relatively clear day, but fog is used to occlude terrain further than 2 km away (which may not be generated yet) and its color must change with the time of day

GROUND

The ground is generated in squares of 2km by 2km. It is strongly recommended that you keep the units in the system in meters, thus the mesh will be 2000 x 2000 for a single square. The terrain is generated with the [diamond-square](#) algorithm. Code that runs the diamond-square algorithm is provided, but it only generates a 2D array of heights and not a geometry.

You will need to have a grid of these generated squares. You initially generate a 3x3 grid of squares. As you visit squares, additional squares are added to the grid to make sure that there is always all terrain within 2km of the plane. This must be done carefully to make sure the new grid squares match their edges to the existing squares using the arguments to provided code for matching. Note that they will still have some seams, but they will be very small and not very apparent unless viewing from a distance.

AIRCRAFT

The aircraft must be fairly complex. It can either be made from several built-in shapes (at least 10 shapes) or loaded from an external model file. The propellor on the airplane must spin based on the current thrust (a percent). The current speed and altitude of the plane must be displayed in the provided HTML GUI and updated continuously. The size of the plane must be realistically set in meters. The plane spawns at 200 m above the ground at the origin.

FLYING

The plane maintains a thrust (initially 50%), velocity (initially $[-20, 0, 0] \text{ m/s}$), and angular velocity (initially $[0, 0, 0] \text{ rad/s}$) overtime and must [fly according to](#):

- W/S – Pitch down/up (effects angular velocity by delta time times 2 rad/s^2)
- A/D – Roll left/right (effects angular velocity by delta time times 2 rad/s^2)
- Q/E – Yaw left/right (effects angular velocity by delta time times 2 rad/s^2)
- Shift/Ctrl – Increase/Decrease throttle (by delta time, remember there is a range of 0 to 1)
- Space – Greatly decrease throttle (by delta time times 3, remember there is a range of 0 to 1)

The angular velocity also has a dampening factor of 3 times the delta time (minimum of 0), meaning that each component of the angular velocity is multiplied $1 - 3 * \text{deltaTime}$.

The physics of the aircraft will be simplified for this project:

- Acceleration will be initialized to the direction that plane is facing multiplied by the current throttle times 10.
- The plane's y acceleration is affected by gravity and lift, so subtract gravity (9.81 m/s^2) and add the plane's x/z speed times 0.003.
- Compute the velocity from the acceleration, the acceleration is the added to the current velocity and then overall velocity is multiplied by 99% to account for air resistance.
- The overall speed must be capped to a maximum speed of 55 m/s .
- The position is updated with the current velocity times delta time, with the altitude capped at 4200 m.
- The aircraft is rotated by its angular velocity times delta time.

After updating the plane's position and rotation, the camera is updated to be behind and looking at the plane.

COLLISION DETECTION

Start with a super-simple and fast collision detection: if the max height of terrain under the bounding box (and possibly immediate surrounding area to round to easily known heights on the terrain) for the aircraft intersects the bottom of the aircraft's bounding box, we have a potential collision.

Once we have a potential collision, we will use a ray caster to determine the more accurate distance between the ground and the plane. You will sample a grid of 36 points (6-by-6) from the ground (using the interpolated height of the terrain at those exact points). If the plane is below ground at any of those points, it is considered landed. If any point there is within 0.75 meters above, it is considered landed.

Due to the speed of the plane, it can technically get a little deep into the ground when landing before being detected. In the real world you would look at the trajectory and figure out where along the trajectory it landed and place it there, but we will not worry about that.

Make sure to test by tilting the plane on its side and flying right next to a hill, you should be able to graze it without landing (this approach triggers the first detection but not the second).

Remember that no new vectors or other objects may be created during these checks.

CHECK-INS

There are weekly check-ins on the following dates where you will be expected to show the following progress:

- **Oct 27:** Day/night cycling and lighting along with ground. Recommend you use an orbit controller or similar at this stage so it is easier to examine the environment. The initial 3x3 grid of ground should be made (and the seams should be minimal) but the auto-generation does not need to be working.
- **Nov 3:** Rendering of the aircraft along with flying and infinite ground generation. No collision detection.

Each check-in is worth up to negative 10 pts if not successfully completed.

CODE QUALITY NOTES

- All geometry and materials reused as possible
- No new objects should be created during regular animation iterations (expanding the terrain which only happens infrequently can allocate new objects).
- Magic numbers should be reduced as possible.
- General code quality: good documentation, good variable names, good division of functions, etc.

RUBRIC

- 20 pts Lighting: sky, time-based positioning, dynamic light intensities/colors, good shadows, fog and its color
- 20 pts Ground: generation of initial squares, alignment of squares, infinite terrain
- 20 pts Aircraft: model with realistic scaling, spinning propellor, UI updates, plane spawning
- 20 pts Flying: working controls, working physics
- 20 pts Collision Detection: efficient computation of "landing"

Bad code style, including not reusing geometry and materials as possible or allocating new objects during regular animation iterations, are deductions on top of completing features. Each check-in is worth up to negative 10 pts if not successfully completed.