Similar to Session 5, I opted to go for an object-oriented approach for this project as I had some experience with Java. As the solution code implemented encapsulation of the inherent particle class nicely, I had used the given code as a template to work from and tweaked it slightly to fit my needs.

Firstly, I engaged with Question 2 in the handout, which is the testing phase of the project. The dynamics produced by the code are right, as kinetic energy was always conserved throughout the entire simulation. The result was consistent across using different masses, and a different number of particles. This agrees with theory, which states that kinetic energy is always conserved in elastic collisions (which is assumed to be the case for this system).

Next, I chose to attempt Question 3 of the handout, where I fiddled with unequal masses in the box and plotted histograms of their positions. In a box of 10 particles, I made the first 5 particles on the left hand side much heavier than the rest of the particles on the right-hand side. By tracking the positions of the 4th and 9th particle and plotting their positions, I noticed that their histograms were skewed. The lighter particle on the right had its mean position shifted to the right, while the heavier particle on the left had its mean position shifted to the left slightly.   
  
My tinkering with the initial velocity parameter is summarised in a GIF file, where the plotted trajectories were composed to form a short animation. I have observed that when the initial velocity is close to being radial with respect to the planet’s orbit, the planet would likely crash into the Sun. This is in line with Newton’s Law of Gravitation, which produces the outcome of radial acceleration. Also, the eccentricity of the orbits increased as the direction of the initial velocity tended away from being tangential.

Lastly, perturbations of a perfectly circular orbit were investigated, as directed by Q4 of the handout. The initial velocity was given a slight increase in one of the 8 directions accordingly (N, NE, E, SE, S, SW, W, NW). When the velocity ‘kicks’ were given in the radial direction, the resulting orbit became elliptical, but the period remained unchanged. The outcome produced by the code agrees with theory, as the planet’s angular momentum remains unchanged by these radial velocity kicks. Likewise, velocity kicks with a tangential component will increase the planet’s angular momentum and cause its orbital period to change. For an object in an elliptical orbit to move into a larger circular orbit, a kick that is directed along the tangential velocity is required. Further reading allowed me to learn that this is a part of the Hohmann transfer, where a satellite shifts from one circular orbit to another through increasing its tangential velocity to enter a temporary elliptical orbit and then exit it.

My code is in a file called Orbital.cc