Portfolio Work 1

January 2021

This exercise is worth 12.5% of the course. All questions are mandatory other than those explicitly labelled as 'bonus work' (2(d) and 3(c)). You can still achieve a first-class grade by answering only mandatory questions. For those wishing to obtain 80% or higher, the bonus questions must be attempted.

Questions:

1. Using the Euler method, create a code to model the trajectory of a projectile with a known initial position, speed, and angle of inclination to the horizontal, θ. Extra marks will be awarded for:
   (a) The quality, conciseness and readability of your code.
   (b) The flexibility of your code (i.e. how easy is it to change variables?).
   (c) The quality of your comments.
   (d) How well it works!
2. Using your code, and ignoring drag forces, determine how far a projectile launched from ground level would travel for an initial velocity of 10 m/s at an angle of i) 60 degrees to the horizontal and ii) 30 degrees to the horizontal. Extra marks will be awarded for:
   (a) A high-quality, well-labelled plot of the projectiles' motion.
   (b) A reasoned discussion of how well the value obtained agrees with your expectations.
   (c) A discussion of how varying the timestep dt affects your results.
   (d) **Bonus work I:** Repeat the above using Velocity Verlet or another suitable method. How do your answers differ?
3. Extend your model to simulate a ball bouncing on a flat, solid surface. Use the simple 'hard-sphere' model taught in the lectures. For the case of a steel ball in air, model a particle being dropped vertically on the surface and:
   (a) Adjust the timestep used and comment on how it affects your results. In particular, see what happens at too large a timestep.

(b) Use your observations to choose a sensible timestep to use. Justify your choice.

(c) **Bonus work II:** Add a drag model to your code. Calculate the terminal velocities of a 5 mm diameter nylon sphere and a 5 mm diameter steel sphere in air, water and glycerine. Comment on the results obtained. Compare your results to theoretical values for each of the cases tested. Comment on your results.

Note: It is up to you to choose sensible values for all relevant particle and fluid properties, and to justify these choices in your answer.

The written answers – including text and diagrams – for this piece of the portfolio should be **no longer than 2 pages**, although those attempting the 'bonus questions' are permitted an extra half page for each bonus question attempted. You should append any code used as a text file (ideally saved as .m or .py). Excel workbooks will be accepted but are likely to lose marks pertaining to readability and comments.