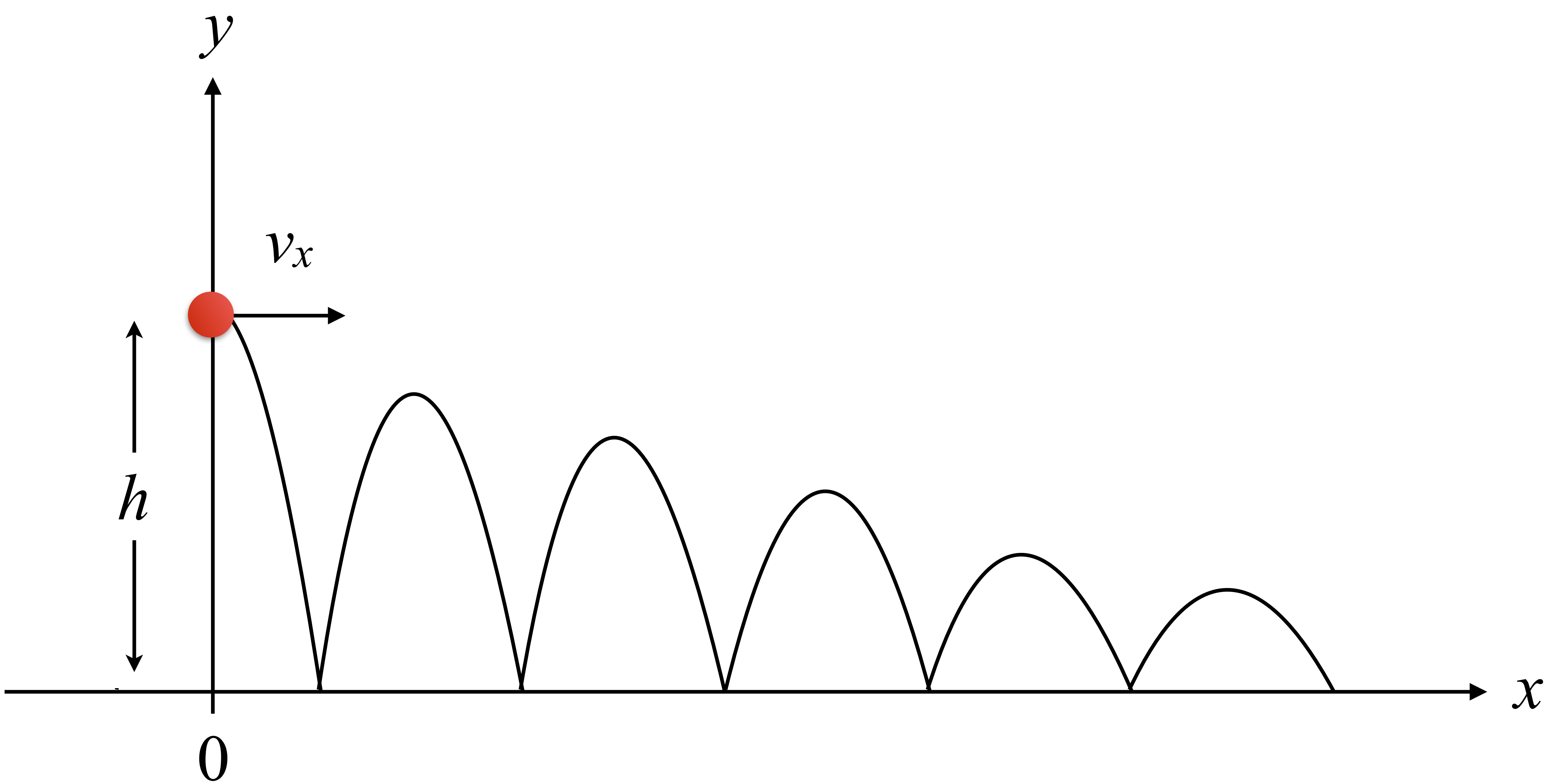
C++ Crash course

Final Practical

Problem



Equations

$$v_x = \mathrm{d}x/\mathrm{d}t = \text{constant}$$

$$v_y = \mathrm{d}y/\mathrm{d}t$$

$$\mathrm{d}v_y \,/\, \mathrm{d}t = g$$

To solve $x(t)$ and $y(t)$ we need:

$$\mathrm{d}x = v_x\,\mathrm{d}t$$
$$\mathrm{d}y = v_y\,\mathrm{d}t$$
$$\mathrm{d}v_y = g\,\mathrm{d}t$$

Given starting positions

$v_x^0 = 1$ m/s $\qquad v_y^0 = 0$ m/s

$x_0 = 0 \qquad y_0 = 10$ m

we have

$$x_{n+1} = x_n + v_x \, \mathrm{d}t$$

$$y_{n+1} = y_n + v_y \, \mathrm{d}t$$

$$v_y^{\mathrm{n+1}} = v_y^n + g \, \mathrm{d}t$$

Practical 5

1. Write a C++ program to solve the time evolution of the ball. The data for the ball should be stored in a struct ball_t composed of two structs (one for position and velocity) where each contains an x and y coordinate (4 variables in total). Initialize a single ball and write a function called move_ball() which takes a single ball_t as its argument to move the ball position. The time step should be relatively small (dt = 0.01s). Within the move_ball function implement an appropriate condition when the y position crosses zero.

2. Output the trajectory of the ball as a function of time to a file. Do you find what you would expect?

3. Implement the improved (symplectic Euler) integration scheme to calculate the integration. What happens now?

4. Generalize the simulation to use a vector of ten balls with different starting heights and velocities. Implement an appropriate condition for interacting balls.

5. Generalize to 3D for fun…

Symplectic Euler scheme

$$x_{n+1} = x_n + v_x \, \mathrm{d}t$$

$$v_y^{\mathrm{n+1}} = v_y^{n} + g \, \mathrm{d}t$$

$$y_{n+1} = y_n + v_y^{\mathrm{n+1}} \, \mathrm{d}t$$