2.

a)

i) Random step size is inversely proportional to the square root of the particle radius, i.e. smaller particles take larger random steps.

ii) The simulation assumes that tau is consistent and constant across all particles for the system. In the provided template files, physical constants for boltzman constant, temperature, viscosity, time step, g, particle/fluid density are not defined, and instead particles motion is dictated solely by

```
newx = x + 1/np.sqrt(R)*np.cos(header)
newy = y + 1/np.sqrt(R)*np.sin(header)
```

Which means the assumption was taken that c1 = 1/sqrt(R)

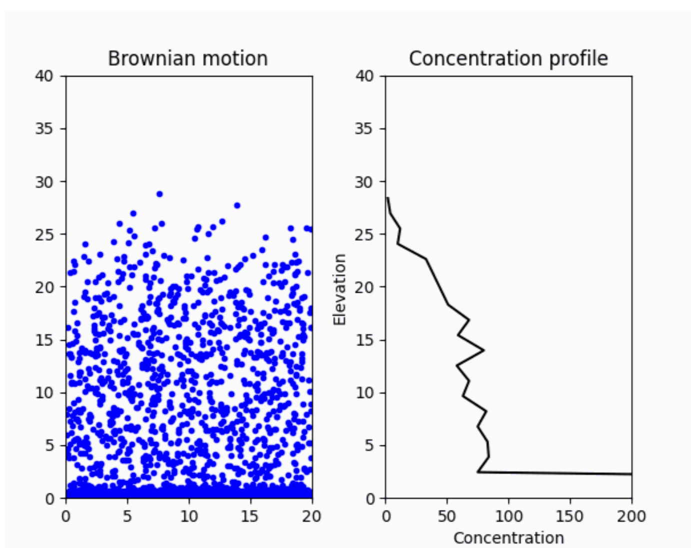
b)

i) Since v_t given by 4/3π(d−df)g t/6πηR

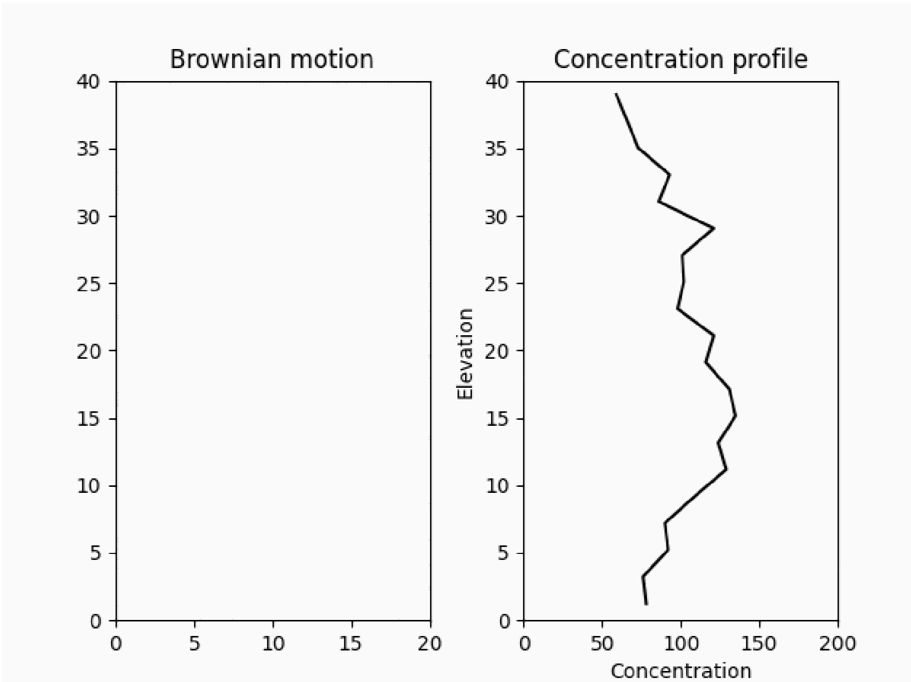
ii) Therefore step size given by v_t * t, which is 4/3π(d−df)g **t^2**/6πηR

c) Larger radius particles should exhibit smaller variations due to brownian motion, therefore leading to more rapid and significant sedimentation over time, where smaller particles have much larger brownian motion artifacts, which are in turn able to counteract the gravitational sedimentation effects. Here we can see the difference between R = 3 (significant sedimentation) and R = 0.01 (no sedimentation)

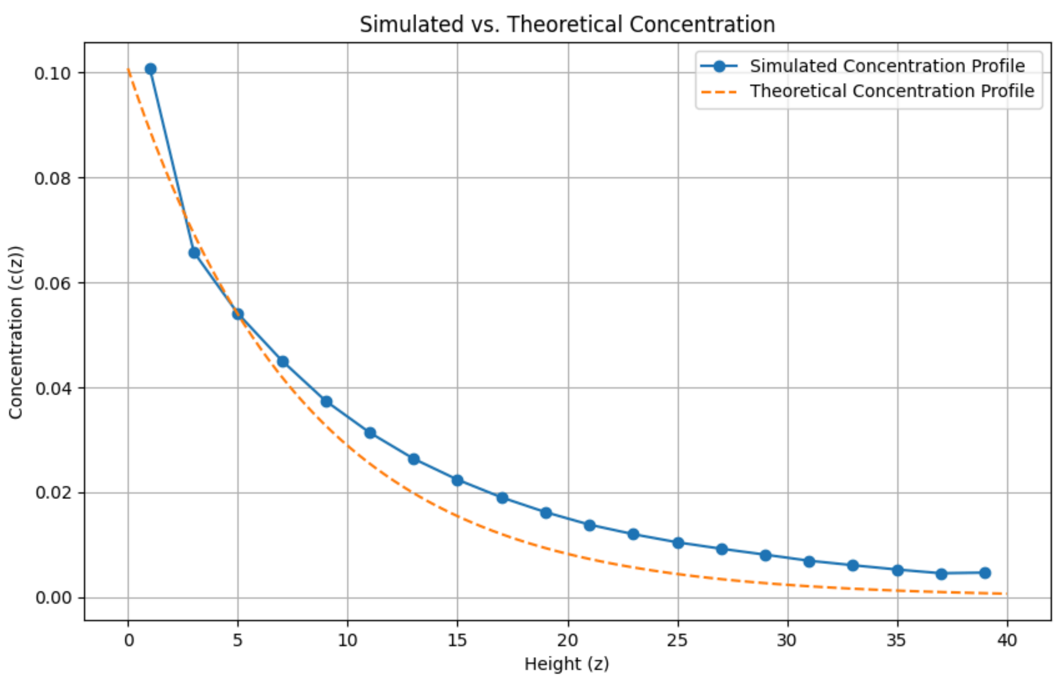
R = 3



R = 0.01



d) Plotting the data and comparing with the theoretical model proposed in part 1f, shows good agreement (as seen below)



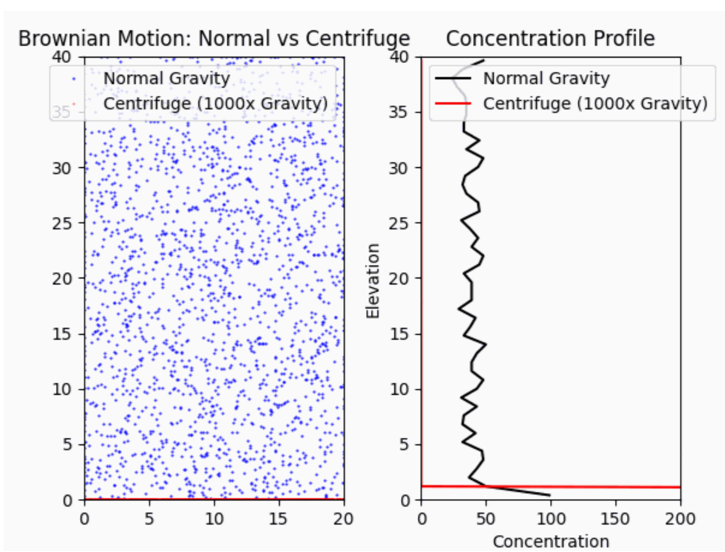
```
# Parameters
N = 2000  # number of particles
boxSizeX = 20  # width
boxSizeY = 40  # height
R = 0.5  # particle size
timeStep = 500  # length of the simulation
histogram_bin_count = 20  # histogram bins when calculating the concentration profile
g_effect = 1  # gravity effect

# Parameters for sedimentation length calculation
kT = 1.38e-23 * 300  # Boltzmann constant * Temperature (Joule)
R_meters = 0.5e-6  # Particle radius in meters (0.5 micrometers)
d = 1.05e3  # Density of particle (kg/m^3)
df = 1e3  # Fluid density (kg/m^3)
g = 9.81  # Acceleration due to gravity (m/s^2)

# Initial concentration
volume_box = boxSizeX * boxSizeY * R  # Volume in arbitrary units
c0 = N / volume_box  # Initial concentration in particles per unit volume

# Sedimentation length (ls)
ls = kT / ((4 / 3) * np.pi * R_meters**3 * (d - df) * g)
```

e) Centrifugation causes almost immediate and complete sedimentation of the particles to the bottom of the box, so quickly, in fact, that without significant modifications to the time step parameters, it is not possible to even see them sediment, compared to the non centrifuged (1xg) particles which make their gradual descent towards the bottom.



https://github.com/udiram/Biophysics_4S03/tree/release/Assignment_1 all files may be found here