HW 3 (no need to do all questions)

- 3 options:
  A. Finish Q1 and Q2,
  B. Finish Q3,
  C. Finish Q4

1) Suppose in a parallel world where the air resistance force is proportional to $V^{5/3}$. Rewrite the motor cyclist program in C or fortran to calculate this problem show in the lecture notes 13(Assume all the parameters are the same). Show the difference between this model and the model shown in the lecture notes.

HW3 A

2) Setup and run the java code of the relaxation method shown in the lecture notes 16(You can also rewrite it in C/C++ or fortran if you don't know how to run Java or you enjoy programming), test 10 different p values and the convergence speed, report the best choice of p values in your code. (Note that I am not asking you to provide the optimum of p among all possible choices of p.)

HW 3 B

3) Solve Tolman–Oppenheimer–Volkoff (TOV) equation using 4th order Runge kutta method
(write your own code if you enjoy coding or import library)
TOV equation is hydrostatic equation of spherically symmetric body in general relativity.
Using polytropic equation of state: $\frac{dp}{dr} = -G\left(\rho\left(1+\frac{\epsilon}{c^2}\right)+\frac{p}{c^2}\right)\frac{m+\frac{4\pi r^3 p}{c^2}}{r\left(r-\frac{2Gm}{c^2}\right)}$

$\frac{dm}{dr} = 4\pi r^2\rho(1+\frac{\epsilon}{c^2}), \quad p = K\rho^{\gamma}, \qquad \epsilon = \frac{p}{(\gamma-1)\rho}$

For neutron star: K = 1.982 x 10^{-6} (in CGS) or = 1.11456 x 10^{-15} (in Si unit), γ = 2.75, ϵ is specific internal energy
A) find the radius and mass of the body, given initial condition
ρ_c =5.0 x 10^{17} kg m^{-3}
B) using different initial condition, plot a M-R curve (use km and mass of sun as units)

Submit the 1) source code, 2)output file with r, P(r) , M(r) and Density(r),3) plotted structure, 4) M-R curve

HW3 C

- Or 4) Three body simulation using gravitational force

  Write a code for three body simulation of gravitational force. Implement Euler method and one predictor-corrector algorithm on same initial condition. Calculate the individual kinetic energy, total kinetic energy and total potential energy.
- Submit the 1) source code, 2) output .xyz files of trajectory, 3) plots of the KE vs time and PE vs time in two different integration methods you chosen, 4) A small report to explain the difference in energy conservation between the two methods you used