Physics Assignment 1

PHY411: Do problems 1-3
PHY 506: Do all four problems.

Accept the assignment from github classroom:https://classroom.github.com/a/GLNzt6iV . You will then get a link to your own github area.
You should submit your code through github classroom. Submit your writeup, and a link to your github classroom area where your code is, on UBLearns.

Problem 1 : Diffusion

Start from the “random_walkers” python notebook. Plot the quantity $<|\vec{x_n}|^2>$ versus n in 1, 2, and 3 dimensions. For each dimension, calculate the diffusion constant from your simulation, compare with theoretical expectations.

Problem 2 : Ising model

Start from the “ising” python notebook.

A. Recall that sudden reversals of the magnetization occur from time to time in systems of finite time. What is a reasonable value of L to be chosen to maintain one single domain instead of flipping throughout? What value of N do you need to ensure an appropriate MC simulation? Show a plot of the average magnetization per spin at temperature T = 2.0 for various values of L and N.

B. Recall from class that the average magnetization per spin $< m >$ can be estimated analytically as

   $$m \sim (T_c - T)^{\beta}$$

   Re-run your simulation from part A (fixing L and N to a reasonable number) and varying the simulation as a function of T. Fit for the critical exponent β and critical temperature T_C.

C. Similarly to part B, numerically compute the energy per spin, and then compute the heat capacity

   $$C = \partial E / \partial T$$

Problem 3 : Computational Fluid Dynamics

Start from the “16_Step_12” python notebook. Repeat the calculation, but add a small rectangular obstruction in the center of the pipe of length 1 / 20 and width 1/40. What boundary conditions are needed? Plot the resulting vector field.

Problem 4 (506 only) : Cosmic inflation

There is no code for you to start from explicitly. But, you can use “planetary.ipynb”, for example, as an inspiration.

Assume space is completely flat so k = 0, and set R(t) = 1 at the present time. You may work in scaled units of the density and pressure as we did in class. The Friedmann equations are then

$$H^2 = \left(\frac{\dot{R}}{R}\right)^2 = \frac{8\pi G}{3}\rho$$

and

$$\dot{H} + H^2 = \left(\frac{\ddot{R}}{R}\right) = -\frac{4\pi G}{3}\left(1+3w\right)\rho$$

With

$$\dot{\rho} = -3H\left(1+w\right)\rho$$

A. Solve this analytically for w = 0, 1, -1/3.
B. Solve this numerically with an adaptive RK4 scheme for w = 0, 1, -1/3, and compare to the analytic solution.