

**Problem 1** Consider the Kuramoto Model of  $N$  coupled oscillators

$$\frac{d\theta_i}{dt} = \omega_i + \frac{K}{N} \sum_{j=1}^N \sin(\theta_j - \theta_i) \quad (1)$$

with  $i = 1, 2, \dots, N$  and  $K$  is the coupling constant. Simulate the above system with random initial conditions  $\theta_i(t=0)$  uniformly distributed in  $[0, 2\pi]$  and random intrinsic frequencies drawn from a Lorentzian density

$$P(\omega) = \frac{1}{\pi(1 + \omega^2)}. \quad (2)$$

Let us define a order parameter  $re^{i\psi} = (1/N) \sum_{j=1}^N e^{i\theta_j}$  and plot the magnitude of the order parameter (in steady state) as function of  $K = [0 : 6]$  for  $N = 100, 200, 400$ .