Exercise 6

These computational exercises should be completed by **January 18** at **11:59AM**. Solutions should be turned in through the course website.

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1. **Advanced Plotting**

   Same as last time—although if you are interested in Matlab, enter `demo` at the prompt!

2. **Random Walks**

   Use Mathematica (or your favorite language) to study the behavior of random walkers (in one or two dimensions). Here are a few things to try (

   - Write a function that moves the walkers a variable number of steps using `Module`. Have the walkers' positions, step-size, and number of steps as variables for the function.
   - Explore how the walk depends on the step-size, the number of walkers, and the number of steps.
   - For the two-dimensional case, force each walker to move a fixed distance but in a random direction.
   - Visualize the results using one of the visualization techniques such as `ListDensityPlot` and/or `ListAnimate` (it should look like the solution to the diffusion equation).

3. **Partial Differential Equations**

   Use Mathematica to visualize the behavior of another partial differential equation. Here are some examples:

   Diffusion with a Source:

   $$\frac{\partial \rho}{\partial t} = D\frac{\partial^2 \rho}{\partial x^2} + f(x,t), \tag{1}$$

   (try $f(x,t) = e^{-x^2}\sin \omega t$).

   Reaction-Diffusion Equation ($\rho_1(x,t), \rho_2(x,t)$):

   $$\frac{\partial \rho_1}{\partial t} = D_1\frac{\partial^2 \rho_1}{\partial x^2} - \gamma_{12}(\rho_1 - \rho_2) \tag{2}$$

   $$\frac{\partial \rho_2}{\partial t} = D_2\frac{\partial^2 \rho_2}{\partial x^2} - \gamma_{12}(\rho_2 - \rho_1) \tag{3}$$

   (4)

The Schrödinger Equation ($\Psi(x,t)$):

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x,t)\Psi. \tag{5}$$

Wave Equation with a Source ($\Psi(x,t)$):

$$\frac{\partial^2\Psi}{\partial t^2} = \frac{\partial^2\Psi}{\partial x^2} + f(x,t). \tag{6}$$

Feel free to try two-dimensional versions, with $\partial^2\Psi/\partial x^2 \to \partial^2\Psi/\partial x^2 + \partial^2\Psi/\partial y^2$.