Problem #1: `fdder()`

Write a MATLAB function to construct matrix derivative operators for scalar functions (i.e. no Yee grid). The operators must perform first- and second-order derivatives on a 2D grid and be able to incorporate the following boundary conditions at any boundary: (1) periodic, (2) Dirichlet, and (3) Neumann.

Use the following header for your function:

```
function [DX,D2X,DY,D2Y] = fdder(NS,RES,BC)
% FDDDER      Finite-Difference Derivative Operators
%
% [DX,D2X,DY,D2Y] = fdder(NS,RES,BC);
%
% This MATLAB function generates matrix derivative operators
% for scalar functions on a collocated grid.
%
% INPUT ARGUMENTS
% ================
% NS          [Nx Ny] size of grid
% RES         [dx dy] grid resolution
% BC          [BCx BCy] Boundary Conditions
%             0=Dirichlet, -1=Periodic, +1=Neumann
%
% OUTPUT ARGUMENTS
% ================
% DX          First-order derivative with respect to x
% D2X         Second-order derivative with respect to x
% DY          First-order derivative with respect to y
% D2Y         Second-order derivative with respect to y
```

Download the tester function `test_fdder.p` from the course website. Install it in the same directory as your function `fdder()`. Run the tester function and verify that your function works correctly. To help, see the *Benchmarking document for fdder()* on the course website as well as download `fdders()` which is `fdder()` for to small grids.

Problem #2: Use `fdder()`

Type in and run the MATLAB program provided below to create the MATLAB data file '`rdat.mat`.' In this data file will be the function $A(x,y)$. Given the grid resolution parameters

$$\Delta x = 0.15 \qquad \Delta y = 0.10\,,$$

calculate the following four derivatives using the derivative matrices calculated by `fdder()`.

$$\frac{\partial A(x,y)}{\partial x} \qquad \frac{\partial^2 A(x,y)}{\partial x^2} \qquad \frac{\partial A(x,y)}{\partial y} \qquad \frac{\partial^2 A(x,y)}{\partial y^2}$$

Plot your results within the same figure window using subplots. Be sure your plots are professional and scaled properly. Include a Graphics Checklist in the appendix of your homework.

MATLAB Code to Generate rdat.mat

```
% HW1_makedata.m

% INITIALIZE MATLAB
close all;
clc;
clear all;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% DASHBOARD
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% GRID
Nx = 100;
Ny = 200;

% FILTER CUTOFF PARAMETER
f = 0.05;

% INITIALIZE RANDOM NUMBERS
rand('seed',0);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% GENERATE DATA
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% INITIALIZE RANDOM DATA
A = rand(Nx,Ny);

% FILTER DATA
nx1 = round(f*Nx);
nx2 = Nx - nx1 + 1;
ny1 = round(f*Ny);
ny2 = Ny - ny1 + 1;

A = fft2(A);
A(nx1:nx2,:) = 0;
A(:,ny1:ny2) = 0;
A = real(ifft2(A));

% SCALE DATA
A = A - mean(A(:));
A = A / max(abs(A(:)));

% SAVE DATA TO FILE
save rdat A;
```