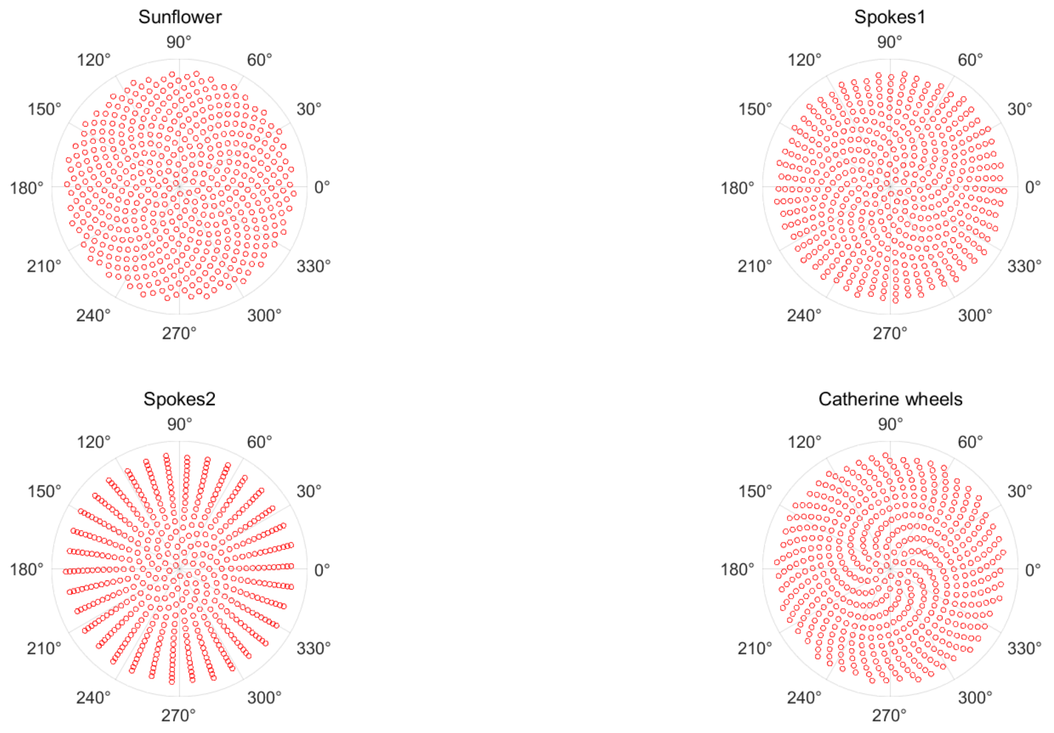
Introduction to Scientific Computing, Homework #3

Problem 1 Solution

```
clear;clc;
figure('units','normalized','outerposition',[0 0 1 1]); % Full screen
subplot(2,2,1);seedsPlot(137.513);
title('Sunflower');set(gca, 'RTick', []);
% To make it a bit more accurate: 137.51(3) (deg)

subplot(2,2,2);seedsPlot(137.45);
title('Spokes1');set(gca, 'RTick', []);

subplot(2,2,3);seedsPlot(137.65);
title('Spokes2');set(gca, 'RTick', []);

subplot(2,2,4);seedsPlot(137.92);
title('Catherine wheels');set(gca, 'RTick', []);
set(gcf, 'Color', 'w'); % white figure background

function seedsPlot(d)
N = 1:500; % Sufficient to show the tendency
theta = pi*d/180*N;
rho = sqrt(N);
polarplot(theta, rho, 'ro', 'MarkerSize', 3);
% NOTE: function "polar" is being deprecated. So I use "polarplot" instead
end
```

Plots:



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Problem 2 Solution

```
clear;clc;
fprintf("%d ", The_date_difference(20210101,20210105));
fprintf("%d ", The_date_difference(20210105,20210101));
fprintf("%d ", The_date_difference(20210105,20210106)); % Consecutive days
fprintf("%d ", The_date_difference(20120228,20120301)); % Leap year
fprintf("%d ", The_date_difference(20110228,20110301)); % Not leap year
fprintf("%d ", The_date_difference(20000228,20000301)); % Leap year
fprintf("%d ", The_date_difference(19000228,19000301)); % Not leap year
fprintf("%d ", The_date_difference(18000128,19050630));


function difference=The_date_difference(time1,time2)

% Manually extract the Y/M/D from integers in the form of YYYYMMDD
m2d = [31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31];
if time1>time2 % inplace swap
    time1=bitxor(time1, time2);
    time2=bitxor(time2, time1);
    time1=bitxor(time1, time2);
end
year1 = fix(time1/10000);year2 = fix(time2/10000);
month1 = rem(fix(time1/100), 100);month2 = rem(fix(time2/100), 100);
day1 = rem(time1, 100);day2 = rem(time2, 100);
isLeapYear = @(n)((rem(n,4)==0&rem(n,100))|(rem(n,400)==0));

difference = 365*(year2-year1) + sum(isLeapYear(year1:year2-1));
% Whole years between dates

m2d(2) = 28 + isLeapYear(year1);
for i=1:month1-1 % Delete remain days in year1
    difference = difference - m2d(i);
end
difference = difference - day1;
m2d(2) = 28 + isLeapYear(year2);
for i=1:month2-1 % Add remain days in year2
    difference = difference + m2d(i);
end
difference = difference + day2 + 1;
end
```

Example Output:

```
5 5 2 3 2 3 2 38504
```

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Problem 3 Solution

```
clear;clc;
disp(Scores_ranking(2));

function rank=Scores_ranking(n)

%% Initialize for File Operation
filename = input('Please input the file name:', 's');
% Must include suffix, like 'score.txt'
% Note: the file MUST under the current working directory.
fid = fopen(filename, 'rt');% Read as a text(ASCII) file

%% Local(in Room) Stuffs
students = fscanf(fid, '%d %d', [2, inf])';% Store all data in a 5n*2 array
rank = zeros(5*n, 5);
for i=1:n
    room = zeros(5, 4);
    room(:,1:2) = sortrows(students(5*i-4:5*i,:), 2, 'descend');
    % Sort by scores, high-to-low order
    % No need to consider the ID column, since all the room will be mixed
    % and re-calculate later.

    for j=1:5 % Dispatch local rankings
        if (j==1 || room(j,2)~=room(j-1,2))
            room(j,4) = j;
        else
            room(j,4) = room(j-1,4);
            % Same score, same ranking.
        end
    end
    room(:,3) = repelem(i, 5)'; % Add the column of room number
    rank(5*i-4:5*i,1:4) = room;
end

%% Generate Global and Final Result
rank = sortrows(rank, [2, 1], {'descend', 'ascend'});
% Sort the result table by both score and ID column.
% If the score is the same, then sort by ID column in non-decreasing order.

for j=1:5*n % Calculate the final/global ranking for every student
    if (j==1 || rank(j,2)~=rank(j-1,2))
        rank(j,5) = j;
    else
        rank(j,5) = rank(j-1,5);
    end
end

end
```

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User Input:

```
Please input the file name:score.txt
```

Output(match√):

```
    22024005         100           1           1           1
    22024014         100           2           1           1
    22024001          95           1           2           3
    22024003          95           1           2           3
    22024004          85           1           4           5
    22024012          85           2           2           5
    22024002          77           1           5           7
    22024013          65           2           3           8
    22024011          25           2           4           9
    22024010           0           2           5          10
```

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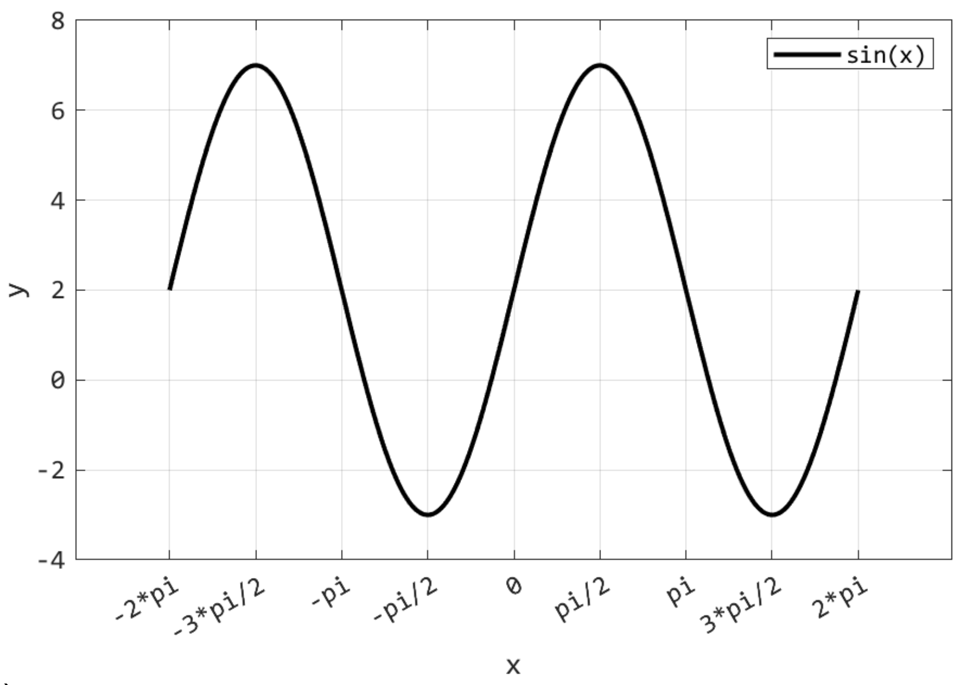
Problem 4 Solution <u>(data saved in test.mat)</u>

```
clear;clc;
saveSineWave('test');
plotSineWave('test');
% Make sure that the 'test.mat' file is under current working directory.
function saveSineWave(fileName)
x = -2*pi:pi/100:2*pi;
y = 5*sin(x) + 2;
save([fileName, '.mat'], 'x', 'y', '-mat'); % Manually add '.mat' suffix
end

function plotSineWave(fileName)
load([fileName, '.mat'], 'x', 'y', '-mat');
% Specific the variables to load to avoid possible conflict with functions
% or variables that already exist.
plot(x, y, '-k', 'LineWidth', 2);
xlabel('x');ylabel('y'); % Required: axis label
axis auto;
ylim([-4 8]); % Breathing room
set(gca,'XTick',-2*pi:pi/2:2*pi)
set(gca,'XTickLabel', ...
    {'-2*pi', '-3*pi/2', '-pi', '-pi/2', '0','pi/2','pi','3*pi/2','2*pi'});
set(gca,'FontSize', 12, 'FontName', 'Consolas'); % Bigger font
grid on;
legend('sin(x)', 'Location','northeast');
end
```

Plot:



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Problem 5 Solution (Test script: glider gun)

```
clear;clc;
%%
% Game of Life
% Based on the script teacher provided, the work is to implement 3 core
% functions(at the end of this file).
block = [1 1; 1 1];
boat = [1 1 0; 1 0 1; 0 1 0];
blinker = [1 1 1];
toad = [0 1 1 1; 1 1 1 0];
glider = [1 1 1; 1 0 0; 0 1 0];
LWSS = [0 1 0 0 1; 1 0 0 0 0; 1 0 0 0 1; 1 1 1 1 0];
gun_left = [
    0 0 1 1 0 0 0 0;
    0 1 0 0 0 1 0 0;
    1 0 0 0 0 0 1 0;
    1 0 0 0 1 0 1 1;
    1 0 0 0 0 0 1 0;
    0 1 0 0 0 1 0 0;
    0 0 1 1 0 0 0 0];% For glider gun
gun_right = [
    0 0 0 0 1;
    0 0 1 0 1;
    1 1 0 0 0;
    1 1 0 0 0;
    1 1 0 0 0;
    0 0 1 0 1;
    0 0 0 0 1];


%% Initialization of the basic patterns
% My shapes inserted here.
% Create a gosper glider gun
in = zeros(100);
in (6:7, 2:3) = block;
in (4:10, 12:19) = gun_left;
in (2:8, 22:26) = gun_right;
in (4:5, 36:37) = block;

%% Simulation
iterations = 1000;

for i = 1:iterations
    image(logical(in));
    colormap ([1 1 1; 0 0 0]);
    grid off; % Get rid of the grid, get it? A pun.
    in = updateCells(in);
    pause(0.001);
end
clear;clc;
%% Function implemented
function out = getCell(in, row, col)
%% Get an element from matrix, but with tolerance of array overrun
[maxrow, maxcol] = size(in);
```

```
if row<1 || row>maxrow || col<1 || col>maxcol
    % Special judge for illegal positions
    out = 0;
else
    out = (in(row, col)==1);
end
end

function out = countNeighbors(in)
[maxrow, maxcol] = size(in);
out = zeros(maxrow, maxcol);
for x=1:maxrow % Question about this methodology:
    % It takes O(n^4) for each period, but maybe it can reduced to O(n^2),
    % just by shifting and overlapping the matrix itself? Codes adhered
    % after this segment.
    for y=1:maxcol
        out(x, y) = getCell(in, x-1, y-1) + getCell(in, x-1, y) + ...
            getCell(in, x-1, y+1) + getCell(in, x, y-1) + ...
            getCell(in, x, y+1) + getCell(in, x+1, y-1) + ...
            getCell(in, x+1, y) + getCell(in, x+1, y+1);
        % 8 neighbors in 8 directions, not 4
    end
end
%% Alternative Method
% Maybe faster.
% out = zeros(maxrow+2, maxcol+2);
% out(1:maxrow,1:maxcol) = in;
% out(1:maxrow,2:maxcol+1) = out(1:maxrow,2:maxcol+1) + in;
% out(1:maxrow,3:maxcol+2) = out(1:maxrow,3:maxcol+2) + in;
% out(2:maxrow+1,1:maxcol) = out(2:maxrow+1,1:maxcol) + in;
% out(2:maxrow+1,3:maxcol+2) = out(2:maxrow+1,3:maxcol+2) + in;
% out(3:maxrow+2,1:maxcol) = out(3:maxrow+2,1:maxcol) + in;
% out(3:maxrow+2,2:maxcol+1) = out(3:maxrow+2,2:maxcol+1) + in;
% out(3:maxrow+2,3:maxcol+2) = out(3:maxrow+2,3:maxcol+2) + in;
% out = out(2:maxrow+1,2:maxcol+1);
end
function out = updateCells(in)
%% Calculate the next frame
neig = countNeighbors(in);
out = (neig==3) | (neig==2 & in);
% Simplified logic.
% Using logical matrix operation, short, easy to understand and fast.
End
```

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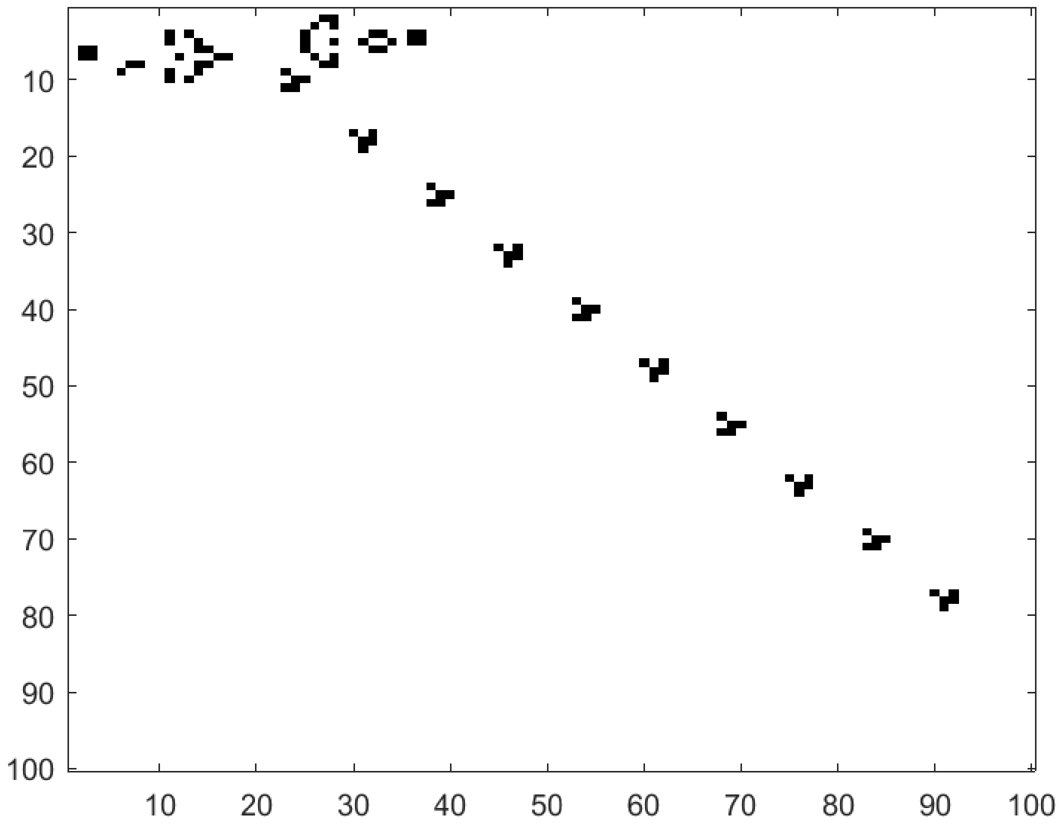
Problem 5 Runtime Screenshot:



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Problem 6 Solution

```
clear;clc;
load('AFMdata0001.mat', 'current', 'friction', 'height', '-mat');
plotAFMdata(height, friction, current, 200, 'AFM_Visualize');

function plotAFMdata(H, F, I, ss, saveName)
%% Arguments Checking
[row, col] = size(H);
assert(row==col);
assert(all(size(H)==size(F)));
assert(all(size(I)==size(F)));
Xcor = linspace(0, ss, row);
Ycor = linspace(0, ss, col); % X-Y surface division

%% Figure Initialization
figure;
set(gcf, 'PaperPositionMode', 'auto');
set(gcf, 'PaperUnits', 'points');
set(gcf, 'Color', 'w'); % Required: white figure background
screen_rect = get(0, 'ScreenSize');
screen_width = screen_rect(3);
screen_height = screen_rect(4);
figure_width = 1000;
figure_height = 460; % Required figure size
set(gcf, 'position', [ ...
    screen_width/2-figure_width/2, screen_height/2-figure_height/2, ...
    figure_width, figure_height]);
% Required: Figure in the center of the screen

%% Axes1: F(x, y)
plotFxy = subplot(2, 2, 3);
[X, Y] = meshgrid(Xcor, Ycor);
surf(X, Y, F);
set(gca,'FontSize', 9, 'FontName', 'Consolas');
xlabel('nm');ylabel('nm');zlabel('nm');
title('Friction overlaid height');
shading interp; % Smooth color shifting when hegiht changes
cb1 = colorbar;
title(cb1, 'Friction (mV)');
colormap(plotFxy, "jet"); % Respectively dispatch styles
view(-40, 60); % Required: specific azimuth and elevation
grid off; % Required: no grid
box on; ax = gca;ax.BoxStyle = "full"; % Required: fully bounding box
axis tight; % Required: axis extend no further than the data range

%% Axes2: I(x, y)
plotIxy = subplot(2, 2, 4);
[X, Y] = meshgrid(Xcor, Ycor);
surf(X, Y, I);
set(gca,'FontSize', 9, 'FontName', 'Consolas');
xlabel('nm');ylabel('nm');zlabel('nm');
title('Current overlaid height');
shading interp;
cb2 = colorbar;
```

```
title(cb2, 'Current Response (V)');
colormap(plotIxy, "parula");
view(-40, 50); % Required: specific azimuth and elevation
grid off; % Required: no grid
box on; ax = gca;ax.BoxStyle = "full"; % Required: fully bounding box
axis tight; % Required: axis extend no further than the data range

%% Axes3: I(F)
subplot(2, 2, 1);
scatter(F, I, 1, 'black', '.');
set(gca,'FontSize', 9, 'FontName', 'Consolas');
% Required: specific font size&name for *ALL* text elements
% Same afterwards
% Note: This must be set after plotting since the plot/scatter reset axes
xlabel('Friction (mV)');
ylabel('Current response (V)');
title('Current response as a function of friction');
axis auto; % Required: Auto axis

%% Axes4: Current histogram
subplot(2, 2, 2);
histogram(I);
set(gca,'FontSize', 9, 'FontName', 'Consolas');
xlabel('Current response (V)');
ylabel('Counts');
title('Current histogram');
xlim([-1 7]); % Required: specific domain of -1 to 7
% no specific range

%% Save&Exit
% Required: save image to 24-bit jpeg file with resolution of
% 300pixels/inch, then close the figure window
print(gcf, '-djpeg', '-r300', saveName);
% -djpeg stands for 24-bit color depth implicitly
% Note: MATLAB for Windows: 1/96 inch/pixel
% Therefore expected image size is 3125 x 1437
% 1000/96*300 = 3125
% 460/96*300 = 1437.5

%% Alternative
% sgtitle('Figure saved as image!', ...
%     'Color','b', 'FontSize', 12, 'FontName', 'Consolas');
% !Only available in version MATLAB 2018b or later
pause(3);
% in case when your computer is too fast to have a glimpse of the figure!
close(gcf);

end
```

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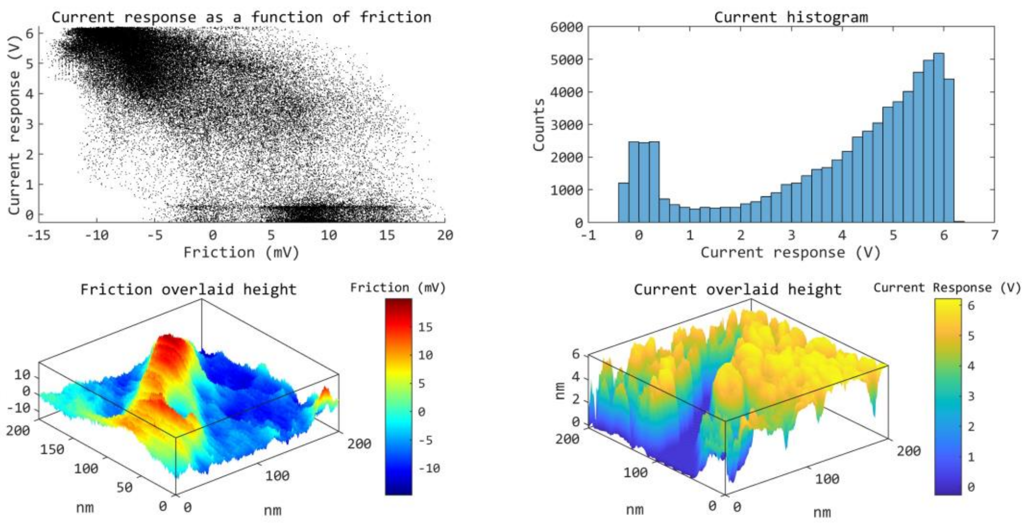
Saved image (AFM_Visualize.jpg, 3125x1437)



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