Introduction to Scientific Computing, Homework #1

Problem 1 Solution

```
clear;clc;
d = floor(6*rand(1,20)+1);
% generate a vector d filled with random integers in range of [1,6]
disp('The vector d is:');
disp(d); % display the content of vector d

a = (d == 6); % Convert d to a logical vector
% ("sixes" replaced by 1, otherwise 0)
fprintf('The ''six(es)'' count of d: %d\n', sum(a));
% Using function sum() to sum the whole logical vector
% Because every "1" in logical vector a represents a "6" in d,
% by summing vector a we can yield the count of 6 in vector d.
```

Example Output:

```
>>The vector d is:

     5     4     4     2     4     1     1     1     6     6     1     3
4     2     5     4     3     2     5     6

The 'six(es)' count of d: 3
```

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Problem 2 Solution

```
clear;clc;
x_in_rad = 0:pi/6:2*pi; % First column from 0 to 2π in steps of π/6
x_in_deg = rad2deg(x_in_rad); % Second column convert rad. to deg.
sinx = sin(x_in_rad); % Calculate sin(x), which constitutes column 3
cosx = cos(x_in_rad); % Calculate cos(x), which constitutes column 4
A = table(x_in_rad', x_in_deg', sinx', cosx',...
    'VariableNames', {'x(rad)', 'x(deg)', 'sin(x)', 'cos(x)'});
% Assemble the final array A and display it.
% Named argument for naming the variables.
% Note that here the ' notation is used for
% transpose the vectors, to make them filled column-by-column,
% instead of row-by-row.
disp('The whole array looks like:');
disp(A);

% Extra work to visualize is followed here.
plot(x_in_rad, sinx, 'g');
hold on; % !Essential for add more curves in one plot figure
plot(x_in_rad, cosx, 'b');
legend('sin(x)','cos(x)')
title('A simple figure')
```

Output:

```
>> The whole array looks like:

    x(rad)    x(deg)      sin(x)        cos(x)
    ______    ______    __________    _________


         0       0               0            1

    0.5236      30             0.5      0.86603

    1.0472      60         0.86603          0.5
```

(more lines omitted)

Figure for sin(x) & cos(x):

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Problem 3 Solution

```
clear;clc;
A = [
    -23,-18,2,-19,-15;
    -1,-16,10,1,3;
    -15,-23,1,8,7;
    -19,7,2,19,-4;
    -15,-11,-3,-11,-15];% Matrix (5 x 5) of coefficients
B = [22;-21;-20;-18;-17];% Vector (5 x 1) of constants
xSol1 = A\B;% Method1: using operator \
disp('Method1 x1~x5: ');disp(xSol1');
xSol2 = inv(A)*B;
disp('Method2 x1~x5: ');disp(xSol2');
% Method2: multiplied by the inverse matrix of A
% Note: Less efficient & less accurate than method1

xSol3 = linsolve(A, B);
disp('Method3 x1~x5: ');disp(xSol3');
% Method3: using built-in MATLAB function linsolve()
% which is designated for solving linear equations.
```

Output:

```
>>Method1 x1~x5:

   -2.7527    2.7366    1.0375   -3.8683    4.5085



Method2 x1~x5:

   -2.7527    2.7366    1.0375   -3.8683    4.5085



Method3 x1~x5:

   -2.7527    2.7366    1.0375   -3.8683    4.5085
```

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Problem 4 Solution

```
clear;clc;
gcd(44,28);
gcd(14,24);
function gcd(M, N)
% Calculate GCD(M,N)
% If M/N is not designated then got it from user input
switch nargin
        case 0
            M = round(input('Input value of M:'));
            N = round(input('Input value of N:'));
end
while M ~= N % 更相减损法/Euclidean algorithm to calculate GCD
    while M > N
        M = M - N;
    end
%     fprintf("M=%d N=%d\n", M, N);
% Deprecated due to typographical problems
% (avoid too many lines in output)
    while M < N
        N = N - M;
    end
    fprintf("M=%d N=%d\n", M, N); % Sketch M and N in loop
end
disp(['Ultimately, value of M is:']);disp(M);
end
```

Output:

```
>>M=16 N=12

M=4 N=4

Ultimately, value of M is:

     4



M=14 N=10

M=4 N=2

M=2 N=2

Ultimately, value of M is:

     2
```

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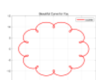
Problem 5 Solution

```
clear;clc;
figure(1);% Seperated window for different curves
spirograph(5,1,0.4);
figure(2);
spirograph(12,-1,1.5);
figure(3);
spirograph(7,-1,1);
function spirograph(R,r,d)
theta = 0:0.0005:10*pi; % Generate theta vector in steps=0.0005 rad
x = cos(theta)*(R+r)+cos(theta*(R+r)/r)*d; % Generate x vector without loop
y = sin(theta)*(R+r)-sin(theta*(R+r)/r)*d; % The same to y vector
plot(x,y,'.b',...
    'LineWidth',2); % Try to change the style/color/width!
grid on; % Display grid on background
title('Beautiful Curve for You');
legend('roulette')
end
```

Plots in different plot() style args:



We can dispatch different option arguments(by editing the "plot" code line) for different visual effects. Here is what I used for 3 figures above:

'.b' for figure1: Blue and dot line;

'-r' for figure2: Red and straight line;

'-c' for figure3: Cyan and straight line.

There're also "named arguments" for it, for example I modified 'LineWidth' to make a **bold line.** The reason not to modify the marker type (diamond, star…) is that there are too many data points, which will lead to overlapped markers.

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Problem 6 Solution

```
clear;clc;
% For test only
output_str=join(string(fib(20)),', '); % More pretty output
fprintf("The Fibonacci sequence for N = 20:\n%s\n", output_str);

function nums = fib(N)
% fib(N) returns a list of the first N Fibonacci Numbers.
% N must be an integer.

if N <= 0
    error('N must be positive.'); % Error reporting for illegal N;
end
if N <= 1 % Special judge
    nums = 0;
    return
end
if N == 2
    nums = [0, 1];
    return
end
nums = [0, 1]; % Initial value for the sequence
for now_index = 3:N+1
% In MATLAB array index starts from 1, but the sequence index starts from 0
% So here is the reason why we offset 1
    nums(now_index) = nums(now_index-1) + nums(now_index-2);
end
end
% Of course we can use the built-in function fib()
% But that's too boring!
% Recursive function? Yes, but the time complexity will be O(n^2)
% When it comes to time complexity, the method that applies binary exponentiation
% to matrix can yield F_n in O(logn).
% However it’s not so effective when generating a whole sequence
% Just keep it simple.
```

Output that required:

```
>> The Fibonacci sequence for N = 20:
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597,
2584, 4181, 6765
```

(End)