

Program Development Worksheet:Problem ID _Sin by a Series Programmer S. Scott MoorSet Up/ IntroductionType of Program: Script Function

1. Problem Statement:

The sin function can be approximated by the series:

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} \dots = \sum_{k=1}^n (-1)^{k+1} \frac{x^{k*2-1}}{(k*2-1)!}$$

This program uses the above series to estimate the sin given the x-value and n, the number of terms to be used in the sequence.

2. Inputs: (full name, variable to be used, units)

Variable Name	Description	Units or Values	Input Source*
x	The number to take the sine of	Radians	Command line
n	The number of terms in the series	Integer	Command line

3. Output: (full name, variable to be used, units)

Variable Name	Description	Units or Values	Output type*
S	Resulting sin	Unitless -1 to 1	Command line

4. Solution Steps (order of these two parts may be varied):

Perform calculation on test case(s)

Identify the steps/equations

(select a test case if one is not given, avoid answers of 0 or 1)

for x =0.5, n = 3

$$\sin(0.5) = (0.5) - (0.5)^3/6 + (0.5)^5/120 = 0.5 - 0.02083 + 0.00026 = 0.479427$$

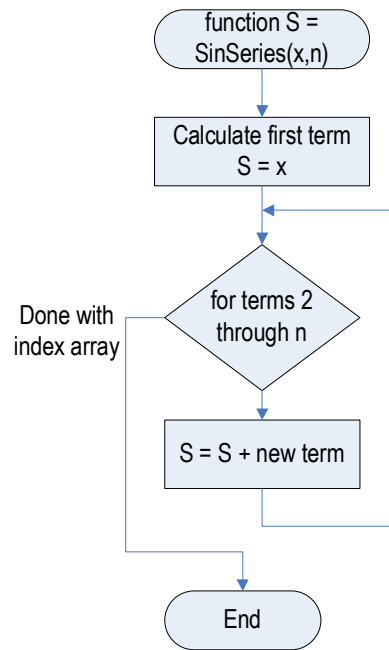
Versus the exact value for sin

$$\sin(0.5) = 0.479426$$

Your Tasks:

- Download the proposed solution to this problem – SinSeries1.m, from the course website. This version has several logical errors.
- Run this program using x = 0.5, n=3 and compare to the above calculation and intermediate results. In a word document show this execution and answer the following questions:
 - What matches the above calculation in the programs execution?
 - What does not match the above calculation in the programs execution?
 - How might you fix the problems noticed?
- Revise the program, run the revised program and show that it matches the above. Add the revised program and the validation run to your word document.

Flowchart for SinSeries Functions:



Coding

Provided Program with Logical Errors:

```

function S = SinSeries1(x, n)
% function S = SinSeries(x, n)
% This function determines the value of the sine based on a series
% expansion. This particular version has several logical errors.
% S. Scott Moor    April 2008
%
% Input variables: x = angle (radians)
%                  n = number of terms in the series approximation
% Output variable: S = the resulting estimate of sin (unitless)
%
% Other variables k = loop index, location of the current term
%                  t = an intermediate value used in the series calculation
%
% initialize the series with its first term,
S = n;

% Add each successive term using a for loop
for k = 1:n
    t = k*2-1;
    S = [S,(-1)^(k+1)*x^t./(factorial(t))];
end
  
```

Logical Errors:

The first term in the series is x not n

The first term has already been entered so this count should begin at 2

Each term should be added to the previous result not concatenated

What a test run of this code looks like

```

>> SinSeries1(0.5, 3)
ans =
    3.0000    0.5000   -0.0208    0.0003
  
```

Notice: 1. A vector results instead of a single answer
 2. The 2nd - last value in this vector are the correct values of the three terms in the series.
 3. The first term is the number of terms desired

5. Corrected Code – fixing the problems noted above you get:

```

function S = SinSeries(x, n)
% function S = SinSeries(x, n)
% This function determines the value of the sine based on a series
% expansion.
% S. Scott Moor    April 2008
%
% Input variables: x = angle (radians)
%                 n = number of terms in the series approximation
% Output variable: S = the resulting estimate of sin (unitless)

% Other variables k = loop index, location of the current term
%                 t = an intermedeate value used in the series calculation

% initialize the series with its first term,
S = x;

% Add each successive term using a for loop
for k = 2:n
    t = k^2-1;
    S = S + (-1)^(k+1)*x.^t./(factorial(t));
end

```

Validation:

6. Test Case Check:

```

>> SinSeries(0.5, 3)
ans =
    0.4794

```

7. Check of Full Problem

Is the result realistic?

Try with more terms:

```

>> SinSeries(0.5, 15)
ans =
    0.4794

```

Format to show more digits

```

>> format long
>> ans
ans =
    0.479425538604203
>> sin(0.5)
ans =
    0.479425538604203

```

This result matches and is reasonable

8. Test on wider cases, as necessary

The function as written above can handle vectors. Try the following vector and compare answer to the regular sin function:

```

>> x = 0:.2*pi:pi
x =
    0    0.6283    1.2566    1.8850    2.5133    3.1416
>> SinSeries(x, 8)
ans =
    0    0.5878    0.9511    0.9511    0.5878   -0.0000
>> sin(x)
ans =
    0    0.5878    0.9511    0.9511    0.5878    0.0000

```

New function matches the sin series and follows the expected pattern for a sin function.