

## ChEE 201 Computer Homework 3

You need to have read Computer Handout 3 before attempting this homework.

This homework will have you:

- 1) show you can write a function that would calculate an infinite series to approximate a function
- 2) demonstrate you can use a function you developed in homework three and include it into a longer program
- 3) demonstrate that you understand and can use the error definitions given in Computer Reading 3

1) In Reading 3, you saw there were some common infinite sums for calculating approximate answers to common functions. Write a program that would find the approximate value of  $\ln(1+x)$  up to a specified number of terms. Your VBA program should receive two pieces of information from Excel: the value of  $x$ , and the number of terms you want to include in your approximation.

In Excel, put the value 0.4 in cell A1.

Then in Column B, put the word "Number of terms" in B1

Finally, put 1 in B2, 2 in B3,...etc., down to number 6 in cell B7

Create a VBA module and then write a program to use the infinite sum from Reading 3 to approximate  $\ln(1-x)$ . Your module should send back only one number, which is the value of the summed approximation for the number of terms you want.

Go back to Excel and put the word "Approximate Value" in cell C1

In cell C2, put " $=$ your function name( $\$A\$1,B2$ ). Then copy this formula into the cells beneath this one until you have a table with answers for each of the number of terms.

Print out your spreadsheet and the program module for credit. Include a description of what you find as the number of terms increases. You do NOT need to email this solution to the professor.

**Solution:** The spreadsheet should have looked like:

	A	B	C	D	E	F	G
1	0.4	Number of Terms					
2		1	0.4				
3		2	0.32				
4		3	0.341333				
5		4	0.334933				
6		5	0.336981				
7		6	0.336299		Actual answer		0.336472
8							

And our program could have looked like:

*Option Explicit*

*Function approx(x, n)*

*Dim sum As Single, i As Single*

*sum = 0*

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For i = 1 To n
    sum = sum + (-1) ^ (i + 1) * (x ^ i) / i
Next i

approx = sum

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*End Function*

Comment: As the number of terms increases, we get closer and closer to the actual answer.

2) In Computer HW 2, you wrote a program that found the factorial of a number. You're going to use that code here to find the approximate value to sin(x). To do this, first look at the infinite series for sine and try to find the general functional description of how the terms are increasing as you move from term to term. You want to write an infinite sum formula like the one we have for e<sup>x</sup> where:

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

You should realize based on the beginning comments from this problem that you should have a factorial in your function somewhere. Report your infinite sum formula with your answer.

Now that you have the infinite sum formula, write a VBA program to compute cos(3) using that formula. Your VBA program should take in 3 and the number of terms you are going to use. Make a table like you did in problem 1 to show the value of sin(3) for between 0 and 15 terms.

Using your calculator, find the sin(3). Be careful that this is in radians and not degrees because the infinite sum is for use when x is in radians. In the columns next to your approximate value, compute the true error, the true relative error, the approximate error, and the approximate relative error, like was done on the fourth page of Reading 3. Print out a copy of your table and your computer program and include that with your hard copy solution.

Now change your Excel file to find sin(5), sin(7), sin(9). Comment on what you see in the column for the value as the number of terms increases for each case.

Also, save this spreadsheet and module by itself as your "first name+last name+HW3.2.xls" and email to blowers@engr.arizona.edu before class on the day it is due. As an example, my own submission would be saved as PaulBlowersHW3.xls

**Solution:** Our function that we have should have used is:

$$\cos x = \sum_{n=1}^{\infty} (-1)^{n-1} \frac{x^{2n-1}}{(2n-1)!}$$

Once we have this, we can write our VBA program and it should look like:

*Option Explicit*

*Function sinapprox(x, n)*

*Dim i As Single, j As Single*

*Dim sum As Single, fact As Single, powern As Single*

*sum = 0*

*For i = 1 To n*

*fact = 1*

*For j = 1 To 2 \* i - 1*

*fact = fact \* j*

*Next j*

*sum = sum + (x ^ (2 \* i - 1)) \* ((-1) ^ (i - 1)) / fact*

Next  $i$   
 $\sin_{\text{approx}} = \text{sum}$

End Function

See the professor or TA if you are having a difficult time with the programs since we will continue to get more complicated throughout the semester.

The  $\sin(3)$  is 0.14112 and this is our true value.

We use the formulas from Reading 1 and we get a table that looks like:

Number of terms	Approximate Answer	True Error	True Relative Error	Approximate Error	Approximate Relative Error
1	3	-2.858879992	-20.25850219	N/A	N/A
2	-1.5	1.641120008	11.62925109	-4.5	3
3	0.524999976	-0.383879968	-2.720237714	2.024999976	3.857142987
4	0.091071405	0.050048604	0.354652783	-0.433928572	-4.764707143
5	0.145312473	-0.004192465	-0.02970851	0.054241069	0.373271939
6	0.140874565	0.000245443	0.001739253	-0.004437909	-0.031502554
7	0.141130596	-1.05883E-05	-7.50307E-05	0.000256032	0.001814148
8	0.141119629	3.78915E-07	2.68506E-06	-1.09673E-05	-7.7716E-05
9	0.141119987	2.12873E-08	1.50846E-07	3.57628E-07	2.53421E-06
10	0.141119972	3.61885E-08	2.56438E-07	-1.49012E-08	-1.05592E-07
11	0.141119972	3.61885E-08	2.56438E-07	0	0
12	0.141119972	3.61885E-08	2.56438E-07	0	0
13	0.141119972	3.61885E-08	2.56438E-07	0	0
14	0.141119972	3.61885E-08	2.56438E-07	0	0
15	0.141119972	3.61885E-08	2.56438E-07	0	0

Comment: As you increase the value of  $x$ , it takes more and more terms to get convergence to a final value. We'll learn why this is when we cover the Taylor series in the next readings and homework.