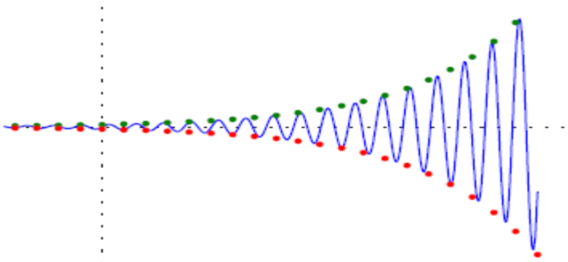
CST 8233 – W21 - Assignment #3

Maclurin Series Application

Due Time: 23.59, 9 April 2021 **Earnings:** 6% of your final grade

NOTE: Plan to finish a few days early to avoid last minute hardware/software holdups for which no allowance is given.
NOTE: The code in this assignment must be your own work. It must not be code taken from another student or written for you by someone else, even if you give a reference to the person you got it from (attribution); if it is not entirely your own work it will be treated as plagiarism .

Purpose: You are employed by an architecture company to write code for a building simulation. The company wants to model the start of the motion response of a tall building hit by strong winds that set it in vibration that builds up catastrophically. The following graph shows the vibration oscillations growing catastrophically in time (along the x-axis) over a large number of Oscillations:



The simulation must run on a PC in real time and is part of a larger simulation that includes the motion of other structures. Because it must run in real-time it is too time consuming to use the more accurate but slow math library functions, so your task is to investigate a less accurate but faster Maclaurin Series approximation for the start of the motion where a few terms might be adequate. The formula you will use for an approximation for the movement D of the top of the building in meters with time t in seconds after the vibration starts up is:

$$D(t) = e^{t}\cos(t)$$

In this application you will investigate the series approximation to the motion for its accuracy over initial times up to 4 seconds after the start of the vibration.

Algorithm: Determine the Maclaurin Series approximation to $D(t) = e^{t}\cos(t)$ as a power series in t (all variables are doubles) as given in lectures up to the first 7 non-zero terms (you need 7 for the truncation error on 6 terms). Then as often as the user wishes to repeat, allow the user to choose the number of non- zero terms (from 1 to 6) in the series approximation and what range (between 0.0 and 4.0) of values of t to evaluate in 10 equal increments.

The purpose of the series approximation is to speed up its execution so no functions are used in the evaluation of the terms of the series, whether they be math library functions such as exp() or pow() etc., or any other function, and terms such as x^3 for example are written explicitly in your code as x*x*x and factorials are precalculated and written in as numbers.

For each value of t the Maclaurin series approximation is output together with the **exact value from the math library**. Also output **the relative error in two ways:**

1. From comparison with the exact value calculated using the math library functions:
   Exact % Error = 100*(exact value – series value)/exact value

2. From the first truncated term. This gives you an idea of how well the first truncated term approximates to the error.

   Truncation % Error = 100*(first truncated term/series value)

What to Submit: Set up an empty project in Visual Studio 2019 with the name ass3, add a new source code file ass3.cpp\c to the project and write your code in it to implement the application, as described above.
Then on Brightspace in the Assignment Submission folder submit your ass3.cpp\c file.
Don't submit the project, submit only .c or .cpp file.
There is a late penalty of 25% per day - even one minute is counted late.
You may lose 60% or more if:

- The output is wrong
- Your program won't build in Visual Studio 2019
- Your program crashes in normal operation
- I can't build it because you submitted the wrong files or the files are missing, even if it's an honest mistake – this gets 100% deduction.

Don't send me the file as an email attachment – it will get 0.
It is also vital that you should follow the **Submission Standard** in your source file so it can be identified as yours.
Make sure you have submitted the correct file. If I cannot build it because the file is wrong even if it's an honest mistake, you get 0.

Example Output

```
Evaluate the Maclaurin Series approximation to D(t) = exp(t)*cos(t)

1: Evaluate the series
2: quit

1

Evaluating the series
```

```
Please enter the number of (non-zero) terms in the series (1, 2, 3, 4, 5 or 6):
6

Please enter the range of t to evaluate in 10 increments (0.0 < t < +4.0): 4

MACLAURIN SERIES
  t             D(t) Series     D(t) Exact      %RExactE        %RSerE
0.000e+00       1.00000e+00     1.00000e+00     0.00000e+00     0.00000e+00
4.000e-01       1.37406e+00     1.37406e+00     1.97652e-05     1.89266e-05
8.000e-01       1.55048e+00     1.55055e+00     4.67032e-03     4.29392e-03
1.200e+00       1.20114e+00     1.20307e+00     1.60134e-01     1.42054e-01
1.600e+00       -1.64517e-01    -1.44626e-01    -1.37529e+01    -1.03598e+01
2.000e+00       -3.19683e+00    -3.07493e+00    -3.96409e+00    -3.17776e+00
2.400e+00       -8.66380e+00    -8.12842e+00    -6.58647e+00    -5.04175e+00
2.800e+00       -1.73567e+01    -1.54945e+01    -1.20181e+01    -8.63769e+00
3.200e+00       -2.99298e+01    -2.44907e+01    -2.22089e+01    -1.45779e+01
3.600e+00       -4.66622e+01    -3.28198e+01    -4.21772e+01    -2.39913e+01
4.000e+00       -6.71270e+01    -3.56877e+01    -8.80954e+01    -3.87420e+01

Evaluate the Maclaurin Series approximation to D(t) = exp(t)*cos(t)

1: Evaluate the series
2: quit

1

Evaluating the series
Please enter the number of (non-zero) terms in the series (1, 2, 3, 4, 5 or 6):
5

Please enter the range of t to evaluate in 10 increments (0.0 < t < +4.0): 3

MACLAURIN SERIES
  t             D(t) Series     D(t) Exact      %RExactE        %RSerE
0.000e+00       1.00000e+00     1.00000e+00     0.00000e+00     0.00000e+00
3.000e-01       1.28957e+00     1.28957e+00     2.90054e-05     2.69193e-05
6.000e-01       1.50381e+00     1.50386e+00     3.42722e-03     2.95478e-03
9.000e-01       1.52797e+00     1.52891e+00     6.19271e-02     4.96870e-02
1.200e+00       1.19546e+00     1.20307e+00     6.32890e-01     4.75767e-01
1.500e+00       2.78125e-01     3.17022e-01     1.22695e+01     9.75120e+00
1.800e+00       -1.52346e+00    -1.37449e+00    -1.08377e+01    -6.37877e+00
2.100e+00       -4.58972e+00    -4.12266e+00    -1.13290e+01    -6.22886e+00
2.400e+00       -9.39181e+00    -8.12842e+00    -1.55428e+01    -7.75156e+00
2.700e+00       -1.65013e+01    -1.34524e+01    -2.26649e+01    -1.00621e+01
3.000e+00       -2.66000e+01    -1.98845e+01    -3.37723e+01    -1.30505e+01

Evaluate the Maclaurin Series approximation to D(t) = exp(t)*cos(t)

1: Evaluate the series
2: quit

2
```