MA 302 – Spring 2019
Homework 4: Due on Wednesday, April 17

Instructions:
The code submitted should be your own creation. You may consult MATLAB's documentation or the notes from class. The submission of codes obtained from online sources is a violation of Loyola's honor code.

Exercise 1: Numerical Integration
In this exercise you will implement and compare the numerical integration techniques we discussed in class. Your function should take as input:

1. `f` - the integrand
2. `a,b` - the lower and upper limits of integration
3. `n` - the number of sub-intervals
4. `method` - an integer corresponding to the method. *Use: 1 – Midpoint method, 2–Trapezoidal method, 3 – Simpsons method*

In other words, your function should have heading:

```
function approx_int = numerical_int(f,a,b,n,method)
```

i.e. it should return the approximate value of $\int_a^b f(x)\,dx$.
In addition, you should also satisfy the following conditions

1. Your function should not print out any output.
2. The Riemann sums should be implemented in **vectorized form**.

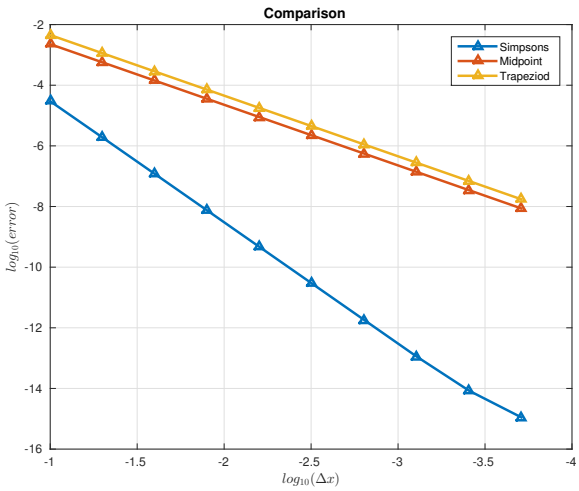
Testing
Write a script to compare the performance of the 3 methods in approximating $\int_0^1 e^{-x^2}\,dx$ by

1. Running each method 10 times starting with $n = 10$ and increasing the number of subintervals by a factor of 2 for each run.
2. Save the errors for each method in a vector and calculate the ratio of successive errors for each method. As we noted in class, the error for the Midpoint and Trapezoidal method is of the form

$$E(\Delta x) = C(\Delta x)^2$$

where $\Delta x = \dfrac{b-a}{n}$. Therefore if Δx decreases by a factor of 2 the error should decrease by roughly a factor of $\dfrac{1}{4}$ therefore you should see that the ratio of successive errors is 4 for the Midpoint and Trapezoidal methods. In the case of Simpsons method the error behaves as $C(\Delta x)^4$, therefore the ratio of those errors should be 16.

3. Plot the errors and values of Δx on a log scale as shown on the plot below Save your plot as `numerical_int_comp.jpg` and include your file with your submission.
Note: The command `set ( gca, 'xdir', 'reverse');` will reverse the order of the values along the x-axis.



4. Explain how the plot above confirms that the Midpoint and Trapezoidal methods are second order and Simpsons method is fourth order.

Exercise 2: Curve fitting and Interpolation
The file `monthly_data.txt` (downloaded from NOAA) contains the monthly mean values of $C0_2$ in parts per million for the last 5 years. Write a script to perform the following:

1. Open and read the file
2. Download the data into matrices and plot on the same figure the data values as well as a spline interpolant of the data on the points `2013:0.1:2019`
3. Save your image as `monthly_data.jpg` and include this with your submission.
4. **Bonus:** It should be clear that the general trend in emissions is upwards. However, in each given year the data exhibits some oscillations. Provide a possible explanations for oscillatory behavior.

Submission of exercises

Place all your files (`m-files, image, movie, summary.txt, diary.txt`) in a folder named `lastname_hwN` and zip the folder to create a file `lastname_hwN.zip`. Email your zip file `lastname_hwN.zip` to `pchidyagwai@loyola.` with subject `MA302_hwN`.