# ENGR3703-Computational Methods in Engineering

# Project, Spring 2023

# Due Date: 4/21/2023, 12 PM

**Please submit the jupyter notebook (with .ipynb extension) together with your project document. You may type the first part of the project in a word document or directly in a jupyter notebook. Handwritten documents will be accepted with 5% penalty.**

**Please upload all your documents to D2L- Project assignment folder.**

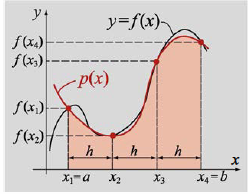
**Part 1. Derivation of Simpson’s 3/8 Method**

In Simpson’s 3/8 Method, a cubic (third-order) polynomial is used to approximate the integrand.



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Third order polynomial in Newton’s form can be written as:

  
Figure 1. Graphical representation of Simpson 3/8 Rule

The coefficients of a cubic polynomial can be determined from 4 points. For an integral over the domain [a, b] , the four points used are the two endpoints a, b and x2 and x3 , as shown in Figure 1.

Once the constants in Eqn. 2 are determined, the polynomial can be easily integrated to give:

Part 1 of this project does not need programming. Please submit a typed document. Handwritten document will be accepted with (5% grade deduction).

Steps to follow:

1. Write a 3rd order Newton polynomial (i.e: Eqn 2)
2. Explicitly write the coefficients of the polynomial
3. Carry out the integration (Eqn 1). At the end of step 3, you supposed to get Equation (3)

**Part 2. Writing a Python code for Simpson’s 3/8 Method**

The general formula for Simpson’s 3/8 Method is written as

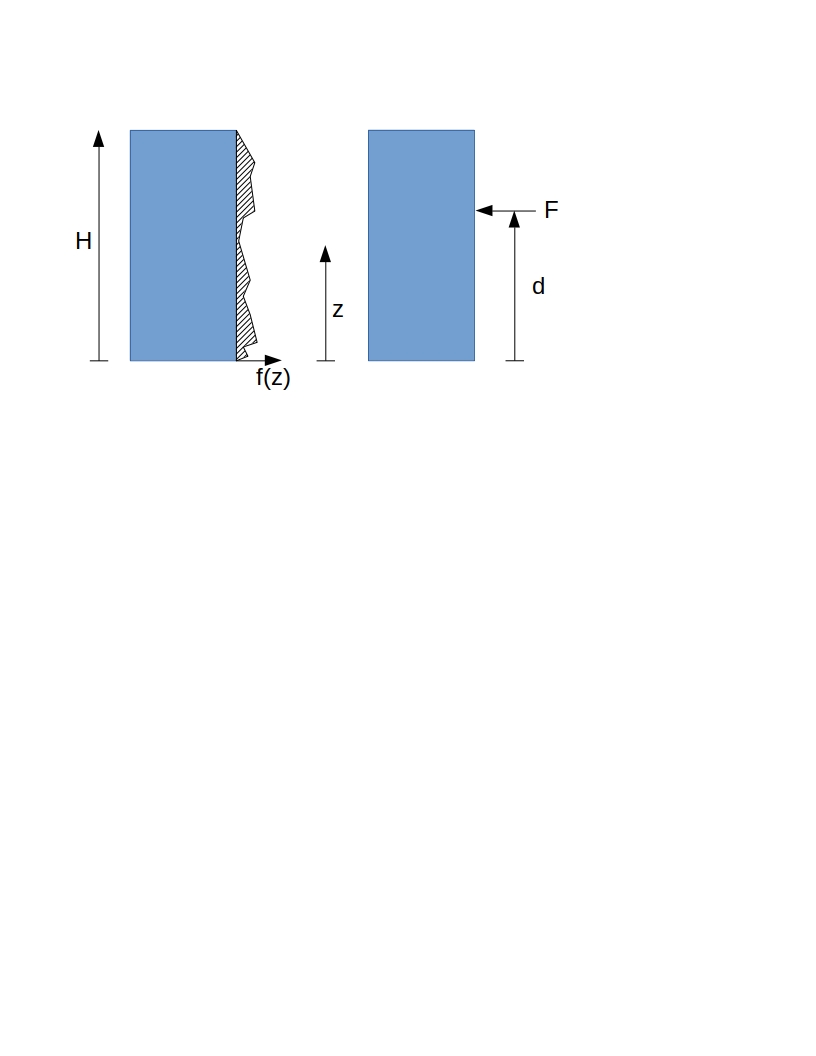
Write a Python user-defined function Simpson\_3\_8, that takes end points of the interval (a,b) and number of panels as parameters.

Your function should check if the number of panels is divisible by 3. If number of panels is not divisible by 3, your function should print out an error message and exit.

The function should return the result of the integration given in equation 4.

**Part 3. Background.** The calculation of total force due to a distributed force is an important engineering calculation:

If you have an object that is *H* meters tall .then the total force, *F*, due to a distributed force (f(z) ~ force per unit length dz) (see Figure 2).and its line of action can be calculated as:

  
Figure 2. Distributed force and line of action

The total force due to the distributed force is

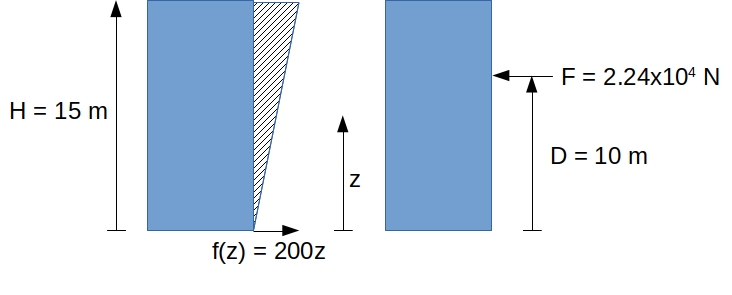
F

The location of the line of action, *d*, of *F* is the effective location of the force *F*.

For example, if

with *z* ranging from 0 to 15 m.

The line of action would be:

  
Figure 3

When *f(x)* is a simple function like in the example above, solving Eqs. 5 and 6 can be done analytically (by hand). However, as in Fig. 2, it is more likely that the functional relationship is complicated. For this situation, numerical methods provide the only alternative for determining the integrals.

In this part of the project you need to find the total wind force exerted on the side of a skyscraper and its line of action. The force is distributed and varies with height. You only know the force per unit height, *f(z)* at certain discrete z values – every 30 meters starting at ground level. These values are given in Table 1.

You will find the force and line of action two different ways:

1. Based on the data in Table 1, determine the coefficients of a third order Newton’s interpolating polynomial that represents f(z). Once you have the polynomial integrate it as in Eqs. 5 and 6 to determine the total force and its line of action, *F* and *d*..
2. Use your python code for Simpson’s 3/8 rule to compute both *F* and *d*.
3. Compare the results for *F* and *d* from each technique of calculation… when we say compare we mean numerically and to analyze how significant the differences are and why there are differences (or not). This section of your project is of equal importance to the calculation portions. This should be a complete analysis of what you did and why there are differences if any and if there are not significant differences why that is the case.

Table 1. Force on side of a skyscraper.

|  |  |
| --- | --- |
| Height (z in *m*) | Force/height (f(z) in *N/m*) |
| 0 | 0 |
| 30 | 340 |
| 60 | 1200 |
| 90 | 1600 |
| 120 | 2700 |
| 150 | 3100 |
| 180 | 3200 |
| 210 | 3500 |