**BME 313L: Introduction to Numerical Methods in Biomedical Engineering**

**Lab Report**

**Lab\_10: Numerical Integration**

**Last name, First name:**

**EID:**

**Lab Section: Tuesday, Wednesday, Thursday, Friday**

**Problem 1.**

Two very important quantities in studying the growth of microorganisms in fermentation processes are the carbon dioxide evolution rate and the oxygen uptake rate. These are calculated from experimental analysis of the inlet and exit gases of the fermentor, and the flow rates, temperature, and pressure of these gases. The ratio of carbon dioxide evolution rate to oxygen update rate yields the respiratory quotient, which is a good barometer of the metabolic activity of the microorganism. In addition, the above rates can be integrated to obtain the total amounts of carbon dioxide produced and oxygen consumed during the fermentation. These total amounts form the basis of the material balancing techniques used in modeling of fermentation processes. Table 1 shows a set of rates calculated from the fermentation of *Penicillium chrysogenum*, which produces penicillin antibiotics.

Write a general MATLAB function named *‘MySimpsons.m’* for integrating experimental data using Simpson’s 1/3 rule, and use it to calculate the total amounts of carbon dioxide produced and oxygen consumed during the ten-hour period of fermentation. Compare the results of this function and those obtained by using the existing MATLAB function *trapz* (trapezoidal rule).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time of Fermentation (h) | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| Carbon dioxide evolution rate (g/h) | 15.72 | 15.53 | 15.19 | 16.56 | 16.21 | 17.39 | 17.36 | 17.42 | 17.60 | 17.75 | 18.95 |
| Oxygen uptake rate (g/h) | 15.49 | 16.16 | 15.35 | 15.13 | 14.20 | 14.23 | 14.29 | 12.74 | 14.74 | 13.68 | 14.51 |

Things to discuss: (100 word minimum for each question, 50 word minimum for discussing what you learned, what was reinforced)

1. Discuss the Simpson’s 1/3 rule and Trapezoidal rule in brief.
2. Does the results match? Explain your answer.
3. Will you use simple or composite Simpson’s 1/3 rule? Why?

**MATLAB code:**

**MATLAB function:**

**Results:**

**Discussion:**

**Problem 2.**

The force on a sailboat mast can be represented by the following function:



where *z* = the elevation above the deck and *H* = the height of the mast. Compute *F* for the case where *H* = 30 using:

1. Romberg integration to a tolerance of using the provided MATLAB functions *romberg.m*. and *trap.m*. Report the integral estimates and the approximate percentage errors at every iteration.
2. Two-point Gauss-Legendre formula. Besides the integral value, also report the variable transformation used for the two-point Gauss-Legendre formula.
3. MATLAB *quad* and *quadl* function

Things to discuss: (100 word minimum for each question, 50 word minimum for discussing what you learned, what was reinforced)

1. Discuss Romberg Integration technique in brief. Discuss its efficiency over Trapezoidal rule.
2. Why do we need transformation to apply Two-point Gauss-Legendre formula? Discuss the transformation.
3. What is the difference between *quad* and *quadl* function?

**MATLAB code:**

**MATLAB function:**

**Results:**

**Discussion:**