ME 2016 Computing Techniques

Section C - Spring 2017

Computing Project Three

Due Thursday, March 30th at 3:00pm

Numerical integration: computation of the dissipated energy in a viscoelastic material

Submission of your answers

- At the end of the class on 03/16, upload on T-Square any Matlab code that you have written.
- By Thursday 03/30 at 3:00pm, upload your final Matlab codes on T-Square.
- At the start of the class on 03/30, submit the **print-out of your Matlab** codes **and the 2 figures**.

Engineering problem

In this computer project, you will use a numerical integration algorithm to compute with the work done to deform a viscoelastic material. The work can be computed using the equation:

$$W = V \int_0^T \sigma(t) \frac{d\epsilon(t)}{dt} dt = V \int_0^T \sigma(\epsilon) d\epsilon$$

where σ is the stress, ϵ is the strain and V is the volume (you can use $V = 1m^3$). The stress vs strain curve is shown in Fig. 1.

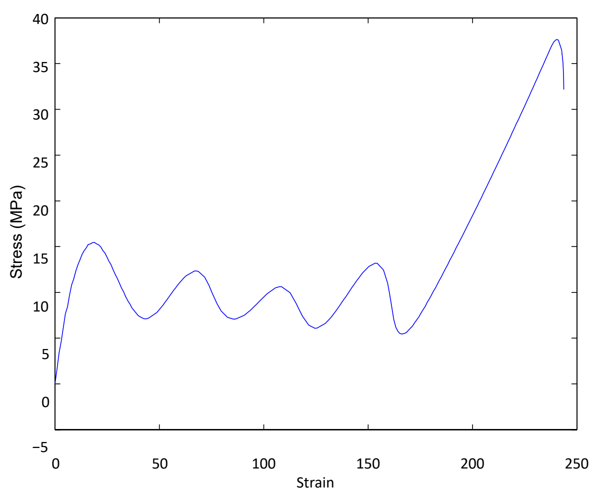

Figure 1: Stress vs strain curve

Tasks

In this project you will have to write 5 Matlab functions (*CP* 3*LastnameFirstname*, *trapezoidal*, *compositeSimp*13, *Simp*38, *SimpInt*). The function *CP* 3*LastnameFirstname* should have no input and no output. The inputs of the other 3 functions should be the vector of the *x* values of the data, and the vector of the $y = f(x)$ values of the data. The 4 functions should be in a single *m* file name *CP* 3*LastnameFirstname*, *Lastname* is your lastname and *Firstname* is your firstname.

1. Write a function named *trapezoidal* that returns the multiple applications (or composite) trapezoidal rule.
2. Using your *trapezoidal* function, compute $I = \int_0^\pi sin(x)dx$ using $n = 1, 2, 3, ...1000$ segments. In figure 1, plot the true percent relative error as a function of *n* using logarithmic scales.
3. Write a function named *compositeSimp*13 that returns the composite 1/3 rule (assuming that *n* is multiple of 2).
4. Using your compositeSimp13 function, compute $I = \int_0^\pi \sin(x)dx$ using $n = 2, 4, ..., 1000$ segments. In figure 1, plot the true percent relative error (for compositeSimp13) as a function of n using logarithmic scales (do not use a continuous line but a cross symbol).
5. Write a function named *Simp*38 that returns the single application of the 3/8 rule. The inputs should be the value of the step size, *h*, and the values of the function at the 4 points ($f0$, $f1$, $f2$ and $f3$).
6. Write a function named *SimpInt* that computes the integral for any value of n (trapezoidal if n=1, Simpsons 3/8 rule for the last 3 segments if *n* is odd, Simpsons 1/3 rule for the remaining segments).
7. Using your *SimpInt* function, compute compute $I = \int_0^\pi sin(x)dx$ using $n = 1, 2, 3, ..., 1000$ segments. In figure 1, plot the true percent relative error (for *SimpInt*) as a function of *n* using logarithmic scales.
8. Download the file *Loading.dat* in the same folder as your *m* file. Import the data corresponding to Fig. 1 using the function *importdata*. The 1st column of the data corresponds to the time, the 2nd column to the stress and the 3rd column to the strain. Plot the stress vs strain in Figure 2.
9. Compute the work using (1) your *trapezoidal* function (2) your *SimpInt* function.
10. Write on the printout of your 2nd graph the numerical values you obtain for the work.