

3650:350 Modeling and Simulation Spring 2005
Homework #1
due: Friday, January 28

Reading Assignment:

- For additional information on this week's material, please
 - review the chapter on kinematics in your introductory physics text
 - review the definition of the derivative in your calculus text
 - review Taylor expansions in your calculus text
- To prepare for next week, please read
Giordano *Computational Physics* Chapter 1 and Appendix A1.1, A1.2

Exercises:

1. Kinematics in one dimension (2-D plots):
 - (a) Open the file *kinematics.m* in the Matlab editor and familiarize yourself with its contents. To run the program, go to Debug in the menu bar and click on Run. Do the resulting graphs look reasonable, why or why not? (Please copy the graphs into your Word document and type the answer to the question underneath the graphs).
 - (b) Modify the program by using a longer range of times, i.e. change $t_f = 10.0$ to $t_f = 1000.0$. Then run the program again. Has the shape of the curves changed? Explain why these result should not be valid for very long times (think speed of light!). (Please include graphs and answers in your Word document.)
 - (c) Modify the program by adding the equations for relativistic kinematics. Please remember to change the filename and the header.
Note: The following equations are valid **only** for $v_0 = 0$. The more general expressions seemed a bit long for our purpose

$$x_r(t) = \frac{c^2}{F/m} \left(\sqrt{1 + \left(\frac{F/m}{c} (t - t_0) \right)^2} - 1 \right) + x_0, \quad (1)$$

$$v_r(t) = \frac{(t - t_0)F/m}{\sqrt{1 + \left(\frac{F/m}{c} (t - t_0) \right)^2}}. \quad (2)$$

Plot $x_r(t)$ and $v_r(t)$ for very long times (what is long?). Compare with your earlier plots. Do the results make sense? Explain. (Please include graphs and answers in your Word document.) Please email your Matlab file to me at jutta@physics.uakron.edu by the due date.

2. Numerical derivatives:

- (a) Open the file *testderiv.m* in the Matlab editor and familiarize yourself with its contents. What is the first value of h that will be used to calculate the numerical derivative. What is the second value? (Please answer in your Word document.)
- (b) This program produces output to the Matlab Command Window. Run the program and scroll back to the beginning of the output. Copy the output in the Command window (highlight the output, go to Edit → Copy in the menu bar) and paste it into your Word document. Then answer the following questions in your Word document:
Compare the numerical values, in the middle column, with the exact values in the right column for different values of the step size h (left column). Comment on the accuracy of the numerical answer as the step size decreases. Where do you find the best agreement between numerical and exact results? Where the worst?
Please note: The 0 values for the numerical derivatives at the smallest step size indicate that Matlab treats this as a division by zero.
- (c) Change the calculation of the numerical derivative from the forward difference approximation to the centered difference approximation. (Please remember to change the filename and the header and send me the program by email.)
- (d) Run your program, repeat the steps in (b), and compare your results for the centered difference approximation with those for the forward difference approximation used in (b).

3. On paper, please staple your answer to your word document:

Calculate the first three terms in the Taylor expansion of

- (a) $\sin(x)$ about $x = 0$,
- (b) $\sin(x)$ about $x = \pi/2$.