1.12 Computer Models of Physical and Engineering Systems **Spring 1994**
QUIZ 2 **9 A.M. Thursday, April 14, 1994**

Instructions:

- Write your name on each one of the pages that you use for your exam.
- There are a total of 3 problems.
- **ASK** for clarification if you do not understand **ANY of the QUESTIONS**.
- The problems are presented with consistent **UNITS**. In some cases, the units will not make that much sense for the real world and standard units have been given in parenthesis. **AVOID MISSING UNITS.**
- This quiz is **OPEN BOOK** and **OPEN NOTES**.

Problem #1: [25%]
(Integration)

Determine the axial deformation for a column having the following characteristics:

- $N = \frac{1}{12}x^2$ kips/in
- $L = 144$ in (12 ft)
- $A = -\frac{1}{4000}x^2 + \frac{1}{60}x + 2\ in^2$
- $E = 30$ x 10^3 ksi

Use the three-term Gaussian Quadrature, knowing that:

$$u = \int_{x_1}^{x_2} \frac{N}{EA} dx \tag{1}$$

The Gauss point coordinates and weights for three-term Gauss formula are given by:

- Position Weight
- -0.7745 0.5555
- 0.0000 0.8888
- 0.7745 0.5555

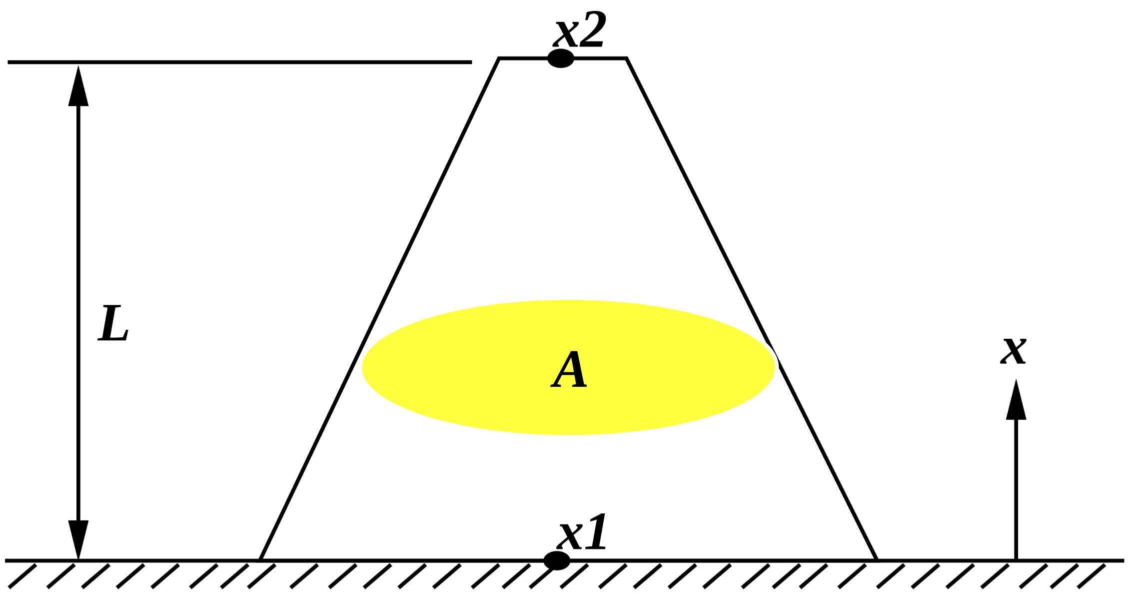

Figure 1: Column Diagram

Extra Page for Problem #1:

Problem #2: [50%]
(Ordinary Differential Equations)

When a vehicle travels over a rough road, a vertical displacement will result. Consider the following highly idealized model:

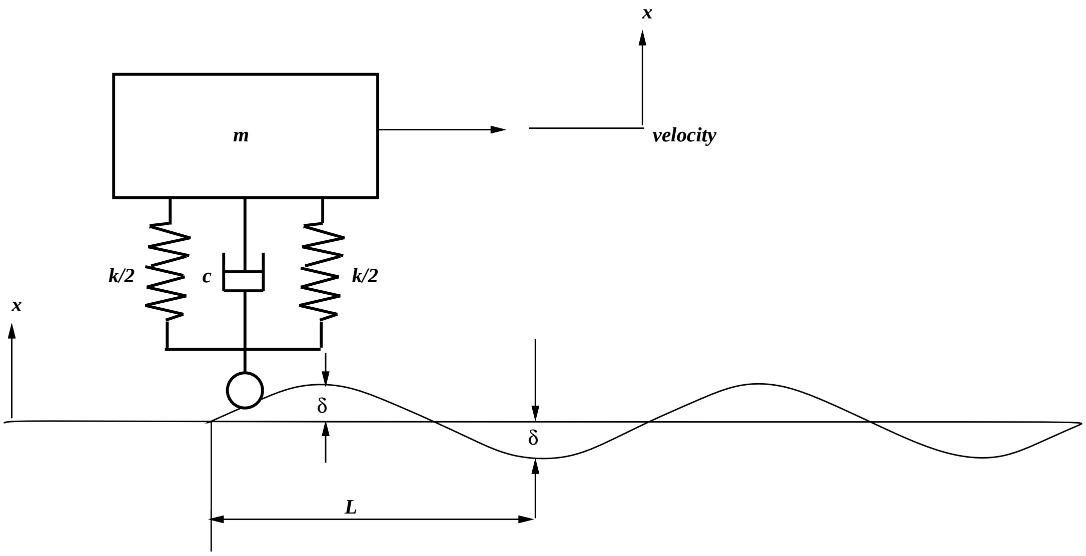

Figure 2: Car Diagram

Suppose that a manufacturer is interested in determining the vertical displacement x for a vehicle traveling a velocity of 968 inches per second (55 miles per hour) over a sinusoidal surface, given:

- $m = 10$ lb-s^2/in
- $k = 1210$ lb/in
- $c = 0$
- $L = 600$ in (50 ft)
- $\delta = 1$ in

The mathematical model describing this behavior is given by:

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = m\varpi^2\delta sin(\varpi t) \tag{2}$$

where $\varpi = 2\pi v/L$ where v is the velocity of the vehicle. Remember that the velocity is constant at 968 in/sec (55 mph). 1) Determine the displacement at $x = 0.2$ inches using the Runge-Kutta-Fehlberg method and $\Delta t = 0.2$ seconds. 2) Comment on the judgment of choosing such Δt. Assume that the vehicle was initially at rest in the x direction $x(0) = \dot{x}(0) = 0$. Note that when you are calculating $sin(\varpi t)$ you need to set your calculator to work with radians (degrees or grade are going to give you wrong results).

Extra Page for Problem #2:

Extra Page for Problem #2:

Problem #3: [25%]
(C++)

Write down the code that will implement the Romberg Integration algorithm that appears in Gerald and Wheatley's Applied Numerical Analysis page 336 an that is reproduced below:

Figure 3: Romberg Algorithm

Please, follow the C++ syntax as if you were going to run this code in a computer. I want a complete code.

Extra Page for Problem #3:

Extra Page for Problem #3: