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Algorithms for Uncertainty Quantification

Solution 1: Python overview

Assignment

A linear damped oscillator is a modeled by a second order ODE

$$\begin{cases} \frac{d^2y}{dt^2}(t) + c\frac{dy}{dt}(t) + ky(t) = f\cos(\omega t) \\ y(0) = y_0 \\ \frac{dy}{dt}(0) = y_1, \end{cases} \tag{1}$$

where c is the damping coefficient, k the spring constant, f the forcing amplitude, ω the frequency, y_0 represents the initial position, whereas y_1 is the initial velocity.

Solution 1

$$\begin{aligned} z_0(t) &:= y(t), \\ z_1(t) &:= \frac{dy(t)}{dt} = \frac{dz_0(t)}{dt}, \\ z_2(t) &:= \frac{d^2y(t)}{dt^2} = \frac{dz_1(t)}{dt}. \end{aligned}$$

Write down system:

$$\begin{aligned} \dot{z}_0 &:= \frac{dz_0(t)}{dt} = z_1(t) \\ \dot{z}_1 &:= \frac{dz_1(t)}{dt} = -cz_1(t) - kz_0(t) + f\cos(\omega t) \end{aligned}$$

or in matrix/vector notation:

$$\begin{pmatrix} \dot{z}_0 \\ \dot{z}_1 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -k & -c \end{pmatrix} \begin{pmatrix} z_0(t) \\ z_1(t) \end{pmatrix} + \begin{pmatrix} 0 \\ f\cos(\omega t) \end{pmatrix}$$

Assignment 2

Explicit Euler method is given as:

$$g(t + \triangle t) = g(t) + \triangle t \cdot \frac{dg(t)}{dt} \tag{2}$$

See code assign2.py

Assignment 3

See code sol.py