Pesticides on Apples

Worksheet 12
1 March 2023

In this worksheet, a first order differential equation will be solved using Euler's forward differentiation method. The results will be presented graphically.

During their growth season apples are frequently sprayed with pesticides to prevent damage by insects. By eating apples you accumulate these pesticides in your body. An important factor determining the concentration of pesticides are their half lifes in the human body. An simple but appropriate mathematical model that predicts the number of pesticides $P(t)$ at a given time t is[6]

$$\frac{dP(t)}{dt} = \sigma - \frac{3}{4}\,\lambda_1\,P(t) - \frac{1}{4}\,\lambda_2\,P(t)\,. \tag{1}$$

Here σ is the daily intake of pesticides, i.e., $\sigma = \alpha A$ where A is the number of apples that a person eats per day and α $(= 10^{-6})$ is the amount of pesticides per apple. For this numerical study, it is assumed that the apples are contaminated with two different types of pesticides that decay in human tissue at daily rates of λ_1 $(= 0.01)$ and λ_2 $(= 0.03)$.

Task

Write a complete fortran program which computes the amount of pesticide in your body, $P(t)$, as a function of time, assuming you eat one apple per day for 2 years, i.e., $0 \le t \le T$ (with $T = 2$ years) and that you have no pesticide in your body at $t = 0$.

Code Design

1. Your code must contain a short paragraph which describes the purpose of the program. The different steps/parts of your code must be well commented.

2. Use Euler's forward differentiation method to solve Eq. (1).

3. The value for the temporal time step, $\Delta t = 0.01$ days, and the final time, $T = 2$ years, are keyboard input. The user must be prompted by the code to input these value from keyboard.

4. The amount of pesticides $P(t)$ for $0 < t \le T$ is to be written to an output file named `pesticides_vs_time.dat`.

5. Create a python plot that shows the results graphically. A suitable python script can be downloaded from the class website.

Submission Instructions: Email a gzipped tar file containing copies of your fortran source code and python plot to `ewhart317@gmail.com`. Put `LastFirst PHYS 317 WS 12` in the subject line.

[6] From "Theoretical Biology" by R. J. de Boer and K. ten Tusscher, Theoretical Biology & Bioinformatics, Utrecht University, 2015.