Homework 4: Calculating the Period of a Nonlinear Oscillator

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Introduction

The period T of a nonlinear oscillator (no damping nor driving) is computed for various angles θ (12 found in code). For simplicity, $\sqrt{l/g} = 1$, where g is gravitational acceleration and l is the length of the pendulum.

Method

The trapezoidal method is compared to Simpson's rule. The latter is derived from the former via Richardson extrapolation.

Verification of program

In the code, the loop used to compute the trapezoidal method is compared to the respective built-in function. For all angles θ, the same results are found. Meanwhile, Simpson's method behaves as expected.

Data

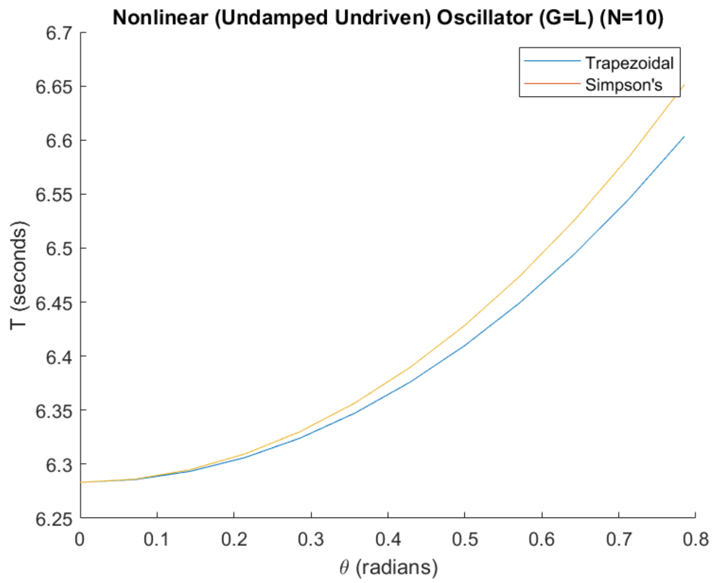

Figure 1: $N = 10$ intervals of x.

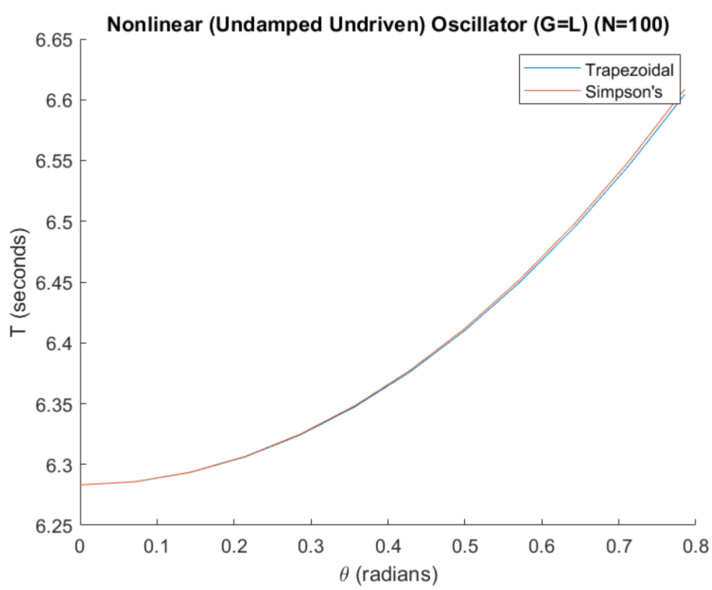

Figure 2: $N = 100$ intervals of x.

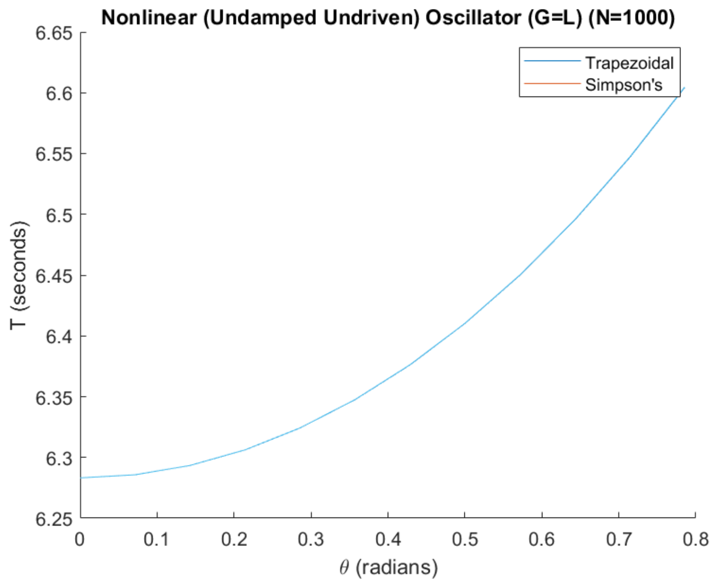

Figure 3: $N = 1000$ intervals of x.

Analysis

Simpson's rule is found to be an improvement of the trapezoidal method, especially as seen in smaller numbers N of x intervals. For $\theta = 0$, both methods produce $T = 2\pi$. While the trapezoidal method is somewhat variable between different values of N, the curve for Simpson's method stays relatively the same.

Critique

Simpson's rule is an improvement of the trapezoidal rule because is merely what follows after trapezoidal in Richardson extrapolation, trapezoidal being the first order of the extrapolation.