Bicyle Racer

Homework 9
Due 5 April 2023

The speed of a bicycle racer is governed by the following differential equation,

$$m\,v(t)\,\dot{v}(t) = P - k\,v(t)^3 + m\,s\left(1 - \mathrm{e}^{-v(t)/c}\right)v(t) - \mu\,m\,g\,v(t)\,, \tag{1}$$

where $P = 350$ W denotes the power delivered by the racer on the bicycle, $v(t)$ is the speed of the bicycle, and $m = 80$ kg is the bicycle racer's mass. The terms proportional to k, s ($= 1.5$ m/s^2), and μ ($= 0.01$) account for air resistance and the frictional force between tire and road. The quantity c has a numerical value of 2. The value of the gravitational acceleration is $g = 9.81$ m/s^2.

Task

Write a structured and well commented Fortran program that uses the Euler foward method to compute the speed of the bicycle racer for the first 30 seconds of the race, i.e., $0 \leq t \leq T = 30$ s. The initial speed of the racer is $v_0 = 1$ m/s. Use a temporal step size of $\Delta t = 0.01$ s to solve the differential equation.

Code Design

- The code must contain a preamble.
- The values for T, k, and s are keyboard input. The program must prompt the user to input these values from keyboard, one at a time. Use the `write` statement with the `advance='NO'` option.
- The `DO WHILE` construct is to be used to solve the differential equation.
- The results for the speed as a function of time are to be written to an output file named `v_t.dat`.
- The acceleration $\dot{v}(t)$ is to be computed, for a given value of t, in a `FUNCTION` sub-program.
- The values of $\dot{v}(t)$ are to be written to an output file named `acceleration_t.dat`.
- Show the racer's speed and acceleration as a function of time graphically for air resistance values of $k = 1$ kg/m, $k = 3$ kg/m, and $k = 5$ kg/m (i.e., two different plots, each containing three curvs.) Save the plots as `pdf` files.

Create a gzipped archive file named `LastFirst_HW9.tgz` which contains your Fortran source code and the two `pdf` plots. Email this file to `ewhart317@gmail.com`. Put `PHYS 317 HW 9` in the subject line.