Physics PH256 – HW Assignment 4 (due 9/22/2017)

2.4. Generalize the model to treat motion through mountainous terrain. A steep hill is one with a 10 percent grade (that is, $\tan\theta = 0.1$, where θ is the angle the hill makes with the horizontal). Calculate how fast our bicyclist can travel up and down such a slope. Does racing strategy change in these situations? Determine what conditions (the steepness of the grade and the rider's frontal area) would be required for a bicycle to reach a velocity of 70 mph. This is reportedly the speed that professional riders sometimes attain on steep descents.[8]

***2.5.** You might wonder why we did not let our bicycle begin from rest, but instead gave it a nonzero initial velocity. The reason for this is that (2.7) breaks down when $v_i = 0$, since then the term involving P is infinite.[9] If $v_i = 0$, then for a nonzero P the derivative dv/dt is, according to (2.3), infinite. This is difficult to handle in a numerical approach, and it also doesn't make sense from a physical point of view. The problem arises from our assumption that the bicyclist maintains a constant power output. This assumption must break down when the bicycle has a very small velocity, since it would then require that the rider exert extremely large forces (recall that the instantaneous power is the product of the force and the velocity). At low velocities it is more realistic to assume that the rider is able to exert a constant force. To account for this we can modify our bicycle model so that for small v there is a constant force on the bicycle, F_0, which leads to the equation of motion

$$\frac{dv}{dt} = \frac{F_0}{m} . \qquad (2.12)$$

The corresponding Euler equation is

$$v_{i+1} = v_i + \frac{F_0}{m}\Delta t , \qquad (2.13)$$

and the difficulty that occurs when $v = 0$ is eliminated.

Rewrite your bicycle program to incorporate (2.13). That is, use the Euler method with (2.13) when the velocity is small, and (2.7) when v is large. Let the crossover from small to large v occur when the power ($= F_0 v$) reaches P. Use the same parameters as in Figure 2.2, and take $F_0 = P/v^*$ where $v^* = 7$ m/s. (This corresponds to a force approximately twice that found when the bicycle is traveling at its maximum velocity, which seems like a reasonable approximation.)