Homework II : Realistic kinematics

Guidelines for Homework II : Please read carefully!

1. Homework II is due Monday, 28/11 by 17:30.

2. Homework will be submitted via email to homework.phys343@gmail.com. Please send the Octave functions and scripts as attachments.

3. Note that this assignment has 20 points worth of bonus.

4. VERY IMPORTANT! The subject line of your email MUST only have your name, last name and student number. Nothing more, nothing less.

Reading assignment : Read the third and fourth lecture notes and Chapter 2 of Giordano and Nakanishi.

Question I (40 points): Vertical fall
Suppose that a small ball is released (from rest) from an altitude, \( h \), and falls vertically towards the ground. The friction force that air exerts on the particle is given not only by the square but also by the first power of the velocity as

\[
F_{fr} = -B_1 v - B_2 v^2
\]

where \( B_1 \) and \( B_2 \) are constants (see table below) and \( v \) is the instantaneous velocity of the ball.

Write an Octave function, vertical_fall.m, that takes in \( h \) (in metres), returns the final velocity of the ball at the time step just before it touches the ground and makes a plot of velocity versus time. The constants you will need for this problem are given in the following table :

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( B_1 )</td>
<td>Coeff of the term prop to ( v )</td>
<td>0.05</td>
<td>kg/sec</td>
</tr>
<tr>
<td>( B_2 )</td>
<td>Coeff of the term prop to ( v^2 )</td>
<td>( 6 \times 10^{-4} )</td>
<td>kg/m</td>
</tr>
<tr>
<td>( m )</td>
<td>Mass of the ball</td>
<td>0.25</td>
<td>kg</td>
</tr>
<tr>
<td>( g )</td>
<td>Gravitational acceleration</td>
<td>9.8</td>
<td>m²/sec²</td>
</tr>
<tr>
<td>( \Delta t (dt) )</td>
<td>Time increment</td>
<td>0.1</td>
<td>sec</td>
</tr>
</tbody>
</table>

To check whether your code works properly, make sure that it reaches a terminal velocity for high enough \( h \). Try altitudes higher than 500 m to see the terminal velocity.

Hint : Be careful about the sign of the velocity when you calculate the component of the force that is proportional to \( v \) (the Stokes term). Remember that both this term and the \( v^2 \) term should act to reduce the velocity.

Question II (40 points): Cannon drag function
Start with the script that we have created in class, cannon_drag.m (you might have given it a different name. Make the following changes :

1. Add in the dependence of the air density on altitude. The relevant information is given in the lecture notes (Lecture 4). You have all the constants you need in the notes and in the book. If you are missing any constants you may look them up online.

2. After adding in the dependence on air density, convert your script into a function that takes in the initial velocity in m/sec and angle of launch in degrees of the cannon. Convert this script into a function that returns the angle of impact and the velocity upon impact. Your function should execute as in the following example. NOTE that you are not going to get the exact same numbers due to possible differences in the parameters.

\[
\text{octave:1> [xfin,theta_fin]=cannon_drag(700,30)}
\]
\[xfin = 22.618\]
\[\text{theta_fin} = 44.137\]
\[
\text{octave:2> [xfin,theta_fin]=cannon_drag(700,45)}
\]
\[xfin = 24.501\]
\[\text{theta_fin} = 59.317\]
\[
\text{octave:3> [xfin,theta_fin]=cannon_drag(1000,45)}
\]
\[xfin = 37.958\]
\[\text{theta_fin} = 62.190\]

Send in the final function called `cannon_drag.m`.

**Question III (40 points): Curveball** Write an Octave script called `baseball.m` that describes the motion of a curveball launched with spin. The related equations of motion can be found in the lecture notes. Feel free to use any reasonable constants. Ignore air friction. At the end of the script, your program should plot the trajectory of the ball which should show a deflection out of the xy-plane.