Earthquake Real-Time Simulation

Due Date: 23:59 22 April 2018 **Earnings:** 9% of your final grade.
Purpose: Solve Ordinary differential equations in real-time to simulate an earthquake impact on a building and experimentally determine the most damaging frequency of the seismic wave. The displacement and speed of the centre of the building are plotted.

1. The earthquake seismic wave shakes the base of the building with a sudden shock displacement x0 that is represented by a single cycle of a cosine wave: `x0 = A*cos(2*3.142*f*t)` where f is the frequency (cycles/second or Hz) and A is the amplitude in metres - the user enters values for these.
2. The building is flexible and springy and experiences a restoring deceleration that has the form `k*(x-x0)` where k (= 9.0) is a spring constant and x is the position of the centre of the building
3. There is also friction damping that eventually kills the building vibration of the form - `b*v` where b (= 1.0) is a constant and v (= dx/dt) is the speed of the building centre.

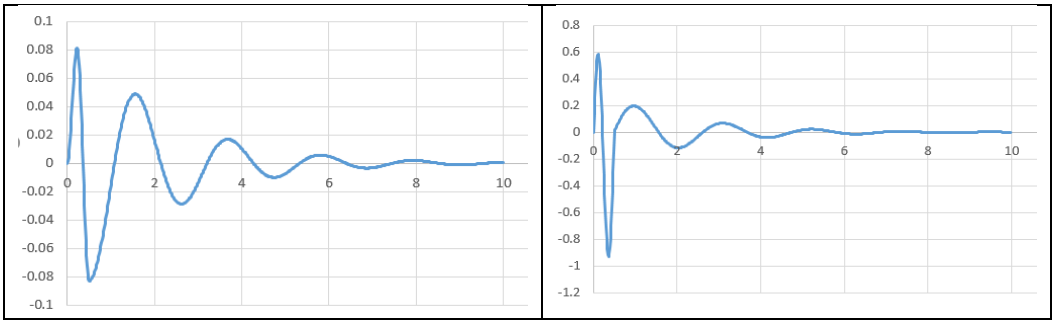
Putting these all together we have the ODEs for the acceleration of the building centre produced by the earthquake:

$$\frac{dv}{dt} = k(x0 - x) - bv$$

$$\frac{dx}{dt} = v$$

These are the ODEs that can be solved for x and v as time t increases from 0.0 onwards. You must use Heun's algorithm.

Algorithm
While the user wishes to continue, the user is asked to select whether to run the simulation one more time. If so, the user chooses values of f and A for the frequency and amplitude of the ground vibration. The simulation then runs for a time specified by the user. The simulation uses Heun's improvement of Euler's method, as explained in lectures, to solve the differential equations above for the displacement and speed of the centre of the building.
When the simulation starts, the building is at rest so the initial condition is v = 0.0 and x = 0.0 when time t=0.0. Thereafter t increases, as read off the system clock (you can use `GetTickCount()` if you `#include <windows.h>` at the top of your file), and the earthquake movement exists for a single cycle and then disappears, simulating the impact of a seismic wave. The displacement and velocity of the building centre are then determined as solutions of the ODEs.
The user is then offered the option of saving the data to file where it can easily be presented as a graph inside Excel. The two graphs below show x (left) and v (right) over a 10 second interval for f = 2.0 and A = 1.0.



Example output is shown at the end - there is not much to look at because the data is

immediately saved to file.

In Addition

You must run the simulation with different frequencies to find the one that causes most movement (and therefore most damage) and include the result in the file header of your submission. For your own interest (no extra marks) you can explain this frequency in terms of the constants in the equation.

What to Submit : Use the Submission on Blackboard to submit this assignment as a zip (not RAR not 7-Zip not 9 Zip) file containing only the source code ass3.c file. The name of the zipped folder **must** contain your name as a prefix so that I can identify it, for example using my name the file would be tyleraAss3CST8233.zip. It is also vital that you include the Cover Information (as specified in the Submission Standard) as a file header in your source file so the file can be identified as yours. Use comment lines in the file to include the header.

Before you submit the code,

- *check that it builds and executes in Visual Studio 2015 as you expect - if it doesn't build for me, for whatever reason, you get a deduction of at least 60%,*
- *make sure you have submitted the correct file – if I cannot build it because the file is wrong or missing from the zip, even if it's an honest mistake, you get 0. No compromises,*
- *do not send me file(s) as an email attachment – it will get 0,*
- ***due to exams, this assignment cannot be late***.

Example output:

```
Earthquake Simulation
1. run the simulation
2. Quit
1
Frequency of the seismic wave in cycles per second(Hz)(e.g. 1.0) : 1
Amplitude of the seismic wave in metres(e.g. 1.0) : 1
How many seconds to run the simulation( e.g. 10) : 10
Calculating...
OPEN FILE TO SAVE
Please enter the name of the file to open: ToadExplode.txt

Earthquake Simulation
1. run the simulation
2. Quit
```