Assignment-2 (22/01/201□) **deadline:** 29th January, 2019

Assignments must be submitted in the form of a report along with MATLAB codes (through moodle). For all the problems below, **provide graphs (from the simulation) in your report.** Instruction regarding submission of report will be provided by the Lab instructors. **Plots/graphs must be properly labeled with proper units and right choice of axis.**

For each problem: describe the model (governing mathematical equations), approximations made and conclusions based on the simulation (final data/plot). Choose realistic initial conditions, take help from google.

You can do more investigations with your program/code in addition to what have been asked in the question for a particular problem (put these investigations under "additional investigation" section in your report below each problem.)

1. Computationally analyze the motion of freely falling body using Euler's method as discussed during the lecture. Consider realistic initial conditions (height, initial velocity etc.)
   Compare your result with analytical solution and study the effect of discretization (time step) on computational result.
   Plot the results showing the velocity of the body and the distance travelled by it at different instant of time.
   The above problem is not realistic from Earth's viewpoint, use the code to analyze the motion of falling body on the moon (there is hardly any atmosphere, so in reality also we can neglect the effect of atmosphere, however initial conditions will be different).

2. Write down the equation for position of an object moving horizontally with a constant velocity "v".
   Assume v=50 m/s, use the Euler method (finite difference) to solve the equation as a function of time.
   - Compare your computational result with the exact solution.

- Compare the result for different values of the time-step.

3. (a) Add the effect of atmosphere to problem 1 (still neglecting viscosity and drag). Suppose the falling object is a sphere of radius "r", computationally study the effect of buoyancy on the motion of the object. Net force needs to be modeled properly (as discussed during lecture); choose proper density of air. Study the effect of "r" and "mass". You can assume constant "g".
   (b) Also computationally investigate the motion of the same object traveling through a liquid (say water), and compare the motion with the case of air. Use computational data and plots to explain your answer (motion as a function of time).

4. Now add the effect of viscous drag to the problem 3(b) assuming a small sphere is falling through the liquid with low speed. Model the system using viscous force given by Stokes law as discussed during the class. Choose proper coefficient of viscosity (look at the unit), and analyze the phenomena of terminal velocity.

5. Modify the program (problem 3) and include the variation of "g" with height. Use the program to computationally investigate the motion of a body dropped from a height of 20 KM (assume constant air density).
   How will you use the above program to investigate free fall in a deep mine (by taking proper initial conditions → Google).

6. A stone is thrown vertically upwards from the ground with some initial velocity in vacuum (choose a proper realistic velocity). Track the complete motion till it comes down to the ground (computationally). What is the velocity when it strikes the ground, compare with analytical result?

7. Computationally study the motion of a balloon filled with Helium (use realistic data from Google). Also study the same for 3-4 different gases of your choice. Will the balloon rise up or fall down? Vary the size of the balloon (5 diff size) to study its effect on velocity and distance

travelled as a function of time. All conclusions should be based on the plots from your computational data.

8. Parachute problem: frictional force on the object increases as the objects moves faster (as we learned today in the class). Role of parachute is to produce the frictional force in the form of air drag. Consider the most simple form, so the equation for velocity :

   $$\mathbf{dv/dt = a - bv}$$

   where a (from applied force), b (from friction) are constants.
   Use Euler's method to solve for "v" as a function of time. Choose a=10 and b=1.
   What is the terminal velocity in this case.