Computational Physics **Problem Set 7** **Due 2019/11/19**

Your solutions should include your source codes (without *.exe files), results, and discussions. The discussion file as well as the proof in the problem 2 should be prepared with a typesetting system, e.g., LaTeX, Word, etc., and it is converted to a PDF file. All files should be zipped into one gzipped tar file, with a file name containing your student number and the problem set number (e.g., r05202043_ps7.tar.gz). Please send your homework from your NTU email account to twchiu@phys.ntu.edu.tw before 24:00 of the due date.

1. **Compare different algorithms for solving ODE**

   Solve the differential equation

   $$\frac{dy}{dx} = y^2 + 1, \qquad y(0) = 0$$

   using a step size $h = 0.01$. Prepare a table of solutions comparing the four algorithms (Euler, modified Euler, improved Euler, and 3rd order Runge-Kutta), on the interval $x \in (0,1)$, along with the exact solution.

2. **Prove the 3rd order and the 4th order Runge-Kutta formulas.**

3. **Install OpenGL for your computer.**

   (a) Cygwin -- X-window and OpenGL for Cygwin.

   (b) macOS -- Packages for running OpenGL in macOS.

   For (a) and (b), you may refer to the instructions at the end of lecture 12.

   (c) Other operating system. (Google for the instructions.)

4. **Physical Pendulum**

   Write a C or C++ program to solve the 2nd order differential equation of the physical pendulum using the adaptive 4th order Runge-Kutta formula. The equation of motion of the physical pendulum is

   $$\frac{d^2\theta}{dt^2} + \frac{g}{l}\sin\theta = 0\,.$$

   Moreover, animate the motion of the physical pendulum with real time graphics, using the output directly from your solver.