PHYS 5120: homework1

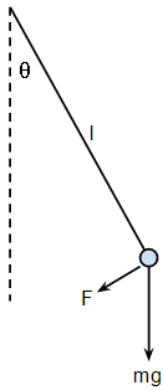
NOTE: Submit your report in the PDF format along with computer codes (.py) to the Canvas website. Pack and compress all the submitted files in the ZIP format. TA will run your codes, so write step-by-step how to do and what your compiler version is. The programming language must be Python3. Please avoid noncommon libraries, modules or packages. For your reference, our programming environment is Ubuntu.

The report doesn't have to be very long, but you must include some concise discussions. Figures must contain axis labels, units, legends, and captions (see figures in published papers).

You are expected to work independently. Cheating or plagiarism in any form is extremely prohibited and may result in disciplinary action. See: `http://acadreg.ust.hk/generalreg.html`

1. The linear and nonlinear pendulums

Consider a pendulum with a arm of length $l = 10$ cm holding a bob of mass m. The arm is massless. The gravitational acceleration $g = 9.81$ m/s^2.



1. A simple pendulum is linear, i.e., $sin\theta \approx \theta$. Write an equation of motion for the pendulum using Newton's second law. Derive the analytic solution. How long is the swing period?
2. The pendulum is released from a *standstill* at θ=2.4° . Write a program to solve the *linear* pendulum using the *velocity Verlet* method and a proper time step.
3. Let's consider a nonlinear pendulum, i.e., $sin\theta \neq \theta$, which is released from a *standstill* at θ=124°. What is the total energy if you solve the motion equation exactly without any numerical errors? Use the *velocity Verlet* method to solve it numerically. Plot the energy as a function of time and show at least 12 swing periods. Compare the exact and numerical energies. Generally increase your time step until you find an obvious energy drift; that is, the total energy increases or decreases over a long time (not short time fluctuations). See, e.g., `https://en.wikipedia.org/wiki/Energy_drift`. Discuss your findings.

15:18 Wednesday 7$^{\text{th}}$ September, 2022