Practical Session n°18: The simple pendulum

INTRODUCTION

The Italian scientist **Galileo Galilei** was the first to study the properties of pendulums, beginning around 1602.

The earliest extant report of his research is contained in a letter to Guido Ubaldo dal Monte, from Padua, dated November 29, 1602.

His biographer and student, Vincenzo Viviani, claimed his interest had been sparked around 1582 by the swinging motion of a chandelier in **the Pisa cathedral**.

Galileo discovered the crucial property that makes pendulums useful as timekeepers, called isochronism.

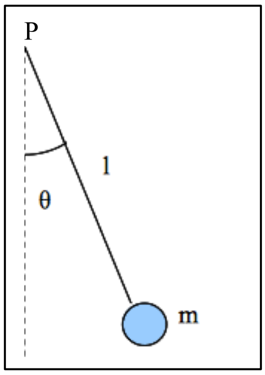
From http://en.wikipedia.org/wiki/Pendulum#1602:_Galileo.27s_research

PART 1

1.1- OBJECTIVE

A student aims at making a pendulum that oscillates with a period of one second. You are asked to help him.

1.2- DEFINITION



A **simple pendulum** consists of a mass *m* hanging from a string of length l and fixed at a pivot point P. When displaced to an initial angle θ and released, the pendulum will swing back and forth with periodic motion.

http://www.acs.psu.edu/drussell/Demos/Pendulum/Pendula.html

1.3- WORK TO BE DONE

a. *What is the nature of the pendulum's motion?*

b. *How can the period of the pendulum be determined the most accurately as possible?*

c. *Which parameters are likely to have an effect on T?*

d. *By mean of experiments, show the effect of each proposed parameter.*

e. The student remembers something about a proportional relation linking the period squared and the length of the string but he is not so sure. *Help him check the validity of this relation.*

f. *Deduce a method to create a pendulum that oscillates with a period of one second and put it into practice.*

PART 2

2.1- OBJECTIVE

We aim at studying the mechanical energy of a pendulum that has been filmed during a few periods. The hung mass m is equal to 45g.

2.2- WORK TO BE DONE

a. *By using the LatisPro software, perform an acquisition of the positions of the centre of gravity G of the hung mass for about one period.*
You will choose the equilibrium position of the pendulum as the origin of the frame of reference (It is marked by a cross on the video).

b. *By using the derivative function and the LatisPro's spreadsheet, calculate the following energies for each position of G:*
- the kinetic energy E_k,
- the potential gravitational energy U,
- the mechanical energy E_m.

c. *Display the curves of these 3 energies in a function of time in the same window.*

d. *Explain the changes in the curves in terms of energy transfer.*

e. *How does mechanical energy vary over time?*

f. *What can be said about the evolution of the mechanical energy if the acquisition time increases? Suggest an explanation.*

Reminder from last year

The **kinetic energy** of a body is due to its motion.
It is denoted E_K and expressed in joules (J).
If a body, of mass m, is moving in translation at a speed v, its kinetic energy is:

$E_K = \frac{1}{2}mv^2$ where m is in kg and v in $m.s^{-1}$.

The **gravitational potential energy** of a body is due to its altitude.
As any potential energy, it is denoted U. It is expressed in joules (J).
If a body, of mass m, is placed at an altitude z (above a reference level such as the ground), its gravitational potential energy is:

$U = m.g.z$ where m is in kg, z in m
and g (the gravitational field strength) = $9.81\ N.kg^{-1}$.

The mechanical energy of a body is the sum of the kinetic and gravitational potential energies.

$E_m = E_K + U$ All these energies are expressed in joules (J).