**Lab 2a. Linear acceleration, velocity, and displacement**

The object of this lab is to record the accelerations of an elevator using a wireless accelerometer. You will start with the elevator at the ground floor, go up three levels and return.

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### *Theory*

$x(t)$ – displacement versus time
$v(t)$ – velocity versus time
$a(t)$ – acceleration versus time

differentiate

$$v(t) = \frac{dx}{dt}, \qquad a(t) = \frac{dv}{dt}, \qquad a(t) = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

integrate

$$v(t) = \int_o^t a(\tau)d\tau + v_o, \qquad x(t) = \int_o^t v(\tau)d\tau + x_o$$

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A. Record the linear acceleration of the elevator. We will reformat data file for each group and place it on the web site after the lab. The file will have rows of numbers with: *time*, $a_x$, $a_y$, $a_z$. For this lab you just need the *time* and $a_z$.

B. Integrate the accelerations to get velocity and plot the velocity versus time. Use the following approximate formula to get velocity.

$$v_i = \sum_{k=0}^{i} a_k \Delta t, \qquad \Delta t - \text{time interval};$$

C. Integrate the velocity to get displacement and plot the displacement versus time. Use the following approximate formula to get displacement.

$$x_i = \sum_{k=0}^{i} v_k \Delta t, \qquad \Delta t - \text{time interval};$$

D. Label the important events on the velocity plot. What is the overall time for a round trip, including stops? What is the maximum speed of the elevator?

**Lab 2b. Harmonic Oscillator**

The object of this lab is to measure the period of a harmonic oscillator and use this to estimate the spring constant $k$. You will also measure the spring constant directly. The harmonic oscillator is a weight at the end of a rubber tube. The accelerometer will be attached to the tube and you will compute the magnitude of the acceleration.

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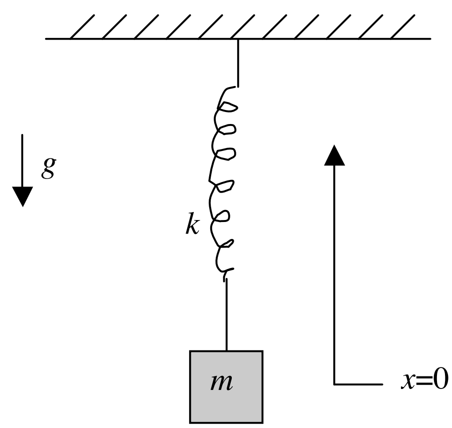
***Theory***

$x(t)$ - displacement versus time
$m$ - mass of weight (1.07 kg)
$k$ - spring constant (N/m)
$T$ - period of oscillation
$g$ - acceleration of gravity (9.8 m/s$^2$)




force of acceleration = spring force

$$m\frac{d^2x}{dt^2} = -kx$$

solution

$$x(t) = x_o \cos\omega t, \qquad \omega = \frac{2\pi}{T}$$

$$m\frac{d^2x}{dt^2} = -\omega^2 m x_o \cos\omega t = -kx_o \cos\omega t$$

$$\omega = \sqrt{\frac{k}{m}}, \qquad T = 2\pi\sqrt{\frac{m}{k}}$$

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A. Measure the spring constant. Raise the weight until the tube is slack. Measure the distance between the equilibrium point (no motion) and the slack point and call it $\Delta x$. The spring constant is $k = \frac{mg}{\Delta x}$. Why is this true? What is the value of $k$?

B. Set the weight in motion and record the oscillations. We will prepare a data file for each group and place it on the web site. The file will have rows of numbers with: *time, $a_x$, $a_y$, $a_z$*.

C. Plot the magitude of the acceleration $|a| = \sqrt{a_x^2 + a_y^2 + a_z^2}$ versus *time*.

D. Measure the period of the oscillation and determine $k$. Does it match the value from part A? (Note my estimates of $k$ are very different.)