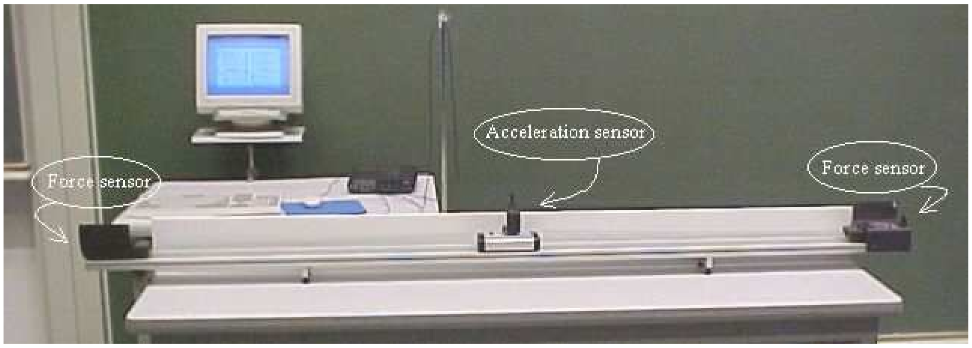
Simple harmonic motion (SHM) (2)

Aim: To show the harmonic motion of a spring-mass system

Subjects: 3A40 (Simple Harmonic Motions)

Diagram:



Equipment:

- Track, 2.2m (PASCO ME9452).
- Cart (PASCO ME9454).
- Mass equal to the cart.
- Two force-sensors (PASCO CI6537), with mounting bracket.
- Acceleration sensor (PASCO CI6558).
- Two springs.
- Data-acquisition system and software (we use Scientific Workshop).
- Beamer to project the monitorscreen.
- Mass, three times the mass of the cart.
- Stopwatch with large display.

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Presentation:

1. Set up the equipment as shown in the Diagram. On the monitorscreen four graphs are prepared: The springforces F_1 and F_2 and the resultant force on the cart (F_1-F_2) and the acceleration *a* of the cart (see Figure1).

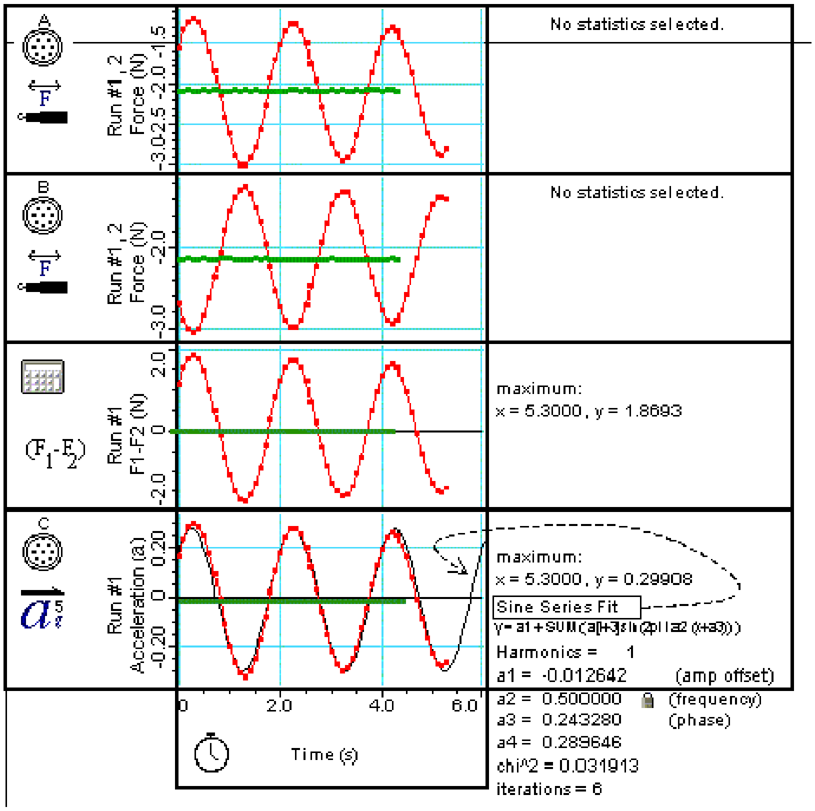

Figure 1

Collect data while the system is at rest. In the graphs F_1 and F_2 show a negative value and (F_1-F_2) and *a* are zero (see the green lines in Figure1). Displace the cart from equilibrium and let it go. Collect data during about 4 complete swings of the system (the red curves in Figure1). Make a sine curve-fit for the graph that displays the acceleration, to show that the motion is really harmonic.

2. Set the cart in motion and clock how long it takes to run five periods. Add masses to the cart so that its total mass is four times its original mass. Make the students predict what will happen to the period. Set the cart in motion and clock again five periods to check if the prediction fits.

Explanation:

1. A mass is in SHM as long as its acceleration (*a*) is always directed towards a fixed central point and increases linearly with displacement. The force on the

mass is a springforce (*F=-kx*). Applying Newton's second law we get *F=-kx=ma* and hence $a = -\frac{k}{m}x$, so $a \propto -x$.

2. Analysis shows that for SHM of a spring-mass system $\omega = \sqrt{\frac{k}{m}}$. So increasing the mass fourfold means a reduction of ω by a factor 2.

Remarks:

- The graphs of F_1-F_2 and acceleration show directly the linear relationship between *F* and *a*. So in this demonstration Newton's second law is visible directly. The values of maximum (F_1-F_2) and maximum *a*, shown in the "statistics box" of the display (see Figure1) give directly the value of *m*: $m = \frac{F_1 - F_2}{a}$.

Sources:

- Mansfield, M and O'Sullivan, C., Understanding physics, pag. 47-52