

TAP 303- 2: Oscillating freely

Mass and spring oscillators

Many oscillators work on the interaction between springs and mass. Here you can look at the effect of these two quantities on the frequency of the oscillation. You will also probably do this in the laboratory, so you might use this software activity in a review session, or to exemplify your findings.

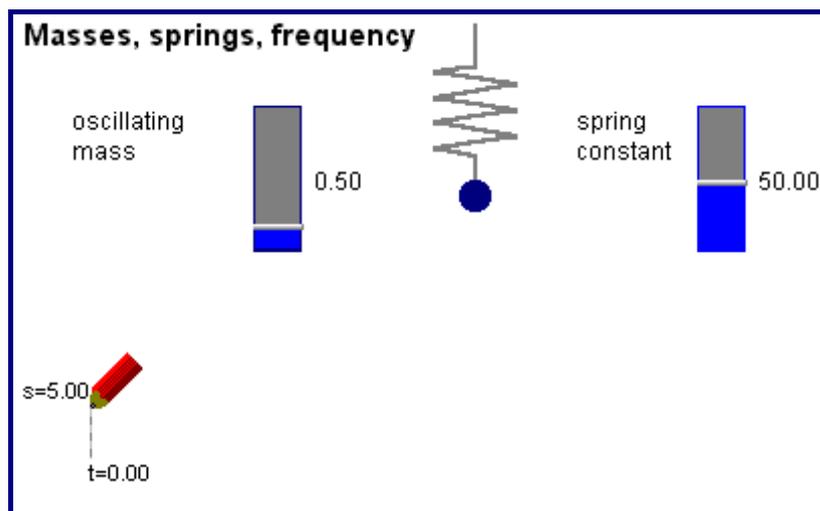
You will need

- ✓ computer running Modellus
- ✓ a Modellus model:

TAP 303-3: Modelling springs and masses

Using the model

1. Launch and run this model. Can you give a qualitative account of the motion?



2. What do you expect to happen to the motion when you double the mass? Can you explain why you expect this to happen? Try it and see, using the slider on the model to alter the mass.
3. What do you expect to happen to the motion when you double the spring constant? Try to account for your expectations, and then use the slider on the model to alter the spring constant.
4. If you have not already done so in the laboratory, collect a set of readings that show the relationship between the frequency ($= 1 / \text{period}$) and the mass. Then repeat for frequency and spring constant.
5. Process these two sets of data to show the relationships graphically.

You have

1. Thought carefully about the dynamics of oscillators – how the forces and masses produce the resulting motions.
2. Found quantitative relationships between mass and frequency and between spring constant and frequency.

Practical advice

The activity emphasises $F \propto -x$ as the condition for SHM, and the relationship:

$$f \propto \sqrt{\frac{k}{m}}$$

This could be used after the free oscillator has been introduced. It will supplement work done in the laboratory in describing the motion, both in relating all the kinematic variables and in relating the characteristics of the oscillation to the dynamic variables. It could make a useful homework exercise. Alternatively you could demonstrate some of the features of the model, using it to introduce the topic. If so, a real system should be demonstrated also. At some stage the students should analyse real data.

This model is deliberately simple, and probably should not be used to replace laboratory work on this topic. It may, however, form a useful focus for discussion or private study. The chance to play the motion back step by step, talking through the changes to understand the dynamics, relating this to the average time for a complete oscillation, and to interact with a range of masses and spring constants should not be missed.

More confident students, or those with more time to spend here, could adapt the model to form a presentation, adding vectors to the animation, and perhaps slowing it down by making the time steps finer grained, to form a tool to help them explain the relationship between the quantities.

Alternative approaches

This model could be introduced much later when a lot of practical experience has been gained and students know about $(k/m)^{1/2}$, as you may choose to base an introduction entirely on laboratory work.

A web based JAVA Applet could also be used:

http://www.her.itesm.mx/academia/profesional/cursos/fisica_2000/Fisicall/PHYSENGL/spring_pendulum.htm

Social and human context

This step-by-step understanding, in which every change is linked to a prior sufficient cause, is central to the theme of the clockwork Universe and Laplace's thought: 'All the effects of nature are only the mathematical consequences of a small number of immutable laws'. Mass and spring oscillators can be used to model everything from car suspensions to molecular vibrations. It is important that students get a feel for the physics involved. In this activity, a model is employed to highlight some of the important physical ideas involved in studying simple oscillating systems.

Modellus

Modellus is available as a FREE download from <http://phoenix.sce.fct.unl.pt/modellus/> along with other sample files and the user manual

External reference

This activity is taken from Advancing Physics chapter 10, 250s