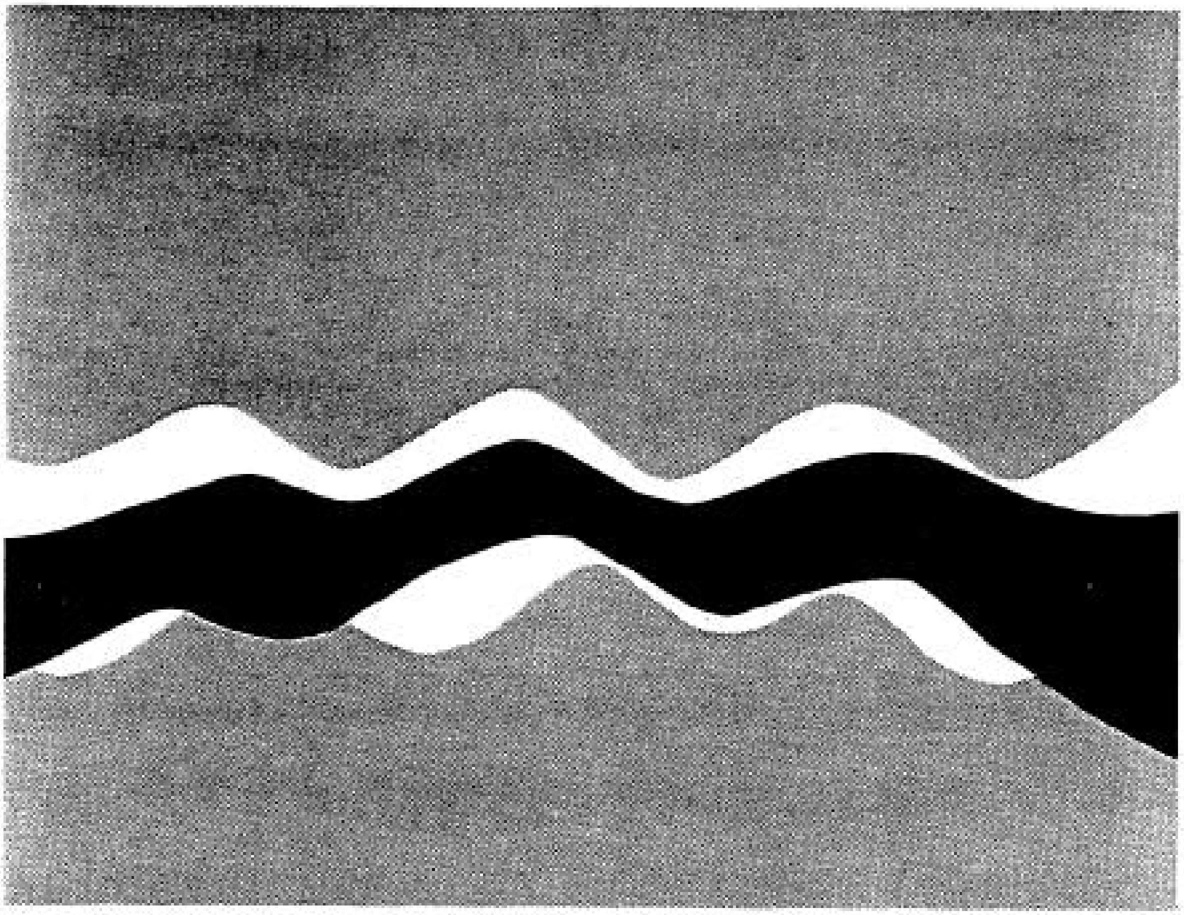
A Teachers Guide for the Videotape Segment 9 | Starts at 16:35:0 | Run Time 02:25:

OSCILLATIONS



NASA
National Aeronautics and Space Administration

FILM FOOTAGE FROM NASA SKYLAB MISSIONS

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I. Introduction

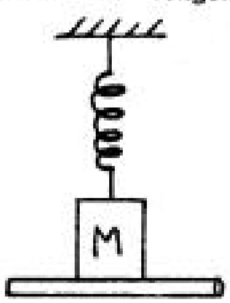
The Skylab orbital workshop provided a unique opportunity to investigate various properties of materials. In this unique weightless environment the usual vibratory modes can be much different.

What does a Wilberforce pendulum have in common with water? Perhaps, because you have not been an astronaut in a weightless environment, you have never noticed the similarities. In Skylab, where water drops are only constrained by the surface tension of water, the oscillations of water drops bring to mind the oscillations of a pendulum.

During the 171 days that astronauts lived in the weightless environment of Skylab they demonstrated both the oscillation properties of water and of a Wilberforce pendulum. This film shows some of these possible modes of oscillations.

II. Basic Physics

The Wilberforce pendulum[1] is ordinarily used to show how the distribution of mechanical energy may periodically change forms during the oscillations of a mechanical system. This phenomena is illustrated by adjusting a simple spring-mass oscillating system to enhance the systems rotational inertia. This can be done by adding a rod (wood or metal) to the vibrating mass as shown below. The length of the rod or the mass m or both are then adjusted until the period of translational vibration is approximately equal to the rotational period of the system. When the motion of the system is started by a translation and/or rotation, the energy distribution will periodically transfer from translational to rotational and back again.



Water of small volume tends to form droplets due to surface tension. Because of the stress produced on the surface of the liquid due to cohesive forces, the water behaves as though it is held by an "elastic skin" and will therefore respond to oscillations produced at its water-air boundary.

III. Film Synopsis

Scene 1. The film opens showing two hands holding a Wilberforce pendulum. One end of the pendulum is released and the resulting oscillation of the pendulum in a weightless environment is shown.

Scene 2. Water drops placed on the ends of two aluminum rods, 0.95 cm (3/8") in diameter and about 3 cm apart are shown. One drop, colored red, is oscillated.

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[1] Sutton, R. M., Demonstration Experiments in Physics, McGraw Hill Book Co., Inc., New York, 1938, (Wilberforce Pendulum, page 135)

Scene 3. The Wilberforce pendulum, stuck to a wall, is shown oscillating with one free end.

Scene 4. A hemisphere of water, about 8 cm in diameter is shown held to a surface by adhesion. The hemisphere of water is excited by a stroke from a drinking straw. Its oscillations are shown.

Scene 5. Longitudinal vibrations of the Wilberforce pendulum are demonstrated.

Scene 6. A water bridge between the two aluminum rods is shown and oscillations of the bridge are produced.

Scene 7. The complicated, two ends free, oscillations of the Wilberforce pendulum are shown.

Scene 8. With two glass rods a water drop, suspended on a string, is excited to oscillate.

Scene 9. The Wilberforce pendulum is twisted and released to show its complex rotational and translational oscillations.

IV. Discussion and Exercises

1. Perform some simple exercises with a Wilberforce pendulum. What differences and similarities can you see with the Skylab behavior of the pendulum?

2. Construct a hemisphere of water on a table top. Put it on teflon or on wax paper. How large can you make the drop? What oscillations can you excite in the water drop? How does it compare with the Skylab film?

3. Construct a water bridge between two aluminum rods. How large a diameter bridge can you make? How long can you make the bridge? Excite oscillations in your bridge. How does it compare to the oscillations of the Skylab water bridge?

4. Compare the behavior of the plain water bridge (Scene 6) with the behavior of the soap-water bridge in the film, "Soap and Water." What can you deduce about the effort of soap on the properties of water in a weightless environment?