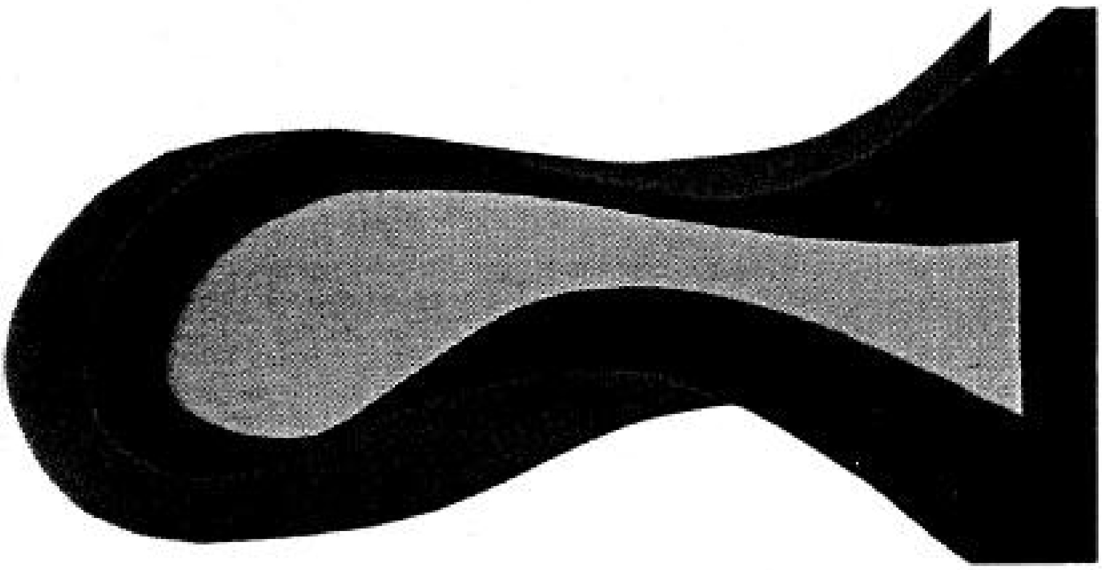
A Teachers Guide for the Videotape
Segment 10

Starts at 19:00:
Run Time 02:10

# *LIQUID DROPS*



FILM FOOTAGE FROM NASA SKYLAB MISSIONS

National Aeronautics and Space Administration

Edited and Produced for the AAPT
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## I. Introduction

On earth we know liquids as well behaved, useful materials, always seeking their own level and always flowing down hill. From the beginning of manned space flights, liquids have presented a containment problem in space vehicles. Water with its adhesive properties sticks to cloth, skin and most inorganic materials. Unconstrained by gravity, water drops float inside the space craft. This was a new experience for man as he used liquids in space. This film introduces some of the properties of water that are only demonstrated in the weightless environment of a spacecraft.

During the Skylab missions of 1973-74, the astronauts performed and filmed many water drop and water bridge demonstrations. This film can serve as an introduction to these demonstrations. Other AAPT films showing liquid demonstrations are "Water Bridges," "Soap and Water," "Oscillations," and "Collisions."

## II. Background Physics

The instructor may wish to discuss surface tension in conjunction with the use of this film. Briefly: the surface of a liquid behaves much like a membrane under stress, such as a balloon or a drumhead. If we consider a line lying in any stressed surface, the forces on the two sides of the line are equal and opposite, and proportional to the length of the line. The force per unit length is called the surface tension, and may be measured in dynes/cm or newtons/meter. Any surface under tension tends to contract to the minimum area compatible with the difference of pressure on the two sides of the surface Hence water tends to form spherical drops in air, with properties demonstrated in this film.

Reference: Sears and Zemansky, University Physics (4th Edition) Addition-Wesley, (1970) p. 188.

2. The liquid drop model was suggested to explain the properties of the atomic nucleus, such as fission and fusion. You may wish to show this film in conjunction with a discussion of nuclear physics.

Reference: Weidner and Sells, Elementary Modern Physics, Alternate Second Edition, Allyn & Bacon (1973) p. 332.

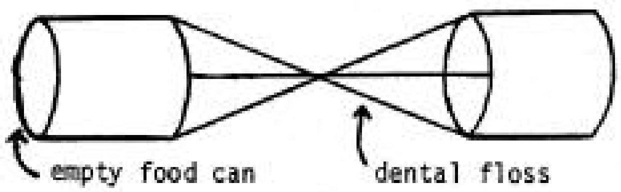
3. The existence of a radial force that acts upon a rotating liquid is illustrated in this film. The accurate mathematical description of the fission of a rotating water drop, as shown in this film, is beyond our present knowledge of fluid dynamics.

## III. Film Synopsis

Scene 1. The film opens with a hemisphere of water sticking to a table top because of its surface adhesion. (Caution: The viewer ought not be deceived by the up-down orientation of the filmed table. Gravity is not holding the water on the table.) The astronaut blows on the water through a drinking straw. The water hemisphere then performs a number of gyrations and oscillations.

Scene 2. Title scene - Liquid Drops

Scene 3. The scene opens with two spheres of water translating slowly across the orbital workshop of the Skylab vehicle. The astronaut attempts to constrain their motion by using a three string rig. The rig was construced of three strings of dental floss and two empty food containers. Since the water does not adhere well to the dental floss, the spheres keep their shape




LIQUID DROP HERDER (LDH)

and drift through the strings. After some effort the astronaut herds the two drops together. Then the astronaut uses the LDH to set the drop rotating. You will notice that the drop assumes a dumbbell shape in response to the bal[illegible] between the surface forces and the centripetal forces acting on the water. Th[illegible] appears to be an air bubble located in the narrow neck of the dumbbell drop. Finally, the drop separates.

Scene 4. This scene opens with a water drop on the LDH. Once again the astronaut uses the LDH to apply a torque to the water drop and get it to spin. Once again the drop finally assumes a dumbbell shape. Finally, the astronaut uses the LDH to make two separate drops.

Scene 5. The scene opens showing a large water drop floating in the Skylab cabin. The converging lens effects to the drop are clearly observed. Then the astronaut uses a syringe to blast the large drop with a burst of air. The water drop is deformed and splits into pieces.

IV. Questions and Exercises

1. What factors limit the size of liquid drop that can be formed in a zero weightless environment like Skylab? What factors limit the size of a liquid drop that can be formed near the surface of the earth?

2. One astronaut claimed that it seemed that he could form any size liquid drop that he wished as long as he had the patience necessary to fill his liqu[illegible] drop with additional liquid with a syringe from the inside. Does that statem[illegible] seem reasonable? Explain your answer.

3. If you have a large liquid drop, and you insert a detergent into it, what do you expect to happen? Explain your answer. (A visual answer to this question is provided in the film "Soap and Water.")

4. Using the stop action feature of your projector, draw several outlines of the dumbbell water drop, just before the water drop breaks at the end of scene 3. Can you see evidence of a shift in the water drop's mass? How do you explain the seeming spontaneous separation of the drop?

5. What is the largest size of hemispherical water drop that you can form on a planar surface on the earth? Perform a series of experiments by carefully putting water on a number of surfaces to which water does not adhere easily. Use graph paper to estimate the area of liquid surface in contact with the supporting plane. In a laboratory class you could sponsor a largest hemisphere competition among the students.

6. What is the largest size liquid drop you have seen falling in the air? Falling as a large rain drop? Dropping from a large faucet? What is the largest size freely falling drop that you can easily make? What technique is best for forming large water drops? In the class you can sponsor a largest falling water drop contest among the students. You can catch a number of drops, say ten, in graduated cylinder and give a prize to the person with the largest volume of water in ten drops.

7. Place as large a drop of water as possible on a piece of dental floss. Place as large a drop of water as possible upon a piece of regular thread. Which drop is the largest? Do you predict the same result would occur in Skylab? Explain.