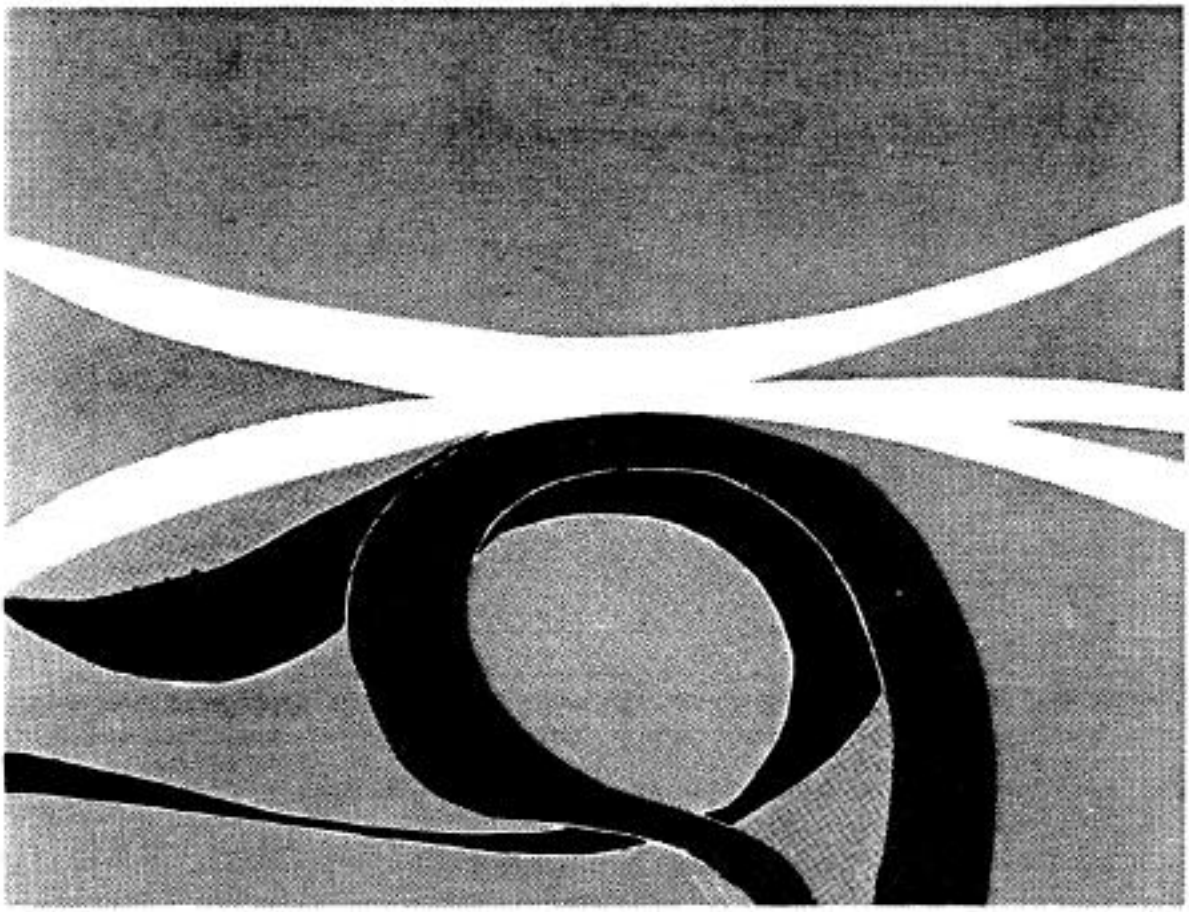
A Teachers Guide for the Videotape
Segment 11

Starts at 21:11:0
Run Time 02:17:

WATER BRIDGES



NASA
National Aeronautics and Space Administration

FILM FOOTAGE FROM NASA SKYLAB MISSIONS

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I. Introduction

Water bridges? No doubt the title calls to mind the Golden Gate Bridge and others that span great bodies of water. What can that have to do with Skylab? In the Skylab, metal is not used to span the space over a body of water, but rather water is used to span the space between two metal rods. The astronauts did, in fact, construct bridges made out of water to span the distance between two 3/8" diameter metal rods. Having never seen a real water bridge before, you may wonder how a water bridge behaves. You're invited to watch.

During the Skylab mission of 1973-74, the astronauts performed and filmed many other liquid demonstrations. Other AAPT films demonstrating the properties of liquids in a weightless environment are "Liquid Drops," "Soap and Water," "Oscillations" and "Collisions."

II. Background Physics

The water bridges shown in this film are made possible by the adhesion of the water to metal rods at both ends of the bridges and by the cohesion of the water manifested by its surface tension. On a microscopic scale adhesion is the result of attraction between the molecules in the surface of one substance and those in the surface of another, while cohesion results from the attraction between molecuIs of the same kind. Surface tension tends to bring an isolated volume of the liquid into a form that has the smallest superficial area compatible with the forces acting on the surface.

Reference: Sears and Zemansky, University Physics, (Fourth Edition) Addison-Wesley, (1970) Chapter 13.

III. Film Synopsis

Scene 1. This film opens with Astronaut Gibson explaining the water bridge apparatus. This apparatus consists of two metal rods supported so that they can be rotated as well as oscillated back and forth. A TV camera is mounted to provide a good view of the gap between the ends of the metal rods.

Scene 2. A syringe is used to put a drop of water on the end of one of the metal rods. The other rod already contains a drop of red colored water. These liquid drops are held to the metal surfaces by the forces of adhesion. Note the adhesion of the drop to the syringe as it is pulled away.

Scene 3. The red and clear water drops are brought together to form a bridge. The curved surface that results between the red and clear volumes of the water bridge is clearly shown.

Then, the red-clear water birdge is set into a spinning motion by causing both of the metal rods to spin in the same direction. The bridge finally separates into two parts.

Finally, a glass rod is used to bring the two separate parts of water together to form a bridge.

Scene 4. This scene opens with a red-clear bridge being formed. The separation between the metal rods is decreased and the cruvature of the bridge surface is decreased also.

Scene 5. A short bridge is set into spinning motion.

Scene 6. A long red bridge is rapidly spun until it breaks apart and drops of water sail away. The astronaut then tries to repair the bridge using his finger. Note the good adhesion of the water to his finger.

IV. Questions and Exercises

1. Take two metal rods and see how large a water bridge you can build between them. How does the separation between the rods compare with the 2 cm separation shown in the film?

2. Use the stop frame feature of your camera to project the scene of the concave bridge surface onto a sheet of graph paper. Then draw a graph of the curvature of the surface. What shape is it? Circular? Parabolic? Cycloidic? Hyperbolic? Why?

3. Suppose you injected soap into the water bridge. What effect do you predict that would have? (For a visual answer to this question see the film "Soap and Water.")