The Video Encyclopedia *of* Physics Demonstrations™

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CHAPTER 29

FLUID DYNAMICS

Demo 13-01 Pitot Tube

A pitot tube, shown diagramatically in *Figure 1*, is used to measure the velocity of a moving air stream.† An opening at the front of the tube is connected to one end of a U-tube manometer, and an opening at the top is connected to the other end. A faster velocity airstream creates a greater pressure differential between the two openings, increasing the difference in fluid level between the two sides of the manometer.

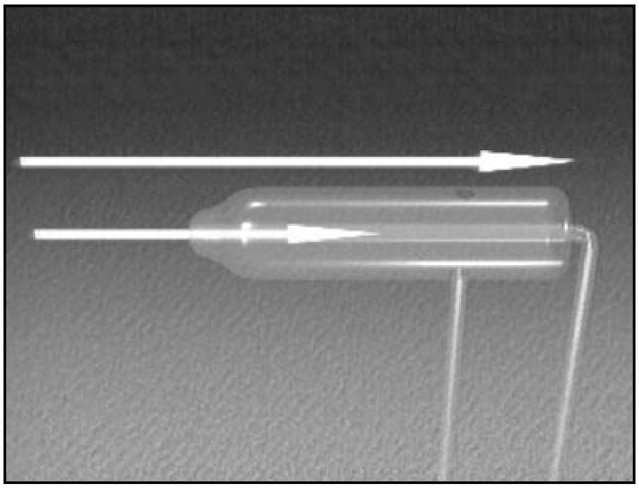

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fj-11, Pitot Tube.

This glass pitot tube can be used to measure the velocity of an air stream flowing past.

The Pitot tube is a water manometer with two openings—one facing into the air stream, and the other perpendicular to it.

When air flows past the Pitot tube, there is a difference in air pressure at the two openings, which causes a difference in water levels within the manometer.

The difference in water levels depends on the speed of the air.

When we increase the speed, the difference in water levels increases.

Equipment

1. Pitot tube with attached all-glass manometer (partially filled with colored water).
2. Support system.
3. Air blower with hose.
4. Variac.

Demo 13-02 Flettner Rotor

A Flettner rotor uses the Magnus effect to create a force on a rotating drum in an external air stream.† In this case, shown in *Figure 1*, wind created by a fan passes across the rotor from the top to the bottom in the Figure, creating a net force with a component perpendicular to the wind direction, and thus propelling the Flettner rotor vehicle to the right in the Figure.

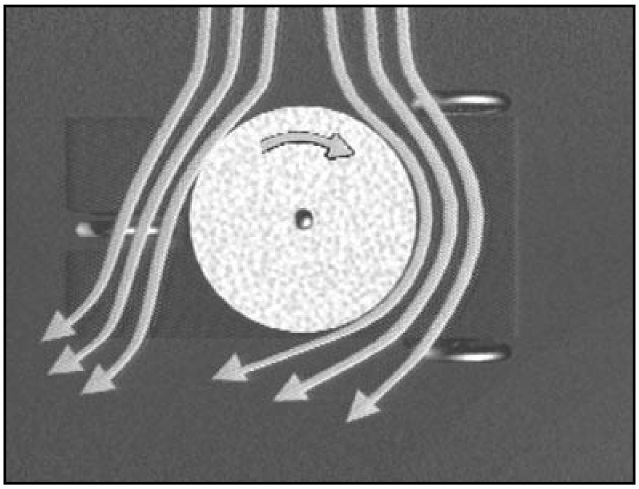

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-300, Flettner Rotor Ship.

This device is known as a Flettner rotor.

The rotor is a styrofoam cylinder powered by a small electric motor and mounted on a rolling car. When switched on, the rotor spins clockwise as seen from above.

If we direct a stream of air from a fan at the rotor, the car moves perpendicular to the airflow.

Reversing the direction of spin reverses the motion of the car.

This animation shows how the moving air stream is deflected as it flows around the rotor, causing a reaction force which propels the car to the side.

Equipment

1. Flettner rotor mounted on a cart that also caries the motor, batteries, and the reversing switch.
2. Large fan with a few paper streamers.

Demo 13-03 Curve Balls

The magnus effect is used to create a curve when a ball is thrown.† The spinning of the ball as the air rushes past the ball leads to the force. In the graphic of *Figure 1* the ball is moving from right to left and spinning counterclockwise, so the magnus force is toward the bottom of the Figure. Examples of curve balls are shown on the video.

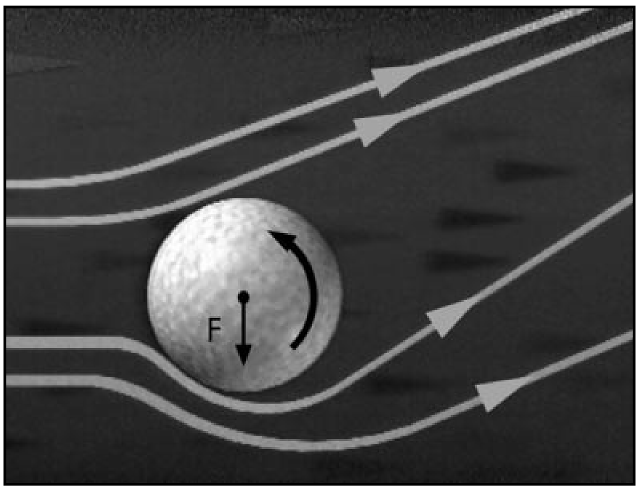

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-297, Curve Balls.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fj-3, Curved Ball Trajectory.

A pitcher can make a baseball curve by applying the proper spin to the ball as it leaves her hand.

We're going to increase the effect by using a light styrofoam ball and a throwing tube which will put a fast spin on the ball.

If the ball is thrown overhand as shown, so that it comes out spinning clockwise as seen by the camera, the ball curves upward.

If the direction of spin is changed by throwing the ball side armed, the ball curves away from the direction of the throw.

This animation shows how the stream of air moving past the ball is deflected by the spinning of the ball.

Equipment

1. Light Styrofoam ball.
2. Throwing tube cut from a cardboard mailing tube by removing approximately one half of the tubing along the major axis beyond the handle area which also retains the end cap.

Demo 13-04 Floating Ball in Air Jet

The Bernoulli effect can be used to support a ball in an air jet, as illustrated in *Figure 1*.[†] In the video a styrofoam ball is suspended in the air stream from a vacuum cleaner. The impact of the air stream deflecting from the ball holds the ball up, and the reduced pressure within the air stream relative to the outside air holds the ball in the air stream.

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-292, Ball on Jet—Bernoulli Effect.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fj-9, Floating Objects in Jet Stream.

If a jet of air from a blower is directed straight up, a styrofoam ball will float inside the jet.

It stays there even if we tip the jet sideways…as long as we don't tip the jet too much.

Equipment

1. Styrofoam ball.
2. Air blower with hose.
3. Variac.

Demo 13-05 Suspended Plate in Air Jet

The Bernoulli effect can be used as illustrated in *Figure 1* to hold two plates together, even supporting a substantial weight.† An air stream moves radially outward between a fixed horizontal plate and a second plate which is held close to the first plate. The rapidly moving air reduces the pressure between the plates, holding the two plates together. In the video weights are hung from the suspended plate.

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fj-5, Lifting Plate.

If we blow air through the hole in the center of this disc, light objects such as this streamer are blown away from the disc.

If we put a second disc up to the first with the air blowing, what will happen?

The second disc is pushed up against the first because the air moving between the discs is at a lower pressure than the air beneath the lower disc.

Even if we attach a weight to the lower disc it still hangs beneath the upper disc.

Equipment

1. Flat metal disc with center hole and tubing coupling with secure flush mounting.
2. Heavy ring stand.
3. Two right angle clamps.
4. Cross bar.
5. One or two paper streamers taped to edge of disc.
6. Length of rubber tubing.
7. Supply of compressed air.
8. Second flat disc with a hook screw mounted in its center—allow screw to protrude through disc a short distance to serve as a lateral guide.
9. Weight hanger and slotted weights, or a series of interconnecting hooked weights.

Demo 13-06 Suspended Parallel Cards

A rapidly moving air stream is injected between two plastic sheets suspended a short distance apart.† The pressure between the cards is less than the atmospheric air pressure outside the cards, so the cards are pushed together, as seen in *Figure 1*.

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-296, Dependence of Pressure on Velocity in Air Stream.

These two parallel plates swing freely on strings.

If we blow air into the space between the plates, the plates swing together.

Equipment

1. Two stiff cardboard squares suspended by strings so they face one another in a parallel fashion.
2. Support system.
3. Length of rubber tubing.
4. Supply of compressed air.

Demo 13-07 Vortex Cannon

A vortex cannon is used to create a circular vortex of air. Because of its circulation the vortex remains intact as it moves through the surrounding atmosphere, as illustrated graphically in *Figure 1*.† A smoke ring is another example. In the video the circular vortex is created when a rubber membrane on one end of a small can is struck soundly, forcing the air out of a circular hole on the other end of the can. The air leaves the can as a circular vortex, as shown in the accompanying animation.

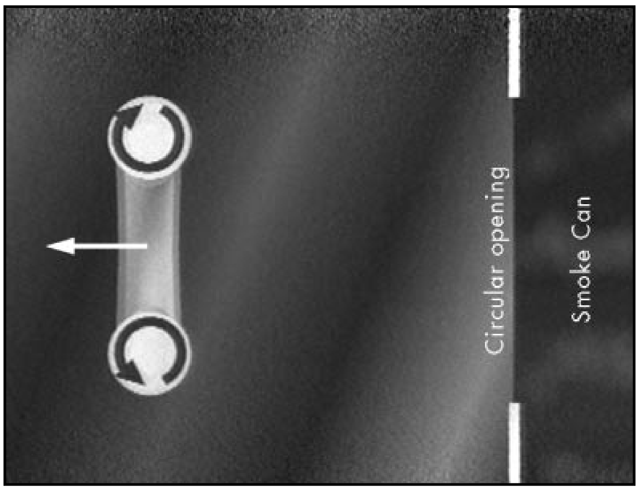

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fp-1, Vortex Rings.
Meiners, *Physics Demonstration Experiments*, Section 17-8.6, Smoke Rings.

This large barrel has a circular hole cut in the front face, and a rubber sheet for the face in back.

If we put smoke inside the barrel,

then strike the rubber sheet with a hand, a vortex ring flies out of the circular hole.

This animation shows how the vortex ring forms as the smoke moves through the hole.

We can use the wind energy of the vortex to put out a candle flame.

Equipment

1. Large metal cylinder with an end cap that has a relatively small hole in it. Cover other end with rubber sheeting.
2. Set barrel on rectangular Lazy Susan for ease of viewing at different angles.
3. Smoke generator (ours is a quart jar with a two-hole rubber stopper with glass tubing and rubber tubing).
4. Supply of cigarettes.
5. Source of flame.
6. Candle.
7. Lab jack.

Demo 13-08 Un-mixing

This demonstration is a very dramatic illustration of laminar fluid flow. A thin line of dark dye is injected in the center of a layer of glycerine between two cylindrical shells.† When the inner cylinder is rotated, the glycerine flows smoothly, with greater motion at the center and less motion toward the outer fixed cylinder. The laminar flow of the glycerine spreads out the dye in a uniform way, as shown diagrammatically in *Figure 1*. When the inner cylinder is rotated in the reverse direction, the glycerine reverses its flow, and because the flow is laminar the line of dye is reconstructed.

Figure 1

† John P. Heller, An Unmixing Demonstration, *Am. J. Phys.* 28, 348-353 (1960).

If a drop of dye is put into a beaker of water

and the water stirred, the dye and the water cannot then be easily unmixed.

We now illustrate a different kind of mixing. The outside of this device is a fixed clear plastic tube, and the inside is a plastic tube which can be rotated by turning the crank. Between the outside and the inside tubes is a layer of glycerine about one centimeter thick.

Using a long hypodermic syringe, a line of blue dye can be inserted into the center of the layer of glycerine.

Rotating the crank two turns mixes the dye into the glycerine.

Reversing the direction of rotation of the crank unmixes the dye.

The mixing and unmixing procedure will now be repeated rotating the crank 5 turns.

This animation illustrates how the uniform or laminar flow of the glycerine leads to mixing and unmixing of the dye.

Equipment

1. Beaker of water.
2. Supply of dye or ink.
3. Spoon or string rod.
4. Unmixer—two concentric cylinders with the inner one being completely enclosed with a pivot hemisphere on one end and a handle on the other. The outer one has a base and socket mounted on its inside center (for the inner cylinder pivot) and a lid with two holes—one at its center through which the handle from the inner cylinder protrudes and one located halfway between the inner and outer walls of the two cylinders.
5. Supply of glycerine.
6. Syringe with long needle with appropriate inside diameter.
7. Supply of dyed glycerine.

Demo 13-09 Tornado Tube

A tornado tube is constructed using two cola bottles that are connected as shown in *Figure 1*, with one bottle filled with water.[†] The problem is to get the water from one bottle to the other in the minimum time. When the bottles are turned upside down, a small amount of water will flow into the lower bottle, but when the air pressure at the top of the bottle becomes small enough the flow ceases. To create the most efficient flow, the upper bottle is moved rapidly in a circle, creating circular flow of the water in the upper bottle. This motion keeps the water at the outside radius of the hole as it passes from the upper bottle into the lower bottle, simultaneously allowing air to rise into the upper bottle.

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fp-2, Tornado Tube.

Here we have two plastic soda bottles connected by a short tube with a small hole through the middle.

The lower bottle is partly filled with water, while the upper bottle contains only air. When we invert the bottles, the water does not run down into the lower bottle.

If we give the upper bottle a quick spin, the water moves toward the outer part of the small hole, letting the air come up through the middle.

A vortex forms and the water drains into the lower bottle.

Equipment

1. Two two-liter clear plastic soda pop bottles.
2. Commercially available plastic coupling.

Demo 13-10 Siphon

A siphon uses a tube to transfer a liquid from one container into a lower one, as shown in *Figure 1*.[†] Atmospheric air pressure keeps the liquid in the transfer hose, making the water column "unbreakable." The weight of the liquid on the vertically longer side of the hose is greater than that on the shorter side, so the liquid will flow into the lower container.

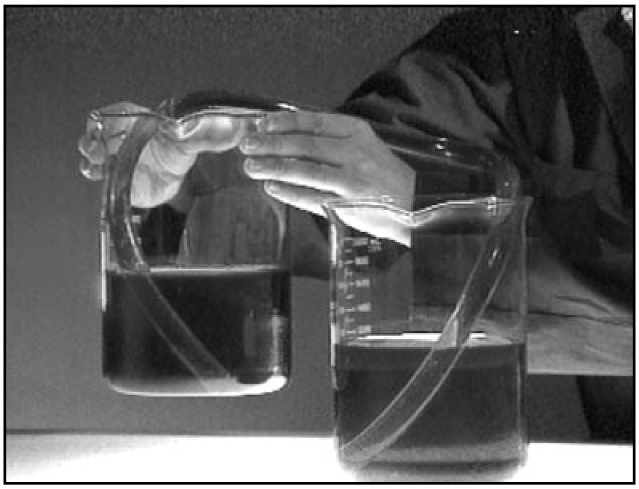

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-278, Siphons.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fe-1, Ordinary Siphon.

A siphon is often used to move liquids from one container to another. We'll use these two cylinders filled with colored water to show how positioning of the containers affects siphon flow.

The containers are initially at the same level, and the tube between them is filled with water. There is no flow of water from one container to another. When we raise the cylinder on the left, water begins to flow from the higher cylinder to the lower. Raising the cylinder higher increases the rate of flow.

When the left cylinder is returned to the table, the water levels equalize.

Raising the right cylinder causes the water to flow the other way.

Equipment

1. Two large beakers.
2. Supply of colored water.
3. Length of clear plastic tubing.

Demo 13-11 Syringe Water Velocity

Water is forced out of a syringe through a small opening, as shown in *Figure 1*. Because the cross-sectional area of the syringe is much greater than the area of the opening through which the water squirts, the speed with which the water squirts out of the hole is much higher than the speed of the moving plunger.

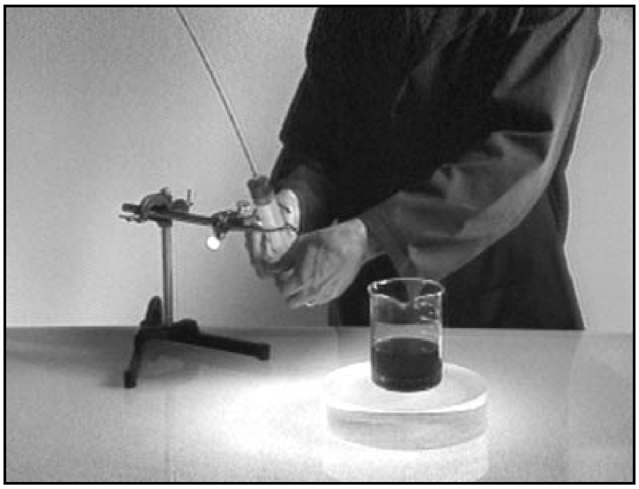

Figure 1

When water flows through a constriction, the velocity of the water inside the constriction is greater than in the wider spaces surrounding it.

We'll use this syringe filled with colored water to demonstrate the velocity increase.

When the plunger of the syringe is pushed in slowly, the water inside is moving at the same speed as the plunger, less than one centimeter per second.

When the water reaches the constriction at the tip of the syringe, its velocity increases dramatically.

Equipment

1. Supply of colored water.
2. Large syringe.
3. Ring stand.
4. Right angle clamp.
5. Three-fingered clamp.

Demo 13-12 Uniform Pressure Drop

Water flows uniformly along a tube, with sensing tubes connected along the flow tube at equal intervals, as shown in *Figure 1*.† The height to which the water rises in the sensing tubes is a measure of the pressure in the tube at those points. The pressure decreases uniformly along the tube, as can be seen on the video and in *Figure 1.* A faster flow creates a larger pressure differential along the tube, but the pressure drop is still uniform along the length of the tube.

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fj-7, Pressure Drop along a Line.

We'll run water through a long tube to show how the pressure in the water varies along the tube.

The water pressure is indicated at these three points by the height the water rises in the vertical tubes.

Floats in the tubes help us see the water levels in each tube.

With the water flowing slowly, the pressure drops gradually and uniformly along the tube.

With a faster flow the pressure drop along the tube is greater, but it is still uniform.

Equipment

1. One horizontal piece of glass tubing and three vertical pieces of glass tubing. Two vertical pieces of tubing are placed near each end of the horizontal tube and the third is placed at the center of the horizontal tube.
2. Support system for glassware.
3. Three brightly colored wooden dowel floats to clearly indicate the height of each vertical tube.
4. Rubber tubing on both ends of apparatus.
5. Supply of water.
6. Sink.

Demo 13-13 Bernoulli's Principle

Water flows along a tube with a constriction near its center, as shown in *Figure 1*. Because the water flows faster in the section of the tube with a smaller radius, the pressure in that region is reduced, as indicated by the water in the attached sensing tubes.† The sensing tube attached to the constriction is initially covered, allowing the students to guess where the water level will be.

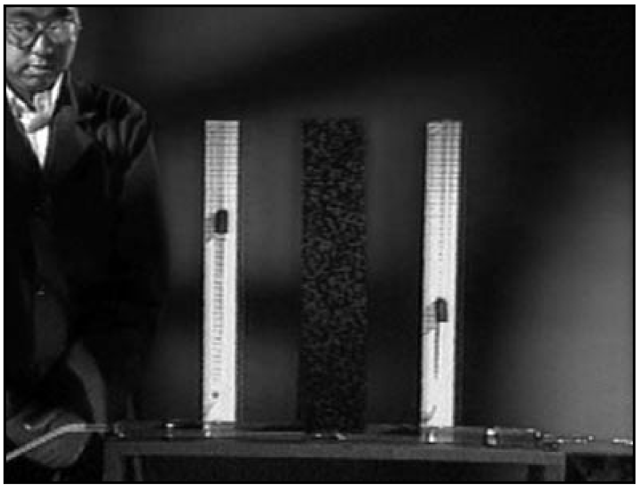

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstrations M-294, Bernoulli Apparatus, and M-305, Venturi Meter.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstrations Fj-1, Bernoulli Tubes, and Fj-8, Constriction in Pipes.

As water flows through a tube, its pressure drops. If the tube has a constant diameter, the pressure drop increases regularly along the length of the tube. We'll use this device to show what happens when the diameter of the tube is not constant.

Water flows through this horizontal glass tube, which has a large diameter at the beginning and end but a constriction in the middle. The pressure in each of the sections is indicated by the water level in the vertical tubes.

The two outer vertical tubes show the pressure drop that occurs along the horizontal tube. The center tube is covered. If the pressure drop was constant, we would expect this tube's level to be here.

Will that be the actual height, or will it be higher or lower?

The water level in the center tube is lower than expected, showing the lowered pressure in the constriction.

Equipment

1. Glassware similar to previous demonstration except the horizontal piece has a constriction at its center with its own vertical tube.
2. Three brightly colored floats.
3. Paper sleeve to temporarily cover the center vertical tube.
4. Rubber tubing at both ends of glassware.
5. Supply of water.
6. Sink.

Demo 13-14 Water Hammer

The water hammer effect occurs when a mass of water moving coherently is stopped suddenly.† One example is when a water faucet is closed very quickly, leading to a strong bang as the water is stopped. The operation of one such water hammer, illustrated in *Figure 1*, is observed on the video. This water hammer consists of water sealed with no air inside a glass tube. In the absence of air in the tube, the water slams sharply into the end when the tube is quickly raised and lowered, creating a loud "click."

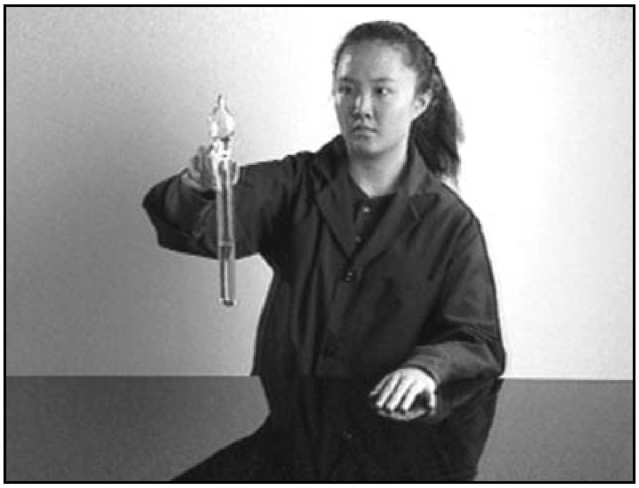

Figure 1

†Sutton, *Demonstration Experiments in Physics,* Demonstration M-290, Water Hammer.

We're used to seeing water fall in a disorganized fashion, and making a sloshing sound as it strikes the ground. But part of the reason for the way water falls is the resistance of air. If we put water in an evacuated glass tube, like this one, and shake the tube rapidly, the water strikes the bottom all at once with a loud "click."

Equipment

Commercially available glass water hammer.

Demo 13-15 Toricelli's Tank

Water squirts out from a series of holes at various heights along a tall water tank.† Neglecting air resistance, the trajectory that the water follows is a parabola. The range of the parabola is greatest for the water that squirts out at the midway point between the bottom of the tank and the level of the water in the tank, as shown in *Figure 1*.

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-314, Water Parabolas. Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fk-2, Velocity of Efflux.

This glass tube is filled with water which is kept at a constant level.

Four outlets on the side of the tube are plugged with small corks.

If we remove one of the corks, water squirts out in a jet which falls to the table.

Given that the pressure of the water in the tube increases with depth, from which outlet will the water jet travel farthest before striking the table?

The jet from the outlet at the center of the water column travels farthest before striking the table.

Equipment

1. Vertical glass tube with four lateral outlets (each with its own cork) at various levels along its height, and having inlet and outlet tubes near its top to maintain water level when corks are removed.
2. Support system.
3. Tubing.
4. Supply of water.
5. Large catch basin.

Demo 13-16 Accelerometers

An accelerometer provides an indication of acceleration. Two accelerometers are shown in the video, one a light ball tethered to the bottom of a jar of water, and one a heavy ball hanging from the top of a jar of water.† When these accelerometers are accelerated to the right along a horizontal line, the light ball moves in the direction of the acceleration, whereas the heavy ball moves opposite to the direction of the acceleration, as shown in *Figure 1*.

Figure 1

† Meiners, *Physics Demonstration Experiments*, Section 8-3.2, Inertial Forces.

These two jars filled with water have different objects attached to strings inside.

This jar has a bobber floating at the end of a string.

This jar has a heavy mass hanging at the end of the string.

If we put these jars on a board and accelerate them to the right, how will the different masses react?

Both masses move away from the center of the jars. The heavy mass shifts in the direction opposite to that of the acceleration, while the bobber shifts in the same direction as the acceleration.

Equipment

1. Two quart jars filled with water. One jar has a fishing bobber attached by string to its lid and the other jar has a lead sphere attached by string to its lid.
2. Sizable chart.

Demo 13-17 Paraboloid of Revolution

When a container of liquid is rotated at a constant angular speed, the surface assumes the shape of a paraboloid of revolution, as shown in *Figure 1*.[†] In the video the shape of the surface of a water container is viewed as the container is set into rotation and the water assumes its equilibrium shape.

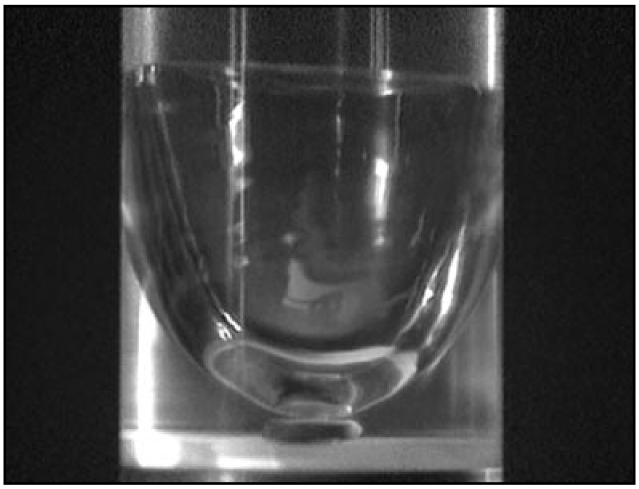

Figure 1

† John M. Goodman, Paraboloids and vortices in hydrodynamics, *Am. J. Phys.* 37, 864-868 (1969).

This water-filled cylinder is attached to a motor so that we can spin it at a high speed. When the cylinder is spinning, what will happen to the surface of the water?

We'll begin by spinning the cylinder slowly, then increasing the speed. At first the water surface stays more or less horizontal. As the speed increases, the water begins to climb up the wall.

When the speed is great enough, the parabolic shape of the water surface becomes clear.

Equipment

1. Clear cylinder equipped with a rotary mount on its end cap.
2. Variable speed rotary motor.
3. Supply of water.

Demo 13-18 Rotating Water Troughs

In this video two thin water troughs are rotated on a turntable, one of which is straight and runs radially outward from the center of the turntable, and one of which is circular and runs along the outer circumference of the turntable. When the turntable is rotated, the water level remains the same for the tank on the circumference, but assumes a parabolic shape for the radial tank, as seen in *Figure 1*.

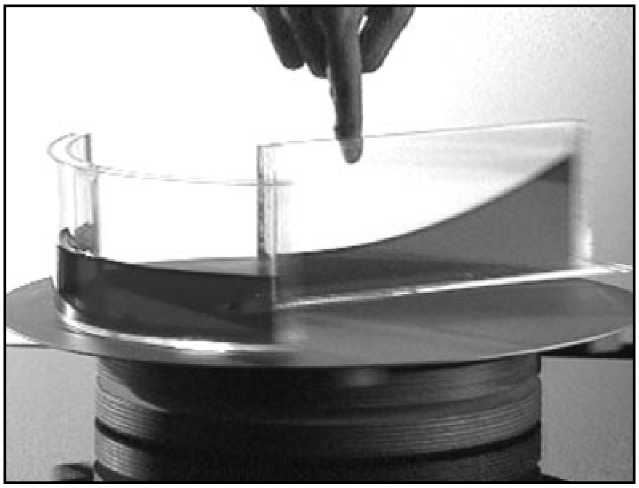

Figure 1

These two plastic troughs are filled with colored water and placed in different positions on a rotating disc.

This trough follows the circumference of the disc.

This trough is lined up along the diameter of the disc.

How will the water surface in the two troughs be affected when the disc is rotated?

In the trough that follows the circumference of the disc the water surface stays level.

In the trough that is lined up along the diameter of the disc the water surface assumes the shape of a parabola.

Equipment

1. A circular disc supporting a circular, narrow walled transparent trough mounted on the opposite side of the disc along a diameter that bisects the circular trough.
2. Circular Lazy Susan.
3. Supply of colored water.

Chapter 30

Surface Tension

Demo 13-19 Surface Tension Disc

A disc connected to a limp spring is lowered onto the surface of water.† When it is lifted, the surface tension of the water pulls the disc downward, causing a rather larger extension of the spring than that caused by the weight of the disc alone, as shown in *Figure 1*.

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-210, Ring Method of Measuring Surface Tension.

We'll use this glass disc hanging from a light spring to demonstrate one effect of surface tension in water.

If the disc is lifted off a dry tabletop, the spring extends this far.

If the disc is placed on a water surface and the spring is gradually pulled upward to lift the disc, the extension of the spring increases dramatically.

The surface water molecules cling to the disc, and a force is needed to break the disc free.

Equipment

1. Flat glass disc with a tripod string suspension that is attached to a light spring.
2. Clear container of distilled water.

Demo 13-20 Floating Metal Sheet

A metal sheet can be floated on the surface of water by carefully placing the sheet on the water without breaking the surface of the water.† The metal sheet remains afloat even with a number of weights placed on it, as seen in *Figure 1*, illustrating the strong surface tension of water.

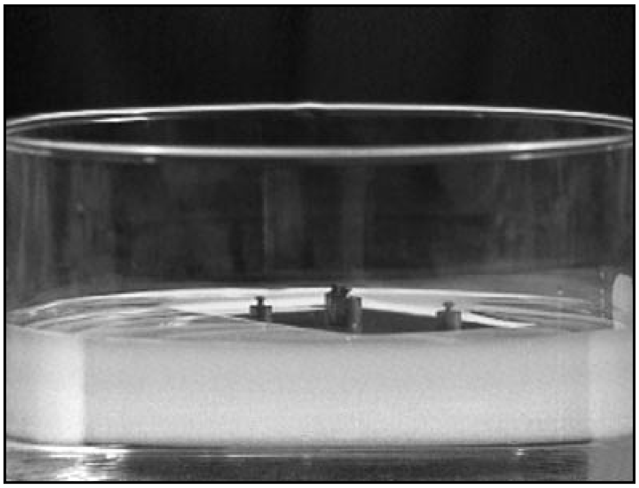

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-212, Floating Metals. Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fi-16, Leaky Boats (Sieves and Razor Blades).

We all know that light materials such as wood float on water, and heavy materials like metals do not. But if we use the surface tension of water it is possible to make a thin metal sheet float. Here's how it works.

We'll carefully lower the metal sheet onto the surface of this distilled water. If the sheet is placed down flat, it floats easily.

When we add weights to the sheet the water appears to stretch like an elastic membrane.

But if we add too much weight the metal breaks through the surface and sinks.

Equipment

1. Large clear container of distilled water.
2. A block or two of wood for comparison.
3. Flat, stiff sheet of metal with rounded corners.
4. Pair of tweezers.
5. Several small weights.

Demo 13-21 Soap Film Pull-up

A U-shaped wire frame has a movable wire joining the two parallel sides, connected to the sides by loops, as shown in *Figure 1*. A soap bubble is formed with the movable wire held in place near the ends of the U. When the movable wire is released, the surface tension in the soap bubble pulls the wire up.†

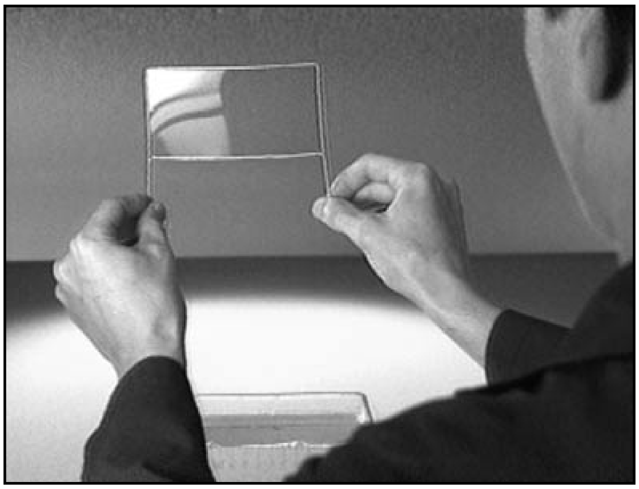

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-233.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fi-7, Force on a Film.

Soap Film Pull-up / Script

This square wire frame has one side that is free to slide up and down.

Dipping the frame into this beaker of soap solution puts a soap film on the frame.

We'll demonstrate the surface tension in the soap film by releasing the loose side of the frame.

The loose side is pulled up by the surface tension of the film.

Equipment

1. Square U-shaped wire frame with a slider wire whose ends are loosely looped around the legs of the frame.
2. Container of soap solution.

Demo 13-22 Soap Film Shapes

A soap bubble assumes a shape such that its potential energy is a minimum.† In this video soap films are created on a variety of different shapes of wire frames to observe the shapes of the resulting soap films. Examples for the tetrahedron and the cube are shown in *Figures 1 and 2*.

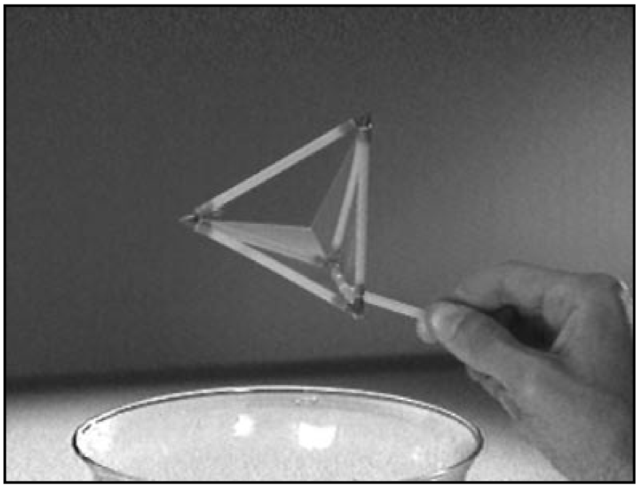

Figure 1

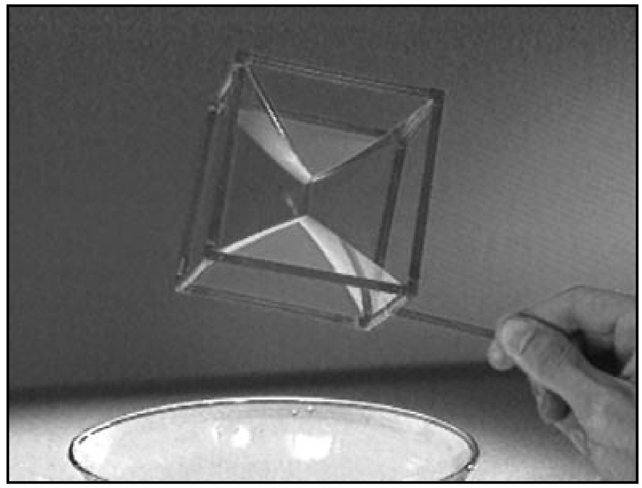

Figure 2

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-236, Minimal Surfaces.

These four plastic frames will be dipped in a soap solution and lifted out to form soap films between the edges.

Here is a four-sided pyramid.

Notice that the soap films meet in the center of the pyramid, with equal angles between all faces.

Here is a cube. Notice equal angles between all films at the points where they meet.

Here is a triangular prism. In this case the three films meet at a central axis at three equal angles, and also meet the fourth film at the end face with equal angles between all films.

Equipment

1. Four plastic frames of differing geometric forms.
2. Container of soap solution.

Demo 13-23 Two Soap Bubbles

When two soap bubbles, one larger than the other, are connected by a tube, what will happen: will the smaller one get smaller and the larger one larger, will they become equal, or will they stay the same as they were originally? This demonstration shows that the smaller bubble will get smaller and the bigger one bigger yet,† as seen in *Figure 1*. This behavior is a result of surface tension: the surface tension of the smaller bubble is greater because the soap film is thicker.

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-239, Pressure within Bubble—Two Bubble Paradox.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fi-3, Soap Bubbles.

This glass T has three stopcocks which can be used to open or close any arm of the T.

We'll first blow a soap bubble at the end of one arm, then close the stopcock to that arm.

We'll blow a soap bubble on the end of the other arm, then close off that arm as well.

If we can open the stopcocks on the arms so that the air can flow between the two bubbles, what will happen to the size of the two bubbles?

The smaller bubble blows up the larger bubble.

Equipment

1. A glass "T" arrangement with a stopcock in each segment with thistle tubes attached to both arms of the "T." A short length of rubber tubing is attached to the vertical leg for blowing bubbles.
2. Framework to support glass and tubing assembly.
3. Supply of soap solution.

Demo 13-24 Minimum Energy Thread

A thread with a loop is attached in the middle of a large wire frame. When the wire frame is immersed in soap bubble solution, a soap film is formed across the frame. When the film is punctured inside the loop of thread, the surface tension in the film outside the thread loop pulls the loop out into a circular shape, the minimum energy configuration,† as seen in *Figure 1*.

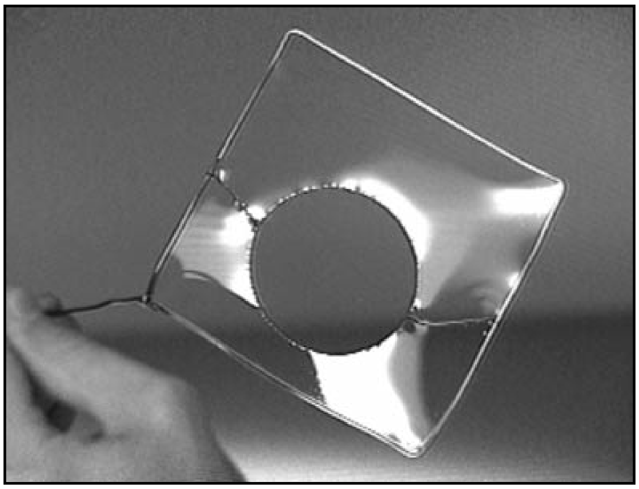

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-237, Ring and Thread. Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fi-13, Ring and Thread.

This square frame has a limp thread between two opposite sides. In the middle the thread splits into two branches tied to a single piece on each side.

We'll dip the frame in a soap solution so that the soap film forms across the frame and thread.

If we pop the soap film between the two branches of the thread by piercing it with a needle, what will the thread do?

The thread springs out to a circular shape, minimizing the surface area of the soap film.

Equipment

1. Square wire framework that has a string loop loosely tied off to opposite sides of the framework.
2. Container of soap solution.
3. Sizable needle-like probe.

Demo 13-25 Capillary Action

When a thin tube is inserted into a container of water the water rises up into the tube, as shown in *Figure 1*. This effect is due to capillary action caused by the attraction of the water molecules to the inner surface of the glass tube.

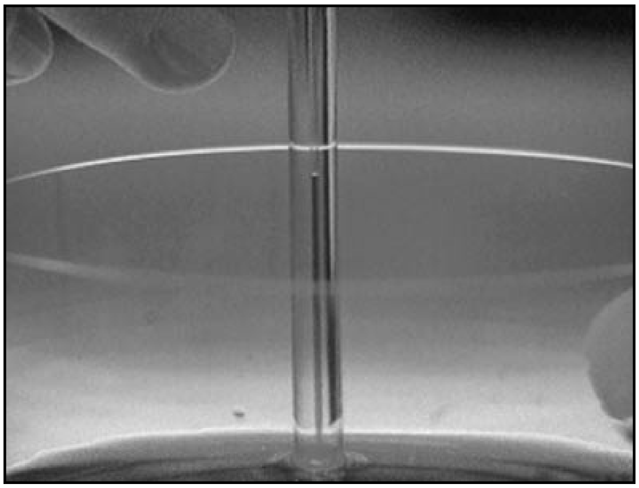

Figure 1

This glass tube has a very small diameter. We'll lower the tube slowly toward a beaker of water until it just touches the water surface.

When the end contacts the surface, the water jumps up into the tube.

Capillary attraction between the glass and the water draws the water up into the tube.

Equipment

1. Glass tube with very small inside diameter.
2. Supply of distilled colored water.

Demo 13-26 Capillary Tubes

A set of four connected capillary tubes is filled with water. The effect of capillary action is greater for a smaller tube, so the water rises highest in the smallest tube. This is readily observed on the video and shown in *Figure 1*.

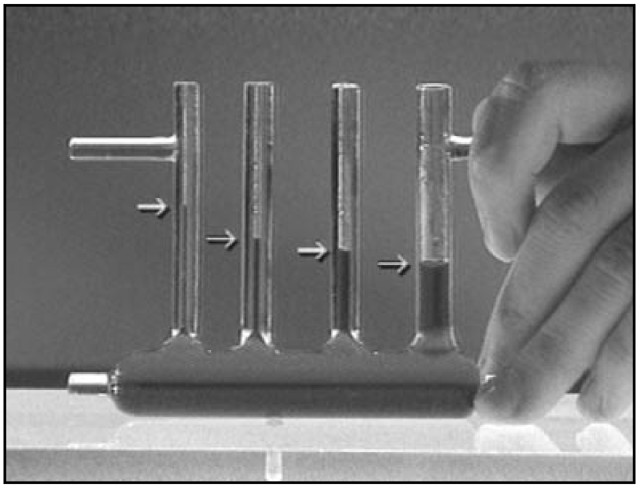

Figure 1

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-214, Capillary Tubes.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Fi-8, Capillary Tubes.

This set of interconnected capillary tubes will be used to demonstrate how capillary action affects the height of a water column in a glass tube of small inner diameter.

Water is added until the level reaches the bottom of the small tube.

The water rises highest in the tube with the smallest inner diameter.

Equipment

1. Set of interconnecting capillary tubes with differing inside diameters with a common reservoir.
2. Supply of distilled colored water.
3. Syringe for injecting the water slowly.