The
Video
Encyclopedia
of
Physics
Demonstrations™

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DISC FIVE

Chapter 11 *Collisions*

Chapter 12 *Rotational Kinematics*

CHAPTER 11

COLLISIONS

Demo 05-01 Colliding Balls

This demonstration illustrates a variety of collisions between balls. The first group of demonstrations shows collisions between equal masses, followed by collisions between unequal masses, with both the smaller mass and the larger mass initially in motion. Finally, collisions of a chain of equal balls, the collision ball apparatus, are shown.[†]

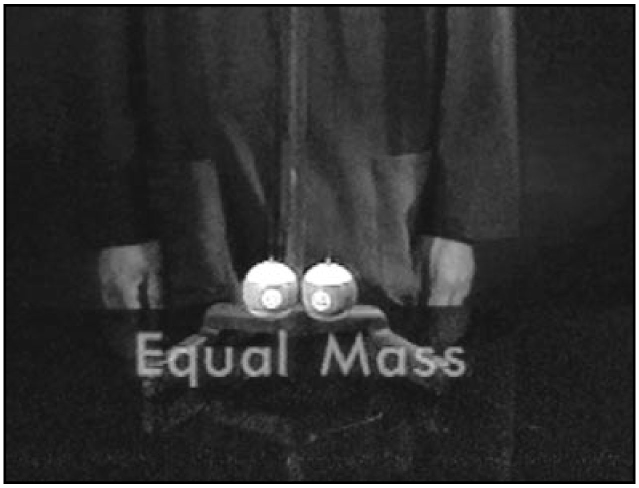

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-68, Impact.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mg-1, Collision Balls.

These sets of pendulum balls will be used to demonstrate collisions between various masses.

Here is a pair of equal mass balls. When we collide one ball with the other, the two balls trade velocities.

The incoming ball stops, and the stationary ball flies away at the same speed as the incoming ball.

Here's a set of balls with a 3:1 mass ratio. When the small ball strikes the larger one, the small ball bounces back and the large ball moves away slowly.

What will happen if the last collision is reversed?

Now the small ball flies away quickly, and the large ball continues in the same direction at a lower speed.

Here is a set of balls with an 80:1 mass ratio.

When the small ball strikes the larger, it bounces back completely while the larger ball hardly moves.

Here's what happens when the last collision is reversed.

Finally, here is a set of 11 pool balls hung in a row. When we pull back and release one ball, a single ball flies out the other end. If we release a larger number of balls together, the same number flies out the other end.

Equipment

1. Equal mass pair: two billiard balls of identical mass—both with eye screws and a bifilar suspension from a support system.
2. Three-to-one mass ratio: same as above except one sphere is one-third the mass of its companion billiard ball.
3. Eighty-to-one mass ratio: same as above except the larger sphere is eighty times more massive.
4. Set of eleven: eleven equal mass billiard balls equipped and suspended as above with #11 being in the center to help highlight the "5 in" and "5 out" example.

Demo 05-02 Equal and Unequal Mass Collisions

This demonstration illustrates a variety of collisions using an air track.[†] Data can be taken from the collisions on the disc to study conservation of linear momentum and conservation of energy during elastic collisions. First, collisions between equal masses are investigated, where one of the air track gliders is initially at rest. The ensuing motion can be used to investigate collisions with a variety of other initial conditions. Finally, collisions between unequal masses are investigated, with each mass initially in motion, for masses in the ratio of 1:2 and 1:3.

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mg-3, Elastic Collisions with Air Carts.

We will illustrate different types of collisions using gliders floating on a cushion of air. These two gliders have the same mass. When a moving glider strikes the stationary glider of the same mass they exchange velocities upon collision.

What will happen if the stationary glider is heavier than the moving glider?

In this case the lighter glider moves backward after the collision. The heavier glider moves off at a lower velocity than the initial velocity of the lighter glider.

What will happen if we switch the gliders so that the heavier glider collides with a lighter stationary glider?

This time the moving glider continues on the same direction after the collision, and the stationary glider flies off at a higher velocity.

Now we will try it with a stationary glider of a greater mass.

Equipment

1. Level air track.
2. Blower system.
3. Two equal mass gliders.
4. One glider whose mass is twice that of one of the pair.
5. One glider whose mass is three times that of one of the pair.

Demo 05-03 Elastic and Inelastic Collisions

This demonstration uses an air track to investigate elastic and inelastic collisions between air track gliders. After a brief review of the elastic collision between equal mass gliders with one initially at rest, an inelastic collision between equal mass gliders is illustrated, again with one initially at rest. Data can be taken from the disc to study conservation of momentum and conservation of energy during inelastic collisions.

Figure 1

This demonstration uses gliders floating on an air track to show two different types of collisions.

In the first collision, two identical gliders have spring bumpers which can return to their original shape after being squeezed. When the gliders collide, they exchange velocities.

If we turn the gliders around, they will stick together after they collide.

After the collision, how will the velocity of the combined gliders compare with that of the first glider?

The two gliders together move at half the velocity of the original glider.

Equipment

1. Level air track.
2. Blower system
3. Two gliders with identical bumpers on one end (for elastic collisions), and the other ends supporting either a screw or a small hollow cylinder mostly filled with molding clay to enable a clean inelastic collision.

Demo 05-04 Coefficient of Restitution

We can determine the coefficient of restitution of several materials by dropping balls made of these materials onto a steel plate.[†] The coefficient of restitution is the square root of the ratio of the height to which they bounce to the height from which they were dropped. The materials composing the dropped balls include glass, steel, rubber, brass, and lead. Results are shown in *Figure 1*.

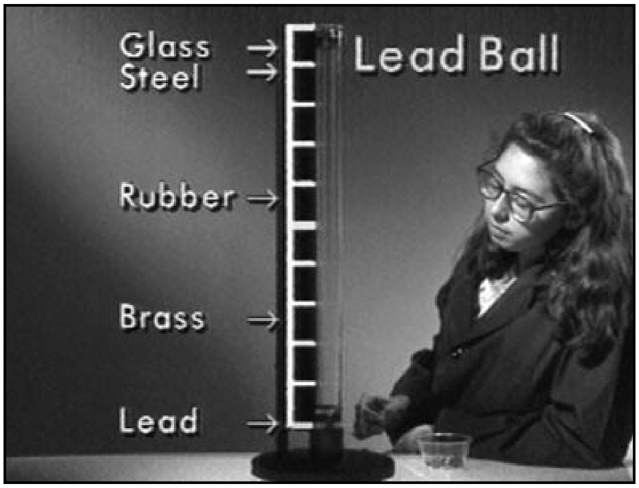

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-69.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mw-12, Coefficient of Restitution.

Coefficient of Restitution / Script

Some materials bounce well when they are dropped, others don't bounce so well.

We'll drop balls made of five different materials down this glass tube onto a steel plate to determine how high each ball bounces.

In order: a glass ball, a steel ball, a rubber ball, a brass ball, and a lead ball.

Equipment

1. Glass tube suspended just above a solid steel cylinder with a polished upper end surface.
2. Glass ball.
3. Steel ball.
4. Rubber ball.
5. Brass ball.
6. Lead ball.

Note: all balls have approximately equal diameters.

Demo 05-05 High Bounce

A small ball is placed on top of a larger ball, and they are dropped from that initial orientation, as illustrated in *Figure 1*. For elastic collisions where the mass ratio is approximately 3:1, after the collision with the floor the larger ball will remain on the floor and all the kinetic energy of the two balls will be transferred to the lighter ball.† The lighter ball on top then flies off very rapidly, as shown in the video. A brief analysis is shown in *Figure 2* at three times: (a) just before the impact of the lower ball with the floor, (b) just after the impact of the lower ball with the floor but before the impact between the two balls, and (c) just after the collision between the two balls. A more general discussion of this problem has also been given, including computer analysis.‡

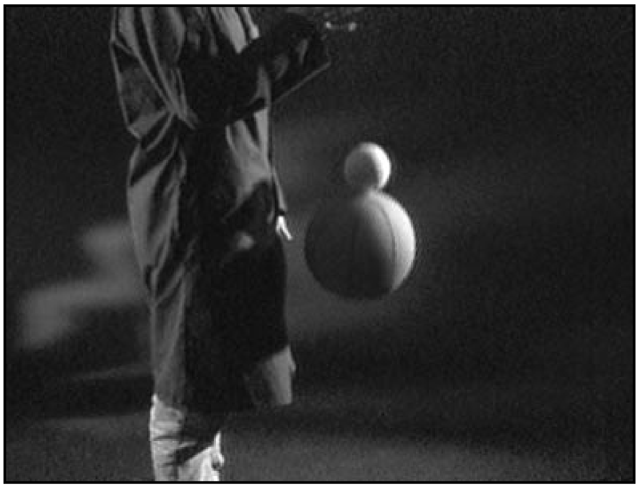

Figure 1

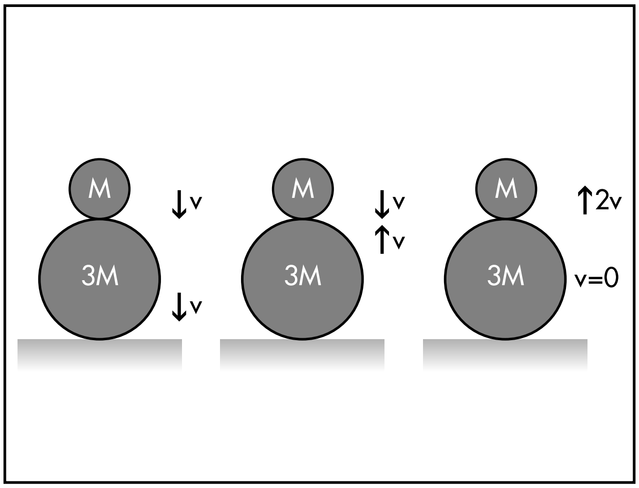

Figure 2

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† G. Stroink, Superball Problem, *The Phys. Teach.* 21, 466 (1983).

‡ Class of William G. Harter (USC), Velocity Amplification in Collision Experiments Involving Superballs, *Am. J. Phys.* 39, 656-663 (1971).

High Bounce / Script

When two balls with the proper mass ratio are dropped together with the lighter ball on top, a very interesting bounce occurs.

The heavy ball barely bounces at all, but the lighter ball bounces many times higher than the drop height.

Equipment

1. Basketball.
2. Softball.

Demo 05-06 Air Table Collisions (Equal Mass)

This demonstration shows elastic collisions between a moving air table puck and a stationary puck of equal mass. Collisions vary from a head-on collision, where all the energy and momentum are transferred to the stationary puck, to a glancing collision, where very little energy and momentum are transferred to the stationary puck. Lines are drawn on the video indicating the paths of the pucks after the collision so that it will be easier to compare the momentum and energy before and after the collision.

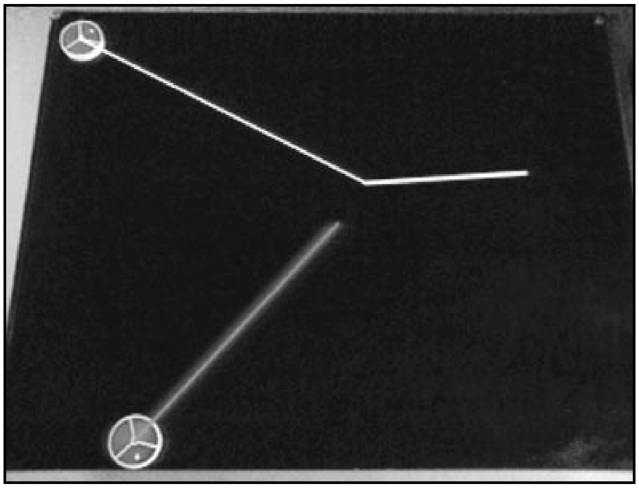

Figure 1

We'll demonstrate two-dimensional collisions using these air table pucks.

The pucks have equal mass. We'll have them collide in different ways and watch how they move after the collision. Here is a head-on collision.

Lines on the screen will follow both pucks to make their paths visible.

This is a collision where the puck strikes slightly off center.

This time the puck strikes even farther off center. Notice that after an off-center collision, the pucks move off at approximately 90 degrees to each other.

Equipment

1. Level air table.
2. Blower system.
3. Two pucks of equal mass.

Demo 05-07 Air Table Collisions (Unequal Mass)

This demonstration shows elastic collisions between a moving air table puck and a stationary puck of different mass. Each puck, whose mass ratio is approximately 2:1, is used as both the moving and the stationary puck. Lines are drawn on the video indicating the paths of the pucks after the collision so that we can compare the momentum and energy before and after the collision.

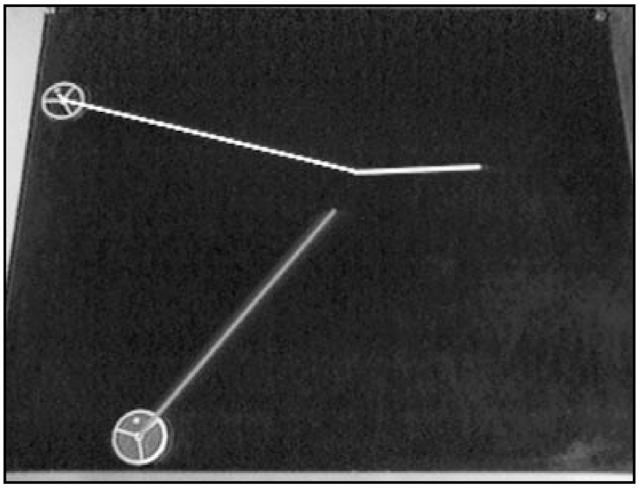

Figure 1

Air Table Collisions (Unequal Mass) / Script

We'll demonstrate two-dimensional collisions between unequal masses using these pucks floating on an air table. These pair of pucks has a mass ratio of two to one. We'll have them collide in various ways and watch how they move after the collision.

Here is a head-on collision.

Lines on the screen will follow both pucks to show their paths.

Here is a collision slightly off center.

We'll now repeat the two last collisions with the heavier puck running into the lighter puck.

Equipment

1. Level air table.
2. Blower system.
3. Two pucks, one having a mass twice the first, but with the same dimensions.

Demo 05-08 Air Table Collisions (Inelastic)

This demonstration shows inelastic collisions between a moving and a stationary puck of the same and different masses. Collisions vary from head-on collisions to a glancing collision. The larger impact parameter of the glancing collisions is seen by the rapid rotation of the two joined pucks after the collision. Analysis of these collisions must therefore take into account angular momentum and rotational energy.

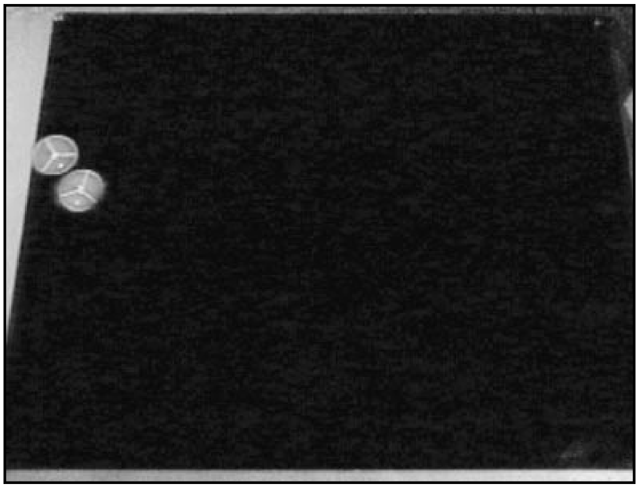

Figure 1

We'll use this air table to demonstrate inelastic collisions between pucks floating on an air table.

The pucks have Velcro strips around the edge to make them stick together. We'll have them collide in various ways and then watch them after the collision.

This pair of pucks has equal mass, and collide slightly off center.

This is the same pair of pucks, colliding farther off center.

Equipment

1. Level air table.
2. Blower system.
3. Two equal mass pucks with Velcro strips to enable clean inelastic collisions.

Demo 05-09 Egg in Sheet

If an egg is thrown into a brick wall, the large force slowing down the egg when it hits the wall will cause the egg to break. If the egg is thrown with the same speed into a hanging bedsheet, it will stop much more slowly, so the force exerted on the egg will be much less, and the egg will remain intact. This demonstration illustrates the concept of impulse. Spreading out the force over a greater time interval decreases the magnitude of the force required to stop the egg:

$$\Delta P = \int F dt \cong F \Delta t$$

as Δt becomes greater, F becomes smaller.

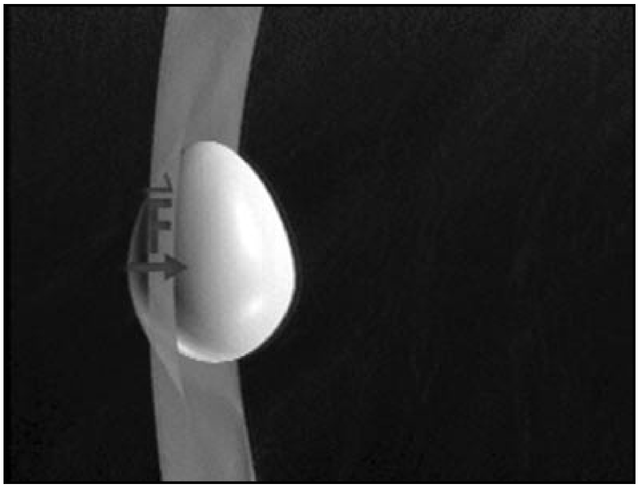

Figure 1

When an egg is thrown against a wall, the forces which stop it are large and act over a very short period. How could we stop the egg without such large forces so that the egg will not break?

If the egg is thrown against a loose sheet, the total change in momentum is the same as before, but the forces acting on the egg are small and the collision takes more time. The egg remains intact.

Equipment

1. Double size bed sheet.
2. Support system for sheet (either two assistants, or a framework where the top edge is held high and to the rear and the bottom edge is held forward and low, thereby forming both a target and a catcher pocket, but only for one egg at a time!).
3. Supply of raw eggs.

Demo 05-10 Pile Driver with Foam Rubber

This demonstration illustrates the concept of impulse. A pile driver is dropped onto a piece of plastic, causing it to break. If a piece of foam rubber is placed on top of the plastic and the pile driver dropped onto the foam rubber, the foam rubber softens the blow, and the plastic sheet will not break. The impulse exerted by the stopping pile driver has been spread out over a greater time, and the force exerted on the plastic is thus decreased.

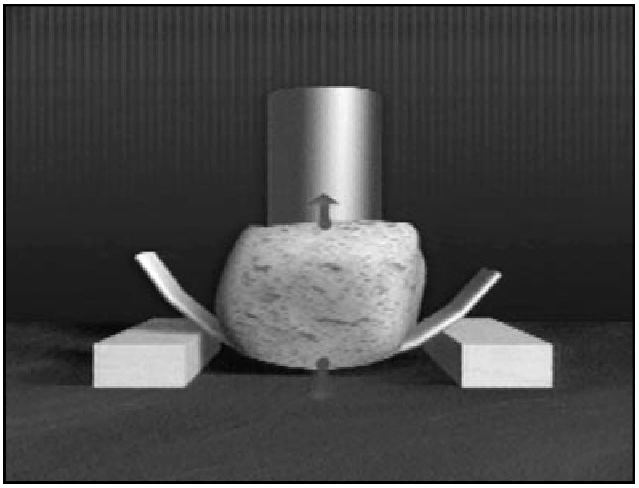

Figure 1

This pile driver has a weight that can be dropped to crack a piece of plastic.

If we put a piece of foam rubber over the plastic, the amount of energy released in the fall is about the same, but the collision takes place more slowly.

The size of the force on the plastic is thus reduced, and the plastic does not crack.

This animation shows the forces which act on the weight and the plastic, first without, and then with the foam rubber in place.

Equipment

1. Massive weight with a rope over a pulley and a support/guidance system.
2. Two rectangular bars to support strips.
3. Supply of thin strips of stiff plastic.
4. Foam rubber block to slow falling weight.

Demo 05-11 Ballistic Pendulum

A ballistic pendulum can be used to measure the speed of a projectile. The projectile, in this case a ball that is shot by the device, is caught in the pendulum receptacle, conserving angular momentum. Because of the distribution of mass in this pendulum, angular momentum (rather than linear momentum) is conserved in the collision in which the ball is caught. After the collision, the energy in the system raises the center of mass of the combined ball and pendulum, converting rotational kinetic energy into gravitational potential energy. Measurement of the height to which the center of mass rises allows determination of the initial speed of the ball. Marks are shown on the screen indicating the position of the center of mass of the system just after the collision and when the pendulum rises to its highest point, as shown in *Figure 1*.

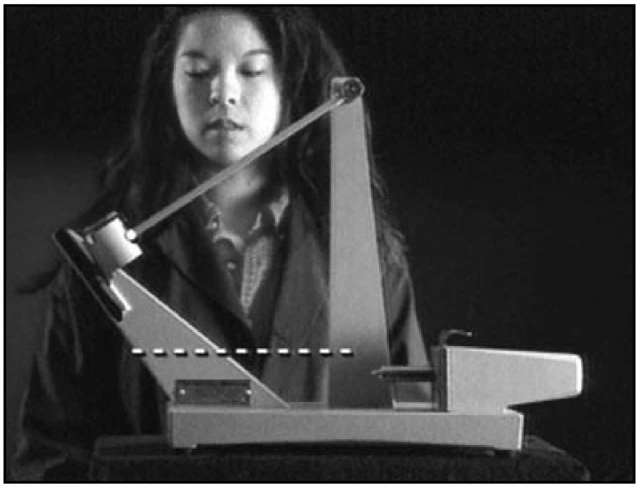

Figure 1

Ballistic Pendulum / Script *Demo 05-11*

This device, called a ballistic pendulum, can be used to measure the speed of a flying ball.

A spring gun on the base fires a steel ball horizontally.

In order to determine the speed of the ball, we'll catch it in the bottom of this pendulum arm.

The height of the rise of the center of mass can be used to calculate the original speed of the ball.

Here are some sample firings of the ball, first with the spring compressed this far.

Then with the spring compressed more.

And with the spring compressed even more.

Equipment

1. Commercially available ballistic pendulum.
2. Supplied projectile.
3. Meter stick.

CHAPTER 12

ROTATIONAL KINEMATICS

Demo 05-12 Radian Disc

This graphics demonstration illustrates the definition of the radian and shows that the circumference of a circle is 6.28 times its radius. Lengths of one radius are bent and placed onto the circumference of a circle, illustrating the definition of the radian. After six radii are placed onto the circle, the remaining part of the circumference is 0.28 of one radius, as shown in *Figure 1*.

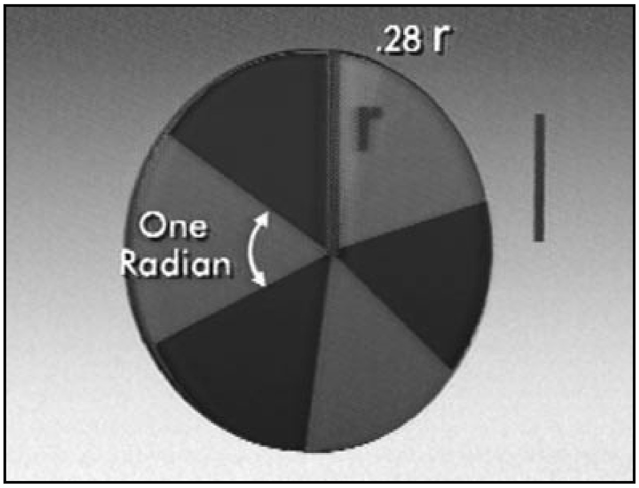

Figure 1

We'll use this disc to show the derivation of the radian, a unit for measuring angle.

This strip is the same length as the radius of the disc. If we lay the strip along the circumference of the disc, the amount of angle subtended by the length of the strip is defined as one radian.

Equipment

1. Circular disc, supported by its center.
2. Flexible strip of plastic equal in length to the radius of the disc.

Demo 05-13 Cycloid Generator

A cylinder of radius r is attached coaxially to a second cylinder of radius R, which is greater than r. If the smaller cylinder is rolled along the edge of a table, any point at a radius a on the larger cylinder will move along a cycloidal path. *Figure 1* gives one example of this. The nature of the cycloid changes for a less than, equal to, or greater than r.

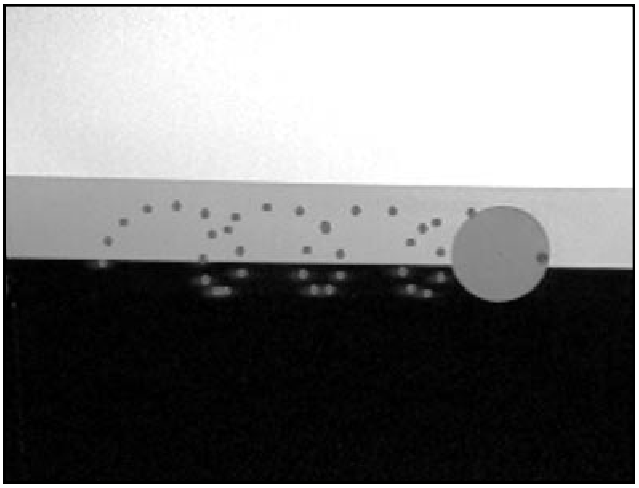

Figure 1

Cycloid Generator / Script

When this disc is rolled along the table top, the orange spot at the edge at first appears to move in a circle. But what is the actual path of the spot?

We'll follow the spot with a line on the screen to show the motion. The spot moves along a path known as a cycloid.

If we attach a cylinder of smaller diameter to the back of the disc and roll it along the table, it generates a different cycloid.

Equipment

1. Disc attached to a solid cylinder whose radius is somewhat smaller than the disc.
2. The method of attachment should permit easy exchange of the cylinder for one or more with even smaller radii.
3. Prominent spot near the edge of the non-roller side of the disc will highlight differing cycloidal paths.

Demo 05-14 Circle with Gap

This demonstration illustrates the kinematics of an object moving in a circle. A ball rolls around a circular hoop with one segment cut out. When the ball reaches the cut-out segment, what will its path be? The video pauses on a disc stop to allow the viewer to choose from among three possible paths, as indicated in *Figure 1*. This demonstration was suggested by McCloskey in an interesting article discussing the relationship between Newton's laws and the development of physical intuition in children.[†]

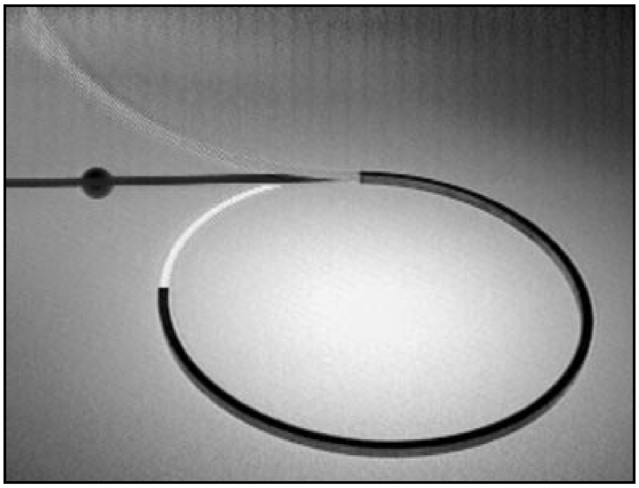

Figure 1

[†] Michael McCloskey, Intuitive Physics, *Sci. Am.* 248 No. 4, 122–130 (1983).

A ball given a push inside an aluminum ring rolls around inside the ring. When it reaches this gap, which path will the ball follow? Will it follow this path?

This path?

Or this path?

The ball follows a straight line in the same direction it was moving at the point of escape. Its path is tangent to the circle at that point.

Equipment

1. Metal ring with short missing section.
2. Steel sphere.

Demo 05-15 Rotating Disc with Erasers

Erasers are placed at various radii on a horizontal disc, which is then rotated with a continually increasing angular velocity. The erasers at larger radii slip off the disc first, because a larger centripetal force is required to keep them in place.

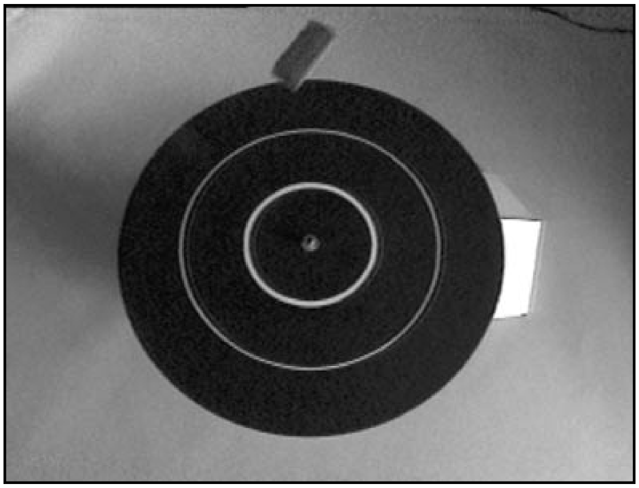

Figure 1

Rotating Disc with Erasers / Script

A rotating disc and three blackboard erasers will be used in this demonstration of circular motion.

If an eraser is placed on the disc and the disc is spun, the eraser initially stays in place because of friction. The speed of the disc is increased until eventually friction can no longer hold the eraser in place and the eraser flies off.

If we place three erasers on the disc at different distances from the center and spin the disc at increasing speed, which eraser will fly off first?

The outer eraser flies off first, then the middle one, and finally the inner one.

Equipment

1. Sizable disc with concentric circles marked on it for reference, with a center mount.
2. Variable speed rotator.
3. Three erasers.

Demo 05-16 Spinning Disc with Water

A flat disc spins horizontally like a top. When red water droplets are placed on the disc they immediately "spin off." The paths of the leaving water droplets are tangent to the outside diameter of the spinning disc, as can be immediately observed in *Figure 1*.

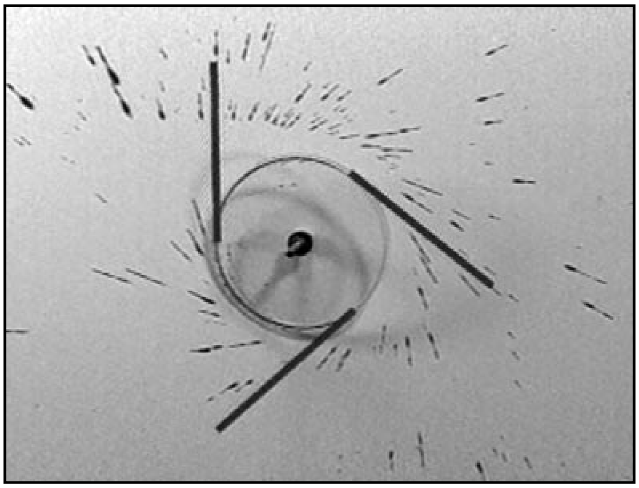

Figure 1

Spinning Disc with Water / Script

This spinning disc and a dropper of colored water will be used to show one effect of circular motion.

The tracks are tangential to the circle at the points where the water droplets left the disc.

Equipment

1. Plastic disc with a machined groove near its perimeter and equipped with a pivot point/handle located at its center.
2. Eye dropper.
3. Supply of water dyed with food coloring.
4. Supply of white paper with sizable dimensions.

Demo 05-17 Ball on Cord

A ball on one end of a rope executes circular motion in a horizontal plane. The other end of the rope passes through a slick vertical tube and is attached to a weight. The weight provides the centripetal force required for the ball to execute circular motion,† as shown in *Figure 1*. When the radius of the circle is increased, the hanging weight provides the same centripetal force, so the angular speed must be decreased.

Figure 1

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† Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Ms-5, Whirlagig.

Ball on Cord / Script

This rubber ball is attached to the end of a long string. When the ball is spun in a circle, an inward force is required to make it move in a circle.

If the string is passed through this tube, a weight can provide the inward force needed to produce circular motion.

When the ball is swung in a circle of small radius, a high angular velocity is needed to keep the ball from being pulled in toward the center.

With a larger radius of rotation, a lower angular velocity is sufficient to maintain a circular path.

Equipment

1. Rubber ball with a string securely tied through its center and a loop on the other end.
2. Plastic tubing sleeve (no sharp edges!).
3. Hooked weights.

Demo 05-18 Coin on a Coat Hanger

A coin is balanced on the flat end of a bent coat hanger.[†] With practice, the coat hanger can be rotated in a complete circle without displacing the coin, as shown in *Figure 1*, which is taken from the video. This is demonstrated in real time and in slow motion. This demonstration makes use of the contact force between the coin and the end of the coat hanger to hold the coin in place. The centripetal force exerted by the coat hanger on the coin and the resultant centrifugal reaction exerted on the coat hanger by the coin provide the contact force.

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-155, Dime on Coat Hanger.

Coin on a Coat Hanger / Script

This coat hanger has been bent so that the tip points straight back toward the finger supporting the hanger. The tip is filed flat so that with care a penny can be balanced on it.

Now watch.

A few swings bring the coat hanger up to speed, then over the top.

Equipment

1. Wire coat hanger, appropriately bent, and with a hook bearing a good clean square cut (the platform for the coins).
2. Supply of coins.

Demo 05-19 Plane on String

A toy plane is tethered to a long string. When the plane is started into motion, the string makes a small angle with respect to the vertical and the plane flies around in a circle, with the string defining a cone, as illustrated in *Figure 1*. As the speed of the plane increases, the angle of the cone, and the radius of the plane's circle, become larger.[†] This demonstration illustrates that a larger centripetal force is required for a greater plane speed.

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-160, Conical Pendulum.

Plane on String / Script

This toy plane hangs at the end of a long string. We'll use it to show how the angle of the supporting string changes as the speed of the plane increases.

When we set the plane into motion, it moves slowly at first and the string is at a small angle away from the vertical.

As the plane picks up speed, the string moves to higher and higher angles.

Equipment

Small battery-powered propeller plane mounted from a high point by a string.

Demo 05-20 Roundup

This demonstration illustrates the role of inertia and centripetal force in the operation of a rotating fairground ride. A toy person is positioned against the inside wall of a rotating cylinder. As long as the cylinder rotates rapidly, the person is "stuck" to the wall by its inertia. The centripetal force exerted on the person by the wall and the resulting centrifugal reaction exerted on the wall by the person hold the person in place, as shown in *Figure 1*, until the cylinder speed is reduced to a very small value.

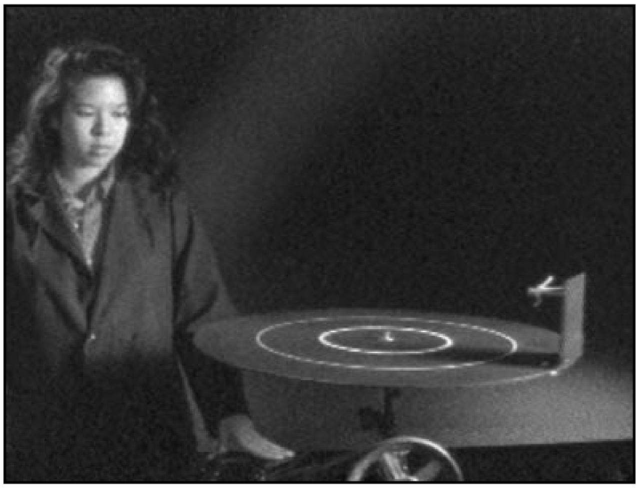

Figure 1

This motorized disc has a small section of vertical wall mounted on the edge.

A toy man is held in place on the wall by the magnet attached to his feet, which is attracted to another magnet on the outer side of the wall.

Now we spin the disc up until the outer magnet flies off.

The man remains standing on the vertical wall, as seen in this slow-motion segment.

When the motor is switched off and the disc slows down there is a critical speed below which the man no longer stays on the wall.

Equipment

1. Rotating disc with mounting center.
2. Variable speed rotating motor.
3. Nonferrous vertical wall attachment.
4. Plastic person bonded to a disc magnet.
5. Keeper magnet with bonded handle.

Demo 05-21 Whirling Bucket of Water

A bucket of water is rotated in a vertical circle. The inertia of the water holds it in the bucket even when the bucket is instantaneously upside down.†

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration M-154, Whirling Bucket of Water.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mb-29, Central Acceleration.

Whirling Bucket of Water / Script

When water is poured into a bucket

and the bucket is turned upside down, the water falls out. Is there any way to keep water in an open bucket that is upside down?

If the bucket is spun in a vertical circle at sufficient speed, the water stays in even when the bucket is upside down.

Equipment

1. Bucket with handle and/or rope.
2. Supply of water.
3. Large catch basin.

Demo 05-22 Centrifuge Hoops

An elastic hoop is rotated about its diameter so that as the angular speed becomes greater, the hoop becomes more oblate,[†] as shown in *Figure 1*. This illustrates how the earth has become oblate due to its rotation.

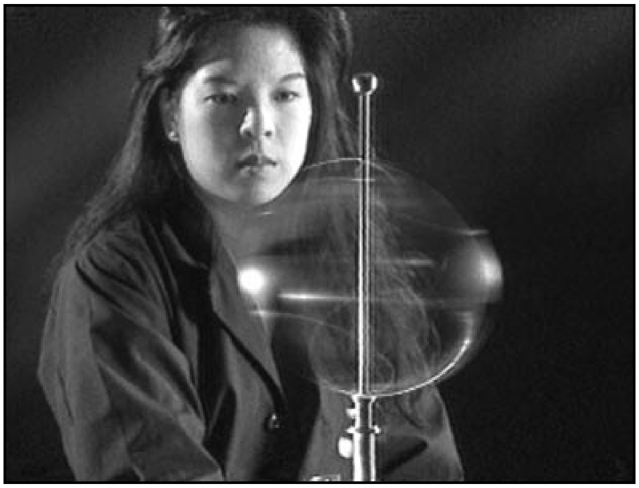

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-147, Flattening of the Earth.

Centrifuge Hoops / Script

This thin brass hoop is mounted on a central rod so that the top of the hoop is free to slide up and down.

When we spin it at a low speed, it stretches outward slightly.

As the rotation speed increases, the hoop stretches farther out.

When the speed is reduced, the hoop returns to its circular shape.

Equipment

1. Thin brass hoop mounted on a center rod with the top portion of the brass free to move vertically.
2. Variable speed rotator—either by hand or with a motor.

Demo 05-23 Water and Mercury Centrifuge

This demonstration illustrates how two liquids of different density, such as milk and cream, can be separated using a centrifuge. Mercury and colored water in a spinning glass sphere become separated, as shown in *Figure 1*, with the mercury at the maximum radius of the sphere and the colored water above, below, and at a smaller radius than the mercury.[†]

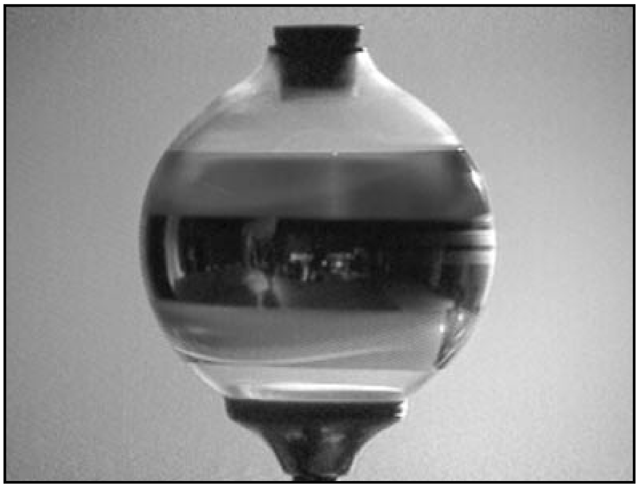

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-159, Cream Separator.

Water and Mercury Centrifuge / Script

This glass globe contains colored water and mercury, a very dense liquid.

We'll put the globe in this motorized rotator and spin it at high speed to show the effect on the fluids.

At low speeds, the liquids begin to climb up the sides of the globe with the water rising higher than the mercury. What will happen if we increase the rotational speed?

Now both liquids leave the bottom of the sphere and climb up onto the sides. The mercury forms a ring around the sphere, with rings of water above and below.

Equipment

1. Round bottom flask bonded to a rotor mount, containing colored water and mercury.
2. Variable speed rotor.

Demo 05-24 Spinning Chain

A flexible chain is rapidly rotated on a spinning disc. It is then pushed gently off the disc.† Its rapid rotation causes it to retain its circular shape, so it rolls along just as though it were solid, and even jumps when it hits a barrier, as shown in *Figure 1*. Both real time and slow motion video are shown on the video.

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration M-139, High-speed Chains.

Spinning Chain / Script

We'll use this limp circular chain to demonstrate an intriguing property of circular motion.

The chain is pushed onto a wooden disc attached to a motor, which spins at high speed when switched on.

Now that the disc and chain are spinning, what will happen to the chain if we carefully push it off the disc?

The chain rolls along the table as if it were a solid ring.

Here's a longer shot of the same action with a low barrier placed in the path. The chain bounces like a solid object.

Here's the same action repeated in slow motion.

Equipment

1. Motor-driven rotor with a slightly tapered disc.
2. Loop of flat chain whose diameter matches that of the average diameter of the tapered disc.
3. Wooden push rod.
4. Rectangular piece of rubber sheet to aid rotating loop gaining frictional contact with the table top.
5. Obstacle for loop to jump over.

Demo 05-25 Rotating Rubber Wheel

A rubber wheel with spokes, shown in *Figure 1*, is rotated with increasing angular speed, causing it to stretch to a larger radius.† The centripetal force required to maintain the outer circle of the rubber wheel becomes greater with increasing angular speed.

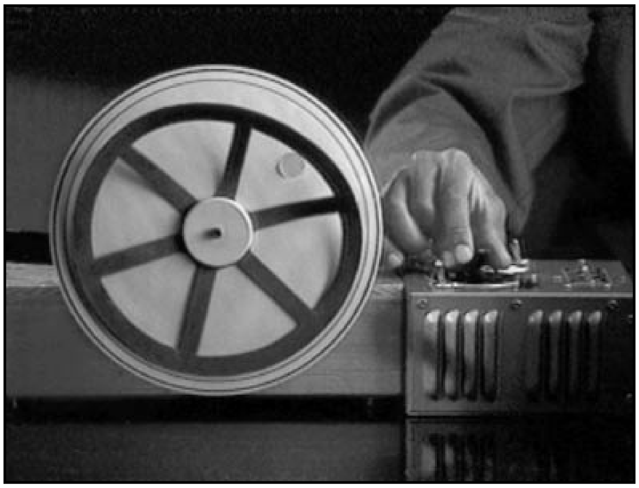

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration M-149, Stroboscopic Demonstration of Dynamic Distortion.

This spoked wheel is made of flexible rubber. We'll spin it at high speed to demonstrate the effect on the diameter of the wheel.

As the speed of the wheel is increased, the wheel stretches outward.

When the speed is reduced, the wheel returns to its former size.

Equipment

1. Spoked thin rubber (≈ 1/16") wheel mounted on an adjacent disc to provide reference markings.
2. Variable speed rotor.
3. Clamps.

Demo 05-26 Centrifugal Governor

A model of a centrifugal governor, shown in *Figure 1*, is rotated with an increasing angular speed.[†] As the angular speed increases, the weights rise, allowing the mechanism to control its angular speed with the appropriate feedback mechanism.

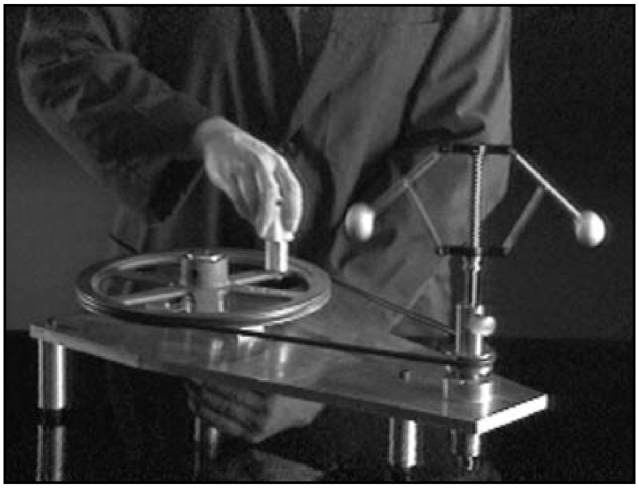

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration M-158, Centrifugal Governor.

Centrifugal Governor / Script

This device has two spring-loaded arms with metal spheres at the ends.

When we spin it, the arms extend out against the force of the springs.

Equipment

1. Commercially available governor.
2. Hand rotor.