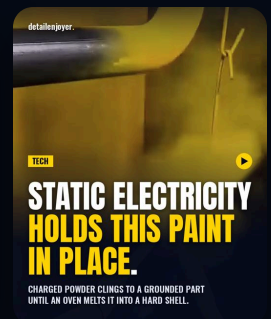
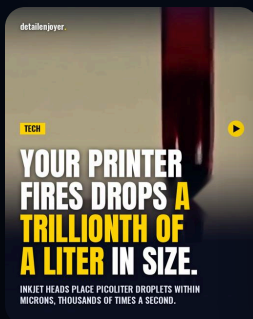




COLLECTION · COL-09

EVERYDAY PHYSICS

Wine tears, inkjet drops, a blue glow that outruns light in water, a street that fools your balance, paint held on by static, the fluid inside an automatic car, water that carries a current, a laser that branches in a soap film, a golf ball that squashes and springs back, a crane kept upright by its counterweights, sunscreen that goes dark on a UV camera, vapor trails left by radiation, rainbows that are really circles, iron too hot for a magnet, beads that fall into a bell curve, metal that sparks in a microwave, a desk toy that passes momentum down the line, plasma made in a microwave, the ball in a ballpoint pen, water that holds itself together, a match head catching fire, a camera that bends propellers, charges that link up into lightning, plasma, the fourth state of matter,, the quartz crystal that keeps your watch on time and the metals that color fireworks.



INSIDE

01 Marangoni Motion

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ABOUT THIS COLLECTION

34 case files on physics you can see or feel: in a wine glass, a printer, a reactor pool, a tilted street, a paint booth, a car's automatic transmission, water carrying a current, a soap film, a golf ball at impact, a crane's counterweights, a UV camera, a cloud chamber, a rainbow, a red-hot piece of iron, a Galton board, a microwave oven, a Newton's cradle, a ballpoint pen, a drop of water, a match, a phone camera and a thunderstorm. In the Marangoni effect, liquid flows from regions of low surface tension toward regions of high surface tension. It's why wine forms 'tears' on the glass. **DD-024** The blue glow in nuclear reactor pools is Cherenkov radiation: electrons moving faster than light travels in water (about 75% of c). **DD-020**

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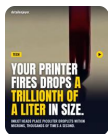
01



Marangoni Motion

DD-024 · Science / Tech · Surface tension can make liquid pull itself across a surface.

02



Print Precision

DD-005 · Tech / Science · Your printer fires drops a trillionth of a liter in size.

03



Cherenkov Glow

DD-020 · Science / Tech · This blue glow is particles outrunning light in water.

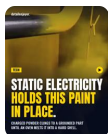
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DD-035 · Science / Locations · This Mexican village is built on a tilt to fool your balance.

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Static Spray

DD-051 · Tech / Science · Static electricity holds this paint in place.

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Torque Conversion

DD-075 · Cars / Tech · How an automatic moves without a clutch pedal.

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Liquid Lights

DD-073 · Science / Tech · Why salt water conducts and pure water barely does.

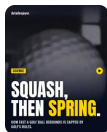
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Branched Flow

DD-739 · Science · A laser inside a soap film splits into branching filaments.

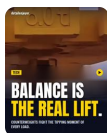
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DD-695 · Science / Tech · Squash, then spring.

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Counter Crane

DD-687 · Tech / Science · Balance is the real lift.

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DD-654 · Science / Tech · Under UV, sunscreen goes dark.

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DD-623 · Science / History · Radiation, made visible.

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Around the Rainbow

DD-651 · Science / Nature · Rainbows are secretly circles.

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DD-669 · Science / Tech · Too hot to stick.

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Central Limits

DD-588 · Science · Random bounces, one bell curve.

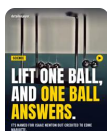
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Microwave Metal

DD-589 · Science · Lightning in a microwave.

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Newtons Cradle

DD-286 · Science · Lift one ball, and one ball answers.

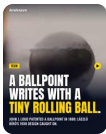
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Making Plasma in the Microwave

DD-287 · Science · A glowing ball of plasma can appear inside a kitchen microwave.

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Getting to the (Ball)Point

DD-304 · Tech · A ballpoint writes with a tiny rolling ball.

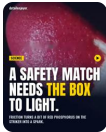
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Is Water Sticky?

DD-296 · Science · A coin can hold a dome of water above its edge.

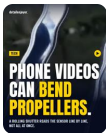
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DD-300 · Science · A safety match needs the box to light.

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DD-301 · Tech / Science · Phone videos can bend propellers.

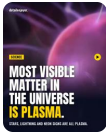
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DD-302 · Science / Nature · Storm clouds sort charge until the air gives way.

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DD-113 · Science · Most visible matter in the universe is plasma.

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Quartz Crystals

DD-168 · Science / Tech · Squeeze a quartz crystal and it makes electricity.

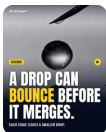
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Fire Works

DD-155 · Science · Strontium burns red, copper blue-green.

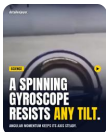
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CASCADE

DD-269 · Science / Nature · A water drop can bounce and shrink several times before it vanishes.

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You're Spinning Me Around

DD-274 · Science / Tech · A spinning gyroscope resists any change to its axis.

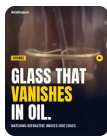
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The Strings of Fate

DD-319 · Science / Space · Some versions of string theory need 10 or 11 dimensions.

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See Right Through Me

DD-332 · Science · Pyrex dipped in vegetable oil seems to disappear.

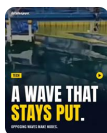
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Sudsy

DD-345 · Science · Soap molecules have one end that loves water and one that loves oil.

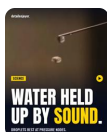
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Computer Wave Control

DD-356 · Tech / Science · Computer-timed wave makers can hold a wave in place.

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Acoustic Levitation

DD-394 · Science · Sound waves can hold water droplets in midair.

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Video Trickery II

DD-461 · Tech / Science · On video, a helicopter's rotor can seem to stand still.



Collection Quiz and Answer Key

68 questions from every case file

Every quick fact has a stable ID (for example DD-024-F01) and comes from a case file with its sources listed. Online edition with videos and slides: <https://detailenjoyer.com/collections/everyday-physics/>



MARANGONI MOTION

When surface tension varies across a liquid, the stronger-pulling (higher-tension) region drags the surface toward itself. Fluid then streams from low surface tension to high. This is the Marangoni effect, named after Carlo Marangoni, who published on it in 1865. James Thomson first explained it in 1855 using 'tears of wine'. It's why a drop of soap or alcohol makes water rush away, why wine climbs the glass, and why sulfur traces change the shape of a weld pool. Chip makers use it to dry silicon wafers without spots.

QUICK FACTS

DD-024-F01

In the Marangoni effect, liquid flows from regions of low surface tension toward regions of high surface tension. It's why wine forms 'tears' on the glass.

DD-024-F02

Traces of sulfur or oxygen can reverse the Marangoni flow in a weld pool, turning a wide, shallow weld into a narrow, deep one.

THE WRITE-UP

Flow along a surface-tension gradient. The Marangoni effect is mass transfer along an interface driven by a gradient in surface tension. Higher-tension liquid pulls harder on its surroundings, so the surface and the fluid under it flow from low tension toward high.

Two ways to make the gradient. The gradient can come from composition (soap, alcohol, surfactants) or from temperature, because surface tension usually falls as a liquid warms. Temperature-driven flow is called thermocapillary or Bénard–Marangoni convection.

Tears of wine. Alcohol evaporates from the thin film of wine on the glass, leaving it watery, with higher surface tension. That film pulls wine up the glass until its own weight brings it back down as 'tears'. A 2015 study found that evaporative cooling contributes too.

Who found it. James Thomson, Lord Kelvin's brother, identified the cause of wine tears in 1855. Carlo Marangoni published his doctoral study of the effect in 1865, and J. Willard Gibbs gave the full theory in the 1870s.

Shaping welds. In a weld pool, Marangoni forces usually push molten metal outward from the hot center, giving a wide, shallow pool. Traces of sulfur or oxygen can reverse the flow inward, making the pool narrow and deep.

Coatings and printing. Paint defects like craters, fisheyes and crawling are caused by flows driven by surface-tension differences. Engineers use Marangoni flows on purpose to cancel the 'coffee ring' that makes drying drops deposit at their edges.

Drying microchips. After wet processing, chip makers blow alcohol vapor over silicon wafers. The resulting Marangoni flow pulls the water off, leaving the wafer dry and spot-free.

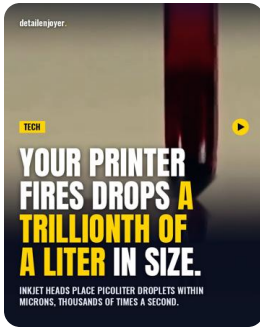
REEL VS. RECORD

- **Confirmed from the frames:** the Reel is about the Marangoni effect (caption at 0.9–2.4 s: 'The Marangoni effect is a physical phenomenon'). The direction, low to high surface tension, is correct. [Wikipedia; coatings chapter; COMSOL paper]
- **Imprecise:** 'because liquids naturally try to minimize surface energy'. The driving force is the surface-tension gradient itself, because higher-tension regions pull harder on the interface. Minimizing surface energy is the general principle behind surface tension, not the specific cause of the flow. [Wikipedia; Scientific Reports 2015]
- **Nuance:** welding and coating are well documented. 'Bubble formation' and 'biological systems' are vaguer: Marangoni stresses stabilize soap films and foams, and they are studied in surfactant spreading. The Reel gives no specific example. [Wikipedia; Langmuir 2018]

SOURCES

1. Marangoni effect (Wikipedia): https://en.wikipedia.org/wiki/Marangoni_effect
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4. Numerical Analysis of Effect of Surface Active Elements on Marangoni Convection (COMSOL conference paper): https://www.comsol.com/paper/download/368741/mishra_paper.pdf
5. Surface Defects: Causes, Prevention, and Remedies (coatings handbook chapter, Wiley): <https://doi.org/10.1002/9781394207305.ch16>
6. Dynamic Control of Particle Deposition in Evaporating Droplets (Langmuir, 2018; PMC): <https://pmc.ncbi.nlm.nih.gov/articles/PMC5797983/>

Permalink: <https://detailenjoyer.com/case/marangoni-motion/> · Last updated Apr 11, 2026



PRINT PRECISION

An inkjet printhead fires drops measured in picoliters, trillionths of a liter. Home printers go down to about 1–1.5 pL, and some lab heads go below 1. Thermal ('bubble jet') heads flash-boil a speck of ink so that a vapor bubble kicks a drop out. Piezo heads flex a crystal to squeeze it out. Drops fly at roughly 5–15 m/s, and Epson heads can fire up to 50,000 times a second. The best industrial heads land each drop within about a micron of its target.

QUICK FACTS

DD-005-F01

The smallest drops from modern inkjet printheads measure about 1–3 picoliters (trillionths of a liter).

DD-005-F02

Inkjet drops typically leave the printhead at roughly 5–15 meters per second (about 14 m/s for HP's thermal heads).

DD-005-F03

Inkjet resolutions like 4800×1200 dpi describe the finest grid a printer can address, not the size of a single dot.

DD-005-F04

Inkjet drops are measured in picoliters (trillionths of a liter). Home printers fire drops as small as about 1.3–1.5 pL.

DD-005-F05

The best industrial inkjet heads land each drop within about ± 1 –2 microns of its target.

THE WRITE-UP

Two ways to fire a drop. Thermal (bubble-jet) heads use a heater to make a vapor bubble that pushes ink out of the nozzle. Piezo heads apply a voltage to a piezoelectric element, which flexes and squeezes the drop out.

Measured in trillionths of a liter. Epson's piezo heads can deposit drops as small as 1.5 picoliters, one-and-a-half trillionths of a liter. HP's low-cost thermal cartridges fire 1.3 pL and 4.7 pL drops from nozzles 8.5 and 14 μm wide.

Even smaller in the lab. Canon's FINE research head ejected drops as small as 0.1 pL from a 2-micron orifice. Industrial heads like the Xaar 1003 AMP jet 1–3 pL sub-drops.

A microsecond boil. In an HP head, a 2.5-microsecond pulse heats a tiny resistor past the superheat point of water. That makes an almost explosive vapor bubble that launches the drop at about 50 km/h (14 m/s).

Speed and frequency. Drop speeds are typically about 5–15 m/s: about 14 m/s for HP's thermal drops, 7 m/s for the Xaar 1003, and 8–12 m/s for Canon's sub-picoliter drops. Epson heads can fire up to 50,000 drops per second.

Within microns. Placement is where the precision shows. A 1 pL head built for printing OLED displays achieved $\pm 1.35\text{ }\mu\text{m}$ landing repeatability. Canon sped up its drops by 1.5 times so that air currents from the moving head push them off target less.

What '4800 dpi' means. Consumer printers advertise figures like 4800×1200 dpi. That's the finest grid the printer can address in its best mode, often combining two drop sizes. It isn't the size of a single dot.

REEL VS. RECORD

- **Confirmed:** droplets are measured in picoliters and placed within microns, and printheads use thermal or piezoelectric actuators. [Epson; Canon; SID Digest; Semiconductor Digest]
- **Correction · earlier version of this page:** '~20 m/s' is high for typical printheads. Sourced values are about 14 m/s (HP thermal), 7 m/s (Xaar 1003) and 8–12 m/s (Canon sub-pL). This page now says 'roughly 5–15 m/s'. [Semiconductor Digest; Xaar; Canon FINE paper]
- **Clarification · earlier version of this page:** 'land at up to 4800 dpi'. 4800×1200 dpi is an advertised addressable resolution in the best mode, not a single dot size or a placement accuracy. [Philstar/HP; Canon]
- **Nuance · earlier version of this page:** '1–3 picoliters' fits the smallest drops of modern home and industrial heads (1.3–1.5 pL consumer, 1–3 pL Xaar sub-drops). Many heads also fire larger 4–12 pL drops for speed. [HP; Epson; Xaar]
- **Nuance:** 'within microns' is achieved by industrial and display heads ($\pm 1.35\text{ }\mu\text{m}$). Desktop printers on paper are looser, because ink spreads and the head moves. [SID Digest; Canon]

SOURCES

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2. Inkjet Printers: thermal and piezo ejection; FINE heads (Canon Global): <https://global.canon/en/technology/canon-tech/tech/ij/>
3. HP optimizes low-cost processing for inkjet printheads (Semiconductor Digest, 2008): <https://sst.semiconductor-digest.com/2008/09/hp-optimizes-low-cost-processing-for-inkjet-printheads/>
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7. Xaar 1003 AMP printhead specifications (Xaar): <https://www.xaar.com/products/printheads/xaar-1003-amp/>

Permalink: <https://detailenjoyer.com/case/print-precision/> · Last updated Oct 17, 2026



CHERENKOV GLOW

Cherenkov radiation is light given off when a charged particle moves through a medium like water faster than light travels in that medium, which in water is about 75% of its vacuum speed. Nothing beats light in a vacuum. The particle's wake of polarized molecules builds into a cone-shaped 'shockwave' of light, much like a sonic boom. In reactor pools, high-energy electrons make the water glow blue. The glow isn't radioactive itself, and inspectors use it to check spent fuel.

QUICK FACTS

DD-020-F01

The blue glow in nuclear reactor pools is Cherenkov radiation: electrons moving faster than light travels in water (about 75% of c).

DD-020-F02

Cherenkov radiation is like a sonic boom for light, and IAEA inspectors use the glow to verify spent nuclear fuel.

THE WRITE-UP

Faster than light, but only locally. Cherenkov radiation is emitted when a charged particle, usually an electron, moves through a medium such as water faster than light travels in that medium. Nothing outruns light in a vacuum.

Water slows light to 75%. In water, light travels at only about 75% of its vacuum speed, so energetic particles can move faster than light there while still staying below c .

A wake of polarized molecules. A passing charged particle polarizes the medium around it. Normally those disturbances cancel out and fade. But when the particle is faster than light in the medium, they pile up into a single cone-shaped wavefront (a 'Mach cone').

A sonic boom for light. The effect is the light version of a sonic boom: a 'shockwave' of light from something moving faster than waves can travel in that medium.

Why reactor pools glow. In pool reactors, fission products release beta particles (high-energy electrons) into the surrounding water. Those electrons produce the blue glow. It's not the fuel itself shining, and it's not fluorescence.

Why it's blue. Cherenkov photons are mostly high-frequency, short-wavelength light, which looks blue or violet to the human eye.

The glow itself is harmless light. Cherenkov radiation is just visible light, so the glow itself isn't radioactive.

Used to check spent fuel. Because the glow's intensity tracks how much radioactive decay is going on, IAEA inspectors use Cherenkov viewing devices to verify spent fuel in storage pools.

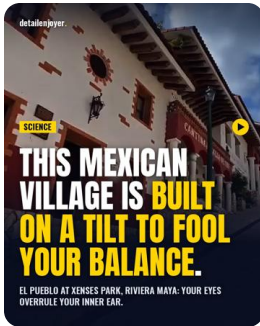
REEL VS. RECORD

- **Note:** No factual errors found. The 75% figure, the 'faster than light in the medium, not in a vacuum' point, polarization, the cone-shaped wavefront and the sonic-boom analogy are all supported. [DOE; IAEA; Wikipedia; HKO]
- **Nuance:** 'electrons produced by nuclear reactions'. In reactor pools these are mostly beta particles from the decay of fission products. [Wikipedia; IAEA]
- **Nuance:** 'eerie blue glow'. The emission is strongest at short wavelengths, which is why it looks blue or violet. [DOE; Wikipedia]

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1. Cherenkov Radiation, Explained (U.S. Department of Energy, Office of Nuclear Energy, 2023): <https://www.energy.gov/ne/articles/cherenkov-radiation-explained>
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Permalink: <https://detailenjoyer.com/case/cherenkov-glow/> · Last updated Aug 21, 2026



TILTED TOWN

At Xenses, a Grupo Xcaret park just south of Playa del Carmen on Mexico's Riviera Maya, 'El Pueblo' (nicknamed the Pueblito al Revés, or Upside-Down Town) is a walk-through tilted-house illusion. It looks like a classic Mexican village, but the whole street sits on a pronounced slope, and the houses, doors and windows are built square to a false horizon instead of true vertical. Your eyes trust the buildings, your inner ear feels the real slope, and the conflict makes you stagger. Psychologists studying 'mystery spots' have found that vision usually wins this tug-of-war over the vestibular sense.

QUICK FACTS

DD-035-F01

Mexico's 'tilted town' at Xenses Park sits on a steep slope with houses built square to a false horizon, so your eyes and your inner ear disagree.

DD-035-F02

In tilted-house illusions, vision usually beats the inner ear: the effect gets two to three times stronger when your body is tilted too.

THE WRITE-UP

Where it is. Xenses is a half-day 'sensory park' run by Grupo Xcaret. It's about 10 km past Playa del Carmen on the highway south from Cancún, next to Xcaret and Xplor, and roughly an hour (about 74 km) from Cancún.

El Pueblo. The tilted village is officially just 'El Pueblo' on Xenses' 'Ruta del Hacer'. It's a white-walled, red-tiled Mexican street where, as the park puts it, you can't tell whether you're walking uphill or down.

How the trick works. The whole village sits on a pronounced slope, but the houses, doors and windows are built square to a false horizon. It's a full-size 'tilted room': the buildings look level, so your brain decides that you're the one leaning.

Eyes vs. inner ear. Berkeley psychologists studying the Santa Cruz Mystery Spot found that when the true horizon is hidden, people take their sense of vertical mostly from the surrounding scene. The tilted-house effect gets two to three times stronger when your body is tilted too.

A hierarchy of senses. Lab work on the 'rod-and-frame' illusion suggests a hierarchy: vision dominates the sense of upright, the vestibular system modulates it, and body sense (proprioception) comes third. A tilted frame is never fully overcome.

Water that runs uphill. Because everything looks level, water and rolling objects seem to move uphill. Visitors tend to stagger and over-correct, which makes it a favorite photo spot.

REEL VS. RECORD

- **Confirmed from the frames:** the Reel is about the tilted village ('El Pueblo') at Xenses Park (captions at 0.9–4.9 s). [Xcaret; Alternativo]
- **Location:** 'near Cancun' is a stretch. Xenses is beside Playa del Carmen on the Riviera Maya, about 74 km (an hour) from Cancún. [Xcaret FAQ; Alternativo]
- **Backwards emphasis:** 'buildings ... at sharp angles, while the pathway itself is subtly sloped.' Sources describe a pronounced slope, with houses built square to a false horizon so the ground looks flat. It's the slope that's large, not subtle. [Alternativo; Mexican Routes]
- **Supported:** 'the brain relies heavily on visual cues to determine orientation.' Mystery-spot and rod-and-frame research shows vision is the dominant cue for upright, with the vestibular sense second. [UC Berkeley 1998; UBC thesis]
- **Name:** the attraction is officially 'El Pueblo'. 'Tilted Town' and 'Pueblito al Revés' are nicknames. [Xcaret; Alternativo]

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Permalink: <https://detailenjoyer.com/case/tilted-town/> · Last updated Mar 13, 2026



STATIC SPRAY

Powder coating is a 'dry paint'. Polymer resin, curatives, pigments and flow additives are melt-mixed, cooled and ground into a powder as fine as baking flour. In electrostatic spray deposition, the most common method, a spray gun charges the particles and an electric field pulls them onto a grounded part, where the charge holds them until the part goes into a curing oven. At about 325–450 °F (163–232 °C) the powder melts, flows and chemically cross-links into a tough finish. Because there's no solvent, the process virtually eliminates volatile organic compounds (VOCs), and overspray can be recovered for reuse. Grounding matters: the path from the part to ground must stay under one megohm.

QUICK FACTS

DD-051-F01

Powder coating is held on by static electricity until a 325–450 °F oven melts and cross-links it into a hard finish.

DD-051-F02

Because powder coating uses no solvents, it virtually eliminates VOC emissions, and overspray can be reused.

THE WRITE-UP

What the powder is. Powder coatings combine polymer resins with curatives, pigments, leveling agents and flow modifiers. These are melt-mixed, cooled and ground into a uniform powder 'similar to baking flour'.

Charge and ground. In electrostatic spray deposition the gun charges the powder and the part is grounded, so the electric field pulls particles onto it. The deposited powder keeps its charge, which holds it in place.

The oven does the rest. The coating isn't finished until it's baked. In the curing oven the powder melts, flows over the part and cross-links into long molecular chains, usually at 325–450 °F (163–232 °C).

Grounding matters. Powder build-up on hangers or conveyors degrades the path to ground. The total resistance to ground must stay under one megohm, which is checked with a megohmmeter.

Cleaner than solvent paint. Powder is a dry process that eliminates solvents and virtually eliminates VOC emissions. Overspray can be collected and returned to the hopper for reuse.

Not just metal. Electrostatic spray is mostly used on metal, but powder can also coat plastics and MDF, or be applied by fluidized bed (dipping a preheated part into fluidized powder).

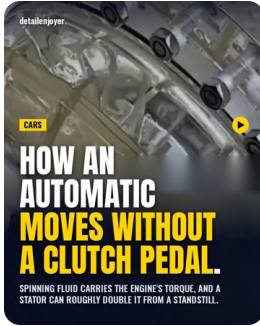
REEL VS. RECORD

- **Confirmed from the frames:** the Reel shows electrostatic powder coating (captions at 0.8–2.4 s). A spray gun charges fine resin-and-pigment powder that's drawn to a grounded part. [Powder Coating Institute; EPA]
- **Missing step:** the Reel stops at 'sticking evenly'. Until it's oven-cured at about 325–450 °F, the powder is held only by electrostatic charge. Heat melts and cross-links it into the durable finish. [Powder Coating Institute; P2 InfoHouse]
- **Too narrow:** 'metal and other conductive surfaces.' Powder can also coat plastics and MDF, and flame spray works on wood and rubber. [Powder Coating Institute; P2 InfoHouse]
- **Simplified:** 'resin and pigment' leaves out the curatives, leveling agents and flow modifiers that make the film form. [Powder Coating Institute]
- **Context the Reel skips:** powder contains no solvents, so it virtually eliminates VOCs, and overspray can be reclaimed. [P2 InfoHouse; Powder Coating Institute]

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Permalink: <https://detailenjoyer.com/case/static-spray/> · Last updated Jan 23, 2026



TORQUE CONVERSION

A torque converter sits between the engine and an automatic transmission and lets the car idle in gear without stalling. The engine-driven impeller (pump) flings automatic transmission fluid outward into the turbine, which turns the transmission input shaft. The stator sits between them on a one-way clutch. When the turbine is turning much slower than the impeller, as when pulling away from a stop, the stator turns the returning fluid so it helps the impeller instead of fighting it. That multiplies torque by up to about 2.5:1 at stall. As speeds even out, the stator freewheels and the unit acts like a plain fluid coupling. Because constant slip wastes energy as heat, virtually all modern automotive converters add a lock-up clutch that mechanically joins the impeller and turbine at cruise.

QUICK FACTS

DD-075-F01

At a standstill, a car's torque converter can multiply engine torque by about 2 to 2.5 times, thanks to a part called the stator.

DD-075-F02

Most modern torque converters still contain a mechanical clutch, which locks up at cruising speed to stop fluid slip.

THE WRITE-UP

Why automatics need one. The torque converter replaces the clutch in most automatic cars. Because it allows slip between input and output, the car can sit still in gear with the engine running.

Pump and turbine. The impeller, bolted to the engine, pumps fluid into the turbine, which drives the transmission input shaft. Together with the stator, these parts form the 'torus' that the fluid circulates through.

What the stator adds. A plain fluid coupling has no stator. Without one, fluid leaving the turbine would hit the impeller against its rotation and brake it. The stator reverses that flow so it helps instead.

Torque multiplication. The effect is strongest at stall, when the turbine is barely turning. Typical converters multiply torque by about 1.8 to 2.5 times there, and the effect fades as the turbine catches up.

The one-way clutch. The stator sits on an overrunning clutch. It's held still during multiplication and freewheels near the coupling point, so it doesn't get in the way.

Lock-up. Slip turns some power into heat, so modern converters include a lock-up clutch that mechanically links the impeller and turbine above roughly a 0.9 speed ratio.

REEL VS. RECORD

- **Confirmed from the frames:** the Reel is about an automatic transmission's torque converter (captions at 0.8–8.4 s). It has three parts: an engine-driven impeller, a turbine on the transmission input shaft, and a stator that multiplies torque at low speed. [IEEE; Wikipedia]
- **Imprecise:** 'a torque converter is a fluid coupling.' It's a fluid coupling plus a stator. A plain fluid coupling can transmit torque but can't multiply it. [IDC; Wikipedia]
- **Outdated:** 'instead of a mechanical clutch.' Virtually all modern automotive converters include a lock-up clutch that mechanically joins the impeller and turbine at cruise to eliminate slip. [IEEE; IDC]
- **Missing detail:** the stator works only at low speed ratios. It sits on a one-way clutch, multiplies torque by up to about 2.5:1 at stall, and freewheels near the coupling point. [IEEE; Wikipedia]
- **Footage note:** the clip shows a converter-style unit in a transparent housing filled with fluid, apparently a demonstration piece. The Reel doesn't say what model it is. [frames]

SOURCES

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Permalink: <https://detailenjoyer.com/case/torque-conversion/> · Last updated Feb 26, 2026



LIQUID LIGHTS

A liquid's electrical conductivity depends on how many ions it holds and how fast they move. Perfectly pure water isn't ion-free: it splits slightly into hydrogen and hydroxide ions, about 10^{-7} mol/L of each at 25 °C, which gives a theoretical conductivity of 0.055 $\mu\text{S/cm}$. Water left open to air absorbs carbon dioxide, which raises that to about 1 $\mu\text{S/cm}$. Strong electrolytes such as table salt, hydrochloric acid and sodium hydroxide split completely into ions and conduct well. Weak ones such as acetic acid and ammonia split only partly and conduct far less. Seawater conducts about a million times better than ultrapure water.

QUICK FACTS

DD-073-F01

Perfectly pure water still conducts slightly (0.055 $\mu\text{S/cm}$ at 25 °C), because a tiny fraction of its molecules split into ions.

DD-073-F02

Weak acids such as acetic acid conduct far less than strong acids such as hydrochloric acid at the same concentration.

THE WRITE-UP

Ions carry the current. In water, salts, acids and bases split into positive and negative ions, and those ions carry the electric current. Conductivity rises with the number of ions and how fast they move.

Pure water isn't ion-free. Pure water splits slightly into hydrogen and hydroxide ions, about 10^{-7} mol/L of each at 25 °C. That gives a theoretical conductivity of 0.055 $\mu\text{S/cm}$.

Air changes it. Water exposed to air absorbs carbon dioxide, which raises its conductivity by a factor of 10 to 30, to roughly 0.8–1.2 $\mu\text{S/cm}$.

Strong vs. weak. Strong electrolytes such as hydrochloric acid and sodium hydroxide split completely into ions. Weak ones such as acetic acid and ammonia split only partly. At 1% by mass, hydrochloric acid conducts about 93 mS/cm and acetic acid about 0.6 mS/cm.

Fast ions. Hydrogen and hydroxide ions are the fastest movers in water. Their limiting ionic conductivities are about 350 and 199, compared with 50 for sodium ($\text{S}\cdot\text{cm}^2/\text{mol}$ at 25 °C).

A million-fold range. Seawater conducts about 0.053 S/cm at 25 °C, roughly a million times more than ultrapure water.

REEL VS. RECORD

- **Nuance:** pure water doesn't completely 'lack free ions'. It splits slightly into H^+ and OH^- (about 10^{-7} mol/L each at 25 °C), giving 0.055 $\mu\text{S}/\text{cm}$. Distilled water left in air picks up CO_2 and reaches about 1 $\mu\text{S}/\text{cm}$. [Metrohm; NIST; CHIMIA]
- **Nuance:** not every acid or base 'conducts well'. Strong ones split fully into ions, but weak ones like acetic acid and ammonia split only partly. At 1%, acetic acid conducts about 0.6 mS/cm versus about 93 mS/cm for hydrochloric acid. [Metrohm; CRC Handbook]
- **Context on mobility:** H^+ and OH^- move far faster than other ions (about 350 and 199 versus 50 for Na^+). That's a big part of why strong acids and bases conduct so well. [Metrohm]
- **Context on scale:** seawater conducts about 0.053 S/cm at 25 °C, roughly a million times more than ultrapure water. [CHIMIA]
- **Confirmed:** conductivity depends on the presence and mobility of ions; dissolved salts make water conductive. Conductivity also changes with temperature, by about 5.8% per °C for pure water. [Metrohm]

SOURCES

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Permalink: <https://detailenjoyer.com/case/liquid-lights/> · Last updated Feb 16, 2026



DD-739 SCIENCE · 8 OF 34

BRANCHED FLOW

Branched flow happens when waves pass through a weak, smoothly varying disorder whose features are larger than the wavelength. The waves form channels of higher intensity that keep dividing. It was first seen with electrons and microwaves. In 2020, Patsyk, Sivan, Segev and Bandres reported the first observation with light in Nature. They sent a laser into a soap film, which acts as a thin waveguide, and the film's smooth thickness variations focused the light into branching filaments that stayed unexpectedly collimated.

QUICK FACTS

DD-739-F01

Branched flow of light was first observed in 2020, in soap films.

DD-739-F02

Branched flow was first seen with electrons.

THE WRITE-UP

The phenomenon. When waves cross a weak disordered landscape whose features are larger than the wavelength, they form channels of higher intensity that keep dividing. This is branched flow. It was first seen for electrons and in microwave cavities, and it has been suggested as a focusing mechanism for ocean waves.

First in light. In 2020, a team from the Technion and the University of Central Florida reported the first observation of branched flow of light, in a laser launched into a thin soap membrane.

How the film steers light. The film works as a slab waveguide, with the light traveling inside the membrane. Its smooth thickness variations, from about 5 nm up to several micrometers, change the effective refractive index and act as a correlated disordered potential.

Surprisingly straight. Counterintuitively, despite the random medium, the filaments stay collimated along their paths. In a curved bubble, the overall curvature adds extra focusing and makes the branches run more parallel.

Seeing the landscape. The researchers mapped the film's thickness using red, green and blue light, which reflects from the film as interference colors. They found that air movement makes the thickness landscape shift over time.

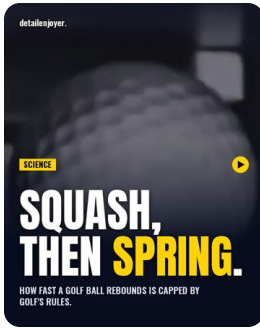
REEL VS. RECORD

- **Mechanism:** the laser is launched into and travels inside the film, which acts as a waveguide. It isn't shone through the bubble from outside.
- **Cause:** the branching comes from the film's smooth thickness variations, which act as a disordered refractive-index landscape. Curvature only adds extra focusing that makes the branches more parallel.
- **Missing context:** branched flow was first observed for electrons and microwaves. Seeing it in light was a first, reported in Nature in 2020 (Patsyk, Sivan, Segev, Bandres).
- **Missing context:** counterintuitively, the filaments stay collimated (nearly straight) despite the random medium.
- **Framing:** 'microscopic lenses' is a helpful analogy. The researchers describe the effect as a correlated disordered potential whose features are larger than the wavelength.

SOURCES

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3. Technion (Segev group): Observation of branched flow of light (PDF): <https://phsites.technion.ac.il/publications/msegev/Nature-583-60-2020.pdf>

Permalink: <https://detailenjoyer.com/case/branched-flow/> · Last updated Sep 14, 2026



GOLF BALLING

When a driver hits a golf ball, the ball flattens noticeably for a fraction of a millisecond and then springs back. The coefficient of restitution (COR) measures how much speed survives that collision: 1 means a perfectly elastic bounce and 0 means none. Because a livelier ball goes farther, golf's governing bodies cap it. In the USGA/R&A Initial Velocity test, a ball is fired at a rigid barrier at 143.8 ft/s. Its initial velocity is calculated from its COR and contact time, and a sample fails if four or more of 24 balls exceed 255 ft/s. Balls must also meet the 317-yard Overall Distance Standard. From January 2028, that test will be run at a 125 mph clubhead speed instead of 120 mph, which the USGA expects to cut the longest hitters' drives by about 13 to 15 yards.

QUICK FACTS

DD-695-F01

The ball's limit is 250 ft/s initial velocity plus a 2% tolerance.

DD-695-F02

From 2028, conformance testing uses a 125 mph clubhead speed.

THE WRITE-UP

What COR measures. COR is the ratio of rebound speed to impact speed. A value of 1 is a perfectly elastic collision, and lower values mean more energy is lost as heat and vibration.

The whole ball deforms. The core and cover compress together, not just the 'outer layers'. The ball flattens against the clubface during a contact lasting well under a millisecond, then springs back.

How the rules test it. The ball is fired at a rigid barrier at 143.8 ft/s. Its initial velocity is calculated from COR and contact time and compared with a 250 ft/s limit plus a 2% tolerance (255 ft/s).

Distance cap. Balls must also pass the 317-yard (plus 3-yard tolerance) Overall Distance Standard, tested with a mechanical golfer.

The 2028 change. From January 2028, the distance test moves from 120 mph to a 125 mph clubhead speed. The USGA estimates the longest hitters will lose 13 to 15 yards and most recreational golfers 5 yards or less. Recreational players can keep using older conforming balls until 2030.

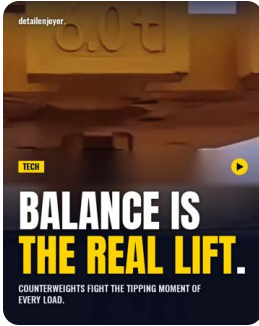
REEL VS. RECORD

- **Missing rule:** a ball's liveliness is capped. In the USGA/R&A test, a sample fails if four or more of 24 balls exceed 255 ft/s (250 ft/s plus 2%).
- **Precision:** 'higher elasticity, greater distance' holds only in part. Distance also depends heavily on launch angle, spin and the dimple aerodynamics.
- **Mechanism:** the whole ball compresses, core included, not just the outer layers. Contact lasts well under a millisecond.
- **Missing context:** clubfaces are limited too. Drivers have a separate 'springiness' limit (Characteristic Time), which the USGA is testing more strictly against 'driver creep'.
- **Since the Reel:** from January 2028, balls will be distance-tested at a 125 mph clubhead speed, cutting the longest hitters' drives by an estimated 13 to 15 yards (USGA).

SOURCES

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Permalink: <https://detailenjoyer.com/case/golf-balling/> · Last updated Jan 25, 2026



COUNTER CRANE

A crane tips over when the overturning moment (the load's weight times its distance from the tipping line, plus wind and slope effects) exceeds the stabilizing moment from the crane's own weight and counterweight. Counterweights sit behind the slewing center to add stabilizing moment. On mobile cranes they're usually stackable cast-iron or steel slabs, like the '10 t' plates in the footage. Tower cranes often use concrete blocks. Counterweight isn't free stability, though. With the boom raised steeply and no load, too much counterweight can tip a crane backward, so standards such as ISO 4305 require backward-stability checks. Outriggers widen the support base. A crane's safe capacity comes from the manufacturer's load chart for its exact counterweight, boom length, radius and outrigger setup, and capacity falls fast as the load moves farther out.

QUICK FACTS

DD-687-F01

A crane tips when the overturning moment exceeds the stabilizing moment.

DD-687-F02

Too much counterweight can tip a crane backward when it's unloaded.

THE WRITE-UP

Moments, not just weight. A crane tips when the overturning moment from the load (weight times radius), wind and slope exceeds the stabilizing moment from the crane and its counterweight.

Counterweights. Counterweights behind the slewing center add stabilizing moment. Mobile cranes use stackable metal slabs, often marked with their mass, like the 10 t plates in the footage.

Backward tipping. Too much counterweight is also a hazard. With a steep boom and no load, a crane can tip backward, and ISO 4305 requires checking backward stability with the crane unloaded.

Outriggers. Outriggers widen the base, which moves the tipping line out and greatly increases capacity.

The load chart rules. Safe lifting capacity comes from the manufacturer's load chart for the exact counterweight, boom, radius and outrigger setup, and it drops as the radius grows.

REEL VS. RECORD

- **Oversimplified:** counterweight doesn't simply 'shift the center of gravity back'. It adds stabilizing moment, and the crane's tipping line, set by its tracks or outriggers, is just as important.
- **Missing hazard:** too much counterweight can tip a crane backward when the boom is steep and there's no load, so standards require backward-stability checks.
- **Materials:** mobile cranes mostly use cast-iron or steel slabs, as in the footage. Concrete blocks are more typical on tower cranes.
- **Missing:** outriggers widen the base and are central to stability. Most lifting capacity depends on how far they're extended.
- **Missing limit:** capacity comes from the load chart and falls quickly with radius, so counterweights don't make any load 'safe'.

SOURCES

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Permalink: <https://detailenjoyer.com/case/counter-crane/> · Last updated Jan 1, 2026



UV FACE

A UV camera records ultraviolet light bouncing back from a scene. Sunscreen filters stop most of that UV from reaching the skin and bouncing back, so covered skin looks dark and bare skin looks lighter. A 2016 study by Cole and colleagues measured the mineral filters zinc oxide and titanium dioxide.

Despite the old 'physical blocker' label, they reflected only about 4-5% of UV, and the rest of their protection came from absorption. Above their absorption edge, in long UVA and visible light, they mainly reflect, which is why thick mineral sunscreen can look white. Organic ('chemical') filters also absorb UV. The camera's look has a practical use. In a 2017 University of Liverpool study, UV imaging of 57 people showed sunscreen was missed on about 14% of the eyelid region, compared with about 7% of the rest of the face. Under UV light, skin pigmentation such as freckles also shows up more strongly.

QUICK FACTS

DD-654-F01

Zinc oxide and titanium dioxide reflect only about 4-5% of UV.

DD-654-F02

UV imaging showed sunscreen was missed on about 14% of the eyelid region.

THE WRITE-UP

What the camera sees. A UV camera images ultraviolet light coming back from a scene. Sunscreen stops most of it, so covered skin looks dark and bare skin looks lighter.

Absorb, not reflect. Zinc oxide and titanium dioxide reflected only about 4-5% of UV in Cole's measurements. Most of their protection comes from absorption.

Why mineral sunscreen looks white. Above their absorption edge, in long UVA and visible light, mineral filters mostly reflect. Larger particles look whiter on the skin.

Chemical filters. Organic ('chemical') UV filters also work by absorbing UV radiation.

Spotting the gaps. In a 2017 study of 57 people, UV imaging showed about 14% of the eyelid region was missed, compared with about 7% of the rest of the face.

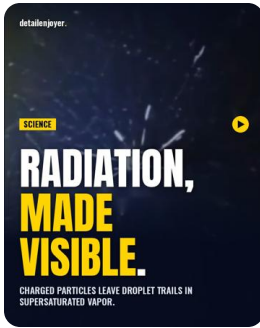
REEL VS. RECORD

- **Mechanism:** mineral filters (zinc oxide, titanium dioxide) mainly absorb UV and reflect only about 4-5% (Cole et al., 2016). 'Block' is fine, but they aren't reflectors.
- **Simplified:** untreated skin doesn't really 'reflect UV' strongly. It reflects some UV, which is more than sunscreen-covered skin does, so it looks lighter by comparison.
- **Missing nuance:** in long UVA and visible light, mineral filters mostly reflect, which is why thick mineral sunscreen can look white.
- **Missing context:** UV imaging is used in research to show where sunscreen was missed. One study found eyelids were missed about twice as often as the rest of the face.
- **Missing detail:** UV cameras also make skin pigmentation, such as freckles, stand out more than normal photos do.

SOURCES

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Permalink: <https://detailenjoyer.com/case/uv-face/> · Last updated Sep 25, 2025



CLOUD CHAMBERS

A cloud chamber makes the paths of electrically charged particles visible. Inside, the air holds more vapor than it normally could, so it is supersaturated and ready to condense. A fast charged particle knocks electrons off molecules along its path and leaves a line of ions behind it. Vapor condenses on those ions as tiny droplets, which form a thin trail. The trail doesn't glow: it shows up because a lamp lights it against a dark background, and it fades within moments. The Scottish physicist C.T.R. Wilson built the first cloud chamber at Cambridge's Cavendish Laboratory in 1911. His version used water vapor and made it supersaturated with a sudden expansion. He shared the 1927 Nobel Prize in Physics for the method. Many classroom chambers today are diffusion chambers, which keep alcohol vapor supersaturated over a very cold plate, so tracks form continuously. The shape of a track hints at the particle: alpha particles leave short, thick tracks and electrons leave thin, wandering ones. In a magnetic field, the tracks curve, which reveals charge and momentum. That is how Carl Anderson identified the positron, the first known antiparticle, in 1932.

QUICK FACTS

DD-623-F01

Cloud-chamber tracks are droplets condensed on ions.

DD-623-F02

C.T.R. Wilson built the first cloud chamber in 1911.

THE WRITE-UP

Why droplets form. The chamber's vapor is supersaturated. A charged particle leaves ions along its path, and the vapor condenses on them as droplets.

Not glowing. The droplet trails scatter light from a lamp. They don't give off light themselves.

Wilson's chamber. C.T.R. Wilson built the first cloud chamber in 1911. A sudden expansion cooled moist air until it was supersaturated. He shared the 1927 Nobel Prize in Physics.

Diffusion chambers. Many modern chambers keep alcohol vapor supersaturated over a cold plate instead, so tracks form all the time.

Reading the tracks. Track length and thickness hint at the particle. In a magnetic field, the curve shows charge and momentum, which is how Anderson found the positron in 1932.

REEL VS. RECORD

- **Note:** 'Glowing tracks': the droplets don't glow. They show up because a lamp lights them, usually from the side against a dark background.
- **Note:** 'Track radiation': only charged particles leave tracks directly. Uncharged radiation such as gamma rays and neutrons shows up only through charged particles it knocks loose.
- **Note:** 'Determine the type, energy': this is read from track length and thickness and, when a magnet is used, from how the tracks curve. A plain chamber gives only rough clues.
- **Missing history:** C.T.R. Wilson invented the cloud chamber in 1911 and shared the 1927 Nobel Prize in Physics for it.
- **Missing:** how the vapor becomes supersaturated. Wilson used a sudden expansion of moist air. Many modern demo chambers are diffusion chambers using alcohol over a very cold plate.

SOURCES

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Permalink: <https://detailenjoyer.com/case/cloud-chambers/> · Last updated Jul 26, 2025



AROUND THE RAINBOW

A rainbow isn't an object in a fixed place. It's a pattern of light that appears when sunlight enters falling drops, bends (refracts) going in, reflects once off the back of each drop, and bends again on the way out. Different colors leave at slightly different angles, so the drops that send light to your eye all sit about 40 to 42° from the antisolar point. That's the point directly opposite the sun, which is always where the shadow of your head falls. Every point on a circle at that angle around your shadow sends rainbow light to you, so the primary rainbow is a ring, red on the outside and violet on the inside. From the ground, the antisolar point is below the horizon whenever the sun is up. You see only the part of the circle above the ground, and only if there are raindrops there. When the sun is right on the horizon you get a half circle, and the higher the sun, the smaller the arc. Once the sun is higher than about 42°, no primary bow appears at ground level. From an airplane, a mountain or a tall building, drops can lie below you too, so you can sometimes see the whole ring. A glory is a different effect: smaller, tighter colored rings around the shadow of an aircraft on cloud. The footage shows a bright rainbow arcing down past the horizon toward the water below, filmed from high above a waterfront.

QUICK FACTS

DD-651-F01

A primary rainbow forms about 42° from the antisolar point.

DD-651-F02

From aircraft, rainbows can appear as full circles.

THE WRITE-UP

Refract, reflect, refract. Sunlight bends entering a drop, reflects off the back, and bends again on the way out.

A 42° ring. The primary bow forms about 40 to 42° from the point directly opposite the sun.

Why we see arcs. From the ground, that circle's center is below the horizon, so only part of it shows.

Higher sun, smaller arc. When the sun is higher than about 42°, no primary bow is visible from the ground.

The whole ring. From aircraft or other high places, drops below you can complete the circle.

REEL VS. RECORD

- **Note:** 'The horizon blocking the bottom half': you only see half the circle when the sun is on the horizon. The higher the sun, the less of the circle shows, and when the sun is above about 42° , none of it does.
- **Note:** 'They are full circles': the circle is a set of directions centered on the antisolar point. You only see the parts where there are raindrops lit by the sun along those directions.
- **Note:** 'From high vantage points... the entire circle': this needs sunlit drops below you as well, and the sun behind you. Full rings are most often seen from aircraft, or from high above spray or rain.
- **Note:** 'Refracted and reflected light': correct. The primary bow involves two refractions and one internal reflection in each drop, which is why red is on the outside.
- **Not the same as a glory:** the small colored rings sometimes seen around a plane's shadow on cloud are a glory, a different optical effect from a full-circle rainbow.

SOURCES

1. WMO International Cloud Atlas: Primary rainbow: <https://cloudatlas.wmo.int/en/primary-rainbow.html>
2. HyperPhysics (Georgia State University): Primary and secondary rainbows: <https://www.hyperphysics.gsu.edu/hbase/atmos/rbowpri.html>
3. BBC Science Focus: Why are rainbows circular when viewed from an aeroplane?: <https://www.sciencefocus.com/science/why-are-rainbows-circular-when-viewed-from-an-aeroplane>
4. National Geographic Education: Rainbow: <https://education.nationalgeographic.org/resource/rainbow/>

Permalink: <https://detailenjoyer.com/case/around-the-rainbow/> · Last updated Sep 19, 2025



POINT CURIE

The Curie point, or Curie temperature, is named after Pierre Curie. His 1895 thesis, 'Propriétés magnétiques des corps à diverses températures' (Magnetic properties of substances at various temperatures), showed how magnetism changes with temperature. In a ferromagnet such as iron, a quantum effect called exchange interaction lines up the atoms' magnetic moments within small regions called domains. Above the Curie temperature, heat scrambles that alignment. The material loses its spontaneous magnetization and becomes paramagnetic: it's only weakly attracted to a magnet, and only while a field is applied. The Curie temperature is about 770 °C for iron, 358 °C for nickel and about 1,115 °C for cobalt. That's why a red-hot piece of iron stops sticking to a magnet and is attracted again as it cools. Being below the Curie point doesn't automatically make something a permanent magnet. In an ordinary iron nail the domains point in different directions and cancel out, which is why the nail isn't a magnet until it's magnetized. Antiferromagnets have a similar transition called the Néel temperature. The footage shows a torch heating a small metal piece until it glows, while a magnet on a rod hangs above it.

QUICK FACTS

DD-669-F01

Iron's Curie temperature is about 770 °C.

DD-669-F02

Pierre Curie published his findings in 1895.

THE WRITE-UP

Named for Pierre Curie. Pierre Curie's 1895 thesis showed how magnetism changes with temperature.

Domains. In a ferromagnet, atomic moments line up within small regions called domains.

Heat scrambles them. Above the Curie temperature, that alignment breaks down and the material becomes paramagnetic.

The numbers. The Curie temperature is about 770 °C for iron, 358 °C for nickel and about 1,115 °C for cobalt.

Not every iron bar is a magnet. Below the Curie point, domains can still cancel out, so an iron nail isn't a magnet until it's magnetized.

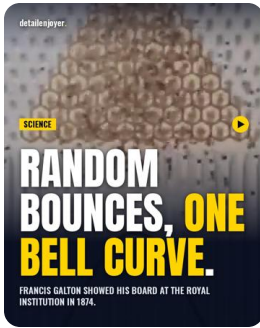
REEL VS. RECORD

- **Note:** 'Loses its permanent magnetism': more precisely, it loses its ferromagnetism, the ability to be strongly magnetized. Many iron objects below the Curie point aren't permanent magnets at all.
- **Note:** 'Creating a stable magnetic field': alignment happens within domains. A piece of iron only makes a net field when its domains are mostly lined up, as in a magnetized bar.
- **Missing numbers:** the Curie temperature is about 770 °C for iron, 358 °C for nickel and about 1,115 °C for cobalt.
- **Note:** 'Becomes paramagnetic': correct. Above the Curie point the material is only weakly attracted to a magnet, which is why the glowing piece in the footage doesn't jump up.
- **Missing:** it's named after Pierre Curie, whose 1895 thesis studied magnetism at different temperatures. The title's 'Point Curie' is my stylized title.

SOURCES

1. Britannica: Curie point: <https://www.britannica.com/science/Curie-point>
2. Pierre Curie (1895): Propriétés magnétiques des corps à diverses températures (Internet Archive): <https://archive.org/details/propritsmagntiq00curigoog>
3. Supermagnete: Curie temperature, explanations and illustrations: <https://www.supermagnete.de/eng/magnetism/Curie-temperature>
4. HyperPhysics (Georgia State University): Ferromagnetism: <http://hyperphysics.phy-astr.gsu.edu/hbase/Solids/ferro.html>

Permalink: <https://detailenjoyer.com/case/point-curie/> · Last updated Nov 5, 2025



DD-588 SCIENCE · 15 OF 34

CENTRAL LIMITS

The Galton board, also called the quincunx or bean machine, has interleaved rows of pegs above a row of bins. Each bead that falls through bounces left or right at each peg. The number of paths to each bin follows Pascal's triangle, so the bead counts follow a binomial distribution. With many rows and many beads, that binomial distribution approaches the normal distribution, the bell curve. That's a special case of the central limit theorem known as the de Moivre–Laplace theorem. Francis Galton designed the board for a Royal Institution discourse on February 27, 1874. He described a two-stage version in an 1877 letter to George Darwin and celebrated the 'Law of Frequency of Error' in his 1889 book *Natural Inheritance*. He used it to illustrate his ideas about heredity and regression toward the mean ('reversion to mediocrity'), ideas that were part of his eugenics. The bell shape isn't automatic. A tilted board or biased pegs shift and skew it, and other peg shapes give other distributions: Jacobus Kapteyn built a board that produces a log-normal curve. Large Galton boards designed by Charles and Ray Eames appeared in the IBM Pavilion at the 1964–65 New York World's Fair. The footage shows a modern desktop Galton board with a printed bell curve, its beads settling into the shape.

QUICK FACTS

DD-588-F01

The number of paths to each bin of a Galton board follows Pascal's triangle.

DD-588-F02

Francis Galton designed his board for a Royal Institution discourse in 1874.

THE WRITE-UP

Left or right. Each bead bounces left or right at every peg, and the bin counts follow a binomial distribution.

Toward the bell. With many rows, the binomial approaches the normal distribution (the de Moivre–Laplace theorem).

Galton's 1874 lecture. Galton designed the board for a Royal Institution discourse on February 27, 1874.

Heredity and eugenics. Galton used it to illustrate regression toward the mean, part of his eugenic ideas.

Not always a bell. Biased pegs or other peg shapes give other distributions, such as Kapteyn's log-normal board.

REEL VS. RECORD

- **Note:** 'Demonstrate the central limit theorem': fair, with one detail. Strictly, it shows the de Moivre–Laplace theorem, the special case where a binomial distribution approaches the normal.
- **Note:** 'Regardless of the underlying random process at each peg': I'd call that an overstatement. The bell needs many roughly independent bounces. A tilted board or biased pegs shift and skew it, and differently shaped pegs can produce other curves, such as Kapteyn's log-normal board.
- **Missing:** Galton designed the board for a lecture on February 27, 1874, and used it to argue about heredity and regression toward the mean, ideas tied to his eugenics.

SOURCES

1. Wikipedia: Galton board: https://en.wikipedia.org/wiki/Galton_board
2. Kunert, Montag & Pöhlmann, The quincunx: history and mathematics, Statistical Papers (2001): <https://doi.org/10.1007/s003620100048>
3. Four Pines Publishing: The Galton Board: <https://www.galtonboard.com/>

Permalink: <https://detailenjoyer.com/case/central-limits/> · Last updated Jun 3, 2025



DD-589 SCIENCE · 16 OF 34

MICROWAVE METAL

A microwave oven's magnetron fills the metal cooking cavity with microwaves at about 2,450 MHz, with a wavelength of about 12 centimeters. Food absorbs them, mostly through its water, fats and sugars. Metal reflects them instead, and a conductor in the cavity acts like an antenna: the oscillating field induces currents and voltages in it. The field is strongest at sharp points, edges, corners and narrow gaps. There it can become strong enough to ionize the surrounding air, which then conducts and glows as a spark or arc, jumping to the oven wall or to another piece of metal. MIT materials scientist Caroline Ross compares it to lightning. That's why a pile of nails or screws, crumpled foil, metal twist ties or gold-trimmed china spark so readily. Smooth, rounded metal is less prone to arcing but not risk-free. The USDA says small amounts of new, smooth foil can be used to shield food, if the manufacturer's manual allows it, the foil is shaped smoothly to the food, and it stays at least an inch from the oven walls. It also says to remove it at once if arcing starts. Arcing can damage the oven and start a fire. The footage shows a heap of nails inside a microwave, sparking and glowing as the plate turns.

QUICK FACTS

DD-589-F01

In a microwave, electric fields concentrate at sharp points and edges of metal.

DD-589-F02

The USDA says to keep shielding foil at least an inch from the oven walls.

THE WRITE-UP

Metal reflects. Food absorbs microwaves, but metal reflects them and acts like an antenna.

Points and edges. The induced electric field is strongest at sharp points, edges and narrow gaps.

Ionized air. A strong enough field ionizes the air, which conducts and glows as an arc.

Wrinkles spark. The USDA warns that wrinkled foil can cause arcing.

Smooth foil, carefully. The USDA says small amounts of smooth foil can shield food, kept an inch from the walls.

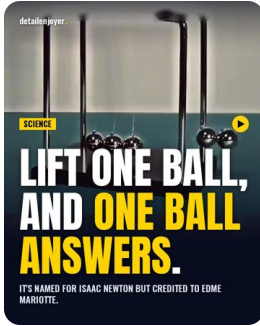
REEL VS. RECORD

- **Note:** 'Smooth metal surfaces like a spoon might reflect microwaves harmlessly': often, but I wouldn't count on it. Smooth metal can still arc near the oven walls or another piece of metal, so the USDA says to follow the oven's manual and stop at once if arcing starts.
- **Note:** Otherwise the Reel's physics is right: the field concentrates at points and edges, ionizes the air and makes an arc.
- **Note:** My Reel vs. Record note: the footage is a heap of nails, which is an extreme exemplar of sharp points. I'm not recommending anyone try it. Arcing can damage the oven and start a fire.

SOURCES

1. MIT School of Engineering: Why can't we put metal objects in a microwave?: <https://engineering.mit.edu/ask-an-engineer/why-cant-we-put-metal-objects-in-a-microwave>
2. Scientific American: Why do metal objects create sparks when placed inside a microwave oven? (1999): <https://www.scientificamerican.com/article/why-do-metal-objects-crea/>
3. USDA FSIS: Cooking with Microwave Ovens (archived 2025): <https://web.archive.org/web/20250502014426/https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/cooking-microwave-ovens>

Permalink: <https://detailenjoyer.com/case/microwave-metal/> · Last updated Jun 5, 2025



DD-286 SCIENCE · 17 OF 34

NEWTONS CRADLE

Newton's cradle is a row of identical metal balls hung from a frame so they just touch. Lift and release one end ball, and after the collision the ball at the far end swings out while the middle ones stay almost still. Pull two, and two swing out. The pattern follows from conservation of momentum and of kinetic energy in nearly elastic collisions: one ball leaving at the same speed is the outcome that satisfies both. Small losses to sound, heat and air resistance make the swings die down. The device is named after Isaac Newton, whose laws explain it, but it's credited to the 17th-century French scientist Edme Mariotte. The footage shows a classic desk cradle with five balls clicking back and forth.

QUICK FACTS

DD-286-F01

Releasing one ball sends one ball out the other end.

DD-286-F02

The cradle is credited to Edme Mariotte.

THE WRITE-UP

Identical balls. A row of identical metal balls hangs so each just touches the next.

One in, one out. Release one end ball, and one ball at the far end swings out.

Two laws at once. Momentum and kinetic energy are both conserved in nearly elastic collisions.

Slowly fading. Sound, heat and air resistance gradually drain the swings.

Named for Newton. The device is named after Isaac Newton but credited to Edme Mariotte.

REEL VS. RECORD

- **Note:** 'Suspended in a straight line by wires': right. Many cradles use two wires or strings per ball in a V shape to keep them in line.
- **Note:** 'Nearly the same speed': right. Small losses to sound and heat make each swing a little lower.

SOURCES

1. Wikipedia: Newton's cradle: https://en.wikipedia.org/wiki/Newton%27s_cradle

Permalink: <https://detailenjoyer.com/case/newtons-cradle/> · Last updated Aug 1, 2024



MAKING PLASMA IN THE MICROWAVE

Plasma is gas in which enough atoms have lost electrons that it conducts electricity and glows. In a microwave oven, plasma usually starts where the field gets concentrated: at sharp metal edges, or in the gap between two grape halves. A 2019 study in PNAS showed the grape effect comes from the fruit acting as a resonator; water-rich spheres trap the microwaves and build a hotspot where they touch, which ionizes the surrounding air. A match flame can do the same by supplying already-ionized gas. Once started, the plasma absorbs microwave energy, rises as a glowing ball and can damage the oven, so I'd treat it as a demonstration, not a kitchen trick. The footage shows a bright, flickering plasma ball inside an inverted glass in a microwave.

QUICK FACTS

DD-287-F01

Plasma is ionized gas that conducts and glows.

DD-287-F02

Grape halves can concentrate microwaves enough to spark plasma.

THE WRITE-UP

Ionized gas. Plasma is gas with enough free electrons to conduct electricity and glow.

Concentrated fields. In a microwave, plasma usually starts at sharp metal edges or between grape halves.

Grapes as resonators. A 2019 study found grapes trap microwaves and build a hotspot where they touch.

A glowing ball. Once started, the plasma absorbs microwave energy and glows as a ball.

Hard on ovens. Microwave plasma can damage the oven, so it's a demonstration, not a kitchen trick.

REEL VS. RECORD

- **Note:** 'Typically created by exciting gases into an ionized state': right. I'd add that it usually needs a starter, such as metal edges, a grape pair or a flame, to concentrate the field.

SOURCES

1. Wikipedia: Plasma (physics): [https://en.wikipedia.org/wiki/Plasma_\(physics\)](https://en.wikipedia.org/wiki/Plasma_(physics))
2. Khattak et al., PNAS (2019): Linking plasma formation in grapes to microwave resonances of aqueous dimers: <https://www.pnas.org/doi/10.1073/pnas.1818350116>

Permalink: <https://detailenjoyer.com/case/making-plasma-in-the-microwave/> · Last updated Aug 2, 2024



GETTING TO THE (BALL)POINT

A ballpoint pen dispenses thick, oil-based ink over a hard ball, usually steel, brass or tungsten carbide, seated in a socket at the tip. As the ball rolls across the paper, it picks up ink from the reservoir on one side and lays it down on the other, while also acting as a cap that keeps the ink inside from drying out. John J. Loud patented a ballpoint on October 30, 1888, for marking leather, but it was too coarse for letters. Hungarian newspaper editor László Bíró, noticing that newspaper ink dried fast and didn't smudge, developed a pen with viscous ink and filed for a British patent on June 15, 1938. He and his brother György later moved to Argentina, where their pens went on sale. The footage shows close-ups of pen tips, the ball and a pen being machined.

QUICK FACTS

DD-304-F01

Ballpoint tips use steel, brass or tungsten carbide balls.

DD-304-F02

László Bíró filed his British patent in 1938.

THE WRITE-UP

Hard ball tip. The ball is usually steel, brass or tungsten carbide.

Rolling ink. As the ball rolls, it carries ink from the reservoir onto the paper.

Thick ink. Ballpoints use viscous, oil-based ink that dries quickly on paper.

Loud's 1888 patent. John J. Loud patented a ballpoint on October 30, 1888.

Bíró's 1938 patent. László Bíró filed for a British patent on June 15, 1938.

REEL VS. RECORD

- **Note:** 'Prevents it from smudging and allows for quick drying': mostly right. The ink is viscous and soaks into paper quickly; I'd still expect some smudging on glossy paper.

SOURCES

1. Wikipedia: Ballpoint pen: https://en.wikipedia.org/wiki/Ballpoint_pen

2. Google Patents: US392046A, Pen (John J. Loud, 1888): <https://patents.google.com/patent/US392046A/en>

Permalink: <https://detailenjoyer.com/case/getting-to-the-ballpoint/> · Last updated Aug 19, 2024



IS WATER STICKY?

Water molecules attract one another through hydrogen bonds. At the surface, molecules have neighbors only below and beside them, so they're pulled inward, and the surface behaves like a stretched film. That's surface tension, and water's is high for a liquid, about 72 millinewtons per meter at room temperature. Attraction between like molecules is called cohesion; attraction to other surfaces, like glass or a plant's xylem walls, is adhesion. Together they drive capillary action. Surface tension shapes drops, lets some insects stand on water and dominates fluid behavior in microgravity, where water forms floating spheres. The footage shows water beading on a coin and drops on surfaces.

QUICK FACTS

DD-296-F01

Surface tension comes from water molecules pulling on each other.

DD-296-F02

Adhesion is attraction to other surfaces.

THE WRITE-UP

Hydrogen bonds. Water molecules attract each other through hydrogen bonds.

A stretched film. Surface molecules are pulled inward, so the surface acts like a film.

Cohesion vs. adhesion. Cohesion is water-to-water attraction; adhesion is attraction to other surfaces.

Capillary action. Cohesion and adhesion together drive capillary action.

In microgravity. Without gravity, surface tension pulls water into spheres.

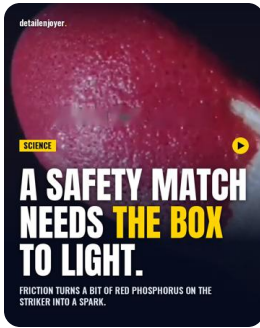
REEL VS. RECORD

- **Note:** 'Water molecules strongly adhere to each other': I'd use 'cohere'. Cohesion is attraction between water molecules; adhesion is attraction to other materials.
- **Note:** 'This adhesive force is crucial...': both cohesion and adhesion matter for water moving up plants.

SOURCES

1. Wikipedia: Surface tension: https://en.wikipedia.org/wiki/Surface_tension

Permalink: <https://detailenjoyer.com/case/is-water-sticky/> · Last updated Aug 11, 2024



DD-300 SCIENCE · 21 OF 34

A REAL HOT HEAD

A safety match head typically contains potassium chlorate as an oxidizer, sulfur and other fuels, ground glass for friction and a binder. The striking strip on the box holds red phosphorus and powdered glass. When the match is struck, friction converts a tiny amount of red phosphorus into white phosphorus, which ignites in air; that heat starts the potassium chlorate decomposing to release oxygen, which burns the sulfur and other fuels in the head and then lights the wood or paper stick. Strike-anywhere matches carry phosphorus sesquisulfide in the head itself. The footage shows close-ups of a match head igniting.

QUICK FACTS

DD-300-F01

Safety matches need the phosphorus on the striker.

DD-300-F02

Potassium chlorate supplies oxygen to the flame.

THE WRITE-UP

The head. A safety match head contains potassium chlorate, sulfur and ground glass.

The striker. The striking strip holds red phosphorus and powdered glass.

The spark. Friction turns a bit of red phosphorus into white phosphorus, which ignites.

Oxygen release. Potassium chlorate releases oxygen that burns the fuels in the head.

Strike anywhere. Strike-anywhere matches have phosphorus sesquisulfide in the head.

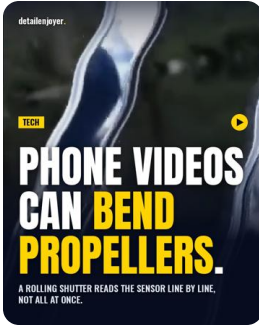
REEL VS. RECORD

- **Note:** 'When struck against a rough surface friction generates heat': for safety matches, I'd add that the key is the red phosphorus on the striking strip, not just any rough surface.

SOURCES

1. Wikipedia: Match: <https://en.wikipedia.org/wiki/Match>

Permalink: <https://detailenjoyer.com/case/a-real-hot-head/> · Last updated Aug 15, 2024



VIDEO TRICKERY

Many CMOS image sensors use a rolling shutter: instead of capturing every pixel at the same instant, they read the frame out row by row, usually top to bottom. When something moves fast during that readout, or the camera itself moves, each row records it at a slightly different moment. The result is skew, wobble ('jello') or strange shapes, like propeller blades that look curved or detached, and flashes that light only part of a frame. A global shutter exposes all pixels at once and avoids this. The footage shows spinning blades and strings distorted on camera.

QUICK FACTS

DD-301-F01

Rolling shutters read the frame row by row.

DD-301-F02

Global shutters expose all pixels at once.

THE WRITE-UP

Row by row. A rolling shutter reads the frame row by row instead of all at once.

CMOS sensors. Many CMOS sensors use a rolling shutter.

Skew and wobble. Fast motion during readout causes skew and wobble.

Odd propellers. Spinning blades can look curved or detached.

Global shutter. A global shutter exposes all pixels at once and avoids the effect.

REEL VS. RECORD

- **Note:** 'Common in cameras with CMOS sensors': right, though I'd add some CMOS sensors now have global shutters.

SOURCES

1. Wikipedia: Rolling shutter: https://en.wikipedia.org/wiki/Rolling_shutter

Permalink: <https://detailenjoyer.com/case/video-trickery/> · Last updated Aug 16, 2024



LINKING UP

Inside thunderstorms, collisions between ice crystals, graupel (soft hail) and supercooled droplets in strong updrafts separate electric charge. Typically the upper cloud becomes positively charged and the middle to lower region negatively charged. When the charge difference grows large enough, the air breaks down and a lightning discharge flashes within the cloud, between clouds, or to the ground. The channel heats the air to around 50,000 °F, and the sudden expansion makes thunder. The footage alternates storm clouds lit by lightning with a dish of metal balls in oil that line up into chains under high voltage, a demonstration of charges linking up, which I read as an exemplar, not lightning itself.

QUICK FACTS

DD-302-F01

Ice and graupel collisions separate charge in storms.

DD-302-F02

Thunder is air expanding from lightning's heat.

THE WRITE-UP

Charge separation. Collisions of ice, graupel and droplets separate charge in storms.

Positive on top. The upper cloud is typically positive and the lower region negative.

Breakdown. When the charge difference is large enough, the air breaks down.

Where it strikes. Lightning can flash in a cloud, between clouds or to the ground.

Thunder. The heated air expands suddenly, making thunder.

REEL VS. RECORD

- **Footage note:** the metal balls chaining in oil are a high-voltage demonstration, not lightning; I treated them as an exemplar.

SOURCES

1. NOAA NSSL: Severe Weather 101: Lightning: <https://www.nssl.noaa.gov/education/svrwx101/lightning/>
2. National Weather Service: Lightning Science overview: <https://www.weather.gov/safety/lightning-science-overview>
3. Wikipedia: Lightning: <https://en.wikipedia.org/wiki/Lightning>

Permalink: <https://detailenjoyer.com/case/linking-up/> · Last updated Aug 17, 2024



DD-113 SCIENCE · 24 OF 34

PLASMA

Plasma is often called the fourth state of matter, after solid, liquid and gas. It forms when a gas is energized enough, by heat or a strong electric field, that electrons are stripped from atoms, leaving a mix of free electrons and positive ions. Because it contains free charges, plasma conducts electricity and responds strongly to magnetic fields. It makes up most of the ordinary visible matter in the universe, including stars like the Sun. On Earth it appears in lightning, auroras, neon and fluorescent lights, and some flames. Plasma physics underpins fusion research and industrial uses such as chip etching. The footage shows plasma balls, lightning, lamps and flames.

QUICK FACTS

DD-113-F01

Plasma is called the fourth state of matter.

DD-113-F02

Electrons are stripped from atoms, leaving ions.

THE WRITE-UP

Fourth state. Plasma is called the fourth state of matter.

Ionized. Electrons are stripped from atoms, leaving ions.

Conducts. It conducts electricity and responds to magnetic fields.

Stars. Most visible ordinary matter, including stars, is plasma.

On Earth. Lightning and fluorescent lights contain plasma.

REEL VS. RECORD

- **Note:** 'Certain types of flames': only the hottest parts of some flames are weakly ionized, so I'd call ordinary flames borderline.

SOURCES

1. Wikipedia: Plasma (physics): https://en.wikipedia.org/wiki/Plasma_%28physics%29

Permalink: <https://detailenjoyer.com/case/plasma/> · Last updated Dec 9, 2023



DD-168 SCIENCE / TECH · 25 OF 34

QUARTZ CRYSTALS

Quartz is silicon dioxide (SiO_2) and one of the most common minerals in Earth's continental crust. It forms hexagonal crystals and comes in many varieties; clear, colorless quartz is called rock crystal. Quartz is piezoelectric: mechanical stress produces an electric charge, and an applied voltage makes it flex. Quartz clocks and watches use this, driving a small crystal resonator, usually tuned to 32,768 Hz, and counting its vibrations to keep time. The footage shows quartz crystals, a demonstration spark and a watch movement, with the presenter.

QUICK FACTS

DD-168-F01

Quartz is silicon dioxide.

DD-168-F02

It's one of the most common minerals in the crust.

THE WRITE-UP

Silicon dioxide. Quartz is silicon dioxide.

Common mineral. It's one of the most common minerals in the crust.

Rock crystal. Clear quartz is called rock crystal.

Piezoelectric. Stress makes quartz produce a charge.

Timekeeping. Quartz watches count a crystal's vibrations.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Quartz: <https://en.wikipedia.org/wiki/Quartz>
2. Wikipedia: Piezoelectricity: <https://en.wikipedia.org/wiki/Piezoelectricity>

Permalink: <https://detailenjoyer.com/case/quartz-crystals/> · Last updated Jan 8, 2024



DD-155 SCIENCE · 26 OF 34

FIREWORKS

Heating certain metals in a flame gives off light of characteristic colors, which is the basis of the flame test in chemistry. Firework makers use metal salts for color: strontium gives red, calcium orange, sodium yellow, barium green and copper blue. Lithium also gives a red flame. Blue is the hardest firework color to make, because copper compounds give a clean blue only in a narrow temperature range. The footage shows flames, fireworks and colored burns, with the presenter.

QUICK FACTS

DD-155-F01

Metals give characteristic flame colors.

DD-155-F02

Strontium gives red.

THE WRITE-UP

Flame test. Metals give characteristic flame colors.

Strontium red. Strontium gives red.

Copper blue. Copper gives blue or green.

Sodium yellow. Sodium gives yellow.

Hard blue. Blue is the hardest firework color.

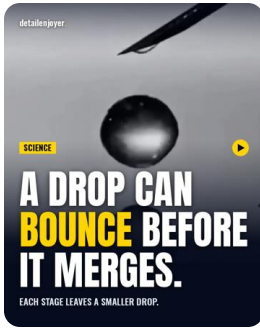
REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Flame test: https://en.wikipedia.org/wiki/Flame_test
2. Wikipedia: Fireworks: <https://en.wikipedia.org/wiki/Fireworks>

Permalink: <https://detailenjoyer.com/case/fire-works/> · Last updated Jan 1, 2024



DD-269 SCIENCE / NATURE · 27 OF 34

CASCADE

When a drop of water lands gently on a pool, a thin film of air can keep it from merging at once, so it appears to bounce. It then partly merges, leaving behind a smaller drop, and this repeats in what is called a coalescence cascade until the drop is fully absorbed. Surface tension holds each drop's shape between the stages. The footage is a slow-motion lab recording of a drop falling from a needle.

QUICK FACTS

DD-269-F01

A thin air film delays merging.

DD-269-F02

Each stage leaves a smaller drop.

THE WRITE-UP

Bounce. A thin air film delays merging.

Partial merge. Each stage leaves a smaller drop.

Cascade. The process repeats.

Surface tension. Surface tension keeps the drop round.

Absorbed. The drop is finally absorbed.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Coalescence (physics): [https://en.wikipedia.org/wiki/Coalescence_\(physics\)](https://en.wikipedia.org/wiki/Coalescence_(physics))

Permalink: <https://detailenjoyer.com/case/cascade/> · Last updated Jul 11, 2024



YOU'RE SPINNING ME AROUND

A gyroscope is a spinning wheel or rotor mounted so its axis can point in any direction. While it spins, it resists changes to the direction of its axis because of the conservation of angular momentum, so it can balance at odd angles and keep its orientation as its base moves. The same principle is used in navigation instruments. The footage shows a toy gyroscope balancing in several positions.

QUICK FACTS

DD-274-F01

A gyroscope has a spinning rotor.

DD-274-F02

Its stability comes from conserved angular momentum.

THE WRITE-UP

Rotor. A gyroscope has a spinning rotor.

Angular momentum. Its stability comes from conserved angular momentum.

Resists change. It resists changes to its axis.

Balance. It can balance at odd angles.

Navigation. Gyroscopes are used in navigation.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Gyroscope: <https://en.wikipedia.org/wiki/Gyroscope>
2. Wikipedia: Angular momentum: https://en.wikipedia.org/wiki/Angular_momentum

Permalink: <https://detailenjoyer.com/case/youre-spinning-me-around/> · Last updated Jul 19, 2024



DD-319 SCIENCE / SPACE · 29 OF 34

THE STRINGS OF FATE

String theory proposes that particles are tiny vibrating strings. Superstring theories require 10 spacetime dimensions, and M-theory, which links them, requires 11. Beyond the three dimensions of space and one of time, the extra dimensions are thought to be compactified, curled up at scales far too small to detect. String theory remains untested by experiment. The footage is an animated tesseract and other higher-dimensional shapes.

QUICK FACTS

DD-319-F01

Particles are modeled as strings.

DD-319-F02

Superstring theory needs 10 dimensions.

THE WRITE-UP

Strings. Particles are modeled as strings.

10 dimensions. Superstring theory needs 10 dimensions.

11 dimensions. M-theory needs 11.

Compactified. Extra dimensions are curled up.

Untested. It is not yet tested by experiment.

REEL VS. RECORD

- **Note:** The Reel says string theory proposes 11 dimensions; superstring theories use 10, and M-theory uses 11.

SOURCES

1. Wikipedia: String theory: https://en.wikipedia.org/wiki/String_theory

2. Wikipedia: M-theory: <https://en.wikipedia.org/wiki/M-theory>

Permalink: <https://detailenjoyer.com/case/the-strings-of-fate/> · Last updated Sep 7, 2024



DD-332 SCIENCE · 30 OF 34

SEE RIGHT THROUGH ME

Borosilicate glass such as Pyrex has a refractive index of about 1.47, close to that of many vegetable oils. When the glass is submerged, light passes from oil to glass with almost no bending or reflection, so the edges our eyes use to see the glass nearly vanish. The footage shows Pyrex objects disappearing as they are lowered into oil.

QUICK FACTS

DD-332-F01

Pyrex has an index of about 1.47.

DD-332-F02

Vegetable oils are similar.

THE WRITE-UP

Index. Pyrex has an index of about 1.47.

Oil. Vegetable oils are similar.

No bending. Light barely bends between them.

Edges. We see glass by its edges.

Vanishes. The glass seems to disappear.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Refractive index: https://en.wikipedia.org/wiki/Refractive_index
2. Wikipedia: Borosilicate glass: https://en.wikipedia.org/wiki/Borosilicate_glass

Permalink: <https://detailenjoyer.com/case/see-right-through-me/> · Last updated Sep 27, 2024



DD-345 SCIENCE · 31 OF 34

SUDSY

Soap is made by saponification, reacting fats or oils with a strong base to make fatty acid salts and glycerol. Each soap molecule has a water-attracting head and an oil-attracting tail. In water the tails gather around grease and germs, forming micelles with the dirt inside, which rinse away. The footage shows microscope imagery.

QUICK FACTS

DD-345-F01

Soap is made by saponification.

DD-345-F02

The head is hydrophilic.

THE WRITE-UP

Made by. Soap is made by saponification.

Head. The head is hydrophilic.

Tail. The tail is hydrophobic.

Micelles. Micelles trap grease.

Rinse. Micelles wash away.

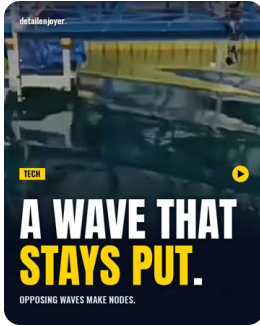
REEL VS. RECORD

- **Note:** The Reel says soap cleans by saponification; saponification is how soap is made, while cleaning works through micelles.

SOURCES

1. Wikipedia: Soap: <https://en.wikipedia.org/wiki/Soap>
2. Wikipedia: Micelle: <https://en.wikipedia.org/wiki/Micelle>

Permalink: <https://detailenjoyer.com/case/sudsy/> · Last updated Oct 15, 2024



DD-356 TECH / SCIENCE · 32 OF 34

COMPUTER WAVE CONTROL

A standing wave forms when two waves of equal amplitude and frequency travel in opposite directions and interfere. Points that never move are nodes and points of maximum motion are antinodes. Computer-controlled wave generators in test tanks and wave pools can time their paddles precisely enough to build these patterns. The footage shows a pool with synchronized wave makers.

QUICK FACTS

DD-356-F01

Opposing waves combine.

DD-356-F02

Nodes do not move.

THE WRITE-UP

Two waves. Opposing waves combine.

Nodes. Nodes do not move.

Antinodes. Antinodes move most.

Control. Computers time the paddles.

Uses. Research and recreation.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Standing wave: https://en.wikipedia.org/wiki/Standing_wave
2. Wikipedia: Wave pool: https://en.wikipedia.org/wiki/Wave_pool

Permalink: <https://detailenjoyer.com/case/computer-wave-control/> · Last updated Oct 28, 2024



DD-394 SCIENCE · 33 OF 34

ACOUSTIC LEVITATION

In acoustic levitation, ultrasonic transducers send sound toward a reflector or an opposing transducer, creating a standing wave with alternating high- and low-pressure regions. Small objects such as water droplets settle at the pressure nodes, where acoustic radiation pressure balances gravity. The footage shows droplets floating in a levitator.

QUICK FACTS

DD-394-F01

Ultrasound is used.

DD-394-F02

Reflected sound makes a standing wave.

THE WRITE-UP

Sound. Ultrasound is used.

Standing wave. Reflected sound makes a standing wave.

Nodes. Droplets sit at nodes.

Balance. Radiation pressure balances gravity.

Small. Works for small objects.

REEL VS. RECORD

- **Note:** None needed.

SOURCES

1. Wikipedia: Acoustic levitation: https://en.wikipedia.org/wiki/Acoustic_levitation
2. Wikipedia: Standing wave: https://en.wikipedia.org/wiki/Standing_wave

Permalink: <https://detailenjoyer.com/case/acoustic-levitation/> · Last updated Nov 27, 2024



VIDEO TRICKERY II

A camera records a series of still frames at a set frame rate. If a helicopter's blades rotate by exactly one blade spacing, or a whole turn, between frames, each frame catches them in the same position and they appear frozen, a stroboscopic effect also called the wagon-wheel effect. Rolling shutter is a different effect that bends fast-moving blades. The footage shows a flying helicopter with apparently still rotors.

QUICK FACTS

DD-461-F01

Video is still frames.

DD-461-F02

Rotation matches frame rate.

THE WRITE-UP

Frames. Video is still frames.

Sync. Rotation matches frame rate.

Effect. Wagon-wheel effect.

Rolling shutter. A different distortion.

Appearance. Blades look still.

REEL VS. RECORD

- **Note:** The Reel calls this the rolling shutter effect; frozen blades come from the stroboscopic wagon-wheel effect, while rolling shutter bends or warps them.

SOURCES

1. Wikipedia: Wagon-wheel effect: https://en.wikipedia.org/wiki/Wagon-wheel_effect

2. Wikipedia: Rolling shutter: https://en.wikipedia.org/wiki/Rolling_shutter

Permalink: <https://detailenjoyer.com/case/video-trickery-ii/> · Last updated Jan 17, 2025

COLLECTION QUIZ

Test Your Knowledge: 68 questions from Everyday Physics. Answers are on the next page.

1. In the Marangoni effect, which way does liquid flow? (DD-024 · Marangoni Motion)

- A. From high to low surface tension
- B. From low to high surface tension
- C. Only downhill
- D. Only toward heat

2. Which everyday sight is a classic example of the Marangoni effect? (DD-024 · Marangoni Motion)

- A. Rainbows
- B. 'Tears' running down a wine glass
- C. Ice floating
- D. Boiling water

3. What are the two main ways inkjet printheads eject ink? (DD-005 · Print Precision)

- A. Laser and toner
- B. Thermal bubbles and piezoelectric elements
- C. Magnets and springs
- D. Compressed air and vacuum

4. How small can Epson's Micro Piezo inkjet drops be? (DD-005 · Print Precision)

- A. 1.5 picoliters
- B. 1.5 milliliters
- C. 1.5 microliters
- D. 1.5 liters

5. In water, light travels at roughly what fraction of its speed in a vacuum? (DD-020 · Cherenkov Glow)

- A. About 25%
- B. About 75%
- C. About 99.9%
- D. About 150%

6. Cherenkov radiation is often compared to which everyday effect? (DD-020 · Cherenkov Glow)

- A. A rainbow
- B. An echo
- C. A sonic boom
- D. Static electricity

7. Which park is home to Mexico's 'tilted town'? (DD-035 · Tilted Town)

- A. Xcaret
- B. Xplor
- C. Xenses
- D. Xel-Há

8. What city is Xenses actually right next to? (DD-035 · Tilted Town)

- A. Mexico City
- B. Playa del Carmen
- C. Tulum
- D. Mérida

9. What holds powder on the part before curing? (DD-051 · Static Spray)

- A. Glue
- B. Electrostatic charge
- C. Magnets
- D. Water

10. What turns the loose powder into a hard coating? (DD-051 · Static Spray)

- A. Air drying
- B. A curing oven
- C. UV light
- D. Freezing

11. Which torque converter part is driven by the engine? (DD-075 · Torque Conversion)

- A. Turbine
- B. Impeller
- C. Stator
- D. Lock-up clutch

12. What does the stator do? (DD-075 · Torque Conversion)

- A. Cools the oil
- B. Redirects returning fluid to multiply torque
- C. Shifts gears
- D. Starts the engine

13. What carries current through salt water? (DD-073 · Liquid Lights)

- A. Free electrons
- B. Dissolved ions
- C. Photons
- D. Water molecules

14. Theoretical conductivity of pure water at 25 °C? (DD-073 · Liquid Lights)

- A. Exactly zero
- B. 0.055 $\mu\text{S}/\text{cm}$
- C. 1 mS/cm
- D. 0.053 S/cm

15. In which kind of wave was branched flow first observed? (DD-739 · Branched Flow)

- A. Light
- B. Electrons
- C. Sound
- D. Gravity waves

16. When was branched flow of light first reported? (DD-739 · Branched Flow)

- A. 1905
- B. 1970
- C. 2020
- D. 2025

17. What does COR compare? (DD-695 · Golf Balling)

- A. Rebound speed to impact speed
- B. Weight to size
- C. Spin to height
- D. Dimples to cover area

18. What initial-velocity limit do the rules set (before tolerance)? (DD-695 · Golf Balling)

- A. 150 ft/s
- B. 250 ft/s
- C. 350 ft/s
- D. 500 ft/s

19. When does a crane tip over? (DD-687 · Counter Crane)

- A. When overturning moment exceeds stabilizing moment
- B. When the load is over 10 t
- C. When the boom is vertical
- D. When the engine stalls

20. What do the '10 t' slabs in the footage show? (DD-687 · Counter Crane)

- A. Counterweight mass
- B. Boom length
- C. Fuel capacity
- D. Hook speed

21. Why does sunscreen look dark on a UV camera? (DD-654 · UV Face)

- A. It stops UV light coming back from the skin
- B. It's dyed black
- C. It absorbs visible light
- D. The camera is faulty

22. About how much UV do zinc oxide and titanium dioxide reflect? (DD-654 · UV Face)

- A. About 4-5%
- B. About 50%
- C. About 95%
- D. None

23. What makes a cloud-chamber track? (DD-623 · Cloud Chambers)

- A. Droplets condensing on ions
- B. Light given off by the particle
- C. Sparks between wires
- D. Bubbles in boiling liquid

24. Why are the tracks visible? (DD-623 · Cloud Chambers)

- A. A lamp lights the droplets
- B. The droplets glow
- C. The vapor is radioactive
- D. The walls fluoresce

25. About how far from the antisolar point does the primary rainbow form? (DD-651 · Around the Rainbow)

- A. About 42°
- B. About 4°
- C. About 90°
- D. About 180°

26. Where is the antisolar point? (DD-651 · Around the Rainbow)

- A. Directly opposite the sun
- B. At the sun
- C. Straight overhead
- D. Due north

27. Who is the Curie point named after? (DD-669 · Point Curie)

- A. Pierre Curie
- B. Marie Curie
- C. Ève Curie
- D. Irène Joliot-Curie

28. About what is iron's Curie temperature? (DD-669 · Point Curie)

- A. About 770 °C
- B. About 77 °C
- C. About 7,700 °C
- D. About 0 °C

29. What does a bead do at each peg of a Galton board? (DD-588 · Central Limits)

- A. Bounces left or right
- B. Stops
- C. Splits in two
- D. Rolls back up

30. What shape do the beads form with many rows and beads? (DD-588 · Central Limits)

- A. A bell curve
- B. A straight line
- C. A spiral
- D. A U shape

31. What does metal do to microwaves? (DD-589 · Microwave Metal)

- A. Reflects them
- B. Absorbs all of them
- C. Slows them to a stop
- D. Turns them into light

32. Where is the electric field on metal strongest? (DD-589 · Microwave Metal)

- A. At sharp points and edges
- B. At the center of flat sheets
- C. Inside hollow tubes
- D. Nowhere in particular

33. How are the balls arranged? (DD-286 · Newtons Cradle)

- A. Touching in a row
- B. Stacked vertically
- C. Spread far apart
- D. In a circle

34. What happens when one end ball is released? (DD-286 · Newtons Cradle)

- A. One ball swings out the far end
- B. All balls swing
- C. Nothing moves
- D. The middle ball jumps

35. What is plasma? (DD-287 · Making Plasma in the Microwave)

- A. Ionized gas
- B. Superheated water
- C. A type of metal
- D. Liquid light

36. Where does microwave plasma usually start? (DD-287 · Making Plasma in the Microwave)

- A. At sharp metal edges or between grape halves
- B. In the oven's fan
- C. In the door glass
- D. Anywhere at random

37. What are ballpoint balls usually made of? (DD-304 · Getting to the (Ball)Point)

- A. Steel, brass or tungsten carbide
- B. Glass
- C. Plastic
- D. Gold

38. How does the ink reach the paper? (DD-304 · Getting to the (Ball)Point)

- A. The rolling ball carries it
- B. Gravity drips it
- C. A pump sprays it
- D. A felt wick spreads it

39. What attracts water molecules to each other? (DD-296 · Is Water Sticky?)

- A. Hydrogen bonds
- B. Magnetism
- C. Gravity
- D. Static from air

40. Why does the surface act like a film? (DD-296 · Is Water Sticky?)

- A. Surface molecules are pulled inward
- B. Air pushes down
- C. Dust forms a layer
- D. Light hardens it

41. What oxidizer is in a match head? (DD-300 · A Real Hot Head)

- A. Potassium chlorate
- B. Table salt
- C. Baking soda
- D. Sugar

42. What's on a safety match's striker? (DD-300 · A Real Hot Head)

- A. Red phosphorus and glass
- B. Sulfur only
- C. Sandpaper only
- D. Magnesium

43. How does a rolling shutter read a frame? (DD-301 · Video Trickery)

- A. Row by row
- B. All at once
- C. Randomly
- D. By color

44. Which sensors commonly use rolling shutters? (DD-301 · Video Trickery)

- A. CMOS
- B. Film
- C. Vacuum tubes
- D. Mirrors

45. What separates charge in storm clouds? (DD-302 · Linking Up)

- A. Collisions of ice, graupel and droplets
- B. Sunlight
- C. Wind on the ground
- D. Magnetism

46. Which part of the cloud is usually positive? (DD-302 · Linking Up)

- A. The top
- B. The bottom
- C. The middle only
- D. None

47. What is plasma often called? (DD-113 · Plasma)

- A. The fourth state of matter
- B. A liquid
- C. A solid
- D. A vacuum

48. What happens to atoms in plasma? (DD-113 · Plasma)

- A. Electrons are stripped
- B. They freeze
- C. They vanish
- D. They merge

49. What is quartz made of? (DD-168 · Quartz Crystals)

- A. Silicon and oxygen
- B. Carbon
- C. Iron and sulfur
- D. Aluminum

50. How common is quartz? (DD-168 · Quartz Crystals)

- A. Very common in the crust
- B. Extremely rare
- C. Only in meteorites
- D. Only underwater

51. What produces firework colors? (DD-155 · Fire Works)

- A. Metal salts
- B. Food dye
- C. Paint
- D. Glass

52. Which metal gives red? (DD-155 · Fire Works)

- A. Strontium
- B. Copper
- C. Sodium
- D. Barium

53. What is the process called? (DD-269 · CASCADE)

- A. A coalescence cascade
- B. Evaporation
- C. Condensation
- D. Sublimation

54. Why does the drop bounce? (DD-269 · CASCADE)

- A. A thin air film
- B. Magnetism
- C. Heat
- D. Wind

55. What principle keeps a gyroscope steady? (DD-274 · You're Spinning Me Around)

- A. Conservation of angular momentum
- B. Magnetism
- C. Buoyancy
- D. Friction

56. What does it resist? (DD-274 · You're Spinning Me Around)

- A. Changes to its axis
- B. Gravity entirely
- C. Heat
- D. Light

57. What are particles in string theory? (DD-319 · The Strings of Fate)

- A. Vibrating strings
- B. Tiny balls
- C. Waves of sound
- D. Magnets

58. How many dimensions does M-theory use? (DD-319 · The Strings of Fate)

- A. 11
- B. 4
- C. 26
- D. 3

59. Why does Pyrex vanish in oil? (DD-332 · See Right Through Me)

- A. Similar refractive index
- B. It dissolves
- C. It melts
- D. It is painted

60. About what is Pyrex's index? (DD-332 · See Right Through Me)

- A. 1.47
- B. 1.00
- C. 2.42
- D. 3.50

61. How is soap made? (DD-345 · Sudsy)

- A. Saponification
- B. Distillation
- C. Fermentation
- D. Smelting

62. What traps grease? (DD-345 · Sudsy)

- A. Micelles
- B. Bubbles only
- C. Salt
- D. Heat

63. What forms a standing wave? (DD-356 · Computer Wave Control)

- A. Two opposing waves
- B. One wave
- C. Wind
- D. Rain

64. What are still points called? (DD-356 · Computer Wave Control)

- A. Nodes
- B. Peaks
- C. Troughs
- D. Crests

65. What lifts the droplets? (DD-394 · Acoustic Levitation)

- A. Sound
- B. Magnets
- C. Air jets
- D. Strings

66. Where do droplets sit? (DD-394 · Acoustic Levitation)

- A. At pressure nodes
- B. On the transducer
- C. On the floor
- D. Randomly

67. What is frame rate measured in? (DD-461 · Video Trickery II)

- A. Frames per second
- B. Meters
- C. Volts
- D. Hertz only

68. Why do blades look still? (DD-461 · Video Trickery II)

- A. Rotation matches frame rate
- B. They stop
- C. Camera is broken
- D. Wind

ANSWER KEY

1. **B. From low to high surface tension** Now You Know: Higher-tension regions pull harder, so fluid flows from low toward high surface tension. (DD-024)
2. **B. 'Tears' running down a wine glass** Now You Know: Alcohol evaporating from the film raises its surface tension and pulls wine up the glass. (DD-024)
3. **B. Thermal bubbles and piezoelectric elements** Now You Know: Thermal heads boil ink into a bubble; piezo heads flex a crystal to squeeze it out. (DD-005)
4. **A. 1.5 picoliters** Now You Know: As small as 1.5 picoliters, one-and-a-half trillionths of a liter. (DD-005)
5. **B. About 75%** Now You Know: Light slows to about 75% of its vacuum speed in water, so fast particles can outrun it there. (DD-020)
6. **C. A sonic boom** Now You Know: It's a 'shockwave' of light, the optical version of a sonic boom. (DD-020)
7. **C. Xenses** Now You Know: El Pueblo is part of Xenses, Grupo Xcaret's sensory park. (DD-035)
8. **B. Playa del Carmen** Now You Know: It's just past Playa del Carmen, about 74 km from Cancún. (DD-035)
9. **B. Electrostatic charge** Now You Know: Charged powder is attracted to the grounded part and stays put. (DD-051)
10. **B. A curing oven** Now You Know: It's baked at about 325–450 °F, where it melts and cross-links. (DD-051)
11. **B. Impeller** Now You Know: The impeller pumps fluid into the turbine. (DD-075)
12. **B. Redirects returning fluid to multiply torque** Now You Know: It turns the returning flow so it helps the impeller. (DD-075)
13. **B. Dissolved ions** Now You Know: Salts split into positive and negative ions. (DD-073)
14. **B. 0.055 $\mu\text{S}/\text{cm}$** Now You Know: It comes from water splitting slightly into ions. (DD-073)
15. **B. Electrons** Now You Know: It was first seen for electrons, then microwaves. (DD-739)
16. **C. 2020** Now You Know: In Nature in 2020. (DD-739)
17. **A. Rebound speed to impact speed** Now You Know: Speed after the collision divided by speed before it. (DD-695)
18. **B. 250 ft/s** Now You Know: 250 ft/s, plus a 2% tolerance. (DD-695)
19. **A. When overturning moment exceeds stabilizing moment** Now You Know: It's a balance of moments. (DD-687)
20. **A. Counterweight mass** Now You Know: Each counterweight slab's mass. (DD-687)
21. **A. It stops UV light coming back from the skin** Now You Know: Sunscreen stops most UV, so little comes back to the camera. (DD-654)
22. **A. About 4-5%** Now You Know: About 4-5%. (DD-654)
23. **A. Droplets condensing on ions** Now You Know: Vapor condenses on the ions a charged particle leaves behind. (DD-623)

24. **A. A lamp lights the droplets** Now You Know: The droplets scatter light; they don't glow. (DD-623)
25. **A. About 42°** Now You Know: About 40 to 42°. (DD-651)
26. **A. Directly opposite the sun** Now You Know: Where the shadow of your head falls. (DD-651)
27. **A. Pierre Curie** Now You Know: His 1895 thesis. (DD-669)
28. **A. About 770 °C** Now You Know: Nickel's is about 358 °C. (DD-669)
29. **A. Bounces left or right** Now You Know: The counts follow a binomial distribution. (DD-588)
30. **A. A bell curve** Now You Know: The normal distribution. (DD-588)
31. **A. Reflects them** Now You Know: Food absorbs them; metal reflects them. (DD-589)
32. **A. At sharp points and edges** Now You Know: That's where arcs start. (DD-589)
33. **A. Touching in a row** Now You Know: They hang so each just touches the next. (DD-286)
34. **A. One ball swings out the far end** Now You Know: Two in gives two out. (DD-286)
35. **A. Ionized gas** Now You Know: Free electrons make it conduct and glow. (DD-287)
36. **A. At sharp metal edges or between grape halves** Now You Know: Those spots concentrate the field. (DD-287)
37. **A. Steel, brass or tungsten carbide** Now You Know: They have to resist wear. (DD-304)
38. **A. The rolling ball carries it** Now You Know: The ball also seals the reservoir. (DD-304)
39. **A. Hydrogen bonds** Now You Know: That's the root of surface tension. (DD-296)
40. **A. Surface molecules are pulled inward** Now You Know: They lack neighbors above. (DD-296)
41. **A. Potassium chlorate** Now You Know: It releases oxygen. (DD-300)
42. **A. Red phosphorus and glass** Now You Know: That's why safety matches need the box. (DD-300)
43. **A. Row by row** Now You Know: Usually top to bottom. (DD-301)
44. **A. CMOS** Now You Know: Many phone cameras do. (DD-301)
45. **A. Collisions of ice, graupel and droplets** Now You Know: Strong updrafts drive it. (DD-302)
46. **A. The top** Now You Know: The lower region is negative. (DD-302)
47. **A. The fourth state of matter** Now You Know: After solid, liquid and gas. (DD-113)
48. **A. Electrons are stripped** Now You Know: Leaving ions. (DD-113)
49. **A. Silicon and oxygen** Now You Know: SiO₂. (DD-168)
50. **A. Very common in the crust** Now You Know: Among the most common minerals. (DD-168)
51. **A. Metal salts** Now You Know: Heated in the burst. (DD-155)
52. **A. Strontium** Now You Know: Lithium too. (DD-155)
53. **A. A coalescence cascade** Now You Know: Stage after stage. (DD-269)
54. **A. A thin air film** Now You Know: Air must drain away. (DD-269)

- 55. **A. Conservation of angular momentum** Now You Know: A spinning rotor. *(DD-274)*
- 56. **A. Changes to its axis** Now You Know: While spinning. *(DD-274)*
- 57. **A. Vibrating strings** Now You Know: One-dimensional. *(DD-319)*
- 58. **A. 11** Now You Know: Superstrings use 10. *(DD-319)*
- 59. **A. Similar refractive index** Now You Know: Light bends alike. *(DD-332)*
- 60. **A. 1.47** Now You Know: Borosilicate. *(DD-332)*
- 61. **A. Saponification** Now You Know: Fat plus base. *(DD-345)*
- 62. **A. Micelles** Now You Know: Clusters. *(DD-345)*
- 63. **A. Two opposing waves** Now You Know: Interference. *(DD-356)*
- 64. **A. Nodes** Now You Know: No motion. *(DD-356)*
- 65. **A. Sound** Now You Know: Ultrasound. *(DD-394)*
- 66. **A. At pressure nodes** Now You Know: Quiet points. *(DD-394)*
- 67. **A. Frames per second** Now You Know: FPS. *(DD-461)*
- 68. **A. Rotation matches frame rate** Now You Know: Sync. *(DD-461)*

NOW YOU KNOW!