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SCIENCE STORMS
DESCRIPTIONS OF HANDS-ON EXPERIENCES and EXPERIMENTS

The Museum of Science and Industry, Chicago's *Science Storms* exhibit uses natural phenomena to explore basic chemistry and physics principles in a dynamic, hands-on way.

As a guest in the exhibit, you'll take part in over 50 amazing experiments and activities that allow you to *wonder, observe, speculate, investigate* and *discover* how the natural world works.
Large-scale and engaging videos in each section allow you to see amazing forces of nature in action and hear from real scientists working in the field. Modern-day and historic artifacts—some of which have been used to research scientific principles, and others that are the result of such research—are on display to offer added understanding.

Below, you'll learn more about the exhibit's key interactive experiences that Museum of Science and Industry, with the help of its lead design partner, Evidence Design of Brooklyn, New York, has created—they take two floors and more than 26,000-square-feet to contain! Believe it or not, the content below is just a taste of what's in store in *Science Storms …*

Avalanches and Motion

Avalanches—or flows of granular material—offer stunning examples of how forces such as friction and gravity can act on an object, affecting its motion.

You'll observe friction, acceleration and gravity revealing themselves on a large scale and in beautiful fashion in the **avalanche disk.** Turn the 20-foot disk to see cascading patterns of granules change as you adjust the speed of the disk. One grain by itself is a solid, but many grains together can behave like a solid, a liquid or even a gas. You'll observe and control the rotation of the disk's changing surface in order to explore basic concepts about these states of matter.

From the Balcony Level, use an **avalanche cam** to take video images of the spectacular patterns inside the rotating disk.

Also in this area, you'll also be inspired by a series of activities that allow you to discover the behaviors of granular materials and the forces that act on them.

Explore snow avalanches and make them flow down a virtual mountainside under different kinds of physical and environmental conditions.

Experiment with granular materials at four consoles. At each, choose from a selection of four transparent containers filled with different types of granular materials, i.e., different sized beads, and shake, vibrate and tilt the containers to understand how granular substances shear, flow, jam, mix, pack, rise and sink. You'll be able to record your results and see how the different sizes and shapes of the grains produce some surprising outcomes.

Discover how stress is distributed in a granular system when you rotate a circular container of small photoelastic disks. You'll see networks of streaks of light that are brightest where the disks are under stress. These lighted streaks are called **force chains** because they show the complex forces at work within a mass of moving granules.

Five other interactives focus on aspects of motion:

The force of friction slows moving objects down at different rates depending on the surfaces in contact and not the area, a phenomenon that has been studied since the time of Leonardo da Vinci. Experience **Leonardo's experiments in friction** in a modern challenge with hockey pucks, each with different frictional properties.

French scientist Jean Bernard Leon Foucault discovered in 1851 that the Earth rotates on an axis by using a pendulum. Observe as a large **Foucault pendulum** swings and makes contact with closely spaced pins attached to the floor. A pin falls approximately every 22.5 minutes when hit by the pendulum, and proves that the Earth is rotating.

On the Balcony Level, interact with a **giant Newton's cradle**, an oversized version of the popular desktop device, to explore the phenomena of momentum, collisions and energy transfer. Observe how colliding objects transfer energy and momentum from one to the next, demonstrating Newton's third law: For every action there is an equal and opposite reaction.

Investigate the forces of gravity in a fun recreation of **Galileo's historic inclined plane experiment.** Set three different angles of the track and then trigger the release of a ball from each angle. Prior to each release, you'll speculate what the ball's location will be at half the total time it takes the ball to reach the bottom of the track. You'll prove that objects rolling down an inclined plane accelerate at a constant rate due to gravity.

Ready, aim, fire! Use launchers to **fire tennis balls across the exhibit** hall to **explore the physics of projectile motion.** Projectiles follow a parabolic path, or an arch-shaped trajectory, due to gravity, making it possible for people like athletes and scientists to predict the trajectory based on initial angle and velocity. In this interactive, you set the launch speed and angle and then let tennis balls fly from both sides of Allstate Court, aiming for a net on the opposite side. On a display monitor, a system tracks and measures the motion of the projectiles. You'll also learn a few tips as you are coached about the importance of the parabola … in the perfect jump shot.

Tornados and Vortices

Tornados form due to a combination of physical conditions that can be isolated and studied. In this area, **be blown away by a 40-foot tornado**—a vortex of swirling, illuminated vapor rising continuously from the floor. Control panels surrounding the vortex allow you to manipulate the air column's dynamics and direct lasers to cut through cross-sections to reveal smooth and chaotic (laminar and turbulent) air flow.

Interactive exhibits surrounding this tornado break the phenomenon into its basic components and allow guests to experiment with the physical principles of pressure, volume and temperature and their effects on gases.

Make your own **miniature air vortex** by activating a fogger, an exhaust fan and positioning small walls to see your vortex form!

Challenge yourself in a **four-player storm chaser simulation** game that arms you with radar and other tools as you "chase" a tornado and measure its properties. Teams of scientists use high-tech equipment to chase tornados and collect data, which allows them to gain new knowledge about how, when and where tornados form.

Heat the air inside **two giant hot air balloons** and observe each balloon's heat profile with a thermal camera. Discover that the hot air inside the balloons cause them to rise three stories … and then cool and sink. This demonstrates the principle of convection: the idea that hot air rises and cold air sinks, leading to a circular current of air. Convection contributes to the movement of hot air balloons and the flow of air in a tornado.

Explore air pressure, a primary physical mechanism that contributes to tornado, as you play with a series of lightweight rubber balls of different sizes. Place them over nozzles of blowing air, **floating the balls in mid-air.** Choose from different balls, tilt the air nozzles and adjust the force of air to observe the results. You'll discover that in a moving column of air, the air pressure is lowest where the wind speed is highest, according to the Bernoulli principle. This explains what causes objects, like these balls, to be lifted up.

The winds associated with tornados have tremendous power. Step into a **wind tunnel booth** on the Balcony Level and experience the wonder of tornado-scale winds. You can test wind speeds up to 80 miles per hour!

View a **turtle probe.** This contemporary artifact, used by storm chaser Tim Samaras, was deployed in June of 2003 into the F4 Manchester tornado. The tornado hit the probe full on with wind speeds estimated to be up to 260 mph. The direct hit resulted in the probe recording the lowest barometric pressure drop ever recorded, 100 millibars. (This is equivalent to catapulting 100 stories in 10 seconds!)

Tsunamis and Waves

Energy can be moved from place to place, through space or materials such as water, in the form of a wave. In this area, learn about the power and motion of waves and their fundamental properties.

Scientists try to explain and predict tsunamis through the study of wave behavior—from the deep ocean to the shoreline. Tsunami waves carry a tremendous amount of energy across long distances, and they can be studied using tools such as wave tanks. In the exhibit's **30-foot wave tank**, unleash your own tsunami and investigate its impact on different coastal environments. Or trigger regular ocean waves. Then use a high-speed camera to record and play back the wave activity to learn about its energy and how it moves differently across different coastlines.

Discover how waves interact with objects and other waves when you set them in motion. With the turn of a dial, create controlled and beautiful patterns on the surface of three **large ripple tanks,** suspended from the balcony. You'll explore the phenomena of diffraction, reflection, diffusion and interference within the different tanks.

All waves can be described by their amplitude, frequency, and wavelength, allowing a direct comparison of different waves. An **interactive wave form light sculpture**, created by artist Paul Frielander, demonstrates the fundamental characteristics of waves in a dramatic way. A 20-foot-tall oscillating rope**,** illuminated with colored light, creates various traveling waves when you adjust its vibration frequency. Video light patterns projected on the moving rope accentuate the regular and chaotic motion and create a work of art—a dynamic sculptural waveform.

View a giant **DART buoy** (Deep-Ocean Assessment and Reporting of Tsunami). This buoy, decommissioned by the National Oceanographic Association (NOAA) in 2008, demonstrates a modern tool for detecting tsunamis and transmitting warnings. The buoy on display recorded a tsunami resulting from an 8.3-magnitude earthquake in the Kuril Islands in Russia.

Sunlight and Rainbows

Scientists have studied visible light for centuries, advancing our knowledge of its behaviors and properties and developing a variety of applications for light. The energy in sunlight can be converted to heat and electricity that can be used to power an enormous range of devices.

The dramatic presence of natural sunlight in the exhibit hall—introduced into the space from a heliostat mirror system on the Museum roof—invites you to wonder at the physical properties and behaviors of light: how it is produced, bends, bounces, transmits and interferes. A recreation of **Newton's famous prism experiment**, in which he discovered that white light can be split into a rainbow of color, allows you to **create a rainbow** and see it soar above you.

Examine the sun as a dynamic energy source through hands-on experiments. Convert **sunlight to electricity** with photovoltaics and power cars driving around a track. Or use a special lens, called a Fresnel lens, to use **sunlight to heat** pools of water. Observe your progress with a thermal camera.

Light interacts with objects in unique and beautiful ways that have inspired scientists and artists for centuries. **Experiment with the visible light spectrum** and the reflection, diffraction and transmittance of light with devices that manipulate it, including a partially mirrored glass cube with a small motor as well as dichroic glass plates, which cause the light to be split up into distinct beams of different wavelengths (colors). Light can reflect off of surfaces in a specific way called total internal reflection, which can be used to transmit information through fiber optic cables. Create magnified silhouettes and learn about fiber-optic technology with the **fiber optic wall**.

Different wavelengths of light combine with each other and interact with objects to create the colors we perceive. Step into the translucent **color room** and manipulate "sliders" to add or subtract different wavelengths of blue, green and red light. In doing so, you'll create a spectrum of colors within the room and get some surprising results.

Lightning, Charge and Magnetism
An enormous **20-foot Tesla Coil,** suspended overhead, will draw you into the spectacle and science of electrical charge and magnetism. A build-up and release of electrical energy in the coil allows you to experience the sight, sound and power of a high-voltage lightning strike twice an hour. As you see this amazing lightning overhead, learn about moving electrical charges and the basic properties of electromagnetism in facilitated programs.

Test variations of historic machines to explore the nature of electricity. Place your hands on a plasma ball, which demonstrates the flow of electrical charges similar to that of lightning, to attract the ribbons of light charge. **Rotate the handle of a Wimshurst machine** to generate static and a loud discharge of sparks.

The interaction of electricity and magnetism—two aspects of the same force —can result in motion that is applied in modern-day devices such as electrical motors and maglev trains. Investigate this firsthand when you **launch a metal ring 20 feet** into the air using electrical currents that create opposing magnetic fields.

An **interactive maglev train activity** lets you build your own model train from a kit of parts, race it on a linear track and learn the basics of magnetic levitation and propulsion.

View the **apparatus used in Millikan's Oil Drop Experiment**, considered one of the most important scientific experiments in history. Millikan designed and used this to measure the charge of a single electron for the very first time, and won the Nobel Prize in 1923 for this experiment. See an **armored lodestone,** a naturally occurring magnet, **actually used by Galileo** in his experiments. The lodestone, circa 1609, was encased with iron and used by Galileo for his studies on magnets.

Fire and Combustion

Fire has inspired scientists to study combustion for centuries, resulting in new knowledge and strategies for fighting and suppressing fires. Fire forms due to a chemical reaction of fuel, oxygen and heat. It responds to varying conditions, and these conditions can be manipulated and studied.

Wage a battle of fire vs. water in a **live-fire experiment**, based upon laboratory test of a sprinkler system. Adjust a live flame, 12-18 inches high, in the center of a fireproof glass enclosure. Then manipulate the flame by turning on an overhead "sprinkler" system that creates a water mist. You can control the characteristics of the flame by adjusting the gas flow rate, and you can also adjust the water spray by varying the amount of water and the size of the droplets. (Speculate what will happen.) Lasers that cut a sheet of light through both the flame and the water allow you to see the fluid-like convection patterns, the circular air currents that are created by the interaction of the flame with the cooling influence of the mist.

Elements emit different colors when heated making it possible to identify the chemical composition of materials and to create fireworks. Create, prepare, and explode **virtual fireworks** in a computer interactive.

Change the behavior of a simulated fire and make your own predictions on the best ways to control its spread. Should you open or close doors and windows? Change the amount of furniture in the room? This station touches upon the cutting-edge fire research scientists do in order to study, predict and better control fires.

Step into the shoes of a firefighter, using the chemistry of fire suppression to **fight a simulated wild fire.** An additional interactive station allows you to experiment with the "**fire triangle"** by combining different types of fuel, oxygen, and heat to power cars and rockets.

Get up close to a **racing suit made for NASCAR star Jeff Gordon**. Made from a fire-resistant material called Nomex that cannot be washed out or worn away, the suit is designed to protect Gordon from gasoline fires. Also view a space-age looking **Newtex fire entry suit**. When tested, a similar suit allowed a firefighter to walk through a 2,500 degree Fahrenheit burning tunnel three times with no injuries.

Atoms and Matter

Underlying every natural phenomena we observe are atoms. Atoms are the basic building blocks of matter. Large-scale projections of spectacular cutting-edge atomic visualizations invite you to journey into the unseen sub-microscopic world where the familiar physics of everyday life gives way to strange, yet predictable, behavior.

The Periodic Table of the elements, a tool used by scientists, classifies elements which can be combined in various ways to create molecules and compounds. Explore the Museum’s dynamic **Periodic Table** and perform "virtual reactions" to learn the ways in which atoms interact and bond together.

The **history of the atom’s discovery** and the evolution of our understanding of its anatomy come to life in an interactive way. Dive into each model and see how our understanding of atoms has changed from the time of the ancient Greeks to today.

Exotic materials whose atomic structure gives rise to their unique behaviors, are available for hands-on investigation. These materials include shape memory alloy, which can be bent and crushed only to "remember" its original shape when heated; and ferrofluid, a magnetic “liquid” that creates amazing and surprising forms as it's exposed to magnets.

View an **LI-900 Space Shuttle Insulation Tile**, made to protect the space shuttle Atlantis during re-entry into Earth’s atmosphere. It is made of 99.9 percent silica glass, and is 94 percent air by volume. This makes the tile very light, but also resistant to heat as high as 2,200 degrees Fahrenheit.

Speculate about the materials used in a piece of **B2 stealth bomber skin—**designed to reduce the radar signature of the planes, making them harder to detect. The U.S. Air Force can neither confirm nor deny the use of ferrofluids on the surface of the B2 skin, as the actual coatings are classified.

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