



SCIENCE– SUMMER ENRICHMENT PROGRAM 2020-2021

[NOTE: Below you will find enrichment opportunities to help prepare for different science courses. They provide an idea of background skills and content that will be useful for that course and enrichment resources including hands on activities)

Course: Physics (For 9th Graders)

Background skills/content: there are no prerequisites for this class. Students come to physics with a variety of different backgrounds and types of preparation. Some topics that we will be covering that it would be useful for students to have some exposure to in advance of the course would be:

- The METRIC System and SI units
- Measurement in science – how and what we measure
- Scientific discovery – any of it! How things get discovered and by who?

Enrichment Resources:

Online:

- [KHAN academy](#) – there are lots of great resources at all levels on Khan Academy.
- YouTube channels worthy of subscription: The following YouTube channels are by creators who make lively (and, ahem, correct) science videos that may get students excited about science, help them ask questions, and see how to investigate mysteries.
 - [SciShow](#)
 - [Veritasium](#)
 - [PhysicsGirl](#)
 - Fysicshow
 - [Mark Rober](#)
 - [The Brain Scoop](#)
 - [Practical Engineering](#)
 - [Real Engineering](#)
 - [Steve Mould](#)
 - [VSauce](#)

Books:

- *Radioactive* (Lauren Redniss) Beautiful, moving biography of Marie and Pierre Curie in artsy-comic-book form.

- *Coming of Age in the Milky Way* (Ferriss) Engaging, elegant historical account of how humans came to understand our place in the cosmos.
- *Thing Explainer* (Munroe) An illustrated attempt to explain complicated things using only the 1,000 most common words in the English language. Funny, makes you think.
- *Girl Code: Gaming, Going Viral, and Getting It Done* (Gonzales, Houser) Perfect for aspiring coders everywhere, Girl Code is the story of two teenage tech phenoms who teamed up to create a viral video game, and ended up becoming world famous. Includes bonus content to help you get started coding!

Activities:

- Make a kite. Keep it simple and cheap. Fly it. Make it better, fix it when it crashes, fly it again. Repeat.
- Taking and basic editing of videos of moving objects using a smartphone, including slow-motion.
- Practice basic use of electronic resources: saving and organizing documents, time-management skills and resources (use of smartphone/computer-based calendars),
- Visit a science/natural history museum or exhibition – ask questions!
- Prepare to debate with your teacher whether the earth is spherical or flat and how we (think we..) know this!

Course: Chemistry (all levels)

Background Skills/Content: Chemistry is all about learning how matter acts and interacts with other matter. The most important general skills needed to prepare for this course are understanding measurement and scale, seeing patterns and trends, making detailed observations, taking organized notes, understanding units, and explaining and analyzing data using addition, subtraction, multiplication, and division. The actual scientific principles explained in chemistry classes are more easily understood if students can use those general skills to synthesize what they learn in the classroom and laboratory.

Enrichment Resources: All the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- [Crash Course](#) - great 10-15-minute videos organized into courses on many science, history, and literature topics. Hank Green adds humor and real-life applications to learn about chemistry.
- [Khan Academy](#) - a mix of video and text resources, with quizzes, organized into courses. The chemistry ones are useful to dig deeper into chemical concepts.
- [Bozeman Science](#) - screencasts produced by Paul Andersen. Like Khan Academy, these videos use short videos as lessons for various chemical concepts.
- [Tyler Dewitt Chemistry](#) - easy-to-understand videos taught by Tyler Dewitt on specific chemistry concepts that often include math manipulations.
- [Hunting the Elements](#) – PBS – NOVA, an excellent video exploring the periodic table, the elements around us and the elements of life and death.

Books - This is a short list of some interesting non-fiction and fictional books that include accounts of historical events in chemistry, stories about important, but little-known chemists, some forensic chemistry, and even a fun cookbook to eat your way through chemistry.

- [The Radium Girls](#) - Kate Moore
- [The Radioactive Boy Scout](#) – Ken Silverstein
- [Culinary Reactions, The Everyday Chemistry of Cooking](#) – Simon Quellen Field
- [The Alchemy of Air](#) – Thomas Hager
- [The Rocket Boys](#) – Homer Hickham
- [Rocket Girl](#) – George D. Morgan
- [Stuff Matters](#) – Mark Miodownik
- [The Martian](#) – Andy Weir
- [The Poisoner's Handbook](#) – Deborah Blum

Hands-On Activities: Chemistry is all around us in both benign and not-so benign ways. The best way to learn chemistry is to do chemistry. However, hands-on experiments in chemistry, (especially those questionable ones that can be found on YouTube), should be discussed with and supervised by an adult.

- Be aware of the times chemistry is used in your everyday life. To do this, ask yourself why the “stuff” you are eating, observing, smelling, etc., acts the way it does. Keep a notebook of all the times you ask yourself, “why does this stuff do this?”.
- Ever take the pH of a swimming pool or fish aquarium? Keep a record of the pH when you or an adult in your household test it. Does it change after it rains? After it’s sunny for a stretch of time? Why or why not? What chemicals go into a pool to make it safe to swim, and what do they do?
- Bake something! Prepare a food item using a recipe. Instead of making it for the suggested number of servings, double the recipe or cut it in half. Following directions (procedures) and using math to quantify ingredients are important skills to use in chemistry.
- Practice using metric units. Make a poster or look up metric conversions online. Then measure stuff in meters, liters, grams, or °C.
- Design and run an experiment (again, after discussing it with an adult and having supervision). Consider what variables you’ll change or keep constant. Record careful observations – what you see, what you smell, temperature changes, state of matter changes, changes in color, etc. Try to record quantifiable (measurable) data. Take a quick tutorial online of Excel and see if you can play with your data to make a graph!
- Play with Mentos and soda!
- Play with baking soda and vinegar to make rockets out of film canisters!
- Make some oobleck or a bouncy ball out of white glue and Borax (read safety instructions first!).
- Make some homemade ice cream. There are plenty of recipes online that teach you about colloids and freezing point depression!
- Make rock candy. (This requires high temperatures and adult supervision, but it’s yummy!).

Course: Biology (all levels)

Background Skills/Content: Biology is the study of life on multiple scales, from the molecules that make up life, to cells, to populations and species. The important skills that will be useful in this course are making observations, creative problem solving and experimental design, and analysis of data for trends with graphs and other figures. This course teaches concepts frequently in the lab, therefore a familiarity and understanding of tools, measurements, conversions are essential. An understanding of how to use excel to organize data, make tables and simple graphing is very useful.

Enrichment Resources: All the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- [Amoeba Sisters](#) – Very approachable, humorous and well-paced coverage of important concepts in biology and chemistry.
- [Crash Course](#) - great 10-15-minute videos organized into courses on many science, history, and literature topics. Hank Green adds humor and real-life applications to learn about chemistry.
- [Khan Academy](#) - a mix of video and text resources, with quizzes, organized into courses. The chemistry ones are useful to dig deeper into chemical concepts.
- [Learn.genetics](#) - A great resource for exploring DNA, genetics, and evolution through excellent animations and games.

Books - This is a short list of some interesting non-fiction and fictional books and movies that include cover important concepts in Biology as well as some key events and discoveries in the field of biology.

- Preston, Richard | *The Hot Zone* (1995) (F)
A frightening story of an Ebola outbreak
- Dawkins, Richard | *The Selfish Gene*, 2nd ed. (1989) (NF)
Dawkins makes the case that our genes maintain us in order to make more genes.
- Wilson, Edward O. | *The Diversity of Life* (1992) (NF)
A look at the loss of diversity, its effects, and some solutions.
- Mowat, Farley | *Never Cry Wolf* (1963) (NF)
Mowat tells about his adventures with a family of wolves.
- Jones, Steve | *Darwin's Ghost* (2000) (NF)
Wonderful and easy to read, updated version of *Origin of Species* using Darwin's exact table of contents (and many of Darwin's original words) but replacing the 1800s examples with modern ones that support *Origin's* arguments concerning natural selection.

Movies:

- **Jurassic Park**
- **GATTACA**
- **Contagion**

Hands-On Activities:

- Plant some seeds at home and record changes as the seed germinates and grows over a 30 day period.
- Find a local pond or lake and collect water to bring home in a clear jar. Put the jar near a window and observe if you can see any life (animal or plant) change over time.
- Find an insect or other invertebrate like a worm or slug. Put it in a clear container and see how it responds to stimulus such as soil or grass, water, light, etc. How might you know if it is alive or not?
- As you get some exercise this summer, pay attention to how your body reacts to physical work. How does to your heart, your lungs, your muscles respond. After finishing a workout, how do these systems recover? What do you think is controlling these responses?
- As you walk around your neighborhood, or, even better, a zoo or aquarium, make observations about the different life forms you see. What types of adaptations are evident in the structures you see? What types of adaptations would be seen in the behaviors of certain animals. Basically, what does this organism have that helps it survive? What does this organism do that helps it survive?

Course Environmental Science (all levels); Ecology, Evolution, and Animal Behavior (EEB)

Background Skills/Content: These courses all have chemistry and biology as prerequisites. The most important concepts from those courses are the pH scale and what acids/bases are, solubility, and the basics of photosynthesis/respiration, natural selection, and genetics/inheritance. From a scientific skills perspective, students will need to be familiar with the scientific method and experimental design. Students will collect data and analyze it using graphs (mostly in Excel). While all of these topics will be reviewed when we encounter them, some prior comfort level is extraordinarily helpful.

Enrichment Resources: All of the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- [Crash Course](#) - great 10-15 minute videos organized into courses on many science, history, and literature topics. The chemistry, biology, and ecology ones are particularly useful.
- [Khan Academy](#) - a mix of video and text resources, with quizzes, organized into courses. The chemistry and biology ones are useful.
- [Bozeman Science](#) - screencasts produced by Paul Andersen. The biology, chemistry, and AP Environmental Science ones are particularly useful.

Film/Documentaries/TV Series

There are many documentaries and films that are really interesting and relevant to environmental science and EEB. The list below is by no means complete, and you could binge watch for an entire summer and not see everything that's relevant. We don't recommend binge-watching for an entire summer.

- [Rancher, Farmer, Fisherman](#) (2017)
- [Dirt, the Movie](#)
- [King Corn](#)
- [Last Call at the Oasis](#)
- [A Civil Action](#)
- [The Perfect Storm](#)
- [Chasing Ice](#)
- [Chasing Coral](#)
- [Before the Flood](#)
- [The Zoo](#) (Animal Planet series about the Bronx zoo – especially good for animal behavior)
- [The Aquarium](#) (Animal Planet series about the Georgia Aquarium)
- [NOVA](#) – several episode of this PBS series are relevant, especially “Wild Ways”, “Treasures of the Earth: Power”, and “Saved by the Sun”
- [H₂O: The Molecule that Made Us](#) – PBS series, premiered April/May 2020

Books

If you're looking for a good summer read that is also relevant to environmental science or EEB, try one of the following:

- [The Sixth Extinction](#) – Elizabeth Kolbert
- [A Sand County Almanac](#) – Aldo Leopold
- [The Monkey Wrench Gang](#) – Edward Abbey
- [The Hidden Life of Trees](#) – Peter Wohlleben
- [The Boy Who Harnessed the Wind](#) – William Kamkwamba
- [The Ghost Map](#) – Steven Johnson
- [The Death and Life of the Great Lakes](#) – Dan Egan
- [Rising: Dispatches from the New American Shore](#) – Elizabeth Rush
- [The Overstory](#) – Richard Powers

Hands-on Activities

With most schools in the USA being remote for most of the spring, students have been spending a lot of hours staring at screens. One of the best ways to learn science is to DO science. The following are some suggestions for things you can do that will get you away from the screen and actually doing some science-related activities.

- Go for a hike. Observe your local social distancing guidelines and any posted trail closures, but get outside and walk around in nature. Take a notebook of some sort and find a quiet, out of the way spot where you can sit and observe for 20-40 minutes. Try to record or draw what you see, what you hear, what you smell. Be careful about touching plants and animals – some can be toxic, so make sure you know the area and what something is before touching. Tasting nature is not advised.
- Download the iNaturalist app or the Seek app (by iNaturalist) and try to identify different species around your home. See how many you can find!
- Get an outdoor thermometer and try to measure the temperature at the same time of day every day. Record your data in a notebook. At the end of the summer, try making a graph of it. What trends do you notice?
- Plant a garden. Take care of it. Spend some time observing it every day or two. Record those observations (through notes, data, photos...). What changes do you observe? Do different plants follow different patterns? What animal species do they seem to attract? Does that change over the summer?

Course: Marine Science (all levels)

Background Skills/Content: Pre-requisites for this course are both Chemistry and Biology. A solid understanding of chemistry (especially solutions, ions, and density) is important. Understanding photosynthesis, adaptations, classification and evolution are important concepts covered in Biology. A basic knowledge of food webs, predator prey interactions is also very helpful.

Enrichment Resources: All the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- <https://nautiluslive.org/> Join Dr. Bob Ballard's team as they explore deep sea vents and shipwrecks.
- [Google Earth Ocean Collection](#) Use Google Earth to explore a number of underwater sites that allow you to see 360 degrees and even swim along a line.

Books - This is a short list of some interesting non-fiction and fictional books that include cover important concepts in Marine Science as well as some key events and discoveries in the field of Marine Science.

- [Spineless](#), Juli Berwald
- [Song for the blue ocean](#), Carl Safina
- [Sex drugs and sea slime](#), Ellen Prager
- [Crab wars: A Tale of Horseshoe Crabs, Bioterrorism, and Human Health](#), Bill Sargent
- [The secret life of lobsters](#), Trevor Corson
- [Soul of an octopus](#), Sy Montgomery
- [Grayson](#), Lynne Cox

Movies - This is a short list of some interesting non-fiction and fictional movies/documentaries/TV shows that include cover important concepts in Marine Science as well as some key events and discoveries in the field of Marine Science.

- Finding Nemo
- Finding Dory
- Moana
- Happy feet
- Chasing Coral
- Jaws
- Master and Commander: Far Side of the World
- The Abyss
- All is lost
- The Perfect Storm
- Blackfish
- The Cove
- Blue Planet and Blue Planet 2

- The Aquarium (Animal Planet series about the Georgia Aquarium)
- Tanked (TLC series about running an aquarium business)

Hands-On Activities:

- Go for a walk on the beach and try to identify what has washed up. Use an online guide for beachcombing in the Northeast if that's applicable.
- Participate in a beach cleanup. At least once a month in the summer there are organized beach cleanups near you. You may even be involved in gathering marine debris data for research!
- Go whale watching! There are numerous locations in New England that offer whale watching from Maine, New Hampshire, the North shore, South Shore and Cape and islands of Massachusetts. My advice would be to avoid the largest operations in Boston and other large cities for a smaller boat/operation to allow for better views.
- If possible, visit an aquarium, avoid the crowds by finding an exhibit without the big showy animals. Look into the exhibit and wait for something to happen. Look closely and you may find something others overlook. Make some sketches of organisms. Watch one organism for a long period of time (15 minutes is enough). Most visitors spend less than 2 minutes in front of each exhibit.

Course: Planet Earth (all levels)

Background Skills/Content: This course has a chemistry pre-requisite. It is important to have a general understanding of units and of atoms, molecules, and compounds. Additionally, it is important to be able to analyze data and to look for patterns both in data sets and the natural world. Earth Science is all about piecing together the way our planet formed and understanding the processes that shape the Earth that we live on today.

Enrichment Resources: All the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- <https://www.nhc.noaa.gov/> - This NOAA site explains how hurricanes form and lets you track developing hurricanes in real time.
- <https://earthquake.usgs.gov/> - This website provides a huge amount of information on earthquakes, past and present, as well as tracking and monitoring. Take a look at the interactive earthquake map to view earthquakes as they happen all over the world in real time.
- <https://volcanoes.usgs.gov/index.html> - This website provides information on current active volcanoes that are being monitored as well as past volcanoes. It also gives an in-depth look at some of the monitoring and hazards on volcanoes.

Books - This is a short list of some interesting non-fiction and fictional books that include important concepts in Earth Science as well as some key events and discoveries in the field of Earth Science.

- The Great Quake
- Underland
- Krakatoa: The Day the Earth Exploded

Movies - This is a short list of some interesting non-fiction and fictional movies/documentaries/TV shows that include cover important concepts in geoscience and natural disasters as well as some key events and discoveries in the field of Earth Science.

- The Perfect Storm
- San Andreas
- Men of Rock Series

Hands-On Activities:

- Look for rock out-crops as you are driving on the highway! Look to each side of the road – are there big walls of rock? What do you notice about the rocks? Are there layers? Streaks of colors? Areas where the rock looks bent or twisted?
- Go to the beach (river or ocean)! What do you notice about the sand? Are there different colored grains? What minerals do you think each of the grains contains?

Course: Anatomy

Background Skills/Content: This course deals with the anatomy and physiology of the human body. Dissections of animal specimens are often used as models for human systems. It is important for you to feel comfortable being in the laboratory and working through dissections to get the most out of this class. A strong background in biology is also important and is a prerequisite for this class. Since you will be learning about many different parts of the body, you will be introduced to a great deal of new vocabulary terms. Memorization, or being able to recognize terms through word roots is a useful skill.

Enrichment Resources: All the following are optional. These resources are ones we've found to be useful if you want to review or get a head start before next year. They are sorted into different categories based on the type of resource – pick and choose as you wish.

Online

- [Anatomy Arcade](#) - This fun website has a number of different games to play to learn the locations and names of parts of the body.
- [Khan Academy](#) - Has lots of lessons on the anatomy and physiology of different organ systems
- [Anatomy Corner](#) - Has photos, quizzes, and diagrams of real dissections to study
- [Get Body Smart](#) - Great diagrams of organs and organ systems

Books

- [Gulp: Adventures on the Alimentary Canal](#) – Mary Roach
- [Stiff: The Curious Life of Human Cadavers](#) – Mary Roach
- [The Immortal Life of Henrietta Lacks](#) – Rebecca Skloot
- [The Hot Zone](#) - Richard Preston
- [The Body Farm](#) – Patricia Cornwell (or any of her series)
- [A Conspiracy of Bones](#) – Kathy Reichs (or any of her series)
- [Cut to the Bone](#) – Jefferson Blass (or any of her series)

Movies/Television Shows/Documentaries

- Grey's Anatomy – or any medical TV show (It's fun to research what's real and what's fiction!)
- Contagion
- Outbreak
- Inner Space
- Fantastic Voyage
- The Body
- The Incredible Human Machine
- Osmosis Jones

Hands-On Activities:

- Go to a museum near you (if they're open). The Museum of Science in Boston has a wonderful exhibit about the human body. Many large museums dedicate space to learning about how our bodies work.
- See if there is a *Body Worlds* exhibit near you. This traveling exhibit of plastinated human bodies offers a fascinating look into the human body.
- Watch an animal move, run, eat, sleep, etc. Imagine what's happening beneath the surface. What muscles are working to allow for the animal's movements? What's happening to the food it ate? What messages are its brain sending to allow for it to do what it's doing?
- Make a diary of the food you eat in a day, a week. What kinds of biochemical molecules are there in your food? What effect do they have on your body?
- Observe your pulse and blood pressure before, during, or after an exercise workout. Keep a log. As you become more fit, how do these vital signs change?
- Give blood or platelets! There's definitely a need for blood and platelet donors now. Depending on your age, you may need parental permission. Check the local requirements for your state or area.

Course: Physics (Advanced/Honors)

Background Skills/Content: Physics is an examination of the governing laws and principles that describe how matter and energy behave in the universe. It requires not only a conceptual understanding of these laws and principles, but also the mathematical ability to represent them algebraically. The objective of this optional summer work isn't to try and recreate the content that will be presented in your Physics course next year, but to try and make sure that you have the fundamentals that you will need in order to find success in that course, and also to try and spark your interest in the field of physics in general, which has a much greater scope than any single high school course could cover. Some of the things you should know how to do coming into the course are: plotting a graph in Excel, plotting on your calculator, solving systems of equations, solving quadratic equations, basic trigonometry, unit conversions (including going back and forth between metric and imperial), THE METRIC SYSTEM, and the scientific method.

Enrichment Resources: All the following are optional. The online resources are the ones predominantly aimed at making sure you have the foundational elements that will help you find success in the course, while the books and movies/tv shows are predominantly aimed at sparking your interest and broadening your understanding of the world and the universe.

Online

- [Microsoft Support](#) – This seems kind of corny, but the office support page offers some very comprehensive tutorials on the basic functionality of Excel.
- [TISkills.com](#) – A great resource with online video tutorials on how to use a variety of your TI-84's capabilities.
- [PhET](#) – Provides great interactive visualizations that can be used to help grasp the underlying principles behind many math and physics topics.
- [Khan Academy](#) - a mix of video and text resources, with quizzes, organized into courses. You can also find discrete videos here covering a number of the basic skills you should have, including but not limited to trig, solving quadratics, metric and imperial unit conversions, and systems of equations.
- [OpenStax](#) – While not as interactive or guided as some of the other online options, OpenStax provides free access to hundreds of textbooks online. So if you know what information you're looking for and just need a reliable source to look it up, OpenStax can be a great resource.

Books - This is a short list of some interesting non-fiction and fictional books that cover important concepts in Physics as well as some key events and discoveries in the field of Physics, and even a few options to stretch your brain.

- *[A Brief History of Time](#)* – Stephen Hawking - A landmark volume in science writing by one of the great minds of our time, Stephen Hawking's book explores such profound questions as: How did the universe begin—and what made its start possible? Does time always flow forward? Is the universe unending—or are there boundaries? Are there other dimensions in space? What will happen when it all ends?
Told in language we all can understand, *A Brief History of Time* plunges into the exotic realms of

black holes and quarks, of antimatter and “arrows of time,” of the big bang and a bigger God—where the possibilities are wondrous and unexpected. With exciting images and profound imagination, Stephen Hawking brings us closer to the ultimate secrets at the very heart of creation.

- *Surely You're Joking, Mr. Feynman* - Richard Feynman - Richard P. Feynman, winner of the Nobel Prize in physics, thrived on outrageous adventures. In this lively work that “can shatter the stereotype of the stuffy scientist” (*Detroit Free Press*), Feynman recounts his experiences trading ideas on atomic physics with Einstein and cracking the uncrackable safes guarding the most deeply held nuclear secrets—and much more of an eyebrow-raising nature. In his stories, Feynman’s life shines through in all its eccentric glory—a combustible mixture of high intelligence, unlimited curiosity, and raging chutzpah.
- *Astrophysics for People in a Hurry* – Neil deGrasse Tyson - What is the nature of space and time? How do we fit within the universe? How does the universe fit within us? There’s no better guide through these mind-expanding questions than acclaimed astrophysicist and best-selling author Neil deGrasse Tyson. But today, few of us have time to contemplate the cosmos. So Tyson brings the universe down to Earth succinctly and clearly, with sparkling wit, in tasty chapters consumable anytime and anywhere in your busy day. While you wait for your morning coffee to brew, for the bus, the train, or a plane to arrive, *Astrophysics for People in a Hurry* will reveal just what you need to be fluent and ready for the next cosmic headlines: from the Big Bang to black holes, from quarks to quantum mechanics, and from the search for planets to the search for life in the universe.
- *Gravity's Rainbow* – Thomas Pynchon - “A screaming comes across the sky. . .” A few months after the Germans’ secret V-2 rocket bombs begin falling on London, British Intelligence discovers that a map of the city pinpointing the sexual conquests of one Lieutenant Tyrone Slothrop, U.S. Army, corresponds identically to a map showing the V-2 impact sites. The implications of this discovery will launch Slothrop on an amazing journey across war-torn Europe, fleeing an international cabal of military-industrial superpowers, in search of the mysterious Rocket 00000, through a wildly comic extravaganza that has been hailed in *The New Republic* as “the most profound and accomplished American novel since the end of World War II.”
- *Great Experiments in Physics: Firsthand Accounts from Galileo to Einstein* – Edited by Morris H. Shamos - From Galileo's famous experiments in accelerated motion to Einstein's revolutionary theory of relativity, the experiments recorded here trace the evolution of modern physics from its beginnings to the mid-twentieth century. Brought together for the first time in one volume are important source readings on 25 epochal discoveries that changed man's understanding of the physical world. The accounts, written by the physicists who made them, include:
Isaac Newton: The Laws of Motion
Henry Cavendish: The Law of Gravitation
Augustin Fresnel: The Diffraction of Light
Hans Christian Oersted: Electromagnetism
Heinrich Hertz: Electromagnetic
James Chadwick: The Neutron
Niels Bohr: The Hydrogen Atom,
and 17 more.

Morris H. Shamos, Professor Emeritus of Physics at New York University, has selected and edited the first published accounts of these important experiments and has also added numerous marginal notes that amplify and clarify the original documents. Moreover, the first 19 experiments can be readily re-created by students in a first-year physics course, making the book ideal for classroom and laboratory work as well as individual reference and study. Finally, Dr. Shamos has provided revealing biographical sketches of the scientists and illuminating references to the political and cultural milieu in which the discoveries are made. The result is a superbly readable presentation — accessible to lay readers — of the crucial theoretical and empirical breakthroughs that altered the course of modern science.

- *The Elegant Universe* – Brian Greene - Brian Greene, one of the world's leading string theorists, peels away layers of mystery to reveal a universe that consists of eleven dimensions, where the fabric of space tears and repairs itself, and all matter—from the smallest quarks to the most gargantuan supernovas—is generated by the vibrations of microscopically tiny loops of energy. *The Elegant Universe* makes some of the most sophisticated concepts ever contemplated accessible and thoroughly entertaining, bringing us closer than ever to understanding how the universe works.

- *What If?: Serious Scientific Answers to Absurd Hypothetical Questions* – Randall Munroe (the XKCD guy!) - Millions of people visit xkcd.com each week to read Randall Munroe's iconic webcomic. His stick-figure drawings about science, technology, language, and love have a large and passionate following. Fans of xkcd ask Munroe a lot of strange questions. What if you tried to hit a baseball pitched at 90 percent the speed of light? How fast can you hit a speed bump while driving and live? If there was a robot apocalypse, how long would humanity last?

In pursuit of answers, Munroe runs computer simulations, pores over stacks of declassified military research memos, solves differential equations, and consults with nuclear reactor operators. His responses are masterpieces of clarity and hilarity, complemented by signature xkcd comics. They often predict the complete annihilation of humankind, or at least a really big explosion. The book features new and never-before-answered questions, along with updated and expanded versions of the most popular answers from the xkcd website. *What If?* will be required reading for xkcd fans and anyone who loves to ponder the hypothetical.

- *The Second Kind of Impossible: The Extraordinary Quest for a New Form of Matter* – Paul Steinhardt - When leading Princeton physicist Paul Steinhardt began working in the 1980s, scientists thought they knew all the conceivable forms of matter. *The Second Kind of Impossible* is the story of Steinhardt's thirty-five-year-long quest to challenge conventional wisdom. It begins with a curious geometric pattern that inspires two theoretical physicists to propose a radically new type of matter—one that raises the possibility of new materials with never before seen properties, but that violates laws set in stone for centuries. Steinhardt dubs this new form of matter “quasicrystal.” The rest of the scientific community calls it simply *impossible*. *The Second Kind of Impossible* captures Steinhardt's scientific odyssey as it unfolds over decades, first to prove viability, and then to pursue his wildest conjecture—that nature made quasicrystals long before humans discovered them. Along the way, his team encounters clandestine collectors, corrupt scientists, secret diaries, international smugglers, and KGB agents. Their quest culminates in a daring expedition to a distant corner of the Earth, in pursuit of tiny fragments of a meteorite forged at the birth of the solar system.

Steinhardt's discoveries chart a new direction in science. They not only change our ideas about patterns and matter, but also reveal new truths about the processes that shaped our solar system. The underlying science is important, simple, and beautiful—and Steinhardt's firsthand account is "packed with discovery, disappointment, exhilaration, and persistence...This book is a front-row seat to history as it is made" (*Nature*).

- *A Beautiful Mind* - Sylvia Nasar - "How could you, a mathematician, believe that extraterrestrials were sending you messages?" the visitor from Harvard asked the West Virginian with the movie-star looks and Olympian manner. "Because the ideas I had about supernatural beings came to me the same way my mathematical ideas did," came the answer. "So I took them seriously." Thus begins the true story of John Nash, the mathematical genius who was a legend by age thirty when he slipped into madness, and who—thanks to the selflessness of a beautiful woman and the loyalty of the mathematics community—emerged after decades of ghostlike existence to win a Nobel Prize for triggering the game theory revolution. The inspiration for an Academy Award-winning movie, Sylvia Nasar's now-classic biography is a drama about the mystery of the human mind, triumph over adversity, and the healing power of love.

Movies/TV Shows – These are some optional films and TV shows that may help broaden your understanding of Physics and the way it impacts our world or add depth to your previous understanding.

- *NOVA (Show)* - This long-running, award-winning documentary series focuses on science - the speculation, history and researchers associated with it and its many applications. Inspired by the BBC documentary program 'Horizons', the U.S. series frequently features interviews with scientists directly involved in the topic at hand, and sometimes even boasts footage of a particular discovery.
- *Edge of the Universe (Show)* - Leading astronomers reveal the latest discoveries about death-trap planets, asteroids, comets and other wonders of the cosmos.
- *Explained (Show)* - News site Vox is behind this series that puts the spotlight on topical issues that impact people's lives. The docuseries -- which features episodes that generally range from 15 to 20 minutes in length -- aims to dig deeper into topics, questions and ideas that aren't often part of the daily news cycle. Among the subjects covered are the rise of cryptocurrency, why diets fail, and the world of K-pop music.
- *The Most Unknown (Show)* - An epic documentary film that sends nine scientists to extraordinary parts of the world to uncover unexpected answers to some of humanity's biggest questions.
- *Dream Big (Show)* - Filmmaker Greg MacGillivray explores the human ingenuity behind engineering marvels -- big and small -- and reveals the heart that drives engineers to create better lives for people around the world.
- *Cosmos: A Spacetime Odyssey (Show)* - 'Family Guy' creator Seth MacFarlane, in a departure from the type of material he is best known for, pays homage to Carl Sagan's award-winning and iconic 'Cosmos' with this docuseries. Through stories of humankind's quest for knowledge, viewers travel across the universe. Scientific concepts are presented clearly, with both skepticism and wonder, to impart their full impact. Renowned astrophysicist Neil deGrasse Tyson hosts, and Sagan's original creative collaborator, Ann Druyan, serves as an executive producer.

- [A Beautiful Mind \(Movie\)](#) - A human drama inspired by events in the life of John Forbes Nash Jr., and in part based on the biography "A Beautiful Mind" by Sylvia Nasar. From the heights of notoriety to the depths of depravity, John Forbes Nash Jr. experienced it all. A mathematical genius, he made an astonishing discovery early in his career and stood on the brink of international acclaim. But the handsome and arrogant Nash soon found himself on a painful and harrowing journey of self-discovery.
- [The Theory of Everything \(Movie\)](#) - A look at the relationship between the famous physicist [Stephen Hawking](#) and his wife.

Hands-On Activities:

- This isn't so much a guided lab or activity, but a basic practice you can use in everyday life to start familiarizing yourself with the metric and imperial systems and their relationship. As you go through your day, pay attention to the times when you have the opportunity to use either metric or imperial units. For example, if you're cooking, most measuring cups have cups, ounces, and maybe even liters as units of measure. If a recipe calls for a cup of flour, just take note of how many fluid ounces that is. Or if you go for a walk or a run, one day track your distance in miles, and the next day in kilometers, so you can start to feel the relative distances. If you workout or weigh yourself, see how much you weigh or how much you're lifting in both pounds and kilograms. Just having a rough physical sense for what each of these quantities is representative of will make them seem a lot less foreign when you need to start manipulating them in the fall.
- Play Portal 2 for a while! It's a fun video game that's available on PC, Playstation, and Xbox, and perhaps without realizing it you will be using principles of reflection, conservation of momentum and energy, and projectile motion in order to pass the levels. Once you beat the game, try applying these principles in creating your own custom Portal levels, which is, surprisingly, not as easy as you'd think.
- Watch a good movie with bad physics (pretty much any superhero or Michael Bay film will do). You already understand a great deal of physics just from having existed and interacted with the world for the past X number of years. You've all seen movies where you've employed willing suspension of disbelief for the sake of the cinematic experience, but in the back of your mind you know what's happening on screen isn't physically possible. The next time you watch such a film, see if you can pinpoint exactly why a scene or interaction is unrealistic, and try to imagine what would happen if the laws of physics actually applied.
- If you want to spit in the face of physics using chemistry, make some Oobleck (non-Newtonian fluid) at home! All you need is corn starch and water. Start with 1 cup of water in a bowl. Add corn starch one teaspoon at a time, mixing thoroughly with your fingers after each addition. At a certain point you'll find something interesting starts to happen to the consistency of your mixture.
- Inspired by Simone Giertz, who is world-renowned on Youtube for her "shitty" robots (showcased [here](#) and [here](#)), see if you can make an invention that will perform a simple and/or inconsequential task in a unique way. If possible, see if you can adapt your design so that it can be created using household objects and at not much expense. Or if that seems too difficult, just

check out Simone's Youtube channel and enjoy watching the ingenuity and prowess of a great engineer as she builds a complex robot that will spill soup on her.