PHYSICS 2: TIPS FOR PARENTS &TEACHERS

Using the notes

Each lesson in our physics class contains a video and doodle-style notes to go along with it. You can find which pages go with which lesson in the table of contents. There is also an answer key for the notes which contains answers in blue text. Both PDF files can be downloaded in the introduction page of the course website.

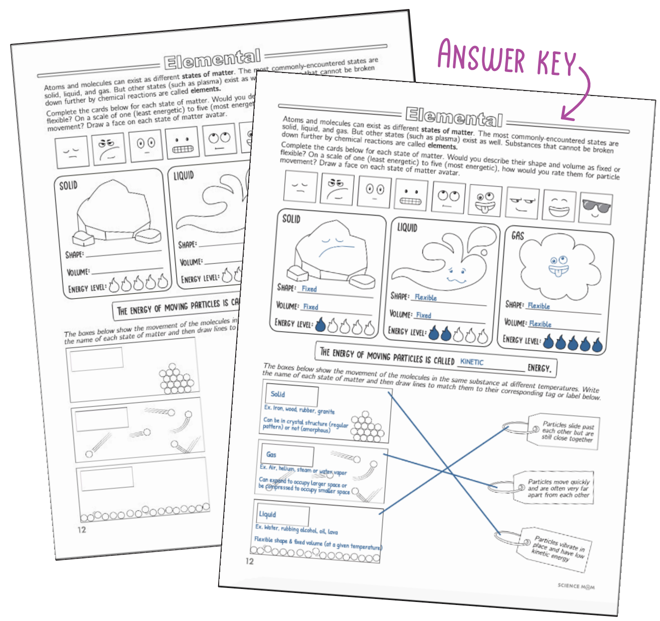
There are multiple approaches for using the notes. Use whichever works best for your learner!

Here are some ideas:

- **Before the lesson:** Become more familiar with the topic by reading over the selected pages before watching the video. Talk about what you expect the answers to be or fill in the pages using pencil.
- **During the lesson:** pause the video and rewind as needed to complete the notes.
- **After the lesson:** fill in the notes after watching as a way to synthesize and review what was learned. Refer to the video as needed.
- **As a guide for verbal discussion and assessment:** For example, instead of asking your student to complete the notes on their own, you might ask them to use the notes to teach you the concepts of the lesson.

We hope you find the notes to be a valuable tool for deepening learning and reinforcing key concepts.

Title of video lesson	Corresponding pages in the notes
Introduction	5-7
What's the Matter?	7-11
Elemental	12-15
Fun Physics Tricks	16-19



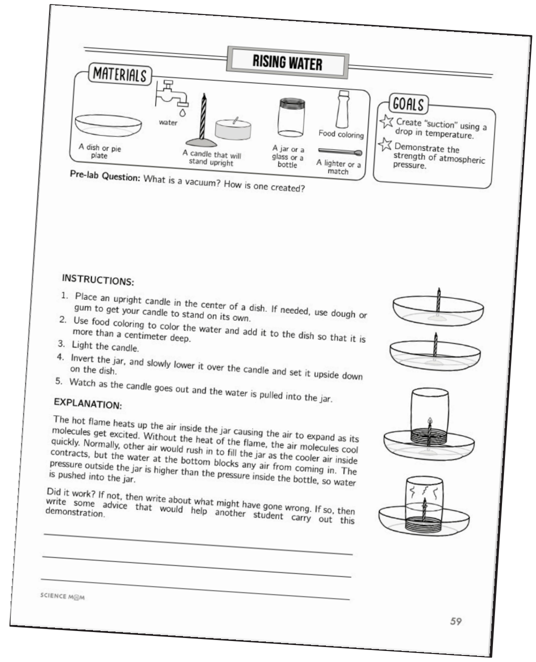
Practice Problems

Physics is a quantitative science and practice problems are a crucial part of learning the material well. We've included practice problems for each video lesson, which you can find in the notes. These problems were targeted at a student with 7th grade math skills.

For students who are younger or older, we recommend the following:

- **Elementary school students:** Drop the problems. Students can still learn a lot by focusing on the conceptual understanding and leaving the quantitative and math-based learning for later.
- **Middle school students:** The practice problems should be a good fit. If too challenging, consider doing them together or reducing the number of problems. If not challenging enough, add in additional problems from thephysicsclassroom.com or one of the books recommended for high school students.
- **High School students:** While our course is not a high school course, I've had several requests for suggestions on how to use it as a base for deeper study. Recommended reading for conceptual physics are listed later in this teacher's guide.

Hands-on Activities and Labs



RISING WATER

MATERIALS

A dish or pie plate

water

A candle that will stand upright

A jar or a glass or a bottle

Food coloring

A lighter or a match

GOALS

Create "suction" using a drop in temperature.

Demonstrate the strength of atmospheric pressure.

Pre-lab Question: What is a vacuum? How is one created?

INSTRUCTIONS:

1. Place an upright candle in the center of a dish. If needed, use dough or gum to get your candle to stand on its own.
2. Use food coloring to color the water and add it to the dish so that it is more than a centimeter deep.
3. Light the candle.
4. Invert the jar, and slowly lower it over the candle and set it upside down on the dish.
5. Watch as the candle goes out and the water is pulled into the jar.

EXPLANATION:

The hot flame heats up the air inside the jar causing the air to expand as its molecules get excited. Without the heat of the flame, the air molecules cool quickly. Normally, other air would rush in to fill the jar as the cooler air inside contracts, but the water at the bottom blocks any air from coming in. The pressure outside the jar is higher than the pressure inside the bottle, so water is pushed into the jar.

Did it work? If not, then write about what might have gone wrong. If so, then write some advice that would help another student carry out this demonstration.

SCIENCE MOM

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There are 10 suggested activities or experiments to do in the course. Instructions and questions are included for each activity and lab. Each lab can be expanded or modified, and students are encouraged to write lab reports, posters, or presentations above and beyond the instructions from the activity.

Tips for a good lab report experience:

- **Share with family or friend:** Explaining or presenting the project does so much to deepen one's understanding and learning!
- **Create visuals:** Make a poster or (if writing a paper) put a graph or other visual representation of your results into your work.
- **Set aside time:** Collecting good data and then writing up a lab report requires more time than the other activities. Help manage expectations by explaining that it will be a larger project that will take multiple days of work to complete.

Most of the activities use supplies that are easily obtainable. The supplies are found on pages 3 and 4 of the notes. Be sure to look at the supply list far in advance so that there is sufficient time to gather supplies. Note that Lesson 35 ask you to make a holiday greeting card using LED lights and conductive tape. Kits can be ordered online.

EXTENSION: *PUBLISHING & SCIENCE COMMUNICATION*

A lab report provides a great opportunity to discuss the importance of communicating science. Consider exploring further with one or both of the following:

- **Science Journal for Kids:** This incredible nonprofit organization was founded by high school teacher Tanya Dimitrova. It publishes an online science magazine for kids (and their teachers) featuring freely downloadable peer-reviewed research papers rewritten in age-appropriate language. https://www.sciencejournalforkids.org/
    - Here are two articles from Science Journal for Kids that relate to topics that will be discussed in physics. Try reading the article on Science Journal for Kids and then compare it to the original research paper. What is the same and what is different?
        - How Can Rescuers Quickly Find People Lost at Sea? https://www.sciencejournalforkids.org/articles/how-can-rescuers-quickly-find-people-lost-at-sea/
        - Why Do Ducklings Swim in a Line behind Their Mother? https://www.sciencejournalforkids.org/articles/why-do-ducklings-swim-in-a-line-behind-their-mother/
- **Understanding Peer Review:** The Understanding Science 101 website run by Berkeley has a great short article about the peer review process which can be found here: https://undsci.berkeley.edu/understanding-science-101/how-science-works/scrutinizing-science-peer-review/

Which science standards are covered in Physics 2?

The standards listed below are middle school national science standards in the United States. These standards are commonly referred to as Next Generation Science Standards or NGSS.

MS-PS1-1. *Develop models to describe the atomic composition of simple molecules and extended structures.* ***Lesson 3. Elemental***

MS-PS1-4 *Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.* ***Lesson 5. No Such Thing as Cold***

MS-PS3-3 *Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* ***Lesson 7. Clay Pot Fridge***

MS-PS3-4 *Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.* ***Lesson 6. Heat Transfer***

MS-PS3-5 *Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.* ***Lesson 8. Heat Capacity and Phase Change***

MS-PS4-1 *Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.* ***Lesson 22. Making Waves***

MS-PS4-2 *Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.* ***Lesson 26. Electromagnetic Spectrum***

MS-PS4-3 *Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.* ***Lesson 28. Colors and Sending Signals***

Lesson	Topic	NGSS	Page(s)
3	Molecules and States of Matter	MS-PS2-2	12-15
5	No Such Thing as Cold	MS-PS1-4	21-25
6	Heat Transfer	MS-PS3-4	26-29
7	Clay Pot Fridge	MS-PS3-3	30-31
8	Heat Capacity and Phase Change	MS-PS3-5	32-36
22	Making Waves	MS-PS4-1	84-87
26	Electromagnetic Spectrum	MS-PS4-2	98-101
28	Colors and Sending Signals	MS-PS4-3	104-107

Looking for lessons on forces and the laws of motion? They're covered in Physics 1: Mechanics. Are you after even more book recommendations? https://guesthollow.com/high-school-physics-book-and-resource-list/

LESSON OBJECTIVES

Below is a list of key lesson objectives. These can be used to give you a quick overview of what the lesson was about, as a reference for reinforcing key ideas, or to help in assessing what your student learned from a given lesson.

What should students know and be able to do after completing each lesson and practice problems?

1. Intro to Physics 2

Students should be able to identify and describe the major branches of physics, such as mechanics, thermodynamics, electromagnetism, optics, and quantum mechanics. Students should know how to utilize course materials effectively, including lectures, notes, and supplementary resources. Students should have a structured study plan for how to complete the course and how to ask for help when they get stuck.

2. What's the Matter?

Student knows that atoms are the smallest unit of an element that still retain the properties of that element. They can explain that atoms are made of protons, neutrons, and electrons and they know the charge and relative location (in the nucleus or not) of all 3 particles. Students should also know that atoms are smaller than a wavelength of light (incredibly small!).

Student should be able to explain that all matter we can touch/see/feel is made of atoms, which can combine to form larger molecules such as water (H2O). They know that atoms form bond by sharing electrons and that the attractions between molecules can be strong or weak

3. Elemental

Students should be able to identify the three fundamental states of matter: solids, liquids, and gases. Students should know the distinct characteristics of each state of matter in terms of shape and volume. Students should be able to describe how particle movement varies between solids, liquids, and gases. Students should understand and be able to give examples of molecules.

Student should know that there are 116 known types of atoms (elements) and be familiar with the symbols and names of common elements such as Hydrogen (H), Oxygen (O), Carbon (C), Nitrogen (N), Silicon (Si), and Iron (Fe).

4. Fun Physics Tricks

Students should be able to gather materials and carry a demonstration by following instructions. Students should be able to troubleshoot problems that arise when making a demonstration. They should be able to make conjectures about how each physics demonstration works.

5. No Such Thing as Cold

Students should be able to define temperature as a measure of the average kinetic energy of the particles in a substance. Students should know how to explain heat as the transfer of thermal energy from one body or substance to another due to a temperature difference. Students should understand the concept of absolute zero, defined as the theoretical temperature at which substances possess minimal thermal energy and particle motion ceases. Students should be able to differentiate between internal (thermal) energy, which is the total energy of all the particles within a substance, and temperature. Students should be able to explain thermal expansion as the increase in volume of substances when the temperature increases, due to the increase in the speed of movement of particles. Students should understand why thermal expansion occurs and be able to give examples of practical effects of thermal expansion in real-world applications (e.g., expansion joints in bridges, gaps in railroad tracks). Students should know how to explain the implications of the absence of "cold" as a physical entity, emphasizing that cold is merely the absence of heat (thermal energy).

6. Heat Transfer

Students should be able to identify and explain the three types of heat transfer: conduction, convection, and radiation. Students should be able to give examples of each type of heat transfer. Students should know several examples of good thermal conductors and insulators. Students should be able to explain why heat is transferred more efficiently through some materials than others based on their molecular structure and electron mobility. Students should understand the factors that influence the rate of heat transfer, including material properties (thermal conductivity), temperature difference, and surface area. Students should be able to apply knowledge of heat transfer mechanisms to solve practical problems, such as designing insulation for buildings or selecting materials for cooking utensils.

7. Clay Pot Fridge

Students should be able to describe the construction process of a clay pot fridge, including the materials needed (two clay pots, wet sand) and the assembly method. Students should understand the principle of evaporative cooling, explaining how the evaporation of water from the wet sand leads to a reduction in temperature inside the inner pot. Students should be able to measure and record temperature data at regular intervals to monitor the cooling effectiveness of the clay pot fridge. Students should bd able to discuss the effectiveness of their clay pot fridge discuss factors that influence the efficiency of the clay pot fridge, such as ambient temperature, humidity, and the amount of water in the sand.

8. Heat Capacity and Phase Change

Students should be able to define heat capacity as the amount of heat energy required to change the temperature of a substance by a certain temperature interval. Students should understand the concept of specific heat capacity, which is the heat capacity per unit mass of a substance, and be able to explain its significance in different contexts.

Students should be able to describe the different types of phase changes and whether or not heat is absorbed or released. Students should understand why certain substances have higher or lower heat capacities and how this affects energy transfer in real-world applications and be able to explain the practical implications of phase changes and heat capacity in everyday phenomena, such as the cooling effect of water evaporation or the heating efficiency of different materials.

9. Laws of Thermodynamics

Students should be able to summarize the First Law of Thermodynamics, stating that energy cannot be created or destroyed, only transformed from one form to another, thus emphasizing the principle of energy conservation.

Students should be able to explain the Second Law of Thermodynamics in simple terms, noting that heat naturally flows from hotter objects to colder ones until thermal equilibrium is reached, and that the entropy of an isolated system tends to increase over time.

Students should know how to define entropy as a measure of the disorder or randomness in a system and understand how it applies to various physical and chemical processes.Students should be able to describe absolute zero as the theoretical lowest possible temperature, at which a system has the minimum internal energy and where the motion of atoms theoretically comes to a complete stop.

10. Make Your Own Ice Cream

Students should be able to explain the role of each ingredient and material used in making ice cream, including the purpose of rock salt in lowering the freezing point of ice. Students should be able to describe the scientific process of phase change from liquid to solid that occurs in the ice cream mixture as it freezes and the heat absorption that comes with freezing.

11. Thermodynamics Quiz Show

Student should use the assessment and quiz show to evaluate their understanding of thermodynamics. The assessment can be used before or after the quiz show.

12. Pressure and Fluids

Students should be able to define pressure as the force exerted per unit area and be able to calculate pressure using the formula $P = F/A$, where P is pressure, F is force, and A is the area over which the force is distributed.

Students should be able to use and explain the units of pressure, including Pascal (Pa), which is the SI unit of pressure, and pounds per square inch (PSI), commonly used in various applications. Students should understand the difference between pressure and weight, knowing that weight is a measure of the gravitational force acting on a mass, while pressure is related to how that force is distributed over an area.

Students should be able to explain the fundamental differences between solids and fluids. Students should be able to explain that fluids include both gases and liquids, and they share the common property of being able to flow due to the space between particles.

13. Going for a Swim

Students should be able to calculate the pressure exerted on an object submerged in a fluid using the formula $P = \rho g h$, where ρ is the density of the fluid, g is the acceleration due to gravity, and h is the depth below the surface.

Students should understand and explain that pressure in a fluid increases with depth due to the weight of the fluid above increasing. Students should be able to define buoyancy as the upward force exerted by a fluid that opposes the weight of an immersed object. Students should be able to explain that an object floats if it is less dense than the fluid or if it displaces a volume of fluid equal to or greater than its own weight.

14. Egg in a Bottle and Rising Water

Students should be able to explain how changes in temperature inside the container affect air pressure and subsequently the movement of the egg or water in these demonstrations.Students should understand that as the air inside the bottle heats up (due to the burning candle), it expands and some escapes out of the bottle. When the candle goes out and the air cools, the pressure inside the bottle drops. Students should be able to explain why the egg or water is sucked into the bottle: the external air pressure becomes greater than the internal air pressure, pushing the egg into the bottle as a result.

15. Density and Buoyancy

Students should be able to define density as the mass of a substance divided by its volume (density = mass/volume).Students should be able to define buoyancy as the upward force exerted by a fluid that opposes the weight of an object immersed in the fluid.

Students should know that buoyancy depends on the volume of the fluid displaced by the object, as stated by Archimedes' principle.

Students should be able to avoid common misconceptions.

- Density does not change just because an object's size or shape changes; it is an intrinsic property of the material.
- Objects do not float or sink based on their mass alone but based on their density relative to the fluid they are in.
- All objects, regardless of their density, experience buoyant force when submerged in a fluid; the question of whether they float or sink depends on the relationship between their density and the fluid's density.
- Buoyancy is not about objects being "light" or "heavy" but about displacing enough fluid to counteract their weight.

16. Ocean of Air

Students should be able to explain why pressure and volume are inversely proportional in a gas and understanding that decreasing volume increases collision frequency among particles, which raises pressure.

Students should understand and be able to explain that air pressure decreases with elevation due to the decreasing weight of the overlying air. Students should be able to explain how a vacuum works, understanding that it is a space devoid of matter where no air pressure is exerted. Students should understand and clarify that there is no such thing as suction; instead, what is perceived as suction is actually the higher pressure of the surrounding environment pushing into the lower pressure area.

17. Boat Float and Density Column

Students should be able to apply the principles of buoyancy and density to predict and analyze the floating capability of an aluminum foil boat. Students should understand that the boat floats by displacing a volume of water that weighs more than the boat itself, according to Archimedes' principle. Students should be able to calculate the volume of the aluminum foil boat they construct. Students should experimentally determine how many pennies their boat can hold before sinking and calculate the overall density of the boat at the time of sinking.

Students should be able to create a liquid density column using various liquids of different densities (such as water, oil, syrup, alcohol). Students should understand and explain why the liquids layer in a specific order based on their density, without mixing.

18. Fluids in Motion

Students should be able to state Bernoulli's principle, which explains that in a fluid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Students should be able to explain how Bernoulli's principle applies to various real-world phenomena, such as the lift generated under airplane wings, foils on a race car, or the behavior of a spinning soccer ball.

19. When Push Comes to Shove

This is mostly a fun lesson. Students should be able to use their knowledge of forces in fluids and principles of pressure, fluid flow, and conservation of energy to predict what will happen in various situations. Students should be able to revise their predications and seek explanations when outcomes are surprising.

20. Ping Pong Tricks

Students should carry out the Ping Pong Launch and Ball on a String demonstrations. Students should be able to explain how they work using Bernoulli's principle.

21. Pressure Quiz Show

Student should use the assessment and quiz show to evaluate their understanding of Fluids. The assessment can be used before or after the quiz show.

22. Making Waves

Students should be able to define and identify the amplitude of a wave as the maximum displacement of a point on the wave from its rest position. Students should know how to define and calculate the frequency of a wave as the number of cycles per second.

Students should understand the difference between transverse and longitudinal waves. Students should be able to provide examples of each type of wave and describe their propagation in different mediums.

Students should be able to distinguish between electromagnetic and mechanical waves. Students should be able to discuss the characteristics and examples of both electromagnetic and mechanical waves.

23. Good Vibrations

Students should be able to explain that sound waves are longitudinal waves consisting of compressions and rarefactions that travel through a medium (such as air, water, or solids). Students should know how sound waves are created by vibrating objects, which disturb the medium around them, causing the particles of the medium to oscillate and propagate the wave.

Students should be able to explain the effects of increasing the wavelength of a sound wave, which results in a lower frequency and consequently a lower pitch. Students should understand the effects of increasing the amplitude of a sound wave, which results in greater loudness. Students should understand how to calculate the speed of a wave using the frequency and wavelength.

24. Make Your Own Instrument

Students should be able to explain how sound is produced in different types of musical instruments, focusing on the vibrations that generate sound waves. Students should understand how materials and design affect the type of sound produced by an instrument. Students should be able to design and construct simple musical instruments using everyday materials such as buckets, rubber bands, straws, or PVC pipes. Students should demonstrate the ability to modify their instrument to produce different pitches and tones.

25. Resonance and Decibels

Students should be able to explain what happens when waves combine, including the concepts of constructive and destructive interference. Students should understand how resonance occurs when a system vibrates at its natural frequency due to constructive interference, leading to amplified wave motions. Students should be able to describe decibels as a unit used to measure the intensity of sound. Students should be able to explain how an increase in decibel levels corresponds to a significant increase in sound intensity (an increase of 10 decibels represents a tenfold increase in sound intensity, while a 20-decibel increase represents a hundredfold increase.)

26. Electromagnetic Spectrum

Students should be able to describe the electromagnetic spectrum as a continuum of all electromagnetic waves arranged according to their frequency and wavelength. Students should understand that the spectrum includes, in order of increasing frequency and decreasing wavelength: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

Students should be able to identify and describe the characteristics and practical applications of each type of electromagnetic radiation. Students should know that all electromagnetic waves travel at the speed of light in a vacuum.

27. Tabletop Kaleidoscope

Students should be able to explain the principle of light reflection, particularly how light bounces off mirrors and the law of reflection (angle of incidence equals angle of reflection). Students should understand how arranging mirrors at an angle creates multiple reflections that form symmetrical patterns.

Students should be able to construct a simple kaleidoscope using two mirrors placed at an angle to each other, with various small, colorful objects placed at one end to create visual effects. Students should experiment with different angles between the mirrors to see how this changes the patterns created.

28. Colors and Sending Signals

Students should be able to explain that visible light is part of the electromagnetic spectrum and that different colors of light correspond to different wavelengths. Students should understand how white light can be separated into its constituent colors through refraction (e.g., using a prism) and how colors can be combined to form white light. Students should be able to describe how the human eye perceives colors and the role of light receptors in interpreting different wavelengths as different colors.

Students should be able to outline the basic steps and types of electromagnetic waves involved in sending signals between devices (such as an email from a cell phone to a laptop).

29. Waves Quiz Show

Student should use the assessment and quiz show to evaluate their understanding of Waves. The assessment can be used before or after the quiz show.

30. Electrostatics

Students should be able to define electrostatics as the study of electric charges at rest, as opposed to electric currents which involve moving charges. Students should understand the basic properties of electric charges, including the types of charges (positive and negative) and the fact that like charges repel while opposite charges attract.

Students should participate in experiments that demonstrate static electricity, such as using a Van de Graaff generator, rubbing different materials together (like cloth and a plastic rod), or experiments involving charged balloons.

Students should learn about practical applications of electrostatics such as in photocopiers and laser printers, which use electrostatic charge patterns to transfer toner onto paper.

31. The Current Event

Students should be able to define electric current as the flow of electric charge through a conductor and explain how it differs from static electricity, which involves fixed charges. Students should know that the fundamental unit of electric charge is the coulombStudents should be able to state and apply Ohm's Law, which defines the relationship between voltage, current, and resistance in an electrical circuit ($V = IR$, where V is voltage, I is current, and R is resistance).

Students should be able to define an electric circuit as a pathway made up of wires and other components like resistors, capacitors, and switches, through which electric current flows. Students should understand the difference between open and closed circuits and be able to identify what constitutes a complete (closed) circuit versus an incomplete (open) circuit.

32. Super Static

Students should understand the conditions under which static electricity is created, primarily through the processes of friction and separation. Students should carry out various experiments with a charged balloon to observe static electricity in action

33. What's a Watt

Students should be able to define power in the context of electricity as the rate at which electrical energy is converted into another form of energy, expressed in watts. Students should know how to calculate power using the formula $P = IV$, where P is power in watts, I is current in amperes, and V is voltage in volts. Students should be able to explain the difference between alternating current and direct current.

Students should understand and be able to explain the analogy between electrical current and water flow, where voltage is analogous to water pressure, current is analogous to the flow rate of water, and resistance is analogous to the size of the pipe.

34. Marvelous Magnets

Students should be able to define a permanent magnet as a material that generates a persistent magnetic field. Students should understand the source of magnetism in permanent magnets, typically involving the alignment of magnetic domains within the material. Students should learn about the basic properties of magnets, including the attraction and repulsion between poles, where opposite poles attract and like poles repel. Students should be able to identify the north and south poles of a magnet and understand how these interact with the Earth's magnetic field.

35. Electromagnets

Students should be able to define an electromagnet as a type of magnet in which the magnetic field is produced by an electric current. Students should understand the principle behind electromagnetism, particularly how current through a wire coil generates a magnetic field. Students should be able to construct simple electromagnets using wire, an iron core, and a battery, and test their strength by counting how many paper clips or other small metal objects they can pick up. Students should learn about electromagnetic induction, including how a changing magnetic field in a coil of wire induces an electric current in the wire. Students should experiment with factors that affect the strength of an electromagnet, such as the number of coil turns, the current strength, and the type of core material.

36. LED Holiday Card

Students should understand how to complete a circuit so that electricity flows from the power source, through the load, and back to the power source. Students should be able to design a simple circuit that integrates a switch, battery, LED lights, and conductive tape into a holiday card. Students should be able to explain the basic components of an electric circuit, including power sources (battery), conductive paths (conductive tape), and loads (LED lights). Students should demonstrate the ability to construct their circuit on paper, ensuring that connections are secure and the circuit is functional.

37. Going Nuclear

Students should be able to define and distinguish between nuclear fission and nuclear fusion. Students should understand the basic principles that govern nuclear reactions, including the concepts of critical mass and chain reactions in the context of fission, and the conditions necessary for fusion to occur, such as high temperature and pressure.

Students should learn about the applications of nuclear fission, primarily in nuclear power plants, including how a reactor works, the role of control rods, and the steam turbine generation system. Students should be able to articulate the pros and cons of using nuclear energy compared to other forms of energy generation.

38. The Weird World of Quantum

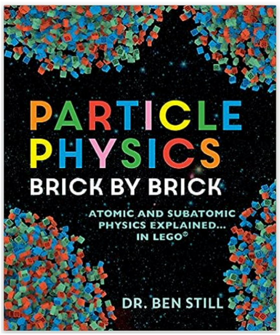
Students should be able to define quantum mechanics as the branch of physics that deals with the behavior of particles at the smallest scales. Students should be able to describe core concepts such as the wave-particle duality, the Heisenberg Uncertainty Principle, the concept of superposition, quantum entanglement, and quantum tunneling.

39. Final Quiz Show

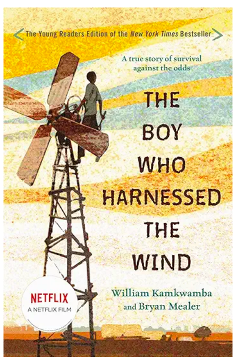
Student should use the assessment and quiz show to evaluate their understanding of the electromagnetism and the other topics of the course. The assessment can be used before or after the quiz show.

RECOMMENDED READING FOR MIDDLE SCHOOL STUDENTS

SEARCHING FOR: more good books on electromagnetism. Let me know if you have recommendations!

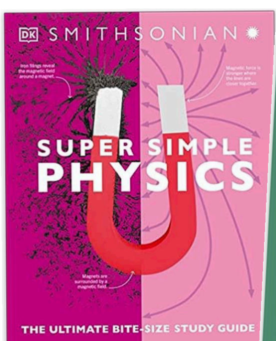


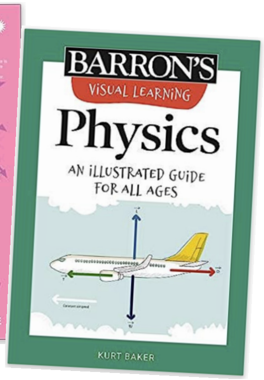
PARTICLE PHYSICS BRICK BY BRICK by Ben Still. This book is a great fit for anyone interested in quantum physics and the overlapping areas of chemistry and physics.The book delves into some detailed exploration of quantum physics but keeps it accessible and fun by using lego bricks.



THE BOY WHO HARNESSED THE WIND by William Kamkwamba. The true story of a boy growing up in an improvised village in Malawi. At age 14, he learned about electrical windmills at his school library. By foraging for junk parts he built a windmill-powered pump that saved his village from famine.

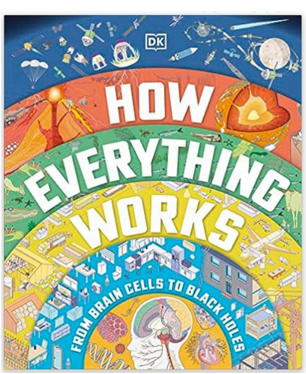
While the book focuses more on the human aspect of the story than the physics of windmill design, it's an excellent connection/supplement to any unit on electromagnetism.





For a reference book or further reading, I very much enjoyed both SUPER SIMPLE PHYSICS by DK/Smithsonian and BARRON'S VISUAL LEARNING: PHYSICS FOR ALL AGES by Kurt Baker.

Super Simple Physics is more text-heavy and detailed in what it covers, but also has wonderful pictures, illustrations, and experiments. Physics for all ages is better for a younger audience or reader who prefers illustrations and diagrams to text. It has less detail in each topic but still does a great job of covering the basic concepts of physics in an engaging and interesting way.



HOW EVERYTHING WORKS by DK is an especially great fit for younger siblings who are watching physics and have more elementary level math and reading skills.

Like physics, this book spans an enormous variety of topics. Sections like "the living world" and "your body" are definitely more in line with a biology class, but the other sections have great connections and crossover into classic physics topics.The illustrations are amazing. In addition to each illustration having a fabulous depth of detail and scientific facts, many also have fun "easter eggs" to find in the form of funny situations, similar to the classic "Where's Waldo" illustrations. They are pages that invite you to come back again and again and discover more each time.

Suggested readings / videos for Middle School Level Students

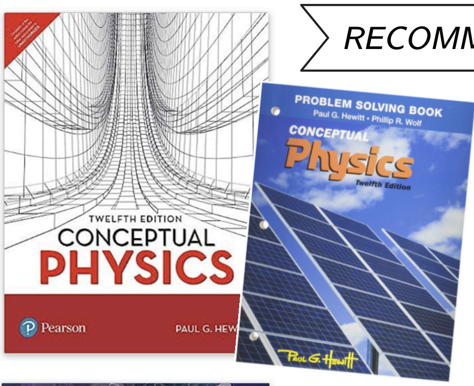
There are lots of great books that could pair with our videos! If you find something that you feel is a great fit, please email me and let me know!

Lesson	Topic	Pages in notes:	Corresponding Reading in Super Simple Physics	Corresponding Crash Course Videos
1	Introduction	5-7	p. 10 The Scientific Method p. 16 Scientific Models	
2	What's the matter?	7-11	pp. 212-214 Particles in Motion	CRASH COURSE CHEMISTRY #1 (NUCLEUS) #5 (ELECTRON) and #3 (FUNDAMENTAL LAWS)
3	Elemental	12-15	pp. 238-239 Elements and the atomic model	CRASH COURSE CHEMISTRY #4 (THE PERIODIC TABLE)
4	Fun Physics Tricks	16-19		
5	No such thing as cold	21-25	pp. 214-215 Particles in Motion p. 218 Internal Energy	CRASH COURSE PHYSICS #20 (TEMPERATURE)
6	Heat transfer	26-29	pp. 42-51 Heat Transfer	CRASH COURSE PHYSICS #22 (HEAT)
7	Clay pot fridge	30-31		
8	Heat capacity & phase changes	32-36	pp. 219-224 Heat Capacity	CRASH COURSE PHYSICS #21 (KINETIC THEORY AND PHASE CHANGE)
9	Laws of thermodynamics	37-40		CRASH COURSE PHYSICS #23 (THERMODYNAMIC LAWS)
10	Make your own ice cream	41-43		
11	THERMODYNAMICS QUIZ SHOW	44-46		
12	Pressure & fluids	48-52	pp. 227-228 Surface Pressure	CRASH COURSE PHYSICS #14 (FLUIDS AT REST)
13	Egg in a Bottle	53-54		
14	Going for a Swim	55-59	p. 229 Pressure in a Liquid	
15	Density & Buoyancy	60-63	p. 230 Floating and Sinking	
16	Boat Float OR Density Column	64-47		
17	Ocean of Air	68-71	pp. 231-235 Pressure in gasses	CRASH COURSE CHEMISTRY #12 and #13 (THE IDEAL GAS LAW)
18	Fluids in Motion	72-75		CRASH COURSE PHYSICS #15 (FLUIDS IN MOTION)
19	Tricks of air	76-77		
20	Push and shove	78-81		
21	FLUIDS/PRESSURE QUIZ SHOW	82-84		

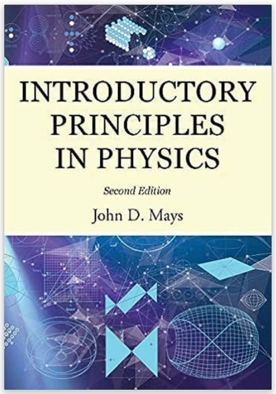
Suggested readings / videos for Middle School Level Students

Lesson	Topic	Pages in notes:	Corresponding Reading in Super Simple Physics	Corresponding Crash Course Videos
22	Making Waves	84-87	p. 113 Waves pp. 117-118 Wave Equations	CRASH COURSE PHYSICS #16 (SIMPLE HARMONIC MOTION) #17 (TRAVELING WAVES)
23	Good Vibrations	88-91	pp. 114-116 Sound pp. 119-123 Measuring Sound	CRASH COURSE PHYSICS #18 (SOUND)
24	Make Your Own Instrument	92-93		CRASH COURSE PHYSICS #19 (THE PHYSICS OF MUSIC)
25	Resonance and Decibels	94-97	pp. 122-124 Sonar and Interference	
26	Electromagnetic Spectrum	98-101	pp. 127-129 Light pp. 148-149 Electromagnetic Radiation	CRASH COURSE PHYSICS #39 (LIGHT IS WAVES)
27	Tabletop Kaleidoscope	102-103	pp. 130-144 Investigating Light	CRASH COURSE PHYSICS #38 (GEOMETRIC OPTICS)
28	Colors and Sending Signals	104-107	pp. 145-147 Color	CRASH COURSE PHYSICS #40 (SPECTRA INTERFERENCE)
29	Wave Quiz Show	108-109		
30	Electrostatics	110-113		CRASH COURSE PHYSICS #25 (ELECTRIC CHARGE)
31	The Current Event	114-117	pp. 153-157 Current Electricity	CRASH COURSE PHYSICS #28 (ELECTRIC CURRENT) See also #26, #27, #29, #30, #31, #33
32	Super Static	118-119	pp. 187-194 Static Electricity	
33	What's a Watt?	120-123	p. 56 Energy and Power pp. 171-173 Power in Circuits pp. 170-186 Using Electricity	CRASH COURSE PHYSICS #36 (AC CIRCUITS) See also #9
34	Marvelous Magnets	124-127	pp. 195-198 Magnetic Fields	CRASH COURSE PHYSICS #32 (MAGNETISM)
35	LED Holiday Card	128-133		
36	Electromagnetism	134-137	pp. 199-207 Using Electromagnets	CRASH COURSE PHYSICS #34 (INDUCTION)
37	Going Nuclear	138-140	pp. 250-254 Fission, Nuclear Power, and Fusion	CRASH COURSE PHYSICS #38 (NUCLEAR PHYSICS)
38	The Weird World of Quantum	141-142		CRASH COURSE PHYSICS #43 & #44 (QUANTUM PHYSICS)
39	FINAL QUIZ SHOW	143-145		

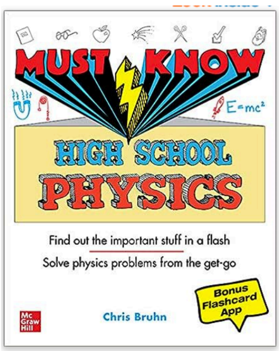
RECOMMENDED READING FOR HIGH SCHOOL AND/OR TEACHERS:



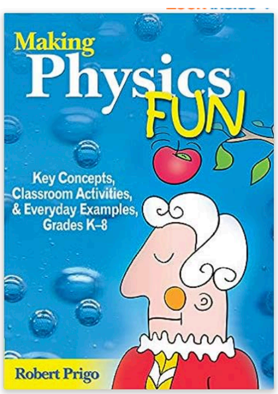
CONCEPTUAL PHYSICS by Paul Hewitt. This textbook Focuses on the concepts and principles of physics rather than analytical or math-based problems. Very readable and engaging. The Problem Solving Book by Hewitt provides a good source of practice problems.



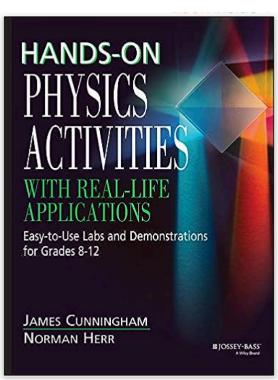
INTRODUCTORY PRINCIPLES IN PHYSICS by John D. Mays. A solid text designed for 9^{th}-10^{th} grade. The math required for practice problems does not go above Algebra 1 (no trigonometry). It has interesting historical anecdotes woven throughout, solid explanations, and practice problems or exercises at the end of each chapter.



MUST KNOW HIGH SCHOOL PHYSICS by Chris Bruhn. This concise reference text has both explanations and math problems (pre-calculus level, contains some problems that require trigonometry). Also comes with a flashcard app. Good for reference or supplemental use but not as solid a stand-alone textbook as the books by Hewitt and Mays listed above.



MAKING PHYSICS FUN by Robert Prigo. A great resource for teachers looking for engaging activities to incorporate into teaching physics.



HANDS-ON PHYSICS ACTIVITIES by James Cunningham and Norman Herr. In addition to describing interesting experiments and investigations, the book also provides excellent explanations and questions. A great resource for teachers or a student who wants additional hands-on activities.

Suggested readings / videos for High School Level Students

*Note: **Our course is not a high school physics course!** We've put this together because we had many requests for a list of resources that could help our course serve as a base for more advanced learning.*

There are many textbooks that could be used to "level up" this course for a high school student. In this table, we've listed suggested readings from Conceptual Physics and videos on similar topics from the Crash Course Physics series by Hank Green. Conceptual Physics has some practice problems and the Problem Solving Book by Hewitt has lots of algebra-based physics problems. The Crash Course Physics course is a calculus-based series of fast-paced summary videos.

Lesson	Topic	Pages in notes:	Corresponding Reading in Conceptual Physics, 12th edition	Corresponding Crash Course Videos
1	Introduction	5-7	Chapter 1: About Science	
2	What's the matter?	7-11	11.1 Atomic Hypothesis 11.2 Characteristics of Atoms 11.4 Atomic Structure 11.7 Compounds and Mixtures 11.8 Molecules	CRASH COURSE CHEMISTRY #1 (NUCLEUS) #5 (ELECTRON) and #3 (FUNDAMENTAL LAWS)
3	Elemental	12-15	11. 5 The Periodic Table 11.6 Isotopes	CRASH COURSE CHEMISTRY #4 (THE PERIODIC TABLE)
4	Fun Physics Tricks	16-19		
5	No such thing as cold	21-25	15.1 Temperature 15.2 Heat	CRASH COURSE PHYSICS #20 (TEMPERATURE)
6	Heat transfer	26-29	16.1 Conduction 16.2 Convection 16.3 Radiation	CRASH COURSE PHYSICS #22 (HEAT)
7	Clay pot fridge	30-31		
8	Heat capacity & phase changes	32-36	Chapter 17: Change of Phase	CRASH COURSE PHYSICS #21 (KINETIC THEORY AND PHASE CHANGE)
9	Laws of thermodynamics	37-40	Chapter 18: Thermodynamics	CRASH COURSE PHYSICS #23 (THERMODYNAMIC LAWS)
10	Make your own ice cream	41-43		
11	THERMODYNAMICS QUIZ SHOW	44-46		
12	Pressure & fluids	48-52	13.1 Pressure	CRASH COURSE PHYSICS #14 (FLUIDS AT REST)
13	Egg in a Bottle	53-54		
14	Going for a Swim	55-59	13.2 Pressure in a Liquid	
15	Density & Buoyancy	60-63	13.3 Buoyancy 13.4 Archimedes Principle 13.5 Sink or float 13.6 Floatation	
16	Boat Float OR Density Column	64-47		
17	Ocean of Air	68-71	14.1-14.4 Atmosphere, Atmospheric Pressure, Boyle's Law, and Buoyancy of Air	CRASH COURSE CHEMISTRY #12 and #13 (THE IDEAL GAS LAW)
18	Fluids in Motion	72-75	14.5 Bernoulli's Principle	CRASH COURSE PHYSICS #15 (FLUIDS IN MOTION)
19	Tricks of air	76-77		
20	Push and shove	78-81		
21	FLUIDS/PRESSURE QUIZ SHOW	82-84		

Suggested readings / videos for High School Level Students

Lesson	Topic	Pages in notes:	Corresponding Reading in Conceptual Physics, 12th edition	Corresponding Crash Course Videos
22	Making Waves	84-87	19.1 Good Vibrations 19.2 Wave Description 19.3 Wave Motion	CRASH COURSE PHYSICS #16 (SIMPLE HARMONIC MOTION) #17 (TRAVELING WAVES)
23	Good Vibrations	88-91	20.1 Nature of Sound 20.2 Sound in Air 21.1 Noise and Music 21.2 Pitch	CRASH COURSE PHYSICS #18 (SOUND)
24	Make Your Own Instrument	92-93	20.5 Forced Vibration 21.4 Quality 21.5 Musical Instruments	CRASH COURSE PHYSICS #19 (THE PHYSICS OF MUSIC)
25	Resonance and Decibels	94-97	20.6 Resonance 21.3 Sound Intensity and Loudness	
26	Electromagnetic Spectrum	98-101	26.1 Electromagnetic Waves 26.2 Electromagnetic Wave Velocity 26.3 The Electromagnetic Spectrum	CRASH COURSE PHYSICS #39 (LIGHT IS WAVES)
27	Tabletop Kaleidoscope	102-103		CRASH COURSE PHYSICS #38 (GEOMETRIC OPTICS)
28	Colors and Sending Signals	104-107	21.7 From Analog to Digital 26.6 Seeing Light - The Eye Chapter 27 Color	CRASH COURSE PHYSICS #40 (SPECTRA INTERFERENCE)
29	Wave Quiz Show	108-109		
30	Electrostatics	110-113	Chapter 22 Electrostatics	CRASH COURSE PHYSICS #25 (ELECTRIC CHARGE)
31	The Current Event	114-117	23.1 Flow of Charge 23.2 Voltage Sources 23.3 Electrical Resistance 23.4 Ohm's Law 23.5 Direct and Alternating Current	CRASH COURSE PHYSICS #28 (ELECTRIC CURRENT) See also #26, #27, #29, #30, #31, #33
32	Super Static	118-119		
33	What's a Watt?	120-123	23.6 Speed and Source of Electrons 23.7 Electric Power 23.8 Lamps 23.9 Electric Circuits	CRASH COURSE PHYSICS #36 (AC CIRCUITS) See also #9
34	Marvelous Magnets	124-127	24.1 Magnetism 24.2 Magnetic Poles 24.3 Magnetic Fields 24.4 Magnetic Domains	CRASH COURSE PHYSICS #32 (MAGNETISM)
35	LED Holiday Card	128-133		
36	Electromagnetism	134-137	24.5 Electric Currents and Magnets 24.6 Electromagnets 24.7Magnetic Forces 24.8 Earth's Magnetic Field Chapter 25. Electromagnetic Induction	CRASH COURSE PHYSICS #34 (INDUCTION)
37	Going Nuclear	138-140	Chapter 34. Nuclear Fission and Fusion	CRASH COURSE PHYSICS #38 (NUCLEAR PHYSICS)
38	The Weird World of Quantum	141-142	Chapter 32. The Atom and The Quantum	CRASH COURSE PHYSICS #43 & #44 (QUANTUM PHYSICS)
39	FINAL QUIZ SHOW	143-145		

Vocabulary List

Amplitude - Maximum displacement from equilibrium.
Archimedes' Principle - Buoyant force equals displaced fluid weight.
Atom - Smallest unit of an element.
Bernoulli's Principle - Pressure decreases with increased velocity.
Buoyancy - Upward force on submerged object.
Current - Flow of electric charge.
Density - Mass per unit volume.
Diffraction - Wave spreading around obstacles.
Electric Charge - Property causing electromagnetic force.
Electric Field - Region of electric force influence.
Electromagnetic Wave - Wave of electric and magnetic fields.
Element - Pure substance of one type atom.
Entropy - Measure of system disorder.
First Law of Thermodynamics - Energy conservation principle.
Frequency - Number of cycles per second.
Heat - Energy transfer due to temperature.
Induction - Generating voltage through changing magnetic field.
Interference - Superposition of two waves.
Longitudinal Wave - Vibration parallel to wave direction.
Magnetic Field - Region of magnetic force influence.
Molecule - Group of bonded atoms.
Ohm's Law - Voltage equals current times resistance.
Pressure - Force per unit area.
Reflection - Wave bouncing off surface.
Refraction - Wave bending through medium.
Resistance - Opposition to electric current.
Second Law of Thermodynamics - Entropy increases in isolated systems.
Specific Heat - Heat needed to change temperature.
Temperature - Measure of heat energy.
Thermal Conductivity - Rate of heat transfer.
Transverse Wave - Vibration perpendicular to wave direction.
Viscosity - Fluid's resistance to flow.
Voltage - Electric potential difference.
Wavelength - Distance between wave peaks.
Wave Speed - Speed at which wave propagates.