PHYSICS 1: TIPS FOR PARENTS &TEACHERS

Using the notes

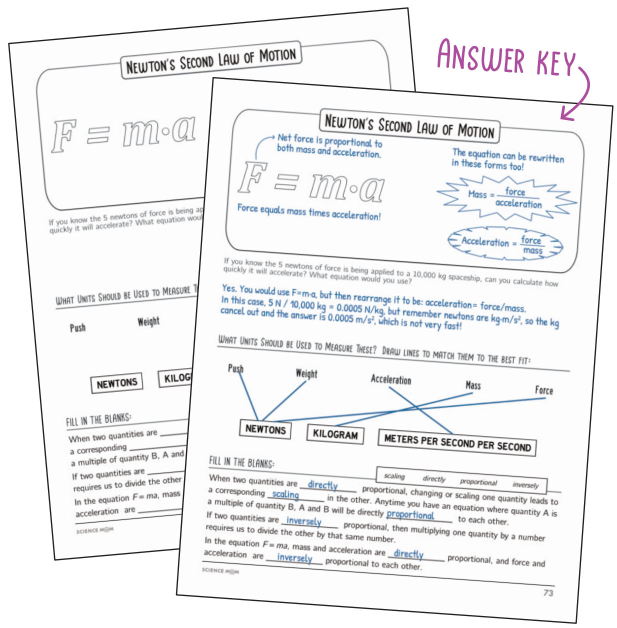
Each lesson in our physics class contains a video and doodle-style notes to go along with it. You can find which pages go with which lesson in the table of contents. There is also an answer key for the notes which contains answers in blue text. Both PDF files can be downloaded in the introduction page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

Title of video lesson	Corresponding pages in the notes
What is Physics?	4-7
Mighty Measures	8-14
Fun Physics Tricks	15-17
Tracking Motion	18-22

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 doing the matching on page 73, you could ask "What unit would be best for measuring the force of a push and why?" or "If you were measuring acceleration, what units would you use and why?"



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

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 Monday/Wednesday video lesson, which you can find in the notes. These problems were designed for 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.

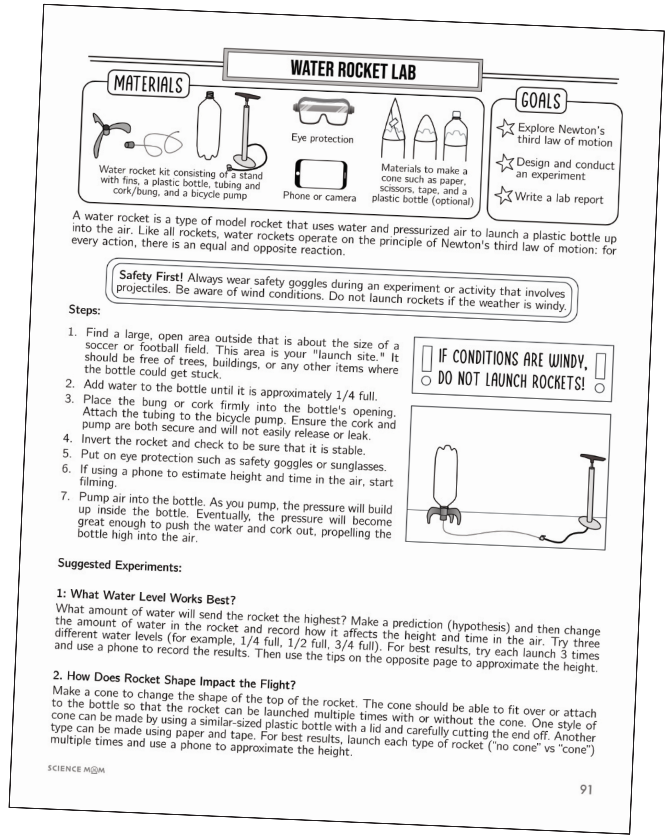
Hands-on Activities and Labs

There are 11 suggested activities or experiments to do in the course. For lesson 24 we recommend doing a full lab report. On page 90 in the notes you'll find instructions and tips for writing a lab report.

In lesson 24, students can choose to do one or more of the following experiments: water rockets, hang time, or horizontal motion vs gravity.

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.



WATER ROCKET LAB

MATERIALS

- Water rocket kit consisting of a stand with fins, a plastic bottle, tubing and cork/bung, and a bicycle pump
- Eye protection
- Phone or camera
- Materials to make a cone such as paper, scissors, tape, and a plastic bottle (optional)

GOALS

- Explore Newton's third law of motion
- Design and conduct an experiment
- Write a lab report

A water rocket is a type of model rocket that uses water and pressurized air to launch a plastic bottle up into the air. Like all rockets, water rockets operate on the principle of Newton's third law of motion: for every action, there is an equal and opposite reaction.

Safety First! Always wear safety goggles during an experiment or activity that involves projectiles. Be aware of wind conditions. Do not launch rockets if the weather is windy.

Steps:

1. Find a large, open area outside that is about the size of a soccer or football field. This area is your "launch site." It should be free of trees, buildings, or any other items where the bottle could get stuck.
2. Add water to the bottle until it is approximately 1/4 full.
3. Place the bung or cork firmly into the bottle's opening. Attach the tubing to the bicycle pump. Ensure the cork and pump are both secure and will not easily release or leak.
4. Invert the rocket and check to be sure that it is stable.
5. Put on eye protection such as safety goggles or sunglasses.
6. If using a phone to estimate height and time in the air, start filming.
7. Pump air into the bottle. As you pump, the pressure will build up inside the bottle. Eventually, the pressure will become great enough to push the water and cork out, propelling the bottle high into the air.

IF CONDITIONS ARE WINDY, DO NOT LAUNCH ROCKETS!

Suggested Experiments:

1: What Water Level Works Best?
What amount of water will send the rocket the highest? Make a prediction (hypothesis) and then change the amount of water in the rocket and record how it affects the height and time in the air. Try three different water levels (for example, 1/4 full, 1/2 full, 3/4 full). For best results, try each launch 3 times and use a phone to record the results. Then use the tips on the opposite page to approximate the height.

2. How Does Rocket Shape Impact the Flight?
Make a cone to change the shape of the top of the rocket. The cone should be able to fit over or attach to the bottle so that the rocket can be launched multiple times with or without the cone. One style of cone can be made by using a similar-sized plastic bottle with a lid and carefully cutting the end off. Another type can be made using paper and tape. For best results, launch each type of rocket ("no cone" vs "cone") multiple times and use a phone to approximate the height.

SCIENCE MOM

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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/**

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.

Introduction and Quiz Show Practice

Students attending the live class should know how to use chat (if desired) and how to disable the chat. Student are able to open Itempool and use it to answer questions.

1. What is Physics?

Student can articulate what physics is (study of matter, energy, and fundamental forces) and has a plan for how they will do the hands-on activities, use the notes, and approach the practice problems. They should have a specific strategy for what they will do if they encounter a lesson or practice problems that are too easy or boring as well as a strategy for what to do if there is material that they don't understand.

2. Mighty Measures

Student should be able to convert between different units and be familiar with the international system of units (SI units). They should know that different different quantities, such as distance and volume, require different units and be able to identify the appropriate units for a situation.

3. Fun Physics Tricks

Student should be able to perform the three physics tricks (mighty match, dollar bill challenge, and book pull) and articulate guesses and ideas about how the tricks work. They do not need to understand the physics behind these tricks. Each one will be explored in more detail in the coming weeks of class. The goal of this first activity is for the student to have fun and experience curiosity about the field of physics.

4. Tracking Motion

Student should be able to distinguish a scalar measurement from a vector measurement, explain the difference between distance and displacement, and be able to calculate speed using the equation speed = distance/time.

5. Graphing Motion

Student can plot the position of an object over time and is also able to interpret position vs time graphs. They should be able to explain what a horizontal line on the graph means (no change in position, a resting or non-moving object) and what a straight slope means (constant motion). The student should be able to explain that vectors have both direction and magnitude.

6. Physics Memory Game

Students should be familiar with the vocabulary terms in the physics vocab memory game set and be able to define some of them.

7. Velocity

Students should be able to distinguish between velocity and speed and be able to define speed as distance traveled in a given amount of time. They should know that velocity is speed with direction (a vector quantity). Students should also be able to look at a velocity vs time graph and tell a story about the graph or interpret what the graph means. They should be able to take a story or series of events that graph the motion of an object. They should understand that constant velocity is represented by a flat line.

8. Acceleration and Forces

Students can explain the differences between acceleration and velocity. They should know that acceleration is both speeding up, slowing down, and changing direction. They should also know that the units of acceleration are meters per second per second.

9. Function Carnival and Degree Golf

During the Desmos activities students should experience hands-on practice with making and interpreting position vs time graphs and estimating angles.

10. Relative Motion and Combining Vectors

Students should be able to explain that motion is relative using examples such as a moving train or plane. They should be able to add two different vectors using coordinates or a graph and be able to apply these skills to basic practical problems such as the motion of a boat being influenced by both river current and engine speed.

11 and 12. Linear Motion Quiz Show and Assessment

Student should use the assessment and quiz show to evaluate their understanding of basic linear motion (position vs time, velocity vs time, acceleration vs velocity). The assessment (pages 44-47) can be used before or after the quiz show.

13. Net Forces

Students should be able to define what a force is (an interaction that causes the motion of an object to change). They should be able to identify and give examples of basic forces such as gravity, friction, the normal force, and the applied force (push or pull).

Students should be able to add forces to obtain the net force and define what net force is (net force = the sum or total of the forces acting on an object). They should know that a net force of zero means no acceleration and constant velocity. The constant velocity could be 0 (no movement) or it could be moving at a constant speed.

14. Free Body Diagrams

Students should be able to calculate net force and draw a simple free body diagram. They should be able to identify forces acting on an object. For example, the student should know that on Earth, gravity will always be present and always be exerting a downward force. Students should be able to classify whether simple situations or objects are experiencing balanced forces or unbalanced forces.

15. Cup Stack Challenge

Student should conduct a simple scientific experiment by changing one thing (speed of the card pull or weight of the cups) while keeping other aspects as similar as possible.

Note: This experiment is introduced BEFORE we talk about the concept of inertia in class. The goal is for the student to experience curiosity and get some practical experience with the concept of inertia before we explore Newton's Laws of Motion.

16. The Law of Inertia

Students should know that ideas of why and how things move have changed over time, from the geocentric model of Ancient Greece to the heliocentric model etc. Students should be able to define and use the word ***inertia***. The quality that objects have to resist changes in motion is called inertia.

Students should be able to recite and explain Newton's first law of motion. (An object at rest will stay at rest unless acted on by a force. An object in motion will continue in motion with same direction and speed unless acted on by a force.)

Students should be able to identify inertia in common daily experiences such as feeling forward motion when a car or bus suddenly slows, water droplets flying off from a dog shaking itself, or a bottle of ketchup being thumped to get the ketchup to the bottom etc.

17. Inertia & Mass

Students should be able to explain the difference between ***mass***, which is constant, and ***weight***, which depends on the gravitational force. They should understand that mass does not change when an object is on different planets but weight does. Students should know that objects with larger mass have more inertia and hence more resistance to changes in motion.

18. Inertia Experiments

EGG SPLASH: The key learning outcome for this activity relates to experimental design and data. The outcome of the egg splash can be variable and with just 1 attempt, students might reach an incorrect conclusion like Andy did in the question on page 68. With 10 attempts, it should be clear that the heavy egg lands in the cup more often than the light egg.

Students should be able to explain that a heavier object will have more inertia or resistance to change in motion, hence the heavy egg is more likely to fall straight down and land in the cup when the toilet paper roll and aluminum pan are removed.

TABLECLOTH PULL: The key learning outcome for this activity relates to experimental design. Students should realize that changing multiple items/variables at once will make it difficult to determine whether or not something has an effect on the outcome.

Students should be able to explain that a silky cloth has less friction than a bath towel. Because of the reduced friction, the silky cloth will be easier to pull out from under the water bottles or dishware.

INERTIA HAT (bonus optional activity): Students should recognize that inertia (object in motion will stay in motion unless acted upon by a force) keeps the hat spinning on the heat. Inertia also keeps the hat in place (object at rest stays at rest) when the person slowly turns underneath it.

19. Newton's Second Law

Students should be able to recite Newton's second law of motion (f=ma) and explain that the acceleration of an object depends on BOTH its mass and the force being applied. They should understand that when quantities are ***directly proportional***, increasing one will cause a corresponding increase in the other. Students should also know that when quantities are ***inversely proportional*** this means an increase in one will cause a proportional decrease in the other.

Students should be able to apply the formula F = ma to solve problems and predict the motion of objects. They should be able to use Newton's second law to explain real-world examples of force and mass influencing how an object accelerates.

20. Actions and Reactions

Students should be able to recite our definition of Newton's Third Law of Motion: ***Forces*** between two interacting objects will always occur in pairs that are ***equal in magnitude*** and ***opposite in direction***.

Students should be able to explain Newton's 3^{rd} law is talking about the FORCES involved, not the object's momentum or acceleration. In regards to the classic phrase "for every action, there is an equal and opposite reaction," students should be able to connect this phrase to what they learned with Newton's 2^{nd} law. They should be able to explain that equal forces does not result in equal acceleration. If two objects experience the same force but their masses are different, then their resulting acceleration will be very different!

Students should be able to identify action-reaction force pairs in real-world situations and explain how these forces affect the motion of objects.

21. Racing Balloons

Students should be able to define the term ***variable*** and be able to identify the ***independent*** and ***dependent*** variables in the racing balloon experiments. Students should be able to repeat the experiment 5 times and average their results for each type of string. They should be able to explain how a reduced force of friction will allow for the balloon to travel a longer distance.

Students should also be able to identify and explain how Newton's 3^{rd} law relates to this experiment

22. Gravity and Free Fall

Students should know that people's understanding of gravity has changed over time. They should be able to explain why Aristotle thought that heavy objects fell faster and be able to give an example where this is observed (ex rock vs feather) and explain why the result would be different in a vacuum with no air resistance.

Students should be able to use the equation for free fall ($h = \frac{1}{2}gt^2$) to calculate how far an object will fall in a given time. They should be able to define and explain the concept of **terminal velocity**.

Bonus content: the distance vs time graph of a falling object is a parabola! Students should know that parabolas are a common and important curve that have many applications.

23. Space Station Physics

Students should be familiar with Newton's general law of gravitation. They should understand the variables in the equation of universal gravitation (G= gravitational constant, m = mass of the objects involved, d= distance between the objects) and have a basic understanding of common examples of the effects of gravity such as tides and orbits.

24. Lab Reports and Gravity Projects

Students should select at least one gravity project and then write a lab report. For any of the chosen gravity projects, students should be able to:

- Use the formula $h = \frac{1}{2}gt^2$ to calculate the fall distance
- Identify the key dependent and independent variables in their experiment
- Gather data and organize it into a format that can be easily communicated/shared
- Discuss what their results mean and explain how gravity and forces influenced the motion of the rocket, ball, or coins.

Students should be able to put their results and conclusions into a format that could be shared with someone else. This could be a formal written lab report, but it could also be done in a video format, an artistic poster with key findings and lessons learned, or an oral presentation.

25. Newton's Laws Quiz Show

Student should use the quiz show/assessment to evaluate their understanding of Newton's laws of motion.

26. Kinetic vs Potential Energy

Students should be able to explain and distinguish between ***kinetic energy***, which is related to an object's motion, and ***potential energy***, which is stored energy based on position, charge, or internal stress. They should be able to recite and understand the principle of the conservation of energy. The total potential and kinetic energy in a system will be conserved over time. Energy can change forms but is not created or destroyed.

27. Assessment and catch up day

Students can use the assessment to evaluate their understanding of Newton's laws or they can use this self-paced day to finish up the lab reports for the gravity project.

28. Work

Students should be able to define work according to physics (what happens when force causes displacement). They should be able to apply the formula W = Fd (work = force times distance). They should be able to distinguish between situations where work is done or not done. They should know that when the force is in the direction of the displacement, the work is positive and the total energy of the object is increasing. When the force is the opposite direction of the displacement the work is negative and the total energy of the object is decreasing.

29. Work and Power

Students should understand the work-energy theorem and know that the work done on an object is equal to the change in its energy. They should be able to define the concept of power in physics, its relationship to work and time, and be able to apply the formula P = W/t (power = work divided by time). They should be able to explain how power relates to the rate at which work is done, and analyze real-world examples to identify instances of power in action.

30. Double Bounce

Students should be able to identify independent and dependent variables and explore the concept of momentum through this hands-on project. When the balls are dropped together the student should be able to identify that the ball with a smaller mass has more velocity and bounces higher than the ball with the larger mass.

Note: this experiment is conducted before we introduce the concept of momentum. It is perfectly okay if students can't fully explain or articulate the reason for the results of the experiment! Part of the goal here is to get them thinking and wondering about the concepts of momentum and collisions before we introduce it.

31-32. Momentum and Collisions

Students should know what momentum is (inertia in motion) and be able to calculate it using p=mv. They know that in isolated systems momentum is always conserved. They should know that changing momentum by applying a force is the same as exerting an ***impulse***. Students should be able to define a ***collision*** as what happens when objects exert force on each other over a short period of time and be familiar with the basic differences between ***elastic*** and ***inelastic*** collisions.

33. Center of Mass & Centripetal Force

Students should know that the ***center of mass*** is the average position of all the mass of a given object. Students should know that if a line drawn straight down from the center of mass falls within the base of the object, then the object is in stable ***equilibrium*** (it won't tip over). They should be able to explain when an applied force can cause an object to travel in a straight line (when it's applied to the center of mass) and when it can cause the object to rotate (when it is applied to a point outside the center of mass).

Students should know that circular orbits are caused by the center seeking force (***centripetal force***). They should be able to explain that in the case of a moon or planet, the force is gravity. In the case of a bucket being spun on a string, that force is from the tension in the string. Students should be able to predict the motion of an object that is released from orbit.

34. Racing Wheels & Center of Mass

RACING WHEELS: The goal of this hands-on activity is for students to design and conduct an experiment to discover that wheels with weights at the center rotate faster than wheels with weights placed at the outside. Students who wish to learn more about why and how things rotate should look up ***moment of inertia***.

CENTER OF MASS: Students should be able to identify the center of mass on a flat shape by using hanging string to draw intersecting lines.

35. Rotational Motion

Students should be able to define and identify **torque**. They should understand practical applications of torque, such as why it is easier to open a door pulling near the handle versus the hinge, and why loosening a bolt with a long wrench requires less force than a short wrench.

36. Simple Machines

Students should be able to identify the 6 classic simple machines (lever, inclined plane, wedge, pulley, screw, and wheel and axle). They should be able to identify these simple machines in common everyday objects. They should be able to calculate the torque acting on levers and be able to balances seesaws when given the weights and distances from the fulcrum.

37. Tensegrity Table

The goal of this hands-on activity is for students to design and assemble a tensegrity table. This is an engineering challenge that will involve some troubleshooting. Students should know that the tension of the center line is what supports the weight of the upper "table."

38. Mechanical Advantage

Students should know that ***mechanical advantage*** is the ratio of load to effort. They should be able to explain that pulleys and levers both use mechanical advantage to make it easier to lift weight.

39. Relativity

Students should know that our understanding of things as fundamental as space and time have changed with further experiments and study. They should know that the speed of light is constant and be able to briefly explain what $E=mc^2$ means in every day language.

40. Rube Goldberg Machine

The goal of this hands-on activity is for students to design their own Rube Goldberg machine using supplies that they have on hand in the classroom or home. Part of engineering is diagnosing and troubleshooting areas where the device doesn't work as planned. During such work students learn problem solving skills, patience, and perseverance. Once the machine is built, students should be able to identify which simple machines have been included in the design and explain how they work to cause the next step in the sequence.

41 and 42. Final Quiz Show and Assessment

Student should use the quiz show/assessment to evaluate their understanding of mechanics.

Suggestions or feedback?

This is my first time putting together a "Teacher's Guide" file like this one. If you have any suggestions or feedback on how it can be improved, please let me know! Email me at jenny@science.mom

Which science standards are covered in Physics 1?

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-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. ***Lessons 20 (Actions and Reactions) and 31 (Momentum and Collisions)***

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. ***Lessons 13 (Net Forces), 14 (Free Body Diagrams), 16 (Law of Inertia), and 19 (Newton's Second Law)***

MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. ***Lessons 22 (Gravity and Free Fall), 23 (Space Station Physics) and 24 (Lab Reports and Gravity Project)***

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. ***Lesson 26 (Kinetic vs Potential Energy)***

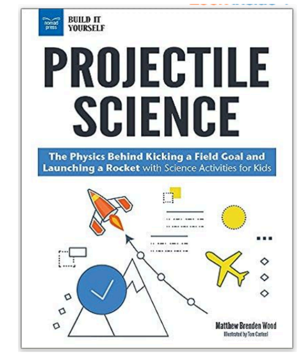
MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. ***Lesson 26 (Kinetic vs Potential Energy)***

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 26 (Kinetic vs Potential Energy)***

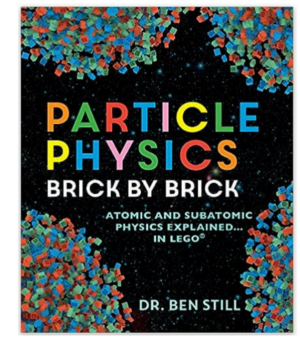
Lesson	Topic	NGSS	Page(s)
13	Net Forces	MS-PS2-2	48-53
14	Free Body Diagrams	MS-PS2-2	54-58
16	Law of Inertia	MS-PS2-2	60-63
19	Newton's Second Law	MS-PS2-2	71-75
20	Actions and Reactions	MS-PS2-1	76-79
22	Gravity and Free Fall	MS-PS2-4	82-86
23	Space Station Physics	MS-PS2-4	87-89
24	Lab Reports and Gravity Projects	MS-PS2-4	90-95
25	Kinetic vs Potential Energy	MS-PS3-1, MS-PS3-2, MS-PS3-3	98-102
31	Momentum and Collisions	MS-PS3-5	112-115

Looking for lessons on heat transfer (thermodynamics), magnetism, electricity, or light and sound (waves)? Those topics will be covered in Physics 2! Are you after even more book recommendations? https://guesthollow.com/high-school-physics-book-and-resource-list/

RECOMMENDED READING FOR MIDDLE SCHOOL STUDENTS

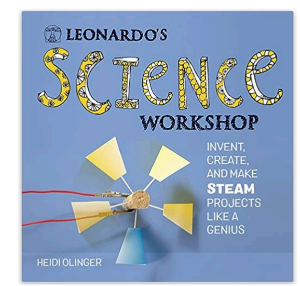


PROJECTILE SCIENCE by Mathew Brenden Wood and Tom Casteel. In addition to a lot of great suggestions of activities for projectile-related experiments, the book provides great information about mechanics and the study of motion.



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, an area we will be covering in more detail in Physics 2.

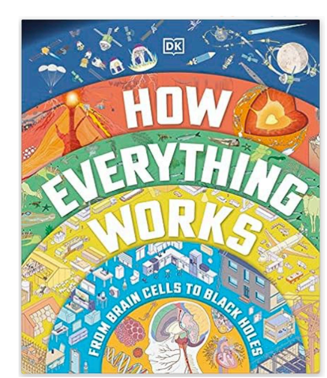
The book delves into some detailed exploration of quantum physics but keeps it accessible and fun by using lego bricks.



LEONARDO'S SCIENCE WORKSHOP by Heidi Olinger. This book has excellent science activities but also weaves in wonderful history and little biographical details from Leonardo Da Vinci's life.

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.

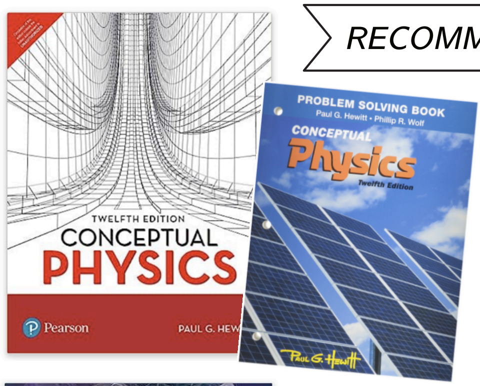
RECOMMENDED READING FOR MIDDLE SCHOOL STUDENTS

There are many books that could be paired with our videos and notes to dive deeper into physics! Below are a suggested pages from SUPER SIMPLE PHYSICS by DK/Smithsonian and PROJECTILE SCIENCE by Matthew Brenden Wood and Tom Casteel.

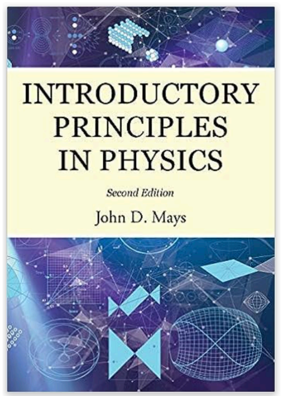
Lesson	Topic	Pages in notes:	Suggested Reading in SUPER SIMPLE PHYSICS	Suggested Reading/ in PROJECTILE SCIENCE
Intro	Introduction & Quiz Show Practice	-		
1	What is Physics?	4-7		
2	Mighty Measures	8-14	20-21, 30	
3	Fun Physics Tricks	15-17		
4	Tracking Motion	18-22	61-63, 66	
5	Graphing Motion	23-27	64-65	
6	Physics Memory Game	28		
7	Velocity	29-33	67	
8	Acceleration and Forces	34-36	68-71, 98-99	
9	Function Carnival and Degree Golf	37-39		
10	Relative Motion & Combining Vectors	40-43		
11	LINEAR MOTION QUIZ SHOW	-		
12	Assessment	44-47		
13	Net Forces	48-53	74-76	22
14	Free Body Diagrams	54-58	77-78	
15	Cup Stack Challenge	59		23
16	The Law of Inertia	60-63		9-14
17	Mass vs Weight	64-66	79	20-21
18	Inertia Experiments	67-70		
19	Newton's Second Law	71-75	97	15-17
20	Actions and Reactions	76-79	92-93	18-19
21	Balloon Races	80-81		25, 108-109

Lesson	Topic	Pages in notes:	Suggested Reading in SUPER SIMPLE PHYSICS	Suggested Reading/ in PROJECTILE SCIENCE
22	Gravity and Free Fall	82-86	94	26
23	Space Station Physics	87-89	110-111	75-76, 102-106
24	Lab Reports and Gravity Project	90-95	16-19,22-27	30-47, 110-111
25	NEWTON'S LAWS QUIZ SHOW	-		
26	Kinetic vs Potential Energy	98-102	32-41, 52-54	50-54
27	Assessment	96-97		
28	Work	103-105	55	
29	Power	106-109	56-59	
30	Double Bounce	110-111		
31	Momentum and Collisions	112-115	100-109	
32	Center of Mass	116-118	86	
33	Racing Wheels and Center of Mass	119-121	87	
34	Rotations and Torque	122-123	84-85. 96	
35	Simple Machines	124-126	88-91	61-63
36	Tensegrity Table	127		
37	Mechanical Advantage	128-129		
38	Relativity	130-132		
39	Rube Goldberg Machine	133		
40	FINAL QUIZ SHOW	-		
41	Assessment	134-136		

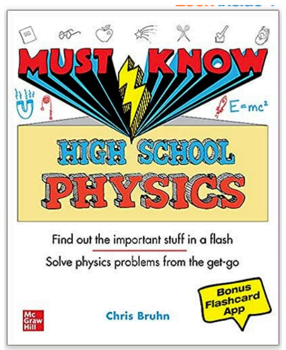
RECOMMENDED READING FOR HIGH SCHOOL AND/OR TEACHERS:



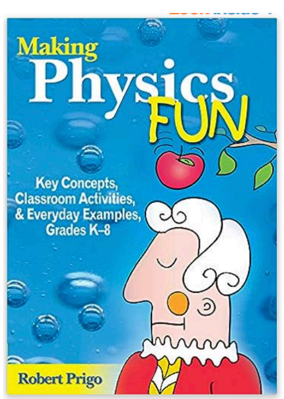
CONCEPTUAL PHYSICS by Paul Hewitt. This textbook Focuses on the concepts and principles of physics rather than analytical or math-based problems. Very readable and engaging. The Problem Solving Book by Hewitt provides a good source of practice problems.



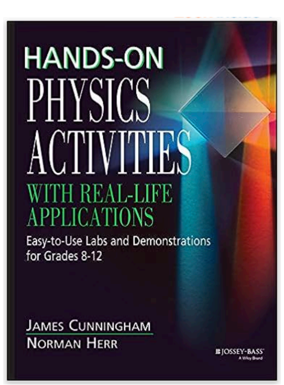
INTRODUCTORY PRINCIPLES IN PHYSICS by John D. Mays. A solid text designed for 9th-10th grade. The math required for practice problems does not go above Algebra 1 (no trigonometry). It has interesting historical anecdotes woven throughout, solid explanations, and practice problems or exercises at the 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**, but we had many requests for recommendations on what books/ resources to pair it from people using it as a base for a high school student.*

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. (Crash Course is a calculus-based series of videos)

Conceptual Physics by Paul Hewitt has some exercises at the end of each chapter but it is largely conceptual – focusing on the principles and concepts of physics rather than quantitative skills. The problem solving book by Hewitt is a good source of practice problems that use higher-level math.

Lesson	Topic	Pages in notes:	Suggested Reading in Conceptual Physics, 12th edition	Corresponding Crash Course Videos
Intro	Introduction & Quiz Show Practice	-	Chapter 1: About Science, 29-44	
1	What is Physics?	4-7		
2	Mighty Measures	8-14		
3	Fun Physics Tricks	15-17		
4	Tracking Motion	18-22		
5	Graphing Motion	23-27		
6	Physics Memory Game	28		
7	Velocity	29-33	3.2 Speed, 3.3 Velocity - p. 66-69	
8	Acceleration and Forces	34-36	3.4 Acceleration - p. 69-72	MOTION IN A STRAIGHT LINE: CRASH COURSE PHYSICS #1
9	Function Carnival and Degree Golf	37-39		
10	Relative Motion & Combining Vectors	40-43	3.1 Motion is Relative - p. 66	VECTORS AND 2D MOTION: CRASH COURSE PHYSICS #4
11	LINEAR MOTION QUIZ SHOW	-		
12	Assessment	44-47		
13	Net Forces	48-53	2.4 Net Force and Vectors, 2.5 The Equilibrium Rule, 2.6 Support Force, 2.7 Equilibrium of Moving Things - p. 53-60	
14	Free Body Diagrams	54-58		FRICTION: CRASH COURSE PHYSICS #6
15	Cup Stack Challenge	59		
16	The Law of Inertia	60-63	2.1 Aristotle on Motion, 2.2 Galileo's Experiments, 2.3 Newton's First Law - p. 47-53 and review questions (p. 60-64)	
17	Mass vs Weight	64-66	4.3 Mass and Weight - p. 87-89	
18	Inertia Experiments	67-70		
19	Newton's Second Law	71-75	4.1 Force Causes Acceleration, 4.2 Friction, 4.4 Newton's Second Law p. 84-90	
20	Actions and Reactions	76-79	5.1 Forces and Interactions, 5.2 Newton's Third Law, 5.3 Action and Reaction - p. 100-107	NEWTON'S LAWS: CRASH COURSE PHYSICS #5

Lesson	Topic	Pages in notes:	Suggested Reading in Conceptual Physics, 12th edition	Corresponding Crash Course Videos
21	Balloon Races	80-81		
22	Gravity and Free Fall	82-86	4.5 When Acceleration is g, 4.6 When Acceleration is < g, Chapter 10 Projectile Motion - p. 90-93	NEWTONIAN GRAVITY: CRASH COURSE PHYSICS #8
23	Space Station Physics	87-89	Chapter 9: Gravity - p. 187-196	
24	Lab Reports and Gravity Project	90-95		
25	NEWTON'S LAWS QUIZ SHOW	-		
26	Kinetic vs Potential Energy	98-102	7.2 Potential Energy, 7.3 Kinetic Energy - p. 139-141	
27	Assessment	96-97		
28	Work	103-105	7.1 Work, 7.4 Work-Energy Theorem 7.5 Conservation of Energy - p. 136-137, 141-143	WORK, ENERGY, AND POWER: CRASH COURSE PHYSICS #9
29	Power	106-109	7.1 Work - p. 138	
30	Double Bounce	110-111		
31	Momentum and Collisions	112-115	Chapter 6: Momentum - p. 117-127	COLLISIONS: CRASH COURSE PHYSICS #10
32	Center of Mass	116-118	8.4 Center of Mass - p. 166-171	UNIFORM CIRCULAR MOTION: CRASH COURSE PHYSICS #7
33	Racing Wheels and Center of Mass	119-121		
34	Rotations and Torque	122-123	Chapter 8: Rotational Motion, 159-166, 171-178	TORQUE: CRASH COURSE PHYSICS #12
35	Simple Machines	124-126	7.6 Machines - p. 146-147	ROTATIONAL MOTION: CRASH COURSE PHYSICS #11
36	Tensegrity Table	127		
37	Mechanical Advantage	128-129	7.7 Efficiency - p. 147-148	
38	Relativity	130-132	Chapter 35: Special Relativity - p. 685-707	SPECIAL RELATIVITY: CRASH COURSE PHYSICS #42
39	Rube Goldberg Machine	133		
40	FINAL QUIZ SHOW	-		
41	Assessment	134-136		

Vocabulary List

Acceleration - The change in velocity over time
Average - Sum of all values divided by the number of values
Density - How much mass per unit of volume
Centripetal - The inward force acting on any rotating object
Displacement - The straight line distance between initial and final position
Force - A push or pull that can make objects move, change, or bend
Free fall - Downward movement under the force of gravity only
Friction - The resistive force between objects in contact
Gram - A unit of mass equal to one thousandth of a kilogram
Gravity - The force that pulls objects toward each other
Inertia - Resistance to a change in motion
Joules - The work done by a force of 1 newton through 1 meter
Kinematics - The branch of mechanics concerned with the motion of objects without reference to the forces which cause the motion.
Kinetic energy - Energy due to motion
Liter - Metric unit of volume equal to 1000 cubic centimeters
Mass - The amount of matter in an object or particle
Mechanics - The branch of physics that studies the interactions of forces and matter
Meter - A metric unit of length
Momentum - The product of mass and velocity
Newton - The force that gives 1 kg an acceleration of 1 m/s2
Potential energy - Stored energy based on position, charge, or internal stress
Projectile Motion - The motion of an object that is only acted upon by gravity
Scalar - A quantity that has a magnitude (measurement) but no direction
Speed - Distance divided by time
Thermal energy - Energy due to the movement of particles
Variable - Any factor, condition, or trait that can exist in different amounts or types
Vector - A quantity that has both magnitude and direction
Velocity - Change in position over time
Weight - The force acting on an object due to gravity
Work - Energy transferred by displacing an object