**AP and University Physics Index**

Chapter titles link to youtube playlist for the chapter (except when they don't!). Individual videos for each chapter follow.[**Chapter 2 - One-Dimensional Kinematics**](https://www.youtube.com/playlist?list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R)

**1.** [**Doc Physics - Displacement and Average Velocity of an Organic, Locally Grown Tomato**](https://www.youtube.com/watch?v=Mk2eJ5v0AHA&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=1)

9:04  We'll see how to make sense of position vs. time graphs. Questions:
1) Can displacement be equal to total distance traveled?…

1. [**Doc Physics - Instantaneous Velocity, Acceleration, Jerk, Slopes, Graphs vs. Time**](https://www.youtube.com/watch?v=STcgrV2L4tw&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=2)

7:46  This is how kinematics begins. It's all calculus, so you should watch my video called Calculus Day 1 - Intro to Derivatives before this video. See above!

1. [**Doc Physics - How Acceleration Affects Velocity and Speed**](https://www.youtube.com/watch?v=4_iOLZvbgrE&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=3)

3:23  Slowing down? Speeding up?

1. [**Doc Physics - British Imperial to Metric SI Unit Conversion Worked Example**](https://www.youtube.com/watch?v=1524117lL8E&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=4)

6:50 Miles per hour (ick) to meters per second

**5.** [**Doc Physics - Average Velocity Speed Worked Example with Multiple Trips, Stops Calculation**](https://www.youtube.com/watch?v=CaH57mVYhxU&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=5)

6:40 We'll work a nice intro problem about three friends who need to go to the bathroom.

[**6.           Doc Physics - Derivation of Key Kinematic Equation appealing to Algebra and Geometry**](https://www.youtube.com/watch?v=7R0XiE8G_h0&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=6)

10:00   Let's be honest. Calculus is the best way to understand what this position-as-a-function-of-time equation is all about. But there are two other simple ways to derive THE CLASSIC.

**7.** [**Doc Physics - Free Fall Acceleration Explained, or COULDN'T YOU FIND AN ORANGE OR SOMETHING?!?**](https://www.youtube.com/watch?v=Du_c6SIfJn8&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=7)

7:41  When stuff feels only gravity, it accelerates downward at 9.81 m/s/s. I'll investigate some of the consequences here.

**8.** [**Doc Physics - Free Fall Acceleration Worked Example (finding time in the air)**](https://www.youtube.com/watch?v=qu_XVjxhybk&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=8)

5:52   We follow a salmon through his testosterone-fueled adventure.

**9.** [**Doc Physics - Free Fall Acceleration Worked Example (finding peak height)**](https://www.youtube.com/watch?v=hDdssebIXo8&list=PLLUpvzaZLf3KmYB83xZ4IUDoTGk2et69R&index=9)

4:28   Using the time it takes for something to reach its peak in free fall, we find the salmon's ultimate jump height.

 [**Chapter 3 - One-Dimensional Kinematics**](https://www.youtube.com/playlist?list=PLLUpvzaZLf3IcI3SbhCzmgy45OISrEfp-)

[**Doc Physics - Adding Vectors 1**](https://www.youtube.com/watch?v=4gWZJtdLiLU&list=PLLUpvzaZLf3IcI3SbhCzmgy45OISrEfp-&index=1)

12:55 rules and start example

[**Doc Physics - Adding Vectors - Conclusion**](https://www.youtube.com/watch?v=QaLqZzs5eEk&list=PLLUpvzaZLf3IcI3SbhCzmgy45OISrEfp-&index=2)

5:03 Draw R vector and find its length and direction

[**Chapter 4 - Projectile Motion**](https://www.youtube.com/playlist?list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq)

**1.** [**Doc Physics - Kinematic Equations in x and y for Projectile Motion**](https://www.youtube.com/watch?v=DzPN6WI4mT4&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=1)

7:02

**2.** [**Doc Physics - Projectile Motion - Launched Horizontally**](https://www.youtube.com/watch?v=Nhojma8a7oY&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=2)

7:46 I call these "Class I Problems" 'cuz they're easy. I've uploaded three examples for your viewing pleasure.

**3.** [**Doc Physics - Projectile Motion Worked Example Class I - find displacement**](https://www.youtube.com/watch?v=tvn1FWbW390&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=3)

6:23 Free fall boulder in x and y. These "Class I Problems" are when the projectile is launched horizontally.

**4.** [**Doc Physics - Projectile Motion Worked Example Class I - find initial velocity**](https://www.youtube.com/watch?v=bFTgf8emKdY&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=4)

6:00 So this French train rolls out of a train station... These "Class I Problems" are when the projectile is launched horizontally.

**5.** [**Doc Physics - Projectile Motion Worked Example Class I - find cliff height**](https://www.youtube.com/watch?v=JjqdFHVmvJU&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=5)

4:10 If we know how fast something is going and how far it has gone, we can find its time of flight! These "Class I Problems" are when the projectile is launched horizontally.

**6.** [**Doc Physics - Projectile Motion - Launched at an Angle**](https://www.youtube.com/watch?v=VwVmL80iGdQ&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=6)

9:18 These can be Class II or Class III problems. Examples follow.

**7.** [**Doc Physics - Projectile Motion Worked Example - Class II Problem - NJCTL**](https://www.youtube.com/watch?v=jvZgQO7Kzgk&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=7)

15:47 We'll resolve the initial velocity vector and find time, final velocities, maximum height, etc. These "Class II Problems" are when the projectile is launched at an angle.

1. [**Doc Physics - Projectile Motion Worked Example - Class III Problem! AAAH!**](https://www.youtube.com/watch?v=seqKPC8bisM&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=8)

10:02 Some projectile motion problems are pretty tricky. I'll show the first one here. Try it before I discuss to test your awesomeness. These "Class III Problems" are when the projectile is launched at an angle.

**9.** [**Doc Physics - Projectile Motion Worked Example - Class III Problem - no initial speed given!**](https://www.youtube.com/watch?v=P-9qAohQMaQ&list=PLLUpvzaZLf3JZFImh2nmqsPRNrRVhQRGq&index=9)

18:23 This is the solution to Holt Physics page 101 Practice E #2. It's the hardest problem in the whole dang book. The golf ball (in the problem) is hit (launched) at an angle, but all you know is the angle and distance traveled.

**AP1 Ch 5 - Newton's Laws of Motion - Introductory Mechanics**

[**Doc Physics - Newton's Three Laws of Mechanics - First Law (Inertia)**](https://www.youtube.com/watch?v=cliJbHYpNic&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

4:45 Newton's first law is hugely counterintuitive. You may have learned it in gradeschool, though. Let's see it for the mind-blowing conclusion it really is.

[**Doc Physics - Newton's Three Laws of Mechanics - Second Law - Part 1**](https://www.youtube.com/watch?v=dFybXASirwQ&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

3:31 Here we'll see how many people can confuse your understanding of Newton's 2nd law of motion through oversight, sloppy language, or cruel intentions.

[**Doc Physics - Newton's Three Laws of Mechanics - Second Law - Part Two!**](https://www.youtube.com/watch?v=_Z7qivqbSBI&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

8:27 Equilibrium is investigated and Newton's 1st law is seen as a special case of Newton's 2nd law! Dang!

[**Doc Physics - What does net force do?**](https://www.youtube.com/watch?v=MOnA_JvaRwU&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

1:08 Acceleration is one of the trickiest topics of intro mechanics. Think about it.

[**Doc Physics - Acceleration on an Elevator**](https://www.youtube.com/watch?v=enTfgXIqUh4&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

4:10 We investigate what net force feels like on an elevator. Think about this next time you stay in a hotel. Get some ice.

[**Doc Physics - Intro to Free-Body Diagrams**](https://www.youtube.com/watch?v=K98Ke3QVppM&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

6:01 I show rules for making FBD's, discuss their incredible power, and give a quick hot-air balloon example.

[**Doc Physics - Using Free Body Diagrams to Solve a Crazy Variety of Problems - General Steps**](https://www.youtube.com/watch?v=7KNeXIv-FpU&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

2:47 These steps will help you solve most problems involving force, acceleration, friction, and mass.

[**Doc Physics - Newton's Third Law is What's Up. But how can stuff happen?**](https://www.youtube.com/watch?v=VR7NfNWuPLk&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

5:21 The most fundamental statement of basic physical reality is also the most often misunderstood. As your mom if she's clear on Newton's Third. Then ask her why things can move if every force has a paired opposite force all the time, forever.

[**Doc Physics - Common Misunderstandings of Newton's Third Law**](https://www.youtube.com/watch?v=i2leq3s5Nn0&list=PLLUpvzaZLf3IXC2VryK5xvYR6t3Z30Va9)

8:04 Chances are, someone you know grossly misunderstands Newton's 3rd law. Find them and cure them.

**AP1 Ch 6 - Applications of Newton's Laws**

[**Doc Physics - Kinetic Friction Introduction**](https://www.youtube.com/watch?v=ZqkV-4rHc4I&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

12:30 Here, I'll explain the microscopic justification of friction and what we can know about it. The coefficient of friction, too!

[**Doc Physics - Static Friction and some friction challenges**](https://www.youtube.com/watch?v=i90-x5Tbnlc&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

7:51 Here, I talk about sneaky ol' static friction.

[**Doc Physics - Kinetic and Static Friction Worked Example**](https://www.youtube.com/watch?v=Gt1JkOtvNY0&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

13:24 This NJCTL problem is the best simple friction problem I've ever seen. If you're unsure about the coefficient of friction and whether something will budge or not, watch on.

[**Doc Physics - Acceleration While Sliding on a Ramp Worked Example**](https://www.youtube.com/watch?v=BEyWcYG5g68&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

12:43 This is a prototypical intro physics problem. Do it while I do it. Try to anticipate my next move.

[**Doc Physics - Box Sliding on a Ramp with No Acceleration Worked Example**](https://www.youtube.com/watch?v=yOUQilucGmQ&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

5:28 Simple physics problems have elegant, surprising solutions. Please solve this similar problem: The painting is at rest on the ramp and it just barely begins to slide at a certain angle theta...find the coefficient of static friction.

[**Doc Physics - Two Boxes of Pokemon Cards Attached with a Rope Worked Example - Tension**](https://www.youtube.com/watch?v=2LEVdqvrUGs&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

9:23 This video introduces tension and some of the funky results that come out of multiple mass problems

[**Doc Physics - Four Weighty Problems Solved - Atwood's Machine Worked Examples**](https://www.youtube.com/watch?v=jucqtMqyVww&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

28:28 I present and solve increasingly complex problems involving boxes attached with rope on ramps and slopes, etc. How to find tension and acceleration for various mass combinations.

[**Doc Physics - Circles are Crazy! (a tribute to Lou Reed and an introduction to circular motion)**](https://www.youtube.com/watch?v=qDbJyHOQKgQ&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

9:11 A strange condition must be met for things to go in a circle. I'm not sure you've realized just how lucky you are, Ducky.

[**Doc Physics - Proof that "The Centrifugal Force" is not real!**](https://www.youtube.com/watch?v=yAfg_8OLjvs&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

1:51 Centripetal force is needed to keep things moving in a circle. And why don't they want to? THEY JUST WANT TO GO IN A STRAIGHT LINE. REALLY. THAT'S ALL EVERYTHING WANTS TO DO.

[**Doc Physics - How Tension Provides a Centripetal Force when things go around in a Circle**](https://www.youtube.com/watch?v=Y6jGKFWBEO0&list=PLLUpvzaZLf3JcyxDrNzO4K2rqSWRs3Irf)

6:51 We use Newton's Second Law to investigate the changes in tension when something is swung in a vertical circle.…

**AP Ch 7 - Energy**

[**Doc Physics - Work, Power, and Energy**](https://www.youtube.com/watch?v=4B_5T7Er7RA&list=PLLUpvzaZLf3L_pZxuynoYVNgZi5QTwUNh)

14:44 Biology is useful.

**AP Ch 8 - Mechanical Energy**

[**Doc Physics - How Potential and Kinetic Energy Change When Forces do Work**](https://www.youtube.com/watch?v=_hECnctQwPY&list=PLAC676D48A67586A6)

9:20

[**Doc Physics - How Potential and Kinetic Energy Change When Forces do Work - Summary**](https://www.youtube.com/watch?v=YLBngCxuN4E&list=PLAC676D48A67586A6)

2:42

[**Doc Physics - Conservation of Mechanical Energy Worked Example**](https://www.youtube.com/watch?v=n637fBmj9Ko&list=PLAC676D48A67586A6)

8:35

[**Doc Physics - Conservative vs. Nonconservative Forces**](https://www.youtube.com/watch?v=C8a8jyihz8s&list=PLAC676D48A67586A6)

10:00

[**Doc Physics - Turning Points and Equipotentials for Simple Harmonic Oscillators**](https://www.youtube.com/watch?v=QcsmimdvS2U&list=PLAC676D48A67586A6)

17:22 We'll see how the energy of things change as they move in quadratic potential wells.

**AP Ch 9 - Momentum and Collisions**

[**Doc Physics - Impulse and Conservation of Momentum**](https://www.youtube.com/watch?v=g-T334fjUyk&list=PLLUpvzaZLf3JJcRz9Iz41Hrr8r_B949_A)

13:20 Collisions!

[**Doc Physics - Center of Mass**](https://www.youtube.com/watch?v=CWvoiW7uUP8&list=PLLUpvzaZLf3JJcRz9Iz41Hrr8r_B949_A)

10:58 How to find it, what it means, and some examples

[**Doc Physics - Examples of Collisions**](https://www.youtube.com/watch?v=1bxsUfurZMc&list=PLLUpvzaZLf3JJcRz9Iz41Hrr8r_B949_A)

12:01

[**Doc Physics - Derivation of Final Velocities in Elastic Collisions**](https://www.youtube.com/watch?v=3VNURjjiwaQ&list=PLLUpvzaZLf3JJcRz9Iz41Hrr8r_B949_A)

11:57

[**Doc Physics - Thrust of a Rocket 'Cuz You and Your Friends can do ROCKET SCIENCE**](https://www.youtube.com/watch?v=qMjpKkIPuXc&list=PLLUpvzaZLf3JJcRz9Iz41Hrr8r_B949_A)

4:15 We consider why shooting mass out the back of a rocket changes its momentum.

**AP Ch 10 - Rotational Motion and Energy**

[**Doc Physics - Rotational Kinematics...Spinning stuff**](https://www.youtube.com/watch?v=9UBdqqStmDg&list=PLLUpvzaZLf3KzbiphvEg4YHvcaSCdwwGf)

9:37

[**Doc Physics - Comparing Linear and Circular (Angular) Kinematics**](https://www.youtube.com/watch?v=7aMbo4ledks&list=PLLUpvzaZLf3KzbiphvEg4YHvcaSCdwwGf)

9:36

[**Doc Physics - Connecting Linear and Rotational Motion! Rolling without Slipping!**](https://www.youtube.com/watch?v=AuBuK1jVyGw&list=PLLUpvzaZLf3KzbiphvEg4YHvcaSCdwwGf)

12:37 How fast does the axle of a bike wheel move? How fast does the BOTTOM of a wheel move?

[**Doc Physics - Moment of Inertia Definition (Rotational Inertia)**](https://www.youtube.com/watch?v=PBo7llsc6LA&list=PLLUpvzaZLf3KzbiphvEg4YHvcaSCdwwGf)

15:44

[**Doc Physics - Kinetic Energy of Rotation**](https://www.youtube.com/watch?v=KGuyId5W6jY&list=PLLUpvzaZLf3KzbiphvEg4YHvcaSCdwwGf)

11:30 Things that roll without slipping have some fraction of their energy as translational kinetic and the remainder as rotational kinetic. The ratio depends on the moment of inertia of the object that's rolling.

**AP Ch 11 - Rotational Mechanics and Torque**

[**Doc Physics - Torque, Angular Acceleration, and the Role of the Church in the French Revolution**](https://www.youtube.com/watch?v=Q1yvWP4J44A&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

16:54 Why do things change their angular velocity? Soon, you'll know.

[**Doc Physics - Static Equilibrium, or What to do when nothing at all is happening**](https://www.youtube.com/watch?v=S-UkIA4jenU&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

9:43 Statics is studied in great depth by mechanical engineers. We get a taste in this video.

[**Doc Physics - Zombie on a Ladder - Simple Sample Statics Worked Example**](https://www.youtube.com/watch?v=49GuRwto-LE&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

10:24 How greasy does the floor have to be before a ladder slips out from under a zombie? Well, it depends on where the zombie is, of course. Can zombies even climb ladders? I hope not.

[**Doc Physics - Angular Momentum Definition and Examples**](https://www.youtube.com/watch?v=R7FkzRhsWm0&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

12:08 What's this script L bidness?

[**Doc Physics - Torque, Angular Momentum, and Newton's Second Law for Rotations**](https://www.youtube.com/watch?v=i6ynCyJ8UcM&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

2:52

[**Doc Physics - Conservation of Angular Momentum Theory and Worked Example**](https://www.youtube.com/watch?v=k9IFb3g2e2M&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

8:57 What it do?

[**Doc Physics - Torque Does Work!!! Awesome!!!**](https://www.youtube.com/watch?v=IbnBdgTOZwE&list=PLLUpvzaZLf3IPBDwkIuSa87tJ-s2tW0Or)

8:19 We find that applying a torque over some angle is equivalent to applying a force over some distance. They even have the same units!

**AP Ch 12 - Gravity**

[**Doc Physics - Gravity**](https://www.youtube.com/watch?v=CynarsHGbmw&list=PLLUpvzaZLf3J_SUAPZh_D4pG5ka9jSpih)

7:38

[**Doc Physics - Kepler's Laws and How Newton Got Cool**](https://www.youtube.com/watch?v=zNeFI_JCXlY&list=PLLUpvzaZLf3J_SUAPZh_D4pG5ka9jSpih)

12:08 Newton derived the proportionality constant from Kepler's Third Law using his newly formed Law of Universal Gravitation. That's how I know you're just as attracted to me as I am to you...which is not very much.

[**Doc Physics - Escape Velocity, or Hey, Where'd that Golf Ball Go?**](https://www.youtube.com/watch?v=SGRgZ1wtW3g&list=PLLUpvzaZLf3J_SUAPZh_D4pG5ka9jSpih)

10:20 How fast does something have to go to completely escape its planet's gravitational pull? I'll define escape as getting infinitely far away, but just barely...

**AP Ch 13 - Periodic Motion and Resonance of Oscillators**

[**Doc Physics - Simple Harmonic Motion Introduction**](https://www.youtube.com/watch?v=iNDRQnhIMK8&list=PLLUpvzaZLf3K-Tl6n_GD3ZEebgQ83QynE)

17:10 A mass on a spring. Some derivatives. And...Angular Frequency!!! Simple Harmonic Oscillators are used to describe pretty much everything in physics at first glance. This is some deeply important stuff up in hur.

[**Doc Physics - Energy of Simple Harmonic Oscillators**](https://www.youtube.com/watch?v=nvc78QWnDH4&list=PLLUpvzaZLf3K-Tl6n_GD3ZEebgQ83QynE)

9:21 We'll discover that energy is conserved in a very surprising way.

[**Doc Physics - Pendulum Modeled as Mass on a Spring**](https://www.youtube.com/watch?v=TBvKNHl8QTA&list=PLLUpvzaZLf3K-Tl6n_GD3ZEebgQ83QynE)

15:29 Connection between SHM and a pendulum. When is sin(theta) about theta?

[**Doc Physics - Damping of Simple Harmonic Motion (not DAMPENING, silly, it might mold!)**](https://www.youtube.com/watch?v=H6wAgtvX_8w&list=PLLUpvzaZLf3K-Tl6n_GD3ZEebgQ83QynE)

10:49 Underdamped, Overdamped, or just right (Critically Damped). Friction's role in oscillators.

[**Doc Physics - Bells, Opera Singers, and the Tacoma Narrows Bridge - Resonance is Everywhere!**](https://www.youtube.com/watch?v=7Yl5cFp1HkU&list=PLLUpvzaZLf3K-Tl6n_GD3ZEebgQ83QynE)

9:00 Driven simple harmonic motion, friction, and uncontrolled increase in amplitude.

**AP Ch 14 - Waves**

[**Doc Physics - Waves Intro**](https://www.youtube.com/watch?v=a89X1fXeVkw&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

15:17 Simple harmonic motion begets waves, which are cool. We also do a bit of dimensional analysis.

[**Doc Physics - Periodic Traveling Wave Motion as a Function of x AND t**](https://www.youtube.com/watch?v=GxAyRJjCAsQ&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

10:33 We develop an equation that accounts for the extent of a traveling wave through space and how that shape evolves as time goes on.

[**Doc Physics - Two Types of Waves: Longitudinal vs. Transverse**](https://www.youtube.com/watch?v=PxB8-BVO82g&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

4:42 Even ocean waves!

[**Doc Physics - The Effect of Boundary Conditions on Reflected Waves**](https://www.youtube.com/watch?v=lwnwqyFWZIs&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

4:29 Some invert, some don't.

[**Doc Physics - Sound Intensity and Decibels Distinctly Defined, Dude**](https://www.youtube.com/watch?v=R5rkg8mTRBI&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

10:18

[**Doc Physics - Intro to Standing Waves on Ropes and in Pipes**](https://www.youtube.com/watch?v=-jP8TemO4jU&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

9:44 We decide what boundary conditions cause nodes and antinodes in standing waves.

[**Doc Physics - Standing wave harmonics on guitar strings (and pianos, banjos, and harps, I guess)**](https://www.youtube.com/watch?v=RUpjYDteYcg&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

9:47 Why do strings make the sounds they do, yo? Various harmonics are investigated and justified.

[**Doc Physics - Standing wave harmonics in a tube with one open end (Organ, Flute, Saxophone, Tuba)**](https://www.youtube.com/watch?v=KZ7intMz2Y4&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

8:45 We derive the equation for the possible resonant frequencies of an organ with one end of the pipe closed.

[**Doc Physics - Doppler Effect Introduction - Moving Observer**](https://www.youtube.com/watch?v=1Ps8BYnDG0A&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

9:01 Doppler what?

[**Doc Physics - Doppler Effect for Moving Source, and Red Shift, and Whatnot**](https://www.youtube.com/watch?v=WDTV_W1FIYw&list=PLLUpvzaZLf3LniC-hTrrrZO3p5Y1eKY60)

14:07 The full Doppler Effect treatment is here.

**AP Ch 15 - Fluids!**

[**Doc Physics - Intro to Fluids and Pressure at a Depth**](https://www.youtube.com/watch?v=bmEwTaJpRh8&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

13:08

[**Doc Physics - Pacsal's Principle, Equilibrium, and Why Fluids Flow**](https://www.youtube.com/watch?v=HiYrsJOyt2Y&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

9:17 If you're going to think of voltage as "electric pressure," then you'd better understand what real pressure does. Hint - differentials in pressure cause currents...but they're not electric currents!…

[**Doc Physics - Why Car Jacks, Bottle Jacks, and Cute Kittens Don't Mix**](https://www.youtube.com/watch?v=cqXPx_vpnLE&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

6:25

[**Doc Physics - Buoyancy - Why and How Stuff Floats**](https://www.youtube.com/watch?v=OhQFdc1mPUA&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

7:41 Density, pressure, buoyant force, fluids. It all comes together here.…

[**Doc Physics - Fluids Flow Finally or How the Continuity Equation Relates to Irritable Bowel Syndrome**](https://www.youtube.com/watch?v=Qeave5FkMVM&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

16:34 We derive the change in pressure as velocity of a fluid changes. Bernoulli!

[**Doc Physics - Bernoulli's Equation is the Conservation of Energy!**](https://www.youtube.com/watch?v=h7FR6PSbKXw&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

10:49

[**Doc Physics - Torricelli's Law - He's Italian!**](https://www.youtube.com/watch?v=2vfTwnlsrCM&list=PLLUpvzaZLf3KFTgLDkcBW9UOU1PGbY82e)

6:53 How fast a fluid goes when it comes out of a hole in a bucket depends on depth and the acceleration of gravity. Wanna guess how?!?

**AP Ch 16 - Thermal Energy & Heat Capacity and Conductivity**

[**Doc Physics - Definition of Temperature**](https://www.youtube.com/watch?v=yvHtB_Bti2k&list=PLLUpvzaZLf3IbtFyTfVns_cQF3TrYKcFL)

13:30 Celsius, Fahrenheit, Kelvin, OH MY. Constant Volume Gas Thermometer

[**Doc Physics - Thermal Expansion (Linear, Area, and Volume!)**](https://www.youtube.com/watch?v=KyaM7O6E3xM&list=PLLUpvzaZLf3IbtFyTfVns_cQF3TrYKcFL)

13:23 We derive why beta (for volume expansion) is three times alpha (for linear expansion).

[**Doc Physics - Mechanical Equivalence of Heat Energy - The Joule and Calorie UNITE!**](https://www.youtube.com/watch?v=ujyIdDHDQ_8&list=PLLUpvzaZLf3IbtFyTfVns_cQF3TrYKcFL)

5:51 Thermal energy was connected with mechanical energy by James Joule. Awesome. Let's name all forms of energy after him.

[**Doc Physics - Heat Capacity and Specific Heat**](https://www.youtube.com/watch?v=hC_NKgHF1MM&list=PLLUpvzaZLf3IbtFyTfVns_cQF3TrYKcFL)

8:56 We investigate the fact that different materials can store heat with varying efficiencies. Efficient thermal energy storage means BIG specific heat. We'll investigate how to get those efficiencies later...

[**Doc Physics - Heat Conductivity and Stefan-Boltzmann Law of Radiated Power**](https://www.youtube.com/watch?v=7U9tza1DaqI&list=PLLUpvzaZLf3IbtFyTfVns_cQF3TrYKcFL)

10:08

**AP Ch 17 - Ideal Gases and Phase Ch-Ch-Ch-Changes**

[**Doc Physics - Ideal Gas Law Intro**](https://www.youtube.com/watch?v=eWsKnWHfv9M&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

10:55 We define an ideal gas and intuit the ideal gas law.

[**Doc Physics - Historical Derivation of the Ideal Gas Law**](https://www.youtube.com/watch?v=BDmDhNZazWs&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

9:42 Charles, Boyle, and Duh.

[**Doc Physics - Mom, why does pressure exist? or...The Kinetic Theory of Gases**](https://www.youtube.com/watch?v=SwdccM91SMM&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

20:18 We arrive at a definition of temperature that finally is useful. We'll find also that heat capacity is

[**Doc Physics - Screwing Up Stuff via Bulk, Young's, and Shear Modulus. Stress and Strain.**](https://www.youtube.com/watch?v=Hoga089lHjs&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

19:14 Elastic deformation is studied in great detail.

[**Doc Physics - Phase Equilibrium, Boiling, Evaporation, Vapor Pressure**](https://www.youtube.com/watch?v=6ZpVwO3JeZY&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

17:01 We think about why people sweat and why that's cool. We also propose a device for faster cooking of potatoes.

[**Doc Physics - How to Draw Phase Diagrams and What they Mean!**](https://www.youtube.com/watch?v=CPIRgmkbZOE&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

21:50 Let's consider how stuff changes phase. Solid to Liquid to Gas or skip-a-step.

[**Doc Physics - Latent Heat of Fusion and Vaporization**](https://www.youtube.com/watch?v=6lAxBTLgYfU&list=PLLUpvzaZLf3J2wZrXosN0cL9F9NQmKpGl)

8:57 We investigate why Home Depot is better than Lowe's. Or is it the other way around?

**AP Ch 18 - Thermodynamics**

[**Doc Physics - The 0th and 1st Laws of Thermodynamics**](https://www.youtube.com/watch?v=T0hOWt5AAPE&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

10:14 These are pretty easy stuff, but they make a nice foundation for what's to come.

[**Doc Physics - Thermal Processes 1 - Isobar is Greek for Constant Pressure**](https://www.youtube.com/watch?v=H7vkTxm2rcQ&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

7:23

[**Doc Physics - Thermal Processes 2 - Isochor is Greek for Constant Volume**](https://www.youtube.com/watch?v=wYTInjJjArw&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

2:36 Wow. Why is he wasting our time?

[**Doc Physics - Thermal Processes 3 - Isotherm is Greek for Constant Temperature**](https://www.youtube.com/watch?v=XvX4JTAwy9A&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

8:28

[**Doc Physics - Thermal Processes 4 - Adiabatic is Greek for Not Passin' Through**](https://www.youtube.com/watch?v=eMW359hxnys&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

9:21 This video also summarizes what we've learned about four types of thermal processes.

[**Doc Physics - Specific Heat...at Constant Volume? or at Constant Pressure?**](https://www.youtube.com/watch?v=EeEr3uFFRYQ&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

13:13 They're different!!!

[**Doc Physics - A Tiny Bit More on Adiabatic Compression and Expansion, because I care.**](https://www.youtube.com/watch?v=IZsrD-oW6kY&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

4:31 Adiabats are neat.

[**Doc Physics - Stabbed by the Arrow of Time or The Second Law of Thermodynamics**](https://www.youtube.com/watch?v=wQS3ADyLsUk&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

3:03 Our first indication that time always goes forward. The universe gets more and more uniform. All things approach the same temperature.

[**Doc Physics - A Heat Engine Can Use Heat to do Work. But It Can't Be Perfectly Efficient!**](https://www.youtube.com/watch?v=LdcEmZjLIiM&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

12:23

[**Doc Physics - Anti-Heat Engines: Refrigerators, Air Conditioners, and Heat Pumps**](https://www.youtube.com/watch?v=E1vAdvsa7bE&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

15:55 These three things use input WORK to move heat from cold to hot (which is NOT the way the heat would like to go).

[**Doc Physics - Entropy, Disorder, and the Eventual Heat Death of the Universe**](https://www.youtube.com/watch?v=UXRFQBad1Hs&list=PLLUpvzaZLf3J3uvFOl2aohGNaM9ersfZe)

12:35 Clean your room.

**AP Ch 19 - Electrostatics and Conductors**

[**Doc Physics - Introduction to Electric Charge (Friction, Conduction, Induction)**](https://www.youtube.com/watch?v=zWQTdr-XsS4&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

15:53

[**Doc Physics - Coulomb's Law Demonstrated with Clear Plastic Tape**](https://www.youtube.com/watch?v=06Z6WeIMdVI&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

7:07 We discuss why gravity is so weak.

[**Doc Physics - The Principle of Superposition for Coulomb's Law of Electric Force**](https://www.youtube.com/watch?v=p3Xugztl9Ho&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

2:17 Electric Forces add up just like all other vectors do.

[**Doc Physics - The Electric Field! (and Spherically Symmetric Distributions of Charge and Mass)**](https://www.youtube.com/watch?v=pB-Fjrs1m94&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

8:31

[**Doc Physics - How to Draw Electric Field Lines and What They Mean**](https://www.youtube.com/watch?v=pbrI1JEBAQU&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

8:04 We'll just lay down some rules and see what happens.

[**Doc Physics - Conductors in Electrostatic Equilibrium - Rules for Electric Fields**](https://www.youtube.com/watch?v=dUNoxVY0p3Q&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

13:46 This video lists and sorta explains the rules of conductors so you can solve problems. If you still wonder why charges like pointy bits, please view my video (and the ensuing glorious discussion with other nerds in the comments) right hurre: https://www.youtube.com/watch?v=IMFgx…

[**Doc Physics - Gauss' Law Explained and Parallel Plate Capacitor Worked Examples**](https://www.youtube.com/watch?v=hnt07JpNE1E&list=PLLUpvzaZLf3ItVF6TbBDJvFOTO4RDSGm2)

17:28 The point charge and infinite sheet of charge

**AP Ch 20 - Voltage and Capacitors**

[**Doc Physics - Electric Potential Equations**](https://www.youtube.com/watch?v=Vek3hTjfXf4&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

19:40 Not to be confused with Electric Potential Energy. But certainly to be confusing. This is a very tricky topic.

[**Doc Physics - Finally, a Useful Explanation of Electric Potential with Analogy to Gravity**](https://www.youtube.com/watch?v=xrQCPYsoBKk&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

13:09 We move from Force to Energy to Potential (the tricky one) to Field Strength, in a Uniform Gravitational Field and a Uniform Electric Field. You already love gravity, so this will help, I hope.

[**Doc Physics - Electric Potential of a Point Charge Derived**](https://www.youtube.com/watch?v=nOm6FB6p8Ko&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

14:38 Starting from Coulomb's Law, we can find the potential of a point charge and then study the superposition of electric potential. No problem - it's a scalar!

[**Doc Physics - Equipotentials and the Direction of Electric Fields**](https://www.youtube.com/watch?v=Q22KjvxOG6U&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

13:42 The topographical method of equipotentials is very useful.

[**Doc Physics - Electric Potential of Conducting Spheres or Why Charges Like Pointy Bits**](https://www.youtube.com/watch?v=IMFgxAmYYp4&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

12:08

[**Doc Physics - Intro to Capacitors**](https://www.youtube.com/watch?v=ohiRxMc9dKI&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

10:10 Super useful things, capacitors. I hope they will be used to run cars within the next twenty years. That's your job, students.

[**Doc Physics - Dielectrics in Capacitors and Otherwise**](https://www.youtube.com/watch?v=P8A1U-RZDao&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

16:38 We'll investigate what happens if you slip a bit of insulator inside a capacitor while you're building it. Like...does the insulator become polarized, and how can this change the capacitance of the capacitor?…

[**Doc Physics - Potential Energy Stored in a Capacitor**](https://www.youtube.com/watch?v=aNrKh4AgAoA&list=PLLUpvzaZLf3Jv7AjU5pfY8s25-QBCfdIZ)

9:19

**AP Ch 21 - Circuits**

[**Doc Physics - Conventional Current, Electric Field, Benjamin Franklin, and Electron Velocity**](https://www.youtube.com/watch?v=8VZb9Khn9Mc&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

12:21 So, Benny made an incorrect assumption, but the electron wasn't even discovered for 110 years after he died. So don't get mad. But it is annoying... Is there a German word for being angry without any justification? I hope so.

[**Doc Physics - Intro to Resistor and Resistivity Theory**](https://www.youtube.com/watch?v=XoI6QmQeAXo&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

13:14 Why?

[**Doc Physics - Energy and Power in Electric Circuits. Joule Heating.**](https://www.youtube.com/watch?v=PEhkDrhWapI&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

11:56 Poison Ivy?

[**Doc Physics - Series and Parallel DC Circuits Intro - Equivalent Resistances of Resistors Reduction**](https://www.youtube.com/watch?v=C9P3Jgr779I&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

12:29 We derive the equivalent resistance of simple combinations of resistors. Here's an example: https://www.youtube.com/watch?v=CZgqGTxL9cA&list=PLLUpvzaZLf­3IM2wmkH0TcDRzkN3joR5Af

[**Doc Physics - Parallel and Series Resistor Circuit Analysis Worked Example using Ohm's Law Reduction**](https://www.youtube.com/watch?v=CZgqGTxL9cA&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

24:05 This procedure is tedious, but it requires very little fancy math and it's conceptually beautiful. You ought to be able to look at the finished product and explain WHY the values of voltage drops and currents for each resistor and combination of resistors have the relationships they do. Yay! …

[**Doc Physics - Kirchhoff's Loop and Junction Rules Theory**](https://www.youtube.com/watch?v=IlyUtYRqMLs&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

7:42 We justify Kirchhoff's Rules from diarrhea and conservation of energy. Some people call 'em laws, but not me!

[**Doc Physics - Kirchhoff's Rules (Laws) Worked Example**](https://www.youtube.com/watch?v=TdCuu-4wm44&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

9:37 The Loop and Junction Rules are in full effect. Some people call 'em laws, but not me!…

[**Doc Physics - Equivalent Capacitance for Capacitors in Series and Parallel Circuits Reduction**](https://www.youtube.com/watch?v=xgQt8dRhDnE&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

12:10 It's all about charge, voltage, and capacitance. In exactly the opposite way as resistors in series and parallel are all about voltage, current, and resistance. Yup.

[**Doc Physics - RC Circuits and Time Dependence**](https://www.youtube.com/watch?v=mKibWHi4-E4&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

8:24 We derive the awesomely asymptotic time dependence of a capacitor's voltage as it is charged. Hint - all real batteries have internal resistance, and this might be an easy way to measure it.

[**Doc Physics - Ammeter vs. Voltmeter Theory**](https://www.youtube.com/watch?v=FWkBGLcUdJ4&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

1:09 Connect your circuit components carefully. Ammeters can be easily damaged! I guess if you connect your voltmeter wrong, you'll just get bad readings. And stop saying "ampmeter." It sounds like you're multiplying current times distance. Pshaw.

**AP Ch 21 - Circuits**

[**Doc Physics - Conventional Current, Electric Field, Benjamin Franklin, and Electron Velocity**](https://www.youtube.com/watch?v=8VZb9Khn9Mc&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

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[**Doc Physics - EMF, Internal Resistance, and Terminal Voltage of Batteries**](https://www.youtube.com/watch?v=hb3V2XboZTs&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

15:33 Some people call it a dry cell; I call it a sling blade. Mmmhmmm. We will figure out why my laptop and cell phone heat up when I use them a lot. Yay!

[**Doc Physics - EMF, Internal Resistance, and Terminal Voltage of Batteries Worked Example**](https://www.youtube.com/watch?v=pXLJD53AM84&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

6:31 We'll do three quick NJCTL.org problems on terminal resistance.

[**Doc Physics - Kirchhoff's Loop and Junction Rules Theory**](https://www.youtube.com/watch?v=IlyUtYRqMLs&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

7:42 We justify Kirchhoff's Rules from diarrhea and conservation of energy. Some people call 'em laws, but not me!

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[**Doc Physics - Equivalent Capacitance for Capacitors in Series and Parallel Circuits Reduction**](https://www.youtube.com/watch?v=xgQt8dRhDnE&list=PLLUpvzaZLf3IM2wmkH0TcDRzkN3joR5Af)

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8:24 We derive the awesomely asymptotic time dependence of a capacitor's voltage as it is charged. Hint - all real batteries have internal resistance, and this might be an easy way to measure it.

**AP Ch 22 - Magnetism from Electricity**

[**Doc Physics - Introduction to Magnetic Forces on Moving Charges - Right Hand Rule**](https://www.youtube.com/watch?v=Ng4aNqlAjKo&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

12:30

[**Doc Physics - Moving Charges Feel Force as they Move with a component Normal to a Magnetic Field**](https://www.youtube.com/watch?v=cgbJdoxCVtI&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

8:35 Hey - they'll go in circles! Or helices!

[**Doc Physics - Magnetic Fields cause Forces on Currents in Wires, too**](https://www.youtube.com/watch?v=4werPdAkrEo&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

8:08 This link shows how to use the right-hand rule (and when to use your left hand!) http://www.youtube.com/watch?v=Ng4aNqlAjKo

[**Doc Physics - Torque on Current-Carrying Loop in Magnetic Field - Motor Theory!**](https://www.youtube.com/watch?v=xER1_SYql44&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

12:53 So, I suppose many comforts of modern life depend on this interaction.

[**Doc Physics - Galvanometers are Awesome. The older the better...**](https://www.youtube.com/watch?v=sB_XOoJV3x8&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

4:55 Meet Big Bertha!

[**Doc Physics - Ampere's Law for Magnetic Field of Current-Carrying Wires - Right-Hand Rule!**](https://www.youtube.com/watch?v=CsdN9VpIOxo&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

9:37

[**Doc Physics - Force Between Two Parallel Current-Carrying Wires**](https://www.youtube.com/watch?v=BXKihkHjYes&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

9:14 A surprising result. I was surprised, anyway...

[**Doc Physics - Magnetic Field of Loops, Solenoids, and Electromagnets**](https://www.youtube.com/watch?v=oB2KDgajhJk&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

9:51 Solenoids are the magnetic equivalent of capacitors - they create a uniform field.

[**Doc Physics - Ampere's Law Example for Solenoid**](https://www.youtube.com/watch?v=SY4A13uTSmM&list=PLLUpvzaZLf3JdYy1MnR1F6yTqMhBok_sN)

5:14

**AP Ch 23 - Electricity from Magnetism**

[**Doc Physics - Faraday's Law of Magnetic Induction or WHY IS THERE ROCK AND ROLL?**](https://www.youtube.com/watch?v=UAjCrl-SPcY&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

8:18

[**Doc Physics - Lenz's Law is an Example of Nature Hating Change**](https://www.youtube.com/watch?v=wXcg7GnwssU&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

10:28

[**Doc Physics - Mechanical and Electrical Energy are Related Intro**](https://www.youtube.com/watch?v=plBajQyHyjk&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

6:45 Force of gravity must equal magnetic force if this falling rod reaches terminal velocity. Course, it'll never REACH terminal velocity - just get closer and closer asymptotically forever - but I digress.

[**Doc Physics - Equivalence of Electrical and Mechanical Power for Expanding Loop in Magnetic Field**](https://www.youtube.com/watch?v=nJ6M_l-exQ4&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

11:49 WOW!

[**Doc Physics - Electric Guitar Pickup Coil to Amplifier to Speaker Voice Coil Theory**](https://www.youtube.com/watch?v=-colsdWF4-s&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

11:38 We investigate how electric guitars and associated paraphernalia manage to send information about guitar string vibration to your ears.

[**Doc Physics - Generators! (or Dynamos as my fine British friends say)**](https://www.youtube.com/watch?v=5Pr72ME4aPs&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

5:48 Rotating a loop in a magnetic field induces a current in the loop that opposes the rotation. In fact, if you keep spinning that sucker, it will ALWAYS want to go back to its immediately previous orientation. How fickle can you be, universe?!?

[**Doc Physics - Inductors and Intro to Self-Inductance**](https://www.youtube.com/watch?v=4PvOFovZQpQ&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

12:31 We discuss how to make an inductor and solve for the self-inductance of a simple solenoid

[**Doc Physics - Further into Inductors. They're the magnetic analog of capacitors!**](https://www.youtube.com/watch?v=0IVJaXO_0XA&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

15:41

[**Doc Physics - Transformers are Awesome!**](https://www.youtube.com/watch?v=jDuxFEgtSAQ&list=PLLUpvzaZLf3JIW6Xw-WgAxm1vvCS0P5z9)

18:09 Step up, step down, step all around town. But who's buying?

**AP Ch 24 - Alternating Currents and Phasors**

[**Doc Physics - Intro to AC Circuits using Phasors and RMS Voltage and Current**](https://www.youtube.com/watch?v=FrRmihdF52o&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

16:11

[**Doc Physics - Capacitors in AC Circuits with Phasors**](https://www.youtube.com/watch?v=P9xSEhPENqM&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

16:58

[**Doc Physics - Intro to Frequency-Dependent Impedance (Capacitors in Alternating Currents)**](https://www.youtube.com/watch?v=csjiObHwVJQ&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

9:44

[**Doc Physics - Phasors for Inductors in AC Circuits**](https://www.youtube.com/watch?v=8-veJf_JX3g&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

15:11

[**Doc Physics - Inductors Have Inductance, Reactance, AND Impedance. DANG, DAWG.**](https://www.youtube.com/watch?v=UgoW2d4EidU&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

10:33

[**Doc Physics - AC Circuit Resonance Bonanza: Radio Tuning Frequency, NMR Coils, & the Complex Plane**](https://www.youtube.com/watch?v=C0j0WD7eNjE&list=PLLUpvzaZLf3IzKJXgclNlVg8GMBczMBZf)

23:06 We discuss damped simple harmonic motion as it applies to electrical circuits and reason our way through why energy appears in the various forms it does in capacitors and inductors. The equivalence of electrical and mechanical resonance is heavily emphasized.…

**AP Ch 25 - Electromagnetic Radiation Fundamentals**

[**Doc Physics - Accelerating Charges Emit Electromagnetic Waves - "Light" - Radio Antennas!**](https://www.youtube.com/watch?v=IWVPJSoJDzA&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

14:45 Every charge that accelerates emits light that indicates how it has been accelerating. This can be used for radio and other long-range communications!

[**Doc Physics - Maxwell's Equations and the Speed of Light**](https://www.youtube.com/watch?v=8PE5GEXqmT8&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

5:46 Gauss's Law, Ampere's Law, and Faraday's Law! Maxwell combined them all and proposed a beautiful symmetry that was later confirmed by a clever experiment. Awesome.

[**Doc Physics - Fizeau's 1850 Experimental Measurement of the Speed of Light**](https://www.youtube.com/watch?v=h_UMabvPrws&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

4:32 I love ancient experiments! So CLEVER! Armand Hippolyte Louis Fizeau - yep, he was French. His name is also engraved in the Eiffel Tower. But not like he was a punk kid - they actually honored him that way! I've got to ask my Francophone readers - is Fizeau French for carbonated water?

[**Doc Physics - Energy Density of Electromagnetic Waves (Light)**](https://www.youtube.com/watch?v=GBlE8Pc-Os4&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

6:44 The oscillating electric and magnetic fields of light carry energy.

[**Doc Physics - Doppler Effect for Light, Red Shift, and Accelerated Expansion of the Universe**](https://www.youtube.com/watch?v=EzZ-HsxCFlU&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

4:53

[**Doc Physics - Light Has Energy and (GASP!) Momentum**](https://www.youtube.com/watch?v=9yc5oXTFqsA&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

12:24 We derive radiation pressure and other cool stuff. Sail through the universe with ease.

[**Doc Physics - Light Speed, Wavelength, and Frequency - Dimensional Analysis**](https://www.youtube.com/watch?v=W2VVoKArRcQ&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

3:37 I use unit analysis to determine some stuff. You should, too.

[**Doc Physics - Intro to Polarization Filters! or...why are those sunglasses so expensive?**](https://www.youtube.com/watch?v=e8aYoLj2rO8&list=PLLUpvzaZLf3JsH6tg4tuf8tBLEeoMFy3V)

7:14 We figure out why light waves that are shaking a certain direction can make it through polarization filters while others can't. We also hint at the Law of Malus and more beautiful Polaroid filter combinations.

**AP Ch 26 - Geometric Optics**

[**Doc Physics - Geometric Optics - Specular vs. Diffuse Reflection, Incident and Reflected Angles**](https://www.youtube.com/watch?v=bkQBgcEQ2MM&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

13:49 We introduce the Law of Reflections. Specular reflection keeps all the rays in nice, pretty order, and can only happen when the surface is incredibly smooth on a microscopic level. Diffuse reflection is overwhelmingly more common.

[**Doc Physics - Geometric Optics - Plane Mirrors**](https://www.youtube.com/watch?v=jIymS1yFLao&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

16:09 We figure out why it seems like there's stuff...THROUGH THE LOOKING GLASS

[**Doc Physics - Geometric Optics - Intro to Reflections from Concave Mirrors**](https://www.youtube.com/watch?v=EXb9gDEYwbc&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

8:09 We figure out some special ways light can hit concave mirrors. If these rays are studied, we can understand ray tracing soon!

[**Doc Physics - Geometric Optics - Intro to Reflections from Convex Mirrors**](https://www.youtube.com/watch?v=OoGqK6sOI04&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

4:49

[**Doc Physics - Geometric Optics - First Ray Tracing Instruction**](https://www.youtube.com/watch?v=sRWlmARmxVw&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

10:14 Say hello to my little friend, RAY. M-Ray. P-Ray. F-Ray. C-Ray.

[**Doc Physics - Geometric Optics - Ray Tracing with Concave Mirrors Worked Example**](https://www.youtube.com/watch?v=MZ4p9lKVIPs&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

18:18 Wondering why I draw only a few rays? Check out this video: https://www.youtube.com/watch?v=jIymS1yFLao

[**Doc Physics - Geometric Optics - Ray Tracing with Convex Mirrors Worked Example**](https://www.youtube.com/watch?v=-WyAgyp_Tn8&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

8:22

[**Doc Physics - Geometric Optics - A Summary of Images Formed by Mirrors**](https://www.youtube.com/watch?v=btZS-UUidwE&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

7:02

[**Doc Physics - Geometric Optics - Derivation of the Mirror Equation, Suckazzzzzzzzzzzzz**](https://www.youtube.com/watch?v=4vNjAB7nAj0&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

10:40 We make some similar triangles and whatnot. Probably discuss the tangent function. Algebra? Check. Cool.

[**Doc Physics - Intro to Refraction, or, Why did that marching band just turn?**](https://www.youtube.com/watch?v=ZDxhoGWJfEE&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

8:26 Waves turn sharply when they enter a new medium at any angle other than normal.

[**Doc Physics - Geometric Derivation of Snell's Law for Refraction**](https://www.youtube.com/watch?v=twURUE075y8&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

8:43 So simple, so elegant. I love you, too.

[**Doc Physics - Geometric Optics Intuition with Mirrors and Lenses Concave Convex Diverging Converging**](https://www.youtube.com/watch?v=uQE659ICjqQ&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

7:01 This video has it all. Seriously, all of it. But no math, and no ray tracing. But maybe you just want to understand. Who can blame you?…

[**Doc Physics - Ray Tracing Converging Convex Lens Worked Example**](https://www.youtube.com/watch?v=Bx212THhykk&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

11:49 We'll put the object all over the place in relation to the focus and find out where the image appears. Geometric optics can be fun? I dunno...

[**Doc Physics - Ray Tracing Concave Diverging Lens Worked Example**](https://www.youtube.com/watch?v=ScUZwLcK2pM&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

8:42 We'll put the object all over the place in relation to the focus and find out where the image appears. I wonder if there's actually light where the image is..…

[**Doc Physics - Geometric Derivation of the Thin Lens Equation for Optics**](https://www.youtube.com/watch?v=-XM-1FI1oSk&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

9:55 Hint - it's exactly the same as the mirror equation. Yay!

[**Doc Physics - Sign Conventions for Mirror and Thin Lens Equation**](https://www.youtube.com/watch?v=zPxwrF4z_04&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

4:44 Did you know that the word lens comes from the Latin word for LENTIL? Yeah, lenses look like lentils. You win!

[**Doc Physics - Exploring Limits of the Thin-Lens Equation**](https://www.youtube.com/watch?v=nMOD0-rU3Ho&list=PLLUpvzaZLf3IB4GEhaCg7L3ioiLkHLk7Q)

5:53 Investigation of limits is a standard physics technique. Apply it to everything to see how functions behave!!

**AP Ch 27 - Optical Systems**

[**Doc Physics - Multiple Lens Systems! Wow! Combination Lenses are Rather Common, Actually.**](https://www.youtube.com/watch?v=N8fUej6lZ5o&list=PLLUpvzaZLf3JMS6nab9fThpMLkbIXwoCH)

5:21 Stuff gets tremendously more complicated when we add two or more lenses. Now we can make telescopes and microscopes and wear glasses!

[**Doc Physics - Corrective Optics for Myopic and Hyperopic Vision - Optometry 'r Us**](https://www.youtube.com/watch?v=jkaakYZZjbM&list=PLLUpvzaZLf3JMS6nab9fThpMLkbIXwoCH)

12:05 I make a sloppy attempt at explaining why people wear glasses. Also, you might like LASIK. I did.

[**Doc Physics - How a Magnifying Glass Works**](https://www.youtube.com/watch?v=3jR-rm1vJAE&list=PLLUpvzaZLf3JMS6nab9fThpMLkbIXwoCH)

12:29 It's all about getting things closer to your eye while still keeping focused. In fact, if the image of the lens is at infinity, you won't even have eye strain if you look at it for a long time! Philatelists - celebrate!

[**Doc Physics - Optometry 102 - Finding Refractive Power (Diopters) Worked Examples**](https://www.youtube.com/watch?v=VDehC_Txa1U&list=PLLUpvzaZLf3JMS6nab9fThpMLkbIXwoCH)

9:37 We find that we can all easily prescribe eyeglasses for our friends! Yay!

**AP Ch 28 - Physical Optics and Diffraction!**

[**Doc Physics - Wave Interference Intro**](https://www.youtube.com/watch?v=_N5Y9PVxHLY&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

15:25 We connect light, sound, and ocean waves to address these questions: Why do "dead zones" and loud locations exist near speakers? Why does light diffract?

[**Doc Physics - Wave Interference Part II**](https://www.youtube.com/watch?v=ZG62R4H7XGk&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

5:11

[**Doc Physics - Huygens Principle - He's Dutch!**](https://www.youtube.com/watch?v=_03sfhb7Mvg&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

6:43 Every point along a wavefront is a source of a new spherical wave at every instant. If that makes sense, I guess you don't need to watch this. Go play soccer.

[**Doc Physics - Young's Double-Slit Diffraction Experiment for Light (and some laser tricks, too)**](https://www.youtube.com/watch?v=o6JHGo2vZQw&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

17:23 Thomas Young was a genius. Learn from his insightful experiment.

[**Doc Physics - Phase Shifts for Reflected Waves of Light and Air Wedge Example**](https://www.youtube.com/watch?v=RRq3th3LbG0&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

15:28 We've got a diabolical method of measuring the thickness of an object that is precise to the nearest 800 nm or so (0.0000008 m). Dang!

[**Doc Physics - Mom, Why are Soap Bubbles so Freakin' Awesome with Pretty Colors?**](https://www.youtube.com/watch?v=TVCsSGKqlQA&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

10:52 Phase shifts at interfaces cause the beautiful colors. As usual, intense physics explains the majesty of creation.

[**Doc Physics - Mom, How does a CD or DVD or Blu-ray Work?**](https://www.youtube.com/watch?v=-MYwF6cW7T8&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

7:40 We'll investigate the interference that causes signal changes in the light sensor of an optical storage drive…

[**Doc Physics - Single Slit Diffraction is like getting surprised by a text you just sent yourself**](https://www.youtube.com/watch?v=ps8IBv5_VeM&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

17:46 Turns out that what looks like just a single gap is actually 512 tiny gaps.

[**Doc Physics - Psst...Hey kids...There's a bright spot in the middle of circular shadows. Really.**](https://www.youtube.com/watch?v=wXS9Nzk_ry0&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

3:00 Poisson's spot, they call it. Sounds fishy to me.

[**Doc Physics - Diffraction-Limited Vision and Photography**](https://www.youtube.com/watch?v=ef211FCxlfs&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

4:59 Circular apertures are kinda like a slit, right? A little?

[**Doc Physics - Diffraction Gratings show supersized Double-Slit Diffraction!**](https://www.youtube.com/watch?v=01X7SMbsIrI&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

12:03 Where's my laser?!?

[**Doc Physics - Intro to X-Ray Diffraction of Crystals**](https://www.youtube.com/watch?v=A1mbgDXag7c&list=PLLUpvzaZLf3KRRaeMVudt1G-iuclmAbfw)

3:44 We figure out how you can determine the structure of a crystal with diffraction!

**AP Ch 29 - Special and General Relativity**

[**Doc Physics - Intro to Einstein's Special Relativity**](https://www.youtube.com/watch?v=IVVFlWD2LHk&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

14:00 We'll talk about fat walruses, the equivalence of all inertial reference frames for all physical observations, and the constancy of the speed of light for all inertial observers. Enjoy getting your head mashed to a pulp.

[**Doc Physics - Derivation of Time Dilation in Special Relativity using a Light Clock**](https://www.youtube.com/watch?v=p2nwdS3ia24&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

18:52 We run into some pretty HUGE conceptual inconsistencies here. Get ready.

[**Doc Physics - The Real Twin Paradox**](https://www.youtube.com/watch?v=rRJZceArkLQ&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

7:49 This emphasizes just how funky time dilation can be. It's also a cool example of real time travel. Unfortunately, I believe the paradox here is not often understood. The fact that they experience time differently is NOT the paradox. The paradox is that (on first glance) each twin witnessed …

[**Doc Physics - Time Dilation has Startling Consequences...Like DANG.**](https://www.youtube.com/watch?v=xfiejp2lzJ0&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

10:14 We'll see that muons shouldn't ever hit the surface of Earth (but they do), things that you think happen at the same place might not be, and things that seem to happen at the same time might not, also. Oh, and light never experiences time. It is created and destroyed at the same in…

[**Doc Physics - Lorentz Length Contraction in Special Relativity**](https://www.youtube.com/watch?v=CFACq0HHpkw&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

14:13 Unfortunately, not agreeing on how time passes also affects whether we agree on how far apart events are. Sorry!

[**Doc Physics - Lorentz Length Contraction Worked Example with Special Relativity Buick**](https://www.youtube.com/watch?v=uQHPAeiiQ3w&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

6:46 When Buicks get going, you get out of the way. They might be short, but they're still WIDE!

[**Doc Physics - Relativistic Length Contraction Explains why Muons hit the Surface of Earth**](https://www.youtube.com/watch?v=4q2aKjrH3TQ&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

3:11 Muons don't have enough time, even moving at 99.5% the speed of light, to hit the ground from 5 km up, in the upper atmosphere, where they are created. Luckily, they don't think they have to go that far. Wheeeee. Special Relativity is FUN!

[**Doc Physics - Relativistic Velocity Transformation Theory**](https://www.youtube.com/watch?v=Mcg4BySwumg&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

4:14 Adding velocities (in terms of beta) is just slightly harder than v1 + v2, 'cuz Einstein needs to make sure that the sum is never greater than 1.…

[**Doc Physics - Relativistic Velocity Addition Worked Example**](https://www.youtube.com/watch?v=7n1mjVFAfZE&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

2:26 0.5 + 0.9 is less than 1. Sorry.

[**Doc Physics - Relativistic Velocity Addition Second Worked Example - Velocity Subtraction!!!**](https://www.youtube.com/watch?v=FQdzMQ3N734&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

10:09 Relativity, where nothing is as it seems. Welcome to wonderland, tough guy.

[**Doc Physics - Special Relativity Summary and Relativistic Momentum Transformation by Lorentz**](https://www.youtube.com/watch?v=vXWK1leN9mk&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

12:47 Momentum is still conserved, it's just not what you thought it was. Or maybe it is...if we REDEFINE MASS, SUCKA!…

[**Doc Physics - Einstein's Mass-Energy Equivalence Equation**](https://www.youtube.com/watch?v=tkCFK7mhVFI&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

0:12 Well, I guess energy can create mass and vice-versa.

[**Doc Physics - Relativistic Kinetic Energy, Rest Energy, Light Energy, and some Nuclear Physics**](https://www.youtube.com/watch?v=0atwaa5Ja_4&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

13:13 We'll see that Kinetic Energy is wrong, just like time, space, mass, and momentum. Sorry. But it's right at low speeds!

[**Doc Physics - Some Startling Consequences of Einstein's Mass-Energy Equivalence E = mc^2**](https://www.youtube.com/watch?v=-paJao9e5wY&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

3:11 Turns out that things become heavier when they store energy. Does this mean that fields have mass?

[**Doc Physics - General Relativity! Einstein's Equivalence Principle and the Curvature of Space-time**](https://www.youtube.com/watch?v=zVIS_01GttQ&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

14:39 Einstein had a knack for shaking things up. Accelerated reference frames are equivalent to gravitational fields, so a gravitational field can be viewed as acceleration, which leads to some really interesting gravitational effects on light. Light feels gravity.

[**Doc Physics - Black Holes Exist 'Cuz Light Curves so Much that it BENDS BACK ON ITSELF**](https://www.youtube.com/watch?v=c5lz5wLHoTw&list=PLLUpvzaZLf3JyQBZ8Jn2qaM0Fsy9Zhb8Y)

5:53

**AP Ch 30 - Intro to Quantum (Modern) Physics**

[**Doc Physics - Blackbody Radiation, Modern Physics, Quantum Mechanics, and the Oxford Comma**](https://www.youtube.com/watch?v=GgD3Um_f0DQ&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

11:26 Lord Kelvin had one of those famously wrong statements in 1900. Don't let anyone tell you that the work is done. Even clouds can hold HUGE changes.

[**Doc Physics - Max Planck Solves the Ultraviolet Catastrophe for Blackbody Radiation**](https://www.youtube.com/watch?v=H-7f-3OAXm0&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

5:27 We continue our investigation into the historical development of quantum physics. Max Planck had four children, and ALL of them died before he did.

[**Doc Physics - Quantum Mechanical Harmonic Oscillator Worked Example**](https://www.youtube.com/watch?v=_J1lJdkZTQc&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

5:26 I mean this in the nicest possible way: How quantum is your gerbil?

[**Doc Physics - Einstein Declares that Light is Particles (Photons)! Dang it, Man!**](https://www.youtube.com/watch?v=ccM-MCoj_W0&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

5:54 But I thought light was a wave. It shows freakin' diffraction. Grrrr.

[**Doc Physics - The Photoelectric Effect. Light is Particles, not Waves. But wait......**](https://www.youtube.com/watch?v=U2LJ1oSO8u4&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

24:08 Einstein explained the photoelectric effect in 1905, but the full philosophical implications weren't understood until the early 1920's. (Or maybe they still aren't...) Quantum physics is the only way to understand the photoelectric effect. So light comes in photons - little light packets. But t…

[**Doc Physics - Light has Momentum and Kinetic Energy but no Rest Mass. What's up now?**](https://www.youtube.com/watch?v=M-VZdJu0bLU&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

5:05 Quantum physics keeps getting weirder and weirder. In fact, the explanation comes more from relativity. What's this video doing here? Oh, I guess I'm about to explain the Compton Effect, so I need to know the momentum of a photon.

[**Doc Physics - Compton Scattering at Washington University in St. Louis - The Compton Effect**](https://www.youtube.com/watch?v=nBhTyD02IU8&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

13:35 Hey, I went there. You can still see a plaque honoring the location of Compton's Nobel Prize-winning work. They call it scattering 'cuz the x-rays go everywhichway after they hit the electrons. The Compton Effect is the fact that light changes color when it hits a free electron. Classical ph…

[**Doc Physics - Louis de Broglie makes Quantum Physics weirder - He's French! (and brilliant)**](https://www.youtube.com/watch?v=wjpg6PRBV58&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

10:54 You have a wavelength. You're a wave? de Broglie's hypothesis about the wave nature of matter won him the Nobel Prize a mere six years later. He was a graduate student when he had the beautiful, symmetry-motivated idea. He also had cool hair. How do you think he parted it?

[**Doc Physics - Double-Slit Diffraction for Electrons! AAAAAHHHHHHHHHH! Quantum!**](https://www.youtube.com/watch?v=O957hpqlqD8&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

5:59 Slowly, I will pull all the experiments and logical consistencies of your youth away from you. Will anything that you thought was real remain?

[**Doc Physics - Heisenberg Uncertainty Principle Derived and Explained**](https://www.youtube.com/watch?v=KIjWzC3jb4Q&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

16:15 One of the most-oft quoted results of quantum physics, this doozie forces us to reconsider what we can know about the universe. Some things cannot be known simultaneously. In fact, if anything about a system is known perfectly, there is likely another characteristic that is completely…

[**Doc Physics - Crazy Weird Quantum Physics Facts, Effects, and Results - a Quick Tour through the Zoo**](https://www.youtube.com/watch?v=2vXt9O5b87w&list=PLLUpvzaZLf3JmP0OYKGktv3ifZukEXlyf)

11:53 Tunneling, Superfluids, Infinite Thermal Conductivity, reflection at negative barriers, Schrodinger's Cat, measurement collapsing wavefunctions, oh my.…

**AP Ch 31 - Atomic Theory and the Bound Electron**

[**Doc Physics - Intro to the History of Atomic Theory - MC Hammer's Unpublicized Speech Impediment**](https://www.youtube.com/watch?v=VLU4dntonhE&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

12:48 Rutherford, Thomson, electrons, nuclei, and plums. I don't mean to be a bohr, but do you think pudding should have a role in serious scientific inquiry? Post in the comments.

[**Doc Physics - The Balmer Series: Spectral Emission Lines of Diffuse Hydrogen Gas**](https://www.youtube.com/watch?v=hj1QaojnlBs&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

8:11 Hey - Teacher - Leave them kids alone and go do some physics…

[**Doc Physics - Intro to Bohr's Model of the Hydrogen-Like Atom - PART 1**](https://www.youtube.com/watch?v=RRzpqDaoIiE&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

20:25 Niels Bohr attempted to explain the stability of the atom, so he took Rutherford's atomic model and simply ordained some orbits as STABLE. If you say so, Dr. Bohr. Whatever you say.…

[**Doc Physics - Intro to Bohr's Model of the Hydrogen-Like Atom - PART 2**](https://www.youtube.com/watch?v=BOU6T9fkPds&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

10:37 We see what size the stable electronic orbits are and how much energy the electron has in its various (infinite) stable orbits.

[**Doc Physics - Intro to Bohr's Model of the Hydrogen-Like Atom - PART 3 (Conclusion)**](https://www.youtube.com/watch?v=XGQHxaraYnc&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

11:58 Finally, Bohr's model makes a prediction that can be tested! And it's good! It just makes no sense at all...

[**Doc Physics - Electron's Atomic Energy Level Transition Diagram Worked Example**](https://www.youtube.com/watch?v=17tyXGgDmtw&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

7:43 We propose some random horizontal lines and ask you to do some physics…

[**Doc Physics - de Broglie's Matter Waves Justify Bohr's Magic Electron Orbital Radii**](https://www.youtube.com/watch?v=EILGg3HZIK0&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

8:16 I include a summary of the hydrogen atom's electronic structure and explain how an electron can interfere with itself in an orbit just like it can in a double-slit experiment.

[**Doc Physics - Electron Probability Density Functions - "Clouds"**](https://www.youtube.com/watch?v=rLikRJOESbU&list=PLLUpvzaZLf3LeHh3JgGDSfkLQX02BsDK1)

4:35 The electron's wave function can be used to predict where it is, but we are fundamentally limited by statistics. YOU CANNOT KNOW WHERE THE ELECTRON IS. IN FACT IT ISN'T AT A PARTICULAR PLACE. The cat is both alive and dead, if you know what I mean.

**AP Ch 32 - Intro to Nuclear Physics**

[**Doc Physics - Intro to Nuclear Physics**](https://www.youtube.com/watch?v=c15xu6QUrC0&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

7:01 We'll see how mass can be measured in really funky units and why carbon 12 weighs less than the sum of its constituent parts.

[**Doc Physics - Estimate Size of Nucleus, Introduce and Motivate Nuclear Decay**](https://www.youtube.com/watch?v=B8QM-ci9m6U&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

9:50 Rutherford's experiment lets us put an upper bound on the radius of a gold nucleus. We also explain the conditions of nuclear stability from first principles.

[**Doc Physics - Intro to Radioactivity, Nuclear Decay, Alpha, Beta, and Gamma Rays**](https://www.youtube.com/watch?v=dIYXu7QsplQ&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

8:23 Radiation is something you can't see; but it can still kill you. Better to know what you're up against.

[**Doc Physics - Alpha Particles - Nuclear Radiation Explained**](https://www.youtube.com/watch?v=je9_RtwhjWg&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

5:12 Smoke detectors save lives. Replace your batteries today if you want to live.

[**Doc Physics - Beta Particles - Nuclear Radiation Explained**](https://www.youtube.com/watch?v=t-NDf2JY6Pk&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

10:24 What's that electron doing all up in your nucleus?

[**Doc Physics - Gamma Rays - Nuclear Radiation Explained**](https://www.youtube.com/watch?v=PW_KNP3glls&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

4:44 Do not hang around excited nuclei.

[**Doc Physics - Radioactivity, Half-Life, Video Games, Exponential Decay, and Dead Rabbits.**](https://www.youtube.com/watch?v=CA2w-twJjfc&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

20:36 In summary, the more dangerous a radioactive sample is, the more rapidly it's becoming safe. But you should still wait before eating it.

[**Doc Physics - Exponential Behavior and Half-Life Summary and Conclusions**](https://www.youtube.com/watch?v=5mJ-vOWOhbU&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

8:44 This is optional, but it shows the graphical effects of half-life and decay constant. You might like it.

[**Doc Physics - Carbon-14 Radioactive Dating Worked Example**](https://www.youtube.com/watch?v=54wR-zwuDGo&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

10:34 I'm thinking about getting back into dating. I'm only going to be seeing bits of cloth and broken plates, so there's no need to tell my wife.…

[**Doc Physics - How to Make an Atomic Bomb**](https://www.youtube.com/watch?v=387-JtAUN8Y&list=PLLUpvzaZLf3JuJLlIiq0O2PJWW22XfvtE)

20:07 Firstly, don't call it atomic. It should be called a nuclear bomb, 'cuz you're messing with nuclei. Secondly, don't make a bomb. Instead, learn about fission and fusion so you can solve humanity's energy problems and make life better for others.

**AP Physics Calculus Lessons**

[**Doc Physics - Calculus Day 1 - Intro to Derivatives**](https://www.youtube.com/watch?v=dXGjJSMZGDA&list=PLBF08786376974702)

26:00 We begin to understand what a derivative is and how it's useful in physics. We'll differentiate polynomials and sine and cosine.

[**Doc Physics - Calculus Day 2 - Why Derivatives are Awesome**](https://www.youtube.com/watch?v=uRSYqrBBt0M&list=PLBF08786376974702)

29:57 Impress your friends! Find local maxima and minima! Journey to the point of inflection, and return to tell the tale.

[**Doc Physics - Calculus Day 3 - Intro to Integrals**](https://www.youtube.com/watch?v=RvovOGigjfE&list=PLBF08786376974702)

30:48 I hope that you will begin seeing integrals everywhere after watching this. 'Cuz integrals are actually everywhere. Now you see them.

[**Doc Physics - Calculus Day 4 - Applications to Physics**](https://www.youtube.com/watch?v=-yYqh7go6GY&list=PLBF08786376974702)

24:41 This video will not be very useful unless you've had some exposure to physics already. I designed it for my second-year students. We derive the classic kinematic equation and gravitational, electric, and elastic potential energies.

[**Doc Physics - Calculus Day 5 - Definite Integrals**](https://www.youtube.com/watch?v=sXKIDaV7vYw&list=PLBF08786376974702)

9:33 The first part of day five. This video should be watched before the video on averages.

[**Doc Physics - Calculus Day 5 - Averages and Other Nice Things**](https://www.youtube.com/watch?v=CjDnxoRGhpE&list=PLBF08786376974702)

10:32 The final lesson on calculus

**Common Math (Algebra) Mistakes in Physics**

[**Doc Physics - Maff Oopsie Number 1 - Multiplied by the Denominator in your Calculator**](https://www.youtube.com/watch?v=H7EpBWoqxGA&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

These eight quick videos are my attempt to help students identify their struggles in algebra. A poster in your room so you can point out mistakes might help!

[**Doc Physics - Maff Oopsie Number 2 - Multiplied a Fraction by 1**](https://www.youtube.com/watch?v=qlFOAIfrjPE&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 3 - Thought Zero was 1**](https://www.youtube.com/watch?v=f9nmAOX7ajE&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 4 - Thought 1 was Nothing**](https://www.youtube.com/watch?v=GHkx7YpNHyw&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 5 - Multiplied Both Sides of an equation, but not really**](https://www.youtube.com/watch?v=_AqO6wee-mc&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 6 - Miscellaneous Algebra Error**](https://www.youtube.com/watch?v=hj-V8Io32EM&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 7 - "Solved" an Equation but unknown on both sides**](https://www.youtube.com/watch?v=Z6z9U5iuVsE&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

[**Doc Physics - Maff Oopsie Number 8 - Got Confused when Dividing by a Fraction**](https://www.youtube.com/watch?v=a7bIqN1x8ww&list=PLLUpvzaZLf3IpqUqYqydYmsK3HUsQNeh8)

**Semiconductor Physics**

[**Doc Physics - How Does a Diode Work? (p-n Junctions in the Hood)**](https://www.youtube.com/watch?v=b3xys6rYM_Q&list=PLLUpvzaZLf3ICzyd5lVwJbpl3r9GC9rMi)

23:32 We will see what a diode does, and then begin to understand why. We'll investigate the structure of silicon and other group (IV) elements. We will discuss doping and other methods of creating mobile charge carriers like electrons and holes. We will finally discover that when p-type silic…

[**Doc Physics - How LED's Work**](https://www.youtube.com/watch?v=fP59RSgQqg8&list=PLLUpvzaZLf3ICzyd5lVwJbpl3r9GC9rMi)

11:44 STOP! WATCH THIS VIDEO FIRST: http://youtu.be/b3xys6rYM\_Q…

[**Doc Physics - How Solar Panels Work - Convert Sunlight to Electricity in Your Own Backyard**](https://www.youtube.com/watch?v=JxOTulMExWU&list=PLLUpvzaZLf3ICzyd5lVwJbpl3r9GC9rMi)

8:17 STOP! WATCH THIS VIDEO FIRST: http://youtu.be/b3xys6rYM\_…

[**Doc Physics - Turning on Diodes. Finally, this is why diodes conduct one way but not the other.**](https://www.youtube.com/watch?v=lJI8Ee3ZiUY&list=PLLUpvzaZLf3ICzyd5lVwJbpl3r9GC9rMi)

6:30 STOP! WATCH THIS VIDEO FIRST http://youtu.be/b3xys6rYM\_…

**Magnetic Monopoles**

[**Doc Physics - Intro to Magnetic Monopoles**](https://www.youtube.com/watch?v=_z8BGcmLq3U&list=PLLUpvzaZLf3J0ZPHZ2WOCGmyweNVkkYQ7)

9:16 We'll discuss the reasons we think there are magnetic monopoles and why they seem to be hard to find...if they exist at all...…

[**Doc Physics - Why a Magnetic Monopole Would Quantize all the Electric Charge in the Universe**](https://www.youtube.com/watch?v=6y_xLz6TScs&list=PLLUpvzaZLf3J0ZPHZ2WOCGmyweNVkkYQ7)

12:33 Watch as Doc Schuster flubs his way through one of the most important Quantum Mechanics papers of all time.…