Dear AP Physics 2 students,

The following pages contain guided notes to take while watching videos about the topics we will cover in physics this coming school year. These videos are short (approximately 10 minutes each) and are meant to be an introduction to the topics for this coming school year. These are not meant to replace the learning we will be doing in anyway, but just to give students a background knowledge of the topics so that you can better participate in the class throughout this year. Please take the time to watch each video carefully and take the notes as you watch. Videos can be found at:

Crash Course Physics

Be sure the video you watch and the notes page have matching titles.

I expect you to turn these in during the first week of school during the 2019 – 2020 school year. I look forward to seeing you then, ready to learn. Until then, have a great summer!

Sincerely,
Mr. Pagliaro
AP Physics Teacher
Shelton High School

“Fluids at Rest: Crash Course Physics #14”:

1. Anything that flows, liquid or _________________, is a fluid.

2. When it comes to fluids, we mostly use __________________________ in units of ___________.

3. We can define pressure as P = __________________. We measure it in units of ___________, or __________.

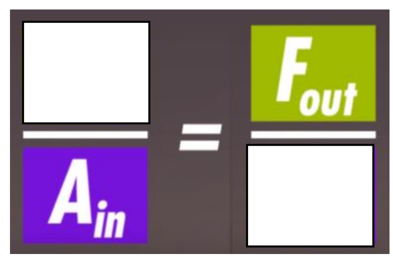
4. The average air pressure at sea level is __________________________________ Pa.

5. There’s an easy way to find the pressure at a certain depth:

6. If you are swimming at the bottom of a 3 m deep pool, you feel _______________ Pa more pressure than at 0.25 m below the surface.

7. __________________________________ states that if you apply pressure to a confined fluid, the pressure in every part of the fluid increases by that amount.

8. If you apply 10,000 N of force to the side of a piston with an area of 1 m^2, you would apply _________________ of force to the right side piston that has an area of 2 m^2. In mathematical terms:



9. A manometer is a _____-shaped tube with a fluid inside.

10. The difference between atmospheric pressure and the pressure inside the tire is called ________________________________ pressure.

11. Archimedes figured out that the volume of the water displaced by an object is _____________ to that object’s volume.

12. The force pushing up on an object in a fluid that counteracts the force of gravity is the ______________ force.

13. According to **Archimedes’ Principile**, the buoyant force (F_B) = ___________________________.

14. If the buoyant force is greater than the force of gravity, the object will **FLOAT** **SINK**

“Fluids in Motion: Crash Course Physics #15”:

1. The study of the flow of fluids is called ____.

2. If we assume that fluids are incompressible, we are assuming that their ___________________ won’t change.

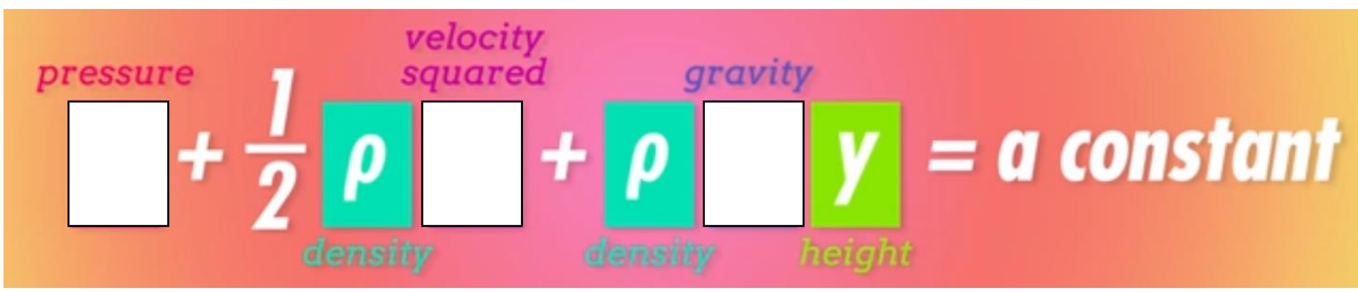
3. One thing that doesn’t change as the size of a pipe changes is the _____________________ of the water passing through any given area over a given time. This is call the ____________________ flow rate and is the same everywhere in the pipe.

4. Write the “equation of continuity”:

5. You can rewrite the equation from #4 in terms of density, area, and volume as: _________________________. Since we are assuming the water is incompressible, the density is the same everywhere, thus we are looking at it just in terms of area and velocity.

6. **Bernoulli’s Principle** states that the ____________ a fluid’s velocity is through a pipe, the ____________ the pressure on the pipe’s walls and vice versa.

7. Fill in the boxes to complete Bernoulli’s equation:



8. When a fluid applies pressure and moves a volume of fluid that’s downstream, it’s doing ________________.

9. The second term of Bernoulli’s equation is called _______________________ energy density.

10. When you look at his equation piece by piece, you can see that Bernoulli was really just putting ____ into a special form that would be useful for fluids.

11. **Torricelli’s Theorem** says that the ___________________ of a fluid coming out of the spout is the _________ as the velocity of a single droplet of fluid that falls from the height of the surface of the fluid in the container. In other words, the pressure that’s pushing the fluid out of the spout gives it the same velocity that it would get from the force of ________________________________.

12. In the barrel problem, if you get rid of the terms that you don’t need, you end up with another ___________________ equation that relates velocity, acceleration, and displacement, without considering time.

<u>“Temperature: Crash Course Physics #20”:</u>

1. The cracks and grating that you see in bridges are called ______________________________. Why they are there has to do with _______________________________________.

2. At its most basic level, temperature is a measure of how much ___________________________ is in a system.

3. The easiest way to figure out if there’s a temperature difference between two systems is through **heat transfer**. The __________________________ will ALWAYS transfer heat to the _______________________ system.

4. Usually an increase in temperature will make a solid _______________________________.

5. The equation used to describe linear expansion is: ____.

6. The value of the coefficient of linear expansion depends on the ___________________ the object is made of.

7. The equation used to describe volume expansion is: ____.

8. An ideal gas is made up of lots of molecules that move around ________________________________.

9. According to **Boyle’s Law**, as you increase the pressure of a gas, while keeping the temperature constant, the volume of the gas will ___________________________ and vice versa.

10. According to **Charles’ Law**, as you increase the temperature of a gas, while keeping the pressure constant, the volume of the gas will ___________________________ and vice versa.

11. According to **Gay-Lussac’s Law**, as you increase the temperature of a gas, while keeping the volume constant, the pressure of the gas will ___________________________ and vice versa.

12. All three of these laws can be combine into one, the **ideal Gas Law**, which is ___________________________.

13. If you have 1 mole of a gas then you have _________________________________ molecules of it. ‘R’ is the universal gas constant. It is __________________ J/(K mol).

14. Solve the ideal gas law for the number of moles. ___________________________________

15. How many moles of air did you lose from your car, just because it got warmer outside? __________________

“Kinetic Theory and Phase Changes: Crash Course Physics #21”:

1. At very low pressures water can’t exist as a liquid, no matter the pressure. This has to do with ______________________.

2. The kinetic theory of gases is based on the idea that if you have all of these gas molecules bouncing around, you can calculate the ______________________________ of each particle. When you do the math, the equation for finding the average kinetic energy (KE_{ave}) of the ideal gases in a container is __________________________, where ‘k’ is the **Boltzmann constant** which can be determined as k = _____________________.

3. This equation (#2) tells you how kinetic energy and temperature are related in an ideal gas: as the kinetic energy of the gas increases, temperature _______________________________ proportionately.

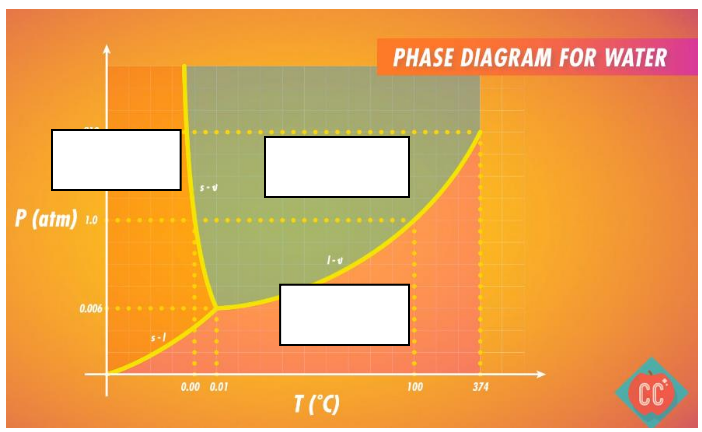
4. We’ve been talking about the velocities of these ideal gas molecules as _________________________. To get the average kinetic energy we didn’t just take the average velocity and square it, but rather we squared ________ the individual velocities and then took the average of those squared velocities.

5. The square root of the average squared velocity is known as the “______________________ square speed”. We write it as V_{RMS} and it is **THE SAME AS** **DIFFERENT FROM** the average speed.

6. If you want to know the speed of a typical molecule, we can use the equation $\frac{1}{2}mv^2_{ave}$ = _________________

7. The molecules in an ideal gas can have a variety of different speeds, but they are mostly near the ____________________________________ speed.

8. High pressure is a problem for gases because it forces molecules _______________________ to the point where they start to interact. At a certain pressure, gases stop acting like gases and turn into ________________.



9. Label the phase diagram for water with solid, liquid, and vapor.

10. The point at the top right is the **critical point**: the maximum temperature and pressure where a gas can be a ___________________.

11. The point where the two lines intersect is the **triple point**: it’s the temperature and pressure at which a substance coexists as a ______________, __________________, and a _____________.

12. Below the triple point a substance cannot exist as a liquid. It can only go directly from a gas to a solid, a process called _______________________.

13. As far as we know, life needs ____________________________________.

“The Physics of Heat: Crash Course Physics #22”:

1. ________________________________ is the measure of the average kinetic energy of each individual molecule in a substance.

2. __________________________________ (U) is the kinetic energy of all the molecules in a system added together – as opposed to temperature, which was a measure of the average kinetic energy for each molecule.

3. To find the thermal energy of a system, you multiple the average kinetic energy by the number of molecules. This equation looks like this: ____

4. The amount of thermal energy added to or removed from a system is ___________________________. It’s the energy that’s transferred between systems when they’re at different temperatures. In equations, it’s represented as ‘______’. In the official International System of Units, it is measured in units of _____________________.

5. How much the flow of heat changes the temperature of a system depends on two things: how much _________ it has and the substance’s ____________________________________, which is a measure of how well the substance stores heat.

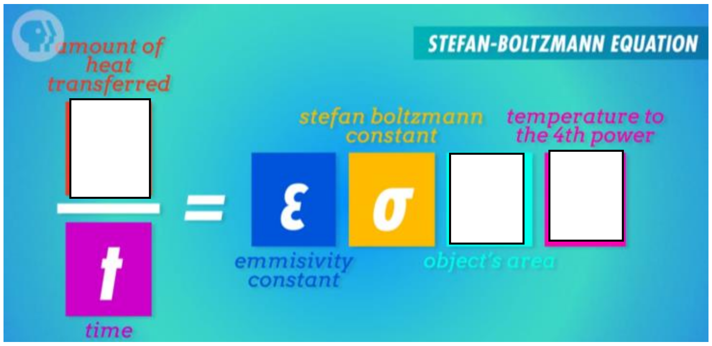
6. Write the equation that determines the amount of heat transferred: ____

7. We don’t use the equation for #6 to determine the amount of heat while the substance is going through a phase change. Instead, the amount of heat that gets transferred (Q) = ___________. ‘L’ is the **latent heat**. It’s the heat required to change the __________________________ of a substance.

8. There are three main ways for heat to spread:

- In **conduction**, heat flow depends on ____ between molecules.
  - The thermal conductivity of a material is represented by the letter ‘________’.
- In **convection**, warmer molecules move **TOWARD** **AWAY FROM** the heat source and are replaced by cooler molecules.
- In **radiation**, heat is transferred by ____ waves.
  - The amount of heat an object radiates over time is proportional to its temperature to the ________________ power. If you double the temperature, you multiply the heat it radiates over time by ___________.
  - Radiation also depends on the material’s _____________________________________ constant, which is based on the material’s inherent ability to radiate heat.

9 The Stefan-Boltzmann equation describes how heat is radiated over time. Fill in the blanks to complete the equation.



10. One of the main ways we lose body heat is via ____________________________.

“Thermodynamics: Crash Course Physics #23”:

1. Perpetual motion is impossible. **TRUE** **FALSE**

2. The goal of thermodynamics is to describe the ________________________________ of energy. As a thermodynamic system does work, it **LOSES** **GAINS** heat. As work is done on the system, it **LOSES** **GAINS** heat.

3. The idea that the change in internal energy is equal to the change in work plus heat is known as the _________ law of thermodynamics. We write this law with this equation: ___________________________________. It’s important to remember that if heat transferred into the system, heat is **POSITIVE** **NEGATIVE** If work is done by the system, then work is **POSITIVE** **NEGATIVE**

4. The first law of thermodynamics is just another way to describe the ____________________________________.

5. In **isovolumetric processes**, _______________________ is kept constant while heat is added or removed. As you add heat, temperature and pressure **INCREASES** **DECREASES** The gas doesn’t do ___________.

6. In **isobarometric processes**, _________________________ is kept constant while heat is added or removed. Since the volume of the container can change, this process can do work. The work done by an isobarometric process can be calculated as _______________________________________.

7. In **isothermal processes**, ______________________________ is kept constant while the heat or volume is changed very slowly. They are similar to isobarometric processes, however they are calculated differently because the pressure changes. Instead you need to take the _______________________________ of the pressure with respect to the volume.

8. In **adiabatic processes**, no _______________________ is allowed to flow into or out of the system, but the gas can expand or be compressed.

9. According to the **second law of thermodynamics**, heat will spontaneously flow from something _____________ to something __________________, but it won’t flow from something colder to something hotter because of _______________________, which is often described as the inherent disorder of a system – the more disordered the system, the _____________________________ its entropy. In real life, entropy can only _____________________________ overall.

10. If the entropy of the system decreases, then the entropy of the environment around it must _______________________.

11. Entropy’s tendency to increase has to do with _____________________________________.

12. In thermodynamics, entropy is related to _____________________________, because when heat flows between systems, their entropy increases. Heat spontaneously flows from warmer systems to cooler ones because that leads to an ______________________ in entropy.

“Engines: Crash Course Physics #24”:

1. Heat engines, like steam engines, turn _________________________ energy into mechanical work.

2. In the case of a heat engine, the change in thermal energy is ______________________, because it always returns to the temperature it started at.

3. As a steam engine runs, it releases exhaust heat. The more exhaust heat it produces, the less _______________ the engine is, and the more ______________ you have to put in for the same amount of work.

4. The efficiency of an engine can be found using the equation _______________________________.

5. In terms of input heat and exhaust heat, we can simply use the equation ____________________ for efficiency.

6. An ideal engine would be ________________________ - meaning you could run it backward, putting in work to transfer heat from something with a lower temperature to something with a higher temperature. This kind of hypothetical engine is called a _______________________ engine.

7. In the Carnot Cycle, the heat **WILL** **WON’T** flow between areas of different temperatures.

8. In a Carnot engine, the first process is _____________________________. The temperature is constant, but heat is slowly added, allowing the gas’s volume to expand and the pressure decrease. The second process is ____________________________. The temperature drops while the heat remains constant, which also allows the volume to expand while the pressure drops. The third process is the opposite of the first one, but is also isothermal. The gas is ______________________________ while the temperature is held constant. It releases heat and its pressure increases while its volume decreases. The last process is the opposite of the second and is _____________________________ again.

9. The ideal efficiency can be found using the equation _______________________________________.

10. Carnot engines are very ___________________________ because during those isothermal processes, the temperature has to be kept constant while heat is transferred – which only works if the heat is transferred super slowly.

11. For refrigerators, efficiency is looked at via the coefficient of performance (COP), which equals ____________

12. For an ideal fridge, the COP = ___________________________________

"Electric Charge: Crash Course Physics #25":

1. ____ occurs when an object obtains a net amount of positive or negative electric charge, creating an imbalance that wants to be returned to equilibrium.

2. Like charges **REPEL** **ATTRACT**

3. Moving electrons are called ______________________ electrons. They reside in an atom's outer shell as ________________ electrons and are easily plucked off and carried around when acted upon by an 'outside force'.

4. Materials that are ____________________________ let free electrons move freely around the solid.

5. An overall negative charge means that the object has **TOO MANY** **TOO FEW** electrons.

6. In the process of charging by friction, no new charges were created. This is known as the law of conservation of ______________________________. It says that you can never create a net electric charge. Instead, charge can only _______________ from one place to another.

7. In the process of polarization, we've ____________________ the charge in order to create an imbalance of charge within in object.

8. Connecting a charged object to the ground creates a way for the charged object to leak that charge into the Earth. This is called ____.

9. The force on charged particles is measured in _________________________. To find it, we need to know the charge (q) in units of __________________________ (C). The charge (q) can have both positive and negative values. 1 electron has a charge of $-1.6x10^{-19}$ C. This value is known as the _________________________ charge (e).

10. The equation for Coulomb's Law is ____.

11. Coulomb's constant (k) depends on medium surrounding the charges. This is mostly air, or maybe a vacuum, making the constant ____________________________________.

12. What is the force between two negative charges that are 1 nanometer apart? ___________________________. The answer is positive, meaning that the charges **REPEL** **ATTRACT** each other.

“Electric Fields: Crash Course Physics #26”:

1. Coulomb’s law tells us the ______________________ generated by two charged particles on one another.

2. An _________________________________ is a measurable effect generated by any charged object.

3. What is the equation for an electric field created by a charged object that relies solely on the point charge (‘Q’)?

____

4. Electric field lines are vectors that show the magnitude and _______________________ of the force exerted on any nearby positive test charge.

5. One positively charged particle and one negatively charged particle that are a distance apart with an equal and opposite magnitude of charge is known as an _____________________________________. We can add their fields together to create a total electric field. This is the principle known as ______________________________.

6. Four important properties of electric field lines:

1. The field lines must be ___________________________ to the direction of the field at any point.
2. The greater the line density, the greater the ___________________________ of the field.
3. The lines always start from ____________________ charged objects and end on negatively charged objects.
4. The lines must never __________________________.

7. The pair of plates shown in the model make up what is known as a ______________________. They are integral in electronic systems partly because they can _______________________ an electric charge.

8. When the net force is 0, the ____ must also be 0.

9. In the model with the hollowed out shell with a single positive particle, there **IS** **ISN’T** an electric field inside the shell.

“Voltage, Electric Energy, and Capacitors: Crash Course Physics #27”:

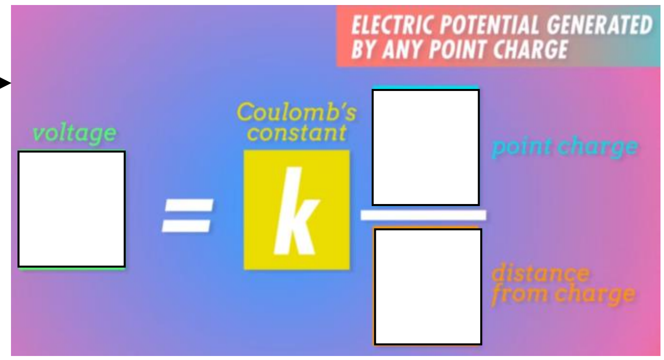
1. Defibrillators work because of two main electrical principles: electric potential energy and _________________.

2. A charged object can have electric potential energy when it’s held in an _________________________________.

3. We can determine the amount of work done on a test charge via the equation __________________________.

4. Electric potential can be found via the equation V = _________________. It depends on the electric field and the position, but it does not depend on the _____________________ of the test charge. The units are Joules over coulombs, or __________________________. The electric potential difference is also known as **voltage**.

5. Fill in the blanks for the equation provided: →



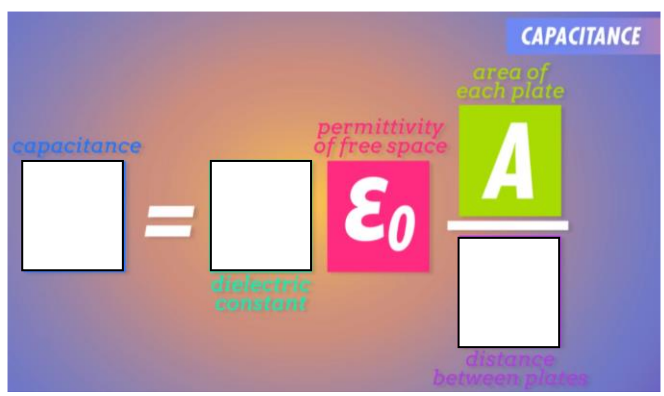
6. When a capacitors plates store electric charge, they are actually storing ____________________

7. Capacitance, how much ___________________ a capacitor is able to hold, is measured in units called ______________________________.

8. A dielectric is typically an _____________________________ material, like plastic or glass, that is used to increase capacitance.

9. By inserting an insulating material into a capacitor, we **INCREASE** **DECREASE** capacitance and can now hold **MORE** **LESS** charge, and thus energy, for the same amount of voltage.

10. Fill in the blanks for the full equation for capacitance:



11. We can calculate the potential energy stored in a field with the equation __________________________

12. The amount of energy stored in the electric field is known as ____________________________.

“Capacitors and Kirchhoff: Crash Course Physics #31”:

1. The design of a circuit depends on the ___________________ of the system it operates, and we need tools to take any configuration into account.

2. **Kirchhoff’s Junction Rule** states that the ______________ of all currents entering into a junction is equal to the _____________ of all currents leaving a junction. What goes in must come out.

3. **Kirchhoff’s Loop Rule** states that the sum of all changes in potential around a loop equals ______________.

4. The first step in using the junction rule in circuit analysis is to _________________ all the junctions. Then you label all the different _______________________ in the diagram.

5. In circuit analysis, you can draw a loop around any part of a circuit where you can imagine a charged particle heading around a circuit in a _____________________ and returning to where we started. Wherever there’s a loop, we can use the ________________________________.

6. If you want to know any of the voltage drops across the resistors, all you’d have to is _________________ the resistance in question by the current running through that resistor.

7. In a DC circuit, a capacitor is useful for _________________ charge temporarily, then releasing it again later on.

8. With capacitors, we deal with **transient conditions**, or circuit responses that _________________ over time.

9. If you connect multiple capacitors connected in parallel, the overall capacitance in the circuit ______________.

10. Capacitors connected in series will have a **LOWER** **HIGHER** overall capacitance.

11. For series capacitors, the combined capacitance is **LESS** **GREATER** than the weakest capacitor.

“Magnetism: Crash Course Physics #32”:

1. In 1820, Orsted demonstrated the connected between ________________________________ and magnetism.

2. Only certain materials, especially those containing ________________________, can be magnets.

3. Magnetic field lines point from the __________________ pole to the __________________ pole.

4. A fundamental principle of electromagnetism is that an electric current produces a ____________________ field.

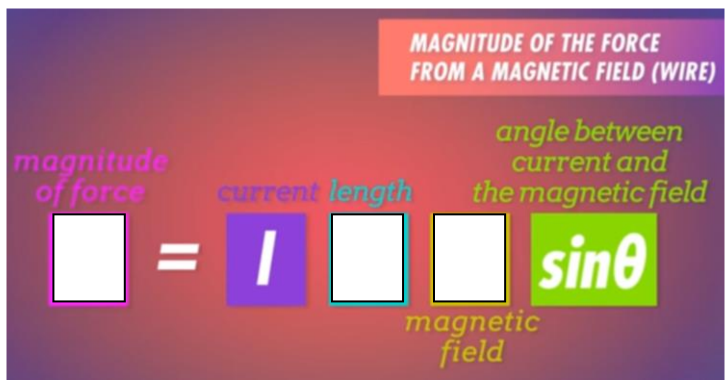
5. When a current runs through a wire, a magnetic field runs ________________________________ it.

6. The **first right hand rule** tells you that the direction your ____________________ are pointing when curled around a wire (with the thumb of your right hand pointing in the direction of the electric current) is the direction of the magnetic field lines.

7. The direction of the force from a magnetic field on a current running through a wire will be _______________ to both the magnetic field and the current.

8. The **second right hand rule** lets you keep track of 3 directions: the direction of the magnetic field, the current, and the force. Point your right __________________ in the direction of the current, then point your fingers so they are perpendicular to your palm – this represents the direction of the ________________________. Your __________________, perpendicular to your fingers, is the direction of the force on the wire.

9. Fill in the blanks for the equation for finding the magnetic force on a wire.



10. The longer the wire, the _________________ the force.

11. If the current is ______________________ to the magnetic field lines, there won’t be any force on the wire at all.

12. Currents are made up of _________________ electric charges, so a magnetic field will exert a force on single electric charges that pass through it. This is the concept that explains why Earth’s magnetic field protects us from charged particles from the _________________.

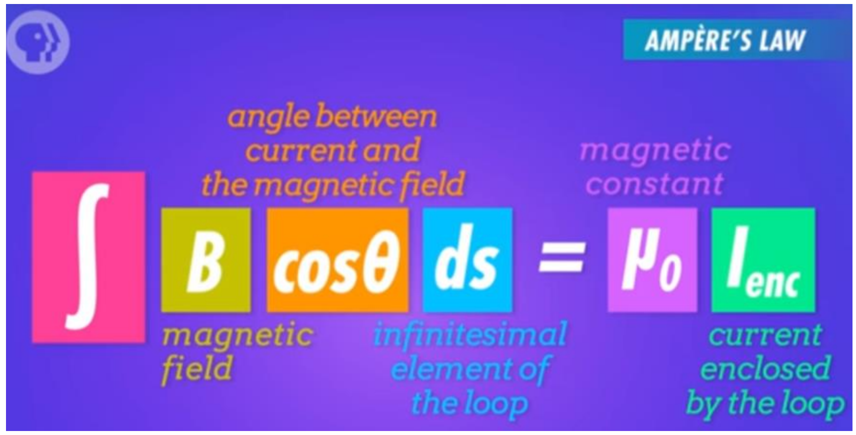
13. For a single charge, the force is **WEAKER** **STRONGER** the closer to perpendicular the charge’s velocity is to the magnetic field lines.

14. For the **third right hand rule**, if the charged particle is ________________________, then your thumb is point in the direction of the force. If the charge is ___________________________, then your thumb is pointing in the direction opposite the force.

<u>**"Ampère's Law: Crash Course Physics #33":**</u>

1. If you wrap a current-carrying wire into a coil, the inside of the coil will act like a ___________________.

2. The basic logic behind Ampere's law is that the stronger the electric current, the _________________ the magnetic field is around it.



3. The equation for Ampere's law (to the right), basically means that he total magnetic field along a loop is equal to the ________________ running through the loop times a constant number.

4. If we apply Ampere's Law to a long, straight wire, the total magnetic field along a circle surrounding the wire is equal to _______________________.

5. When two wires running parallel to each other had current running through them in the same direction, they were **ATTRACTED TO** **REPELLED BY** each other.

6. A coil of wire is called a ___________________________. When it has a current running through it, it generates a ___________________________.

7. When a loop of wire is placed within a magnetic field, the loop of wire turns because a ________________ acts on it. Those moving loops of wire can be used to do mechanical _________________________.

“Induction – An Introduction: Crash Course Physics #34”:

1. Magnetic fields only crate electric currents when the magnetic field is ______________________ with time.

2. **Faraday’s Law of Induction** states that a changing magnetic field will induce an EMF – also known as a _____________________________________ in a loop of wire.

3. Changing the ______________ of the loop of wire induced a current, too, and so did changing the ___________ between the loop and the magnetic field. This was because of a property called _________________________, which is a measure of the magnetic field running through a loop of wire.

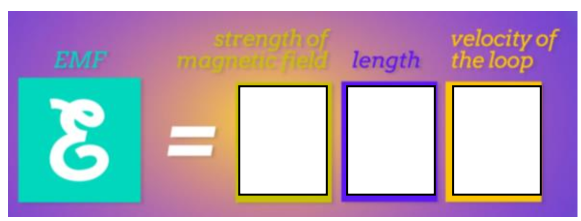
4. There are three factors that affect the magnetic field, and therefore the magnetic flux through the loop: the _________________ of the magnetic field (B), the _____________ of the loop (A), and the _____________ (θ) between the magnetic field and a line perpendicular to the face of the loop. Putting all of these factors together, we find that the magnetic flux (Φ_B) = ____________________________________. If the magnetic flux increases over time, the EMF ____________________________________.

5. A change in the magnetic flux through the coil, induces **THE SAME** **A DIFFERENT** EMF in each loop of the coil.

6. Faraday’s Law of Induction lets us calculate how much EMF – and therefore how much ___________________ - will be induced in a loop of a wire by a change in magnetic flux.

7. **Lenx’s Law** states that the magnetic field generated will be in the direction _______________________ the change in magnetic flux.

8. When you move a loop of wire in or out of a magnetic field, the strength of the EMF can be found with the equation:



9. Your computer stores information on your hard drive by _______________________ small sections of the disk.

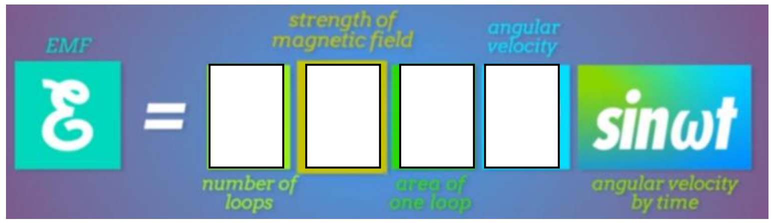
"How Power Gets to Your Home: Crash Course Physics #35":

1. Two of the most important steps in getting electricity to your house involve ______________________________ and ______________________________.

2. Electric generators take mechanical energy and use __________________ to convert them to electrical energy.

3. Because the coil is rotating, the direction of the flow of the current changes every _______________ rotation. This creates a type of flow of electricity known as ________________________________ current (AC).

4. The EMF induced in a coil rotating in a magnetic field can be found with the equation:



5. Transformers only work with __________ power. They are necessary because a problem with transporting electricity over long distances is that if the voltages are low, a lot of electricity is wasted as ________________.

6. In the U.S., the power coming out of your walls is _________________________ volts.

7. **Mutual Inductance** is where a change in the current in one coil leads to a change in EMF in a nearby coil and EMF is the same as ______________________________.

8. In transformers, the power running through the first coil is _____________.

9. The voltage in the secondary coil divided by the voltage in the primary coil is equal to the number of ________ in the secondary coil divided by the number of loops in the primary coil.

10. A Telsa coil is a fancy version of a _________________________ transformer.

11. Mutual inductance is also used in ____.

“AC Circuits: Crash Course Physics #36”:

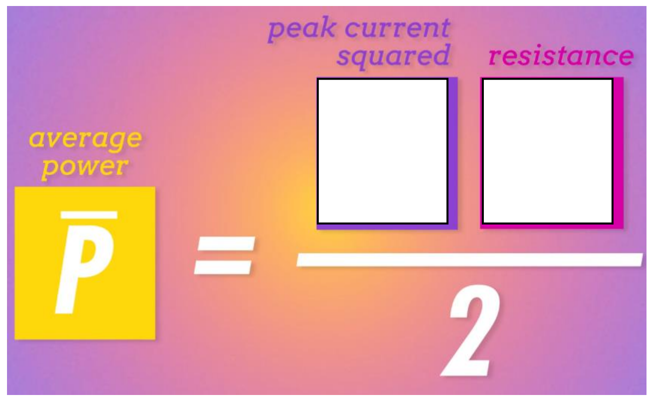
1. We couldn’t keep the lights on without ____.

2. Typically the ____________________ source in a DC circuit is unchanging, so the ________________________ will be unchanging too.

3. ___________________________ means either maximum or minimum, positive or negative, since the flow of current has the same magnitude.

4. Fill in the boxes for the equation for current:

5. Fill in the boxes for the equation for average power in an AC circuit:



6. Power in AC circuits can better be described using the _________________________ squared values for current and voltage.

7. The constant ______________________________ signifies how well a specific coil induces an opposing current depending on its shape and size. It’s expressed in a unit called a ________________________.

8. As time goes to infinity you get closer to the ___________________________ current value.

9. Inductors _______________________ a change in current, whether it’s an increase or a decrease.

10. When the current is zero there is _____________ voltage and when current is maximum voltage is ________.

11. When an AC circuit has an inductor, the current and voltage are out of phase, which means they don’t _______________ at the same time.

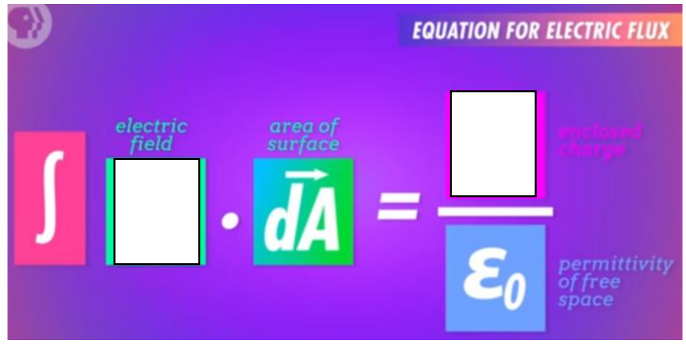
12. In summary: current in inductors ______________ voltage; current in resistors __________________________ voltage; current in capacitors _____________________ voltage.

13. The only thing in an AC circuit that dissipates power as heat are the _______________________________.

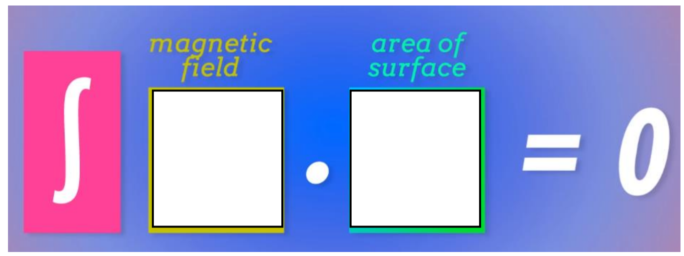
"Maxwell's Equations: Crash Course Physics #37":

1. While coming up with his equations, Maxwell predicted the existence of ______________________________.

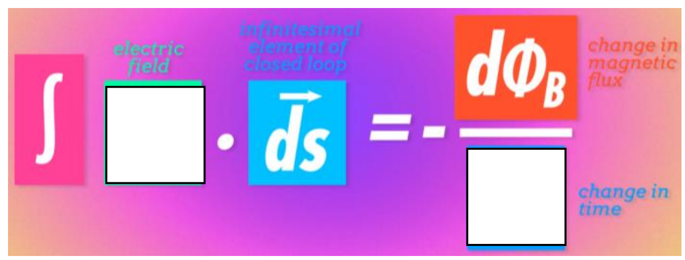
2. Maxwell's First Equation is a form of Gauss's Law which states that the electric flux through a closed surface is proportional to the ___________________________ enclosed by that surface. Mathematically, this equation looks like this (fill in the boxes):



3. Maxwell's Second Law is also a form of Gauss's Law, only with _______________________________ instead of electric flux. Mathematically, this equation looks like this (fill in the boxes):



4. Maxwell's Third Equation is Faraday's Law, just in a more general format. Mathematically, this equation looks like this (fill in the boxes):



5. Maxwell's Fourth Equation tweaks Ampere's Law by adding the _____________________________ current.

6. If a changing electric field is generated, then a ____________________ field is induced, which results in a changing magnetic field that induces an __________________ field and the cycle continues. These oscillations are called ______________________________.

7. The electric and magnetic fields always act ________________________________ to each other.

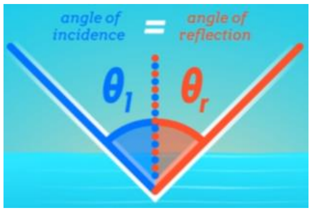
8. The speed of every electromagnetic wave is ________________________________, which is the speed of light.

9. Our knowledge of electric and magnetic fields is thanks to Maxwell alone. **TRUE** **FALSE**

“Geometric Optics: Crash Course Physics #38”:

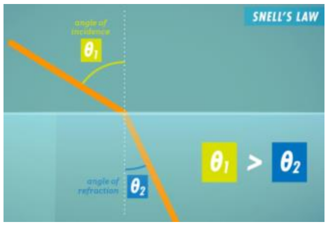
1. The core tenet of the **ray model** is that light travels in ____________________ line paths called ‘rays’.

2. If you view something in a reflection you see its image in ______________________________.



3. The **law of reflection** states that the angle of incidence is _____________________ the angle of reflection.

4. When light rays change from one medium to another they bend in a process called ________________________.



5. When a ray moves from air to water, the ray’s angle after passing into the water will be _____________________ than the incident angle.

6. **Snell’s law** says that the angles of refraction are determined by the _________________ of refraction for each medium and the angle of incidence. The higher the index of refraction, the ______________ the angle.

7. An image is considered to be a _______________ image if the rays from an object converge at some **location**, such as your eye or some other surface, like film. A ______________________ image is one where the light rays don’t actually converge, so your eyes construct an image as if the diverging rays started from a single point, like when you are looking in a mirror.

8. Warped pieces of material that form images of objects are called ________________.

9. In a convex lens, rays that leave the lens are angle toward the ______________________ axis, eventually converging at a single point called the ____________________ point. The distance between the lens and this point is called the _________________ length.

10. When rays converge at a point, that means a **REAL** **VIRTUAL** image has been formed.

11. The ____________________ distance in the location where the image forms on the other side of a converging lens.

12. Converging Lenses have **THE SAME** **A DIFFERENT** focal length on both sides.

13. For convex lenses, the image is always _______________________________.

14. Diverging lenses have a __________________________ shape and generate ________________________ images.

15. Magnification is the ratio of the _______________________________ height to the height of the actual object.

“Light is a Wave: Crash Course Physics #39”:

1. We know that light is both a _______________________ and a ______________________.

2. **Huygens’ Principle** states that you can predict a wave’s position in the future by analyzing its _______________ position.

3. When waves are reshaped by obstacles, _________________________ occurs.

4. Waves interact ___________________________ when the crests (and troughs) of both waves end up in the same spot. Waves interact __________________________ when one wave’s crest run into another wave’s trough.

5. When light waves line up, they interfere **CONSTRUCTIVELY** **DESTRUCTIVELY**

6. The path difference is equal to the _____________________ between the center of each slit (d) multiplied by the ______________________ between the point on the screen and the slits.

7. In waves, the intensity is proportional to the _________________________________ squared. If you triple the amplitude, the light gets ___________ as bright.

8. Light with a higher wavelength and shorter frequency is on the _______________ side of the spectrum while light with a higher frequency and shorter wavelength is on the _______________________ side.

9. A total path difference of a full wavelength means that for each light ray coming through the slit at that angle, there’s a corresponding light ray that’s shifted by _________________ a wavelength. When this happens, ______________________________ interference is created.

10. The places where the waves interfere destructively create __________________________. The places where the waves interfere constructively create _______________________________.

“Spectra Interference: Crash Course Physics #40”:

1. The pattern of lines that appear when you shine a light through a pair of thin slits depends on the spacing of the slits and the light’s ____________________________________.

2. The more slits in a diffraction grating, the more ________________________________ interference you can get.

3. The patterns created using a diffraction grating are called _______________________________.

4. A ____________________________ spectrum is a distinct pattern of lines at certain wavelengths that correspond to the elemental composition of the cloud.

5. When objects like the sun are heated up, they emit a __________________________ spectrum that covers a wide range of wavelength. These things also contain ____________________________ lines – characteristic wavelengths of light that have been absorbed by the same elements that emitted them.

6. Different colors undergo constructive interference at different _________________________.

7. When light reflects off a surface that has a __________________ index of refraction that the medium it travels through, there is no phase shift and constructive interference occurs.

8. Light is a _______________________ wave, meaning that the wave travels in one direction and oscillates back and forth in a direction that’s perpendicular to the direction of travel.

9. When a wave strikes an object, the effects of the changing electric field are felt in a direction that’s ___________________________________ to the direction in which the wave is moving.

10. The filtering of light depending on its oscillation direction is called _______________________________.

11. Polarized sunglasses have lenses that work as _____________________________ polarizers.

“Optical Instruments: Crash Course Physics #41”:

1. Your eyes function much like a camera. The ___________________ controls how much light enters the eye. The ____________________ is controlled by muscles that alter the focal length in order to focus on objects at varying distances. The _______________________ is the sensor that captures the image, sending it to the brain.

2. Your ________________________ is the closest distance at which your eye can focus on an object. If this point for you is farther than average (25 cm), you have hyperopia, also known as _____________________________. This can be remedied with corrective lenses that are _______________________________ lenses.

3. Any simple magnifying glass consists of a single, _______________________________ lens.

4. In order to find the magnifying power of a lens, you divided the angle subtended by the _______________ by the angle subtended by the _____________________ (by your unaided eye).

5. The standard refracting telescope uses a _______________________, converging lens for both the objective lens and the eyepiece. Any objects viewed through a refracting telescope are __________________________.

6. The Hubble Space Telescope is a ____________________________ telescope, using mirrors as the objective lens. The mirrors are _________________________ in shape.

7. Since lenses have edges, the incoming rays will always ______________________ and produce slightly blurred images.

8. The ability of a camera to produces images of points very close together is called ________________________. For telescopes and microscopes, the ability to resolve an image becomes more difficult as the magnification becomes **HIGHER** **LOWER** because the diffraction patterns they create are magnified too.

“Quantum Mechanics – Part 1: Crash Course Physics #43”:

1. Light behaves like a ________________________. It also behaves like a __________________________.

2. A ________________________________ is the idealized version of a radiating object. They ________________ all incoming light without reflecting any and radiate energy accordingly. You can predict the intensity of the energy coming from a blackbody (blackbody radiation) based on its _________________________.

3. The **Rayleigh-Jeans Law** predicted that the higher the frequency, and therefore the shorter the wavelength, the _________________________ the intensity. That matched up with experimental results really well, until the frequency of light got into the _______________________________ range or higher. Blackbodies had a peak intensity based on their temperature and at a certain frequency the light would be at its most intense. After that, the intensity would ________________ as frequency increased. The warmer the object, the ________________ the frequency of the peak intensity.

4. The problem was solved with an equation now known as **Planck's Law** which says that electromagnetic energy takes the form of tiny, discreet packets called ________________________. The energy of each quantum is equal to the frequency of the light times Planck's constant. This looks like E = __________________.

5. Einstein argued that light energy traveled in packets that we now call ______________________ which would essentially make light behave like a particle.

6. The ____ describes what happens when you shine a beam of light on a metal plate. Electrons leave the plate and hit a nearby collector, creating a current.

7. Both the wave theory and the particle theory of light predict that light knocks ____________________ out of the metal.

- The wave theory says that when a light wave hits an electron, it exerts a _____________________ on the electron that ejects it out of the metal. According to wave theory, the ______________________ of light shouldn't make a difference, only the intensity matters.
- The particle theory says that electrons get ejected from the metal when they are hit by individual ___________. The photon transfers its energy to the electron, which pops out of the metal. The photon is destroyed. The photon has a minimum energy that it needs to transfer in order to get the electron to overcome it's attraction to the metal. This energy is called the ______________________(W_0).

8. There is a cutoff frequency. The higher the frequency is above the cutoff, the ________________ the maximum kinetic energy of the ejected electrons. Increasing the intensity of the light only affects the ____________________ of electrons ejected.

9. Photons really exist. Light travels in discrete packets and behaves like a _________________________________.

10. In certain circumstances, light can behave like a particle. In others, it can behave like a wave. This is known as the ____________________________________.

"Quantum Mechanics – Part 2: Crash Course Physics #44":

1. Applying the wave-particle duality to _______________ led to the development of a way to analyze the behavior of tiny particles more accurately than ever before.

2. According to De Broglie, you can find the _____________________ of any bit of matter, as long as you know its momentum. The easiest way to test this is by using ___________________________.

3. If all objects can have wavelengths, why don't we see them?

____

4. What would be the wavelength of a 0.2 kg ball flying through the air? ___________________________

5. When quantum mechanics looks at the wave nature of matter, it's mostly concerned with the ______________ that particles, like electrons or even atoms or molecules, will be in certain places at certain times.

6. You can use Schrödinger's equation to predict the probability of finding a particle at any given point in space, known as the ____ function. The diagrams of electron clouds show the probability of finding an atom's ______________________ in the space around the nucleus.

7. Many physicists think that the electron is ___________________ in a specific place, unless you stop to look at it. Instead, it's in all these _________________________ places at once. Once you observe or measure the electron in some way, it's only in one place. Somehow, you measuring it forces it to be in one spot. The idea that a particle can be in more than one state at one time is an example of quantum ____________________________.

8. The **Heisenberg Uncertainty Principle** states that no matter how good your measuring instrument is, you can only know the position or momentum of a particle up to a certain level of __________________. After that, you could get a better measurement of your electron's position, but you'd have a much less precise measure of its ________________________. Likewise, you could get a better measurement of the electron's momentum, but then you'd have to sacrifice some knowledge of its ________________________.

9. Quantum physicists try to make the best of both worlds by describing things like electrons using what's known as a __________________________ - a collection of waves all added together.

10. There will always be an uncertainty that's at least equal to _______________________ constant divided by four times pi.

11. Quantum mechanics tells us that there's a built in limit to how much we can learn about _________________.

"Nuclear Physics: Crash Course Physics #45":

1. $E = mc^2$ essentially means that matter can be converted into ______________________ and vice versa.

2. The process by which an element turns into an entirely different element is called ________________________.

3. The atomic nucleus contains positively charged particles called ___________________________ and electrically neutral _______________________________. Together, these particles are called _________________________.

4. Any two nuclei that have the same atomic number but different mass numbers are called __________________.

5. It's important to know the masses of different nuclei, since nuclear interactions are all about ________________ conversion.

6. The total mass of a stable nucleus is always ___________________ than the total mass of the individual protons and neutrons put together. That difference in mass is equal to the total ____________________ energy of the nucleus. That is the amount of energy you'd have to apply to the atom to break up the nucleus. This amount of energy peaks around iron – very large nuclei **ARE** **ARE NOT** held as strongly together as smaller ones.

7. The ____ force is the attractive force that acts between protons and neutrons in a nucleus.

8. When a nucleus is unstable, it can breakdown into a more stable state. This decay of unstable nuclei, accompanied by the emission of energetic particles is known as _______________________________.

9. There is three different types of decay:

- _____________________ decay is released when an unstable nucleus loses **two protons and two neutrons**, becoming a different element in the process.
  - This decay occurs because the parent nucleus is too **LARGE** **SMALL**
- _____________________ decay is when an unstable nucleus releases a beta particle, which is just an electron.
  - In this decay, a neutron changes into a _______________________, and an electron is emitted in response.
  - This type of decay is caused by the _________________ force. This force alters _____________: the fundamental particles that make up protons and neutrons.
- _____________________ decay is what results when a nucleus emits high-powered photons in what are known as gamma rays.
  - Gamma rays have the **LOWEST** **HIGHEST** penetrating power.

"Astrophysics and Cosmology: Crash Course Physics #46":

1. ________________________________ study the physics of celestial bodies, such as planets, stars, and galaxies.

2. ________________________________ study the universe overall and ask questions about the origin of everything, as well as its future.

3. A light-year is a unit of ______________________, with one light year equaling the distance that light would travel in a vacuum in one year. Light that comes from the sun is __________________________ old.

4. When we observe the stars, we are seeing what they look(ed) like in the **PAST** **PRESENT** **FUTURE**

5. The phenomenon by which the wavelength of light from sources that are moving away from us in known as ___________________________ because light waves that are longer are closer to the red part of the visible spectrum.

6. Edwin Hubble noted that galaxies that were farther away from us were moving away **FASTER** **SLOWER** than those that are closer to us. It was also found that no matter where you are, all distant galaxies appear to be moving **TOWARD** **AWAY FROM** you.

7. Cosmic Microwave Background Radiation, first discovered by Penzias and Wilson, is the leftover radiation from the ________________________. It provides support for the Big Bang Theory and it tells us a lot about the ____________________ of the early universe.

8. If the universe were filled with only matter and radiation, then the rate of expansion would slow down. That's not the case. Space is filled with a constant form of energy known as __________________________.

9. By current estimates, dark matter makes up __________% of the matter in the universe.