DOWNLOAD PDF FARADAYS LAW AND INDUCTION

Chapter 1 : Electromagnetic induction - Wikipedia

Faraday's law of induction is a basic law of electromagnetism predicting how a magnetic field will interact with an electric circuit to produce an electromotive force.

Magnet moves towards the coil Deflection in galvanometer in one direction Magnet is held stationary at same position near the coil No deflection in galvanometer Magnet moves away from the coil Deflection in galvanometer but in opposite direction Magnet is held stationary at same position away from the coil No deflection in galvanometer Conclusion: From this experiment, Faraday concluded that whenever there is relative motion between conductor and a magnetic field, the flux linkage with a coil changes and this change in flux induces a voltage across a coil. Michael Faraday formulated two laws on the basis of above experiments. This emf induced is called induced emf and if the conductor circuit is closed, the current will also circulate through the circuit and this current is called induced current. Method to change magnetic field: By moving a magnet towards or away from the coil By moving the coil into or out of the magnetic field. By changing the area of a coil placed in the magnetic field By rotating the coil relative to the magnet. The flux linkage of the coil is the product of the number of turns in the coil and flux associated with the coil. Faraday Law Formula Consider, a magnet is approaching towards a coil. Here we consider two instants at time T1 and time T2. By increasing magnetic field strength i. Theoretically, if the coil is passed through a stronger magnetic field , there will be more lines of force for coil to cut and hence there will be more emf induced. By increasing the speed of the relative motion between the coil and the magnet - If the relative speed between the coil and magnet is increased from its previous value, the coil will cut the lines of flux at a faster rate, so more induced emf would be produced. This law finds its application in most of the electrical machines, industries, and the medical field, etc. The Induction cooker is the fastest way of cooking. It also works on the principle of mutual induction. When current flows through the coil of copper wire placed below a cooking container, it produces a changing magnetic field. This alternating or changing magnetic field induces an emf and hence the current in the conductive container, and we know that the flow of current always produces heat in it. Electromagnetic Flow Meter is used to measure the velocity of certain fluids. This induced emf is proportional to the velocity of fluid flowing. It is also used in musical instruments like electric guitar, electric violin etc.

Chapter 2 : Faraday's law of induction - Wikipedia

Faraday's Law of Induction describes how an electric current produces a magnetic field and, conversely, how a changing magnetic field generates an electric current in a conductor. English.

Experimental Setup For Faraday. The experiment itself is somewhat simple. When the battery is disconnected, we have no electric current flowing through the wire. Hence there is no magnetic flux induced within the Iron Magnetic Core. The Iron is like a highway for Magnetic Fields - they flow very easily through magnetic material. So the purpose of the core is to create a path for the Magnetic Flux to flow. When the switch is closed, the electric current will flow within the wire attached to the battery. When this current flows, it has an associated magnetic field or magnetic flux with it. When the wire wraps around the left side of the magnetic core as shown in Figure 1 , a magnetic field magnetic flux is induced within the core. This flux travels around the core. So the Magnetic Flux produced by the wired coil on the left exists within the wired coil on the right, which is connected to the ammeter. Now, a funny thing happens, which Faraday observed. But this was very brief, and the current on the right coil would go to zero. When the switch was opened, the measured current would spike to the other side say Amps would be measured , and then the measured current on the right side would again be zero. Faraday figured out what was happening. When the switch was initially changed from open to closed, the magnetic flux within the magnetic core increased from zero to some maximum number which was a constant value, versus time. When the flux was increasing, there existed an induced current on the opposite side. Hence, a decreasing flux within the core induced an opposite current on the right side. Faraday figured out that a changing Magnetic Flux within a circuit or closed loop of wire produced an induced EMF, or voltage within the circuit. He wrote this as: Equation [2] then says that the induced voltage in a circuit is the opposite of the time-rate-of-change of the magnetic flux. For more information on derivatives, see the partial derivatives page. Lenz was the guy who figured out the minus sign. We know that an electric current gives rise to a magnetic field - but thanks to Farady we also know that a magnetic field within a loop gives rise to an electric current. We know that the rate of change of the total magnetic flux is equal to the opposite of the EMF, or the electric force within the wire. The total magnetic flux is simply the integral or sum of the B field over the area enclosed by the wire: This is known as a line integral. This is written as: Hence, the E-field is actually the spatial-derivative of voltage E-field is equal to the rate of change of the voltage with respect to distance. These facts are summed up in the following: This should have somewhat of an intuitive truth to you: Electric Current gives rise to magnetic fields. Magnetic Fields around a circuit gives rise to electric current. A circulating E-field in time gives rise to a Magnetic Field Changing in time. If a current gives rise to a Magnetic Field then a Magnetic Field can give rise to an electric current. And a changing E-field in space gives rise to a changing B-field in time.

Chapter 3 : Faraday's Law Introduction (video) | Khan Academy

Faraday's law of induction, in physics, a quantitative relationship between a changing magnetic field and the electric field created by the change, developed on the basis of experimental observations made in by the English scientist Michael Faraday.

On the other hand, the SI unit of capacitance is, as we have seen, called the farad abbreviation F. In chapter, we discuss oscillations in capacitative-inductive circuits, we see how appropriate it is to link the names of these two talented contemporaries in a single context. Both were apprentices at an early age. Faraday, at age 14, was apprenticed to a London bookbinder. Henry at age 13, was apprenticed to a watchmaker in Albany, New York. In later years Faraday was appointed director of the royal institution in London, whose founding was due in large part on an American,Benjamin Thomson Count Rumford. Henry, on the other hand, because secretary of the Smithsonian institution in Washington,DC, which was found by an endowment from an Englishman, James Smithson. Faraday observed that if a magnet is moved towards a coil of wire solenoid connected in series with a galvanometer,an electric current is produced in the current. When magnet is moved towards the solenoid ,the galvanometer shows deflection in one direction and when the magnet is moved away from the solenoid,the galvanometer shows deflection in the opposite direction. When the magnet is stationary there is no deflection in the galvanometer. Similar results are obtained when the magnet is kept stationary and the coil is moved. When the magnet is moved if the deflection in the galvanometer is large and when it is moved slowly the deflection is small. It was also found that if there are two closed circuits in close proximity,one containing a battery and the other a galvanometer,and the battery circuit is closed by pressing the tapping key K,and then broken,the galvanometer in the secondary circuit shows a deflection first in one direction and then in the other. It is observed that no deflection is produced in the galvanometer if the current in the primary circuit is flows continuously. The deflection is produced in the galvanometer only at make or break of the current in the primary circuit. Faraday summed up these experimental results in the form of the following laws: Whenever there is a change in the magnetic lines of force or magnetic flux,an induced current is produced in the circuit. The induced current or EMF lasts only for the time for which lines of force or magnetic flux is actually changing. The magnitude of the induced EMF depends upon the rate at which the magnetic lines of force or magnetic flux changes. Figure 1 shows a coil of wire as a part of a circuit containing an ammeter. Normally, we would expect the ammeter to show no current in the circuit because there seems to be no electromotive force. However, if we push a bar magnet toward the coil, with its north pole facing the coil, a remarkable thing happens. While the magnet is moving, the ammeter deflects, showing that a current has been set up in the coil. If we move the magnet away from the coil, the meter again deflects, but in the opposite direction, which means that the current in the coil is in the opposite direction. If we use the north pole end of a magnet instead of the north pole end, the experiment works as described but the deflections are reversed. The faster the magnet is moved, the greater is the reading of the meter. Further experimentation shows that what matters is the relative motion of the magnet and the coil. It marks no differences whether we move the magnet toward the coil or the coil toward the magnet. Specially,it is the rate of change in the number of field lines passing through the loop that determines the induced emf. It is a scalar quantity and its SI unit is Weber Wb. It is measured by the product of magnetic field strength and the component of vector area parallel to the magnetic field. Mathematically it is represented as: When a magnet is moved toward the loop,the ammeter needle deflects in one direction,as shown in the figure a. When the magnet is brought to rest and held stationary relative to the loop figure b ,no deflection is observed. When the magnet is moved away from the loop,the needle deflects in the opposite direction,as shown in figure c. Finally,if the magnet is held stationary and the loop is moved either toward or away from it,the needle deflects. From these observations,we conclude that the loop detects that the magnet is moving relative to it and we relate this detection to a change in magnetic field. Thus,it seems that a relationship exists between current and changing magnetic field. These results are quite remarkable in view of the fact that a current is set up even though no batteries are present in the circuit. We call such a current the induced current which is produced by induced emf. This phenomenon is called electromagnetic induction. There are other related topics in our website are:

Chapter 4 : Faraday's law of induction | physics | blog.quintoapp.com

Lenz's law is a consequence of conservation of energy applied to electromagnetic induction. It was formulated by Heinrich Lenz in While Faraday's law tells us the magnitude of the EMF produced, Lenz's law tells us the direction that current will flow.

Faraday discovered that when he moved a magnet near a wire a voltage was generated across it. If the magnet was held stationary no voltage was generated, the voltage only existed while the magnet was moving. A circuit loop connected to a sensitive ammeter will register a current if it is set up as in this figure and the magnet is moved up and down: The flux depends on the magnetic field that passes through surface. If the magnetic field is not perpendicular to the surface then there is a component which is perpendicular and a component which is parallel to the surface. In this diagram we show that a magnetic field at an angle other than perpendicular can be broken into components. This can be stated mathematically as: A magnetic field is measured in units of teslas T. The minus sign indicates direction and that the induced emf tends to oppose the change in the magnetic flux. The minus sign can be ignored when calculating magnitudes. It is not the area of the wire itself but the area that the wire encloses. This means that if you bend the wire into a circle, the area we would use in a flux calculation is the surface area of the circle, not the wire. In this illustration, where the magnet is in the same plane as the circuit loop, there would be no current even if the magnet were moved closer and further away. This is because the magnetic field lines do not pass through the enclosed area but are parallel to it. The magnetic field lines must pass through the area enclosed by the circuit loop for an emf to be induced. Direction of induced current ESBQ2 The most important thing to remember is that the induced current opposes whatever change is taking place. In the first picture left the circuit loop has the south pole of a magnet moving closer. The magnitude of the field from the magnet is getting larger. The response from the induced emf will be to try to resist the field towards the pole getting stronger. The field is a vector so the current will flow in a direction so that the fields due to the current tend to cancel those from the magnet, keeping the resultant field the same. To resist the change from an approaching south pole from above, the current must result in field lines that move away from the approaching pole. The induced magnetic field must therefore have field lines that go down on the inside of the loop. The current direction indicated by the arrows on the circuit loop will achieve this. Test this by using the Right Hand Rule. Put your right thumb in the direction of one of the arrows and notice what the field curls downwards into the area enclosed by the loop. In the second diagram the south pole is moving away. This means that the field from the magnet will be getting weaker. The response from the induced current will be to set up a magnetic field that adds to the existing one from the magnetic to resist it decreasing in strength. Another way to think of the same feature is just using poles. To resist an approaching south pole the current that is induced creates a field that looks like another south pole on the side of the approaching south pole. Like poles repel, you can think of the current setting up a south pole to repel the approaching south pole. In the second panel, the current sets up a north pole to attract the south pole to stop it moving away. We can also use the variation of the Right Hand Rule, putting your fingers in the direction of the current to get your thumb to point in the direction of the field lines or the north pole. We can test all of these on the cases of a north pole moving closer or further away from the circuit. For the first case of the north pole approaching, the current will resist the change by setting up a field in the opposite direction to the field from the magnet that is getting stronger. Use the Right Hand Rule to confirm that the arrows create a field with field lines that curl upwards in the enclosed area cancelling out those curling downwards from the north pole of the magnet. Like poles repel, alternatively test that putting the fingers of your right hand in the direction of the current leaves your thumb pointing upwards indicating a north pole. For the second figure where the north pole is moving away the situation is reversed. Direction of induced current in a solenoid ESBQ3 The approach for looking at the direction of current in a solenoid is the same the approach described above. The only difference being that in a solenoid there are a number of loops of wire so the magnitude of the induced emf will be different. The flux would be calculated using the surface area of the solenoid multiplied by the number of loops. When the fingers of the right hand are pointed in the direction of the magnetic field, the thumb points in the direction of the current. When the thumb is pointed in the direction of the magnetic field, the fingers point in the direction of the current. The direction of the current will be such as to oppose the change. We would use a setup as in this sketch to do the test: In the case where a north pole is brought towards the solenoid the current will flow so that a north pole is established at the end of the solenoid closest to the approaching magnet to repel it verify using the Right Hand Rule: In the case where a north pole is moving away from the solenoid the current will flow so that a south pole is established at the end of the solenoid closest to the receding magnet to attract it: In the case where a south pole is moving away from the solenoid the current will flow so that a north pole is established at the end of the solenoid closest to the receding magnet to attract it: In the case where a south pole is brought towards the solenoid the current will flow so that a south pole is established at the end of the solenoid closest to the approaching magnet to repel it: An easy way to create a magnetic field of changing intensity is to move a permanent magnet next to a wire or coil of wire. The induced current generates a magnetic field. The induced magnetic field is in a direction that tends to cancel out the change in the magnetic field in the loop of wire. So, you can use the Right Hand Rule to find the direction of the induced current by remembering that the induced magnetic field is opposite in direction to the change in the magnetic field. Induction Electromagnetic induction is put into practical use in the construction of electrical generators which use mechanical power to move a magnetic field past coils of wire to generate voltage. However, this is by no means the only practical use for this principle. If we recall, the magnetic field produced by a current-carrying wire is always perpendicular to the wire, and that the flux intensity of this magnetic field varies with the amount of current which passes through it. We can therefore see that a wire is capable of inducing a voltage along its own length if the current is changing. This effect is called self-induction. Self-induction is when a changing magnetic field is produced by changes in current through a wire, inducing a voltage along the length of that same wire. A device constructed to take advantage of this effect is called an inductor. Remember that the induced current will create a magnetic field that opposes the change in the magnetic flux. The plane of the coil is perpendicular to the magnetic field: Determine the direction of the induced current. We want to determine the magnitude of the emf so we can ignore the minus sign. The axis of the solenoid is parallel to the magnetic field. Determine the radius of the solenoid. Identify what is required We are required to determine the radius of the solenoid. We can use this relationship to find the radius. We can drop the minus sign because we are working with the magnitude of the emf only. Find the induced emf.

Chapter 5 : What is Faraday's law? (article) | Khan Academy

In , Michael Faraday, an English physicist gave one of the most basic laws of electromagnetism called Faraday's law of electromagnetic blog.quintoapp.com law explains the working principle of most of the electrical motors, generators, electrical transformers and inductors.

January 27, English physicist Michael Faraday gets the credit for discovering magnetic induction in ; however, an American physicist, Joseph Henry, independently made the same discovery about the same time, according to the University of Texas. Magnetic induction makes possible the electric motors, generators and transformers that form the foundation of modern technology. By understanding and using induction, we have an electric power grid and many of the things we plug into it. Electricity Electric charge is a fundamental property of matter, according to the Rochester Institute of Technology. Although it is difficult to describe what it actually is, we are quite familiar with how it behaves and interacts with other charges and fields. The electric field from a localized point charge is relatively simple, according to Serif Uran, a professor of physics at Pittsburg State University. When you move twice as far away, the field strength decreases to one-fourth, and when you move three times farther away, it decreases to one-ninth. Protons have positive charge, while electrons have negative charge. However, protons are mostly immobilized inside atomic nuclei, so the job of carrying charge from one place to another is handled by electrons. Electrons in a conducting material such as a metal are largely free to move from one atom to another along their conduction bands, which are the highest electron orbits. A sufficient electromotive force emf , or voltage, produces a charge imbalance that can cause electrons move through a conductor from a region of more negative charge to a region of more positive charge. This movement is what we recognize as an electric current. Compared to the electric field, the magnetic field is more complex. While positive and negative electric charges can exist separately, magnetic poles always come in pairs â€" one north and one south, according to San Jose State University. Typically, magnets of all sizes â€" from sub-atomic particles to industrial-size magnets to planets and stars â€" are dipoles, meaning they each have two poles. We call these poles north and south after the direction in which compass needles point. Interestingly, since opposite poles attract, and like poles repel, the magnetic north pole of the Earth is actually a south magnetic pole because it attracts the north poles of compass needles. A magnetic field is often depicted as lines of magnetic flux. In the case of a bar magnet, the flux lines exit from the north pole and curve around to reenter at the south pole. In this model, the number of flux lines passing through a given surface in space represents the flux density, or the strength of the field. However, it should be noted that this is only a model. A magnetic field is smooth and continuous and does not actually consist of discrete lines. Magnetic field lines from a bar magnet. Therefore, only a small amount of flux passes through a given area, resulting in a relatively weak field. By comparison, the flux from a refrigerator magnet is tiny compared to that of the Earth, but its field strength is many times stronger at close range where its flux lines are much more densely packed. However, the field quickly becomes much weaker as you move away. Induction If we run an electric current through a wire, it will produce a magnetic field around the wire. The direction of this magnetic field can be determined by the right-hand rule. According to the physics department at Buffalo State University of New York, if you extend your thumb and curl the fingers of your right hand, your thumb points in the positive direction of the current, and your fingers curl in the north direction of the magnetic field. Left-hand and right-hand rule for a magnetic field due to a current in a straight wire. Saad Shutterstock If you bend the wire into a loop, the magnetic field lines will bend with it, forming a toroid, or doughnut shape. In this case, your thumb points in the north direction of the magnetic field coming out of the center of the loop, while your fingers will point in the positive direction of the current in the loop. In a current-carrying circular loop, a the right-hand rule gives the direction of the magnetic field inside and outside the loop. OpenStax If we run a current through a wire loop in a magnetic field, the interaction of these magnetic fields will exert a twisting force, or torque, on the loop causing it to rotate, according to the Rochester Institute of Technology. However, it will only rotate so far until the magnetic fields are aligned. If we want the loop to continue rotating, we have to reverse the direction of the current, which will reverse the direction of the magnetic field from the loop. The loop will then rotate degrees until its field is aligned in the other direction. This is the basis for the electric motor. Conversely, if we rotate a wire loop in a magnetic field, the field will induce an electric current in the wire. The direction of the current will reverse every half turn, producing an alternating current. This is the basis for the electric generator. It should be noted here that it is not the motion of the wire but rather the opening and closing of the loop with respect to the direction of the field that induces the current. When the loop is face-on to the field, the maximum amount of flux passes through the loop. However, when the loop is turned edge-on to the field, no flux lines pass through the loop. It is this change in the amount of flux passing through the loop that induces the current. Another experiment we can perform is to form a wire into a loop and connect the ends to a sensitive current meter, or galvanometer. If we then push a bar magnet through the loop, the needle in the galvanometer will move, indicating an induced current. However, once we stop the motion of the magnet, the current returns to zero. The field from the magnet will only induce a current when it is increasing or decreasing. If we pull the magnet back out, it will again induce a current in the wire, but this time it will be in the opposite direction. Magnet in a wire loop connected to a galvanometer. Saad Shutterstock If we were to put a light bulb in the circuit, it would dissipate electrical energy in the form of light and heat, and we would feel resistance to the motion of the magnet as we moved it in and out of the loop. In order to move the magnet, we have to do work that is equivalent to the energy being used by the light bulb. In yet another experiment, we might construct two wire loops, connect the ends of one to a battery with a switch, and connect the ends of the other loop to a galvanometer. If we place the two loops close to each other in a face-to-face orientation, and we turn on the power to the first loop, the galvanometer connected to the second loop will indicate an induced current and then quickly return to zero. What is happening here is that the current in the first loop produces a magnetic field, which in turn induces a current in the second loop, but only for an instant when the magnetic field is changing. When you turn off the switch, the meter will deflect momentarily in the opposite direction. This is further indication that it is the change in the intensity of the magnetic field, and not its strength or motion that induces the current. The explanation for this is that a magnetic field causes electrons in a conductor to move. This motion is what we know as electric current. Eventually, though, the electrons reach a point where they are in equilibrium with the field, at which point they will stop moving. Then when the field is removed or turned off, the electrons will flow back to their original location, producing a current in the opposite direction. Unlike a gravitational or electric field, a magnetic dipole field is a more complex 3-dimensional structure that varies in strength and direction according to the location where it is measured, so it requires calculus to describe it fully. It states that the induced voltage in a circuit is proportional to the rate of change over time of the magnetic flux through that circuit. In other words, the faster the magnetic field changes, the greater will be the voltage in the circuit. The direction of the change in the magnetic field determines the direction of the current. We can increase the voltage by increasing the number of loops in the circuit. The induced voltage in a coil with two loops will be twice that with one loop, and with three loops it will be triple. This is why real motors and generators typically have large numbers of coils. In theory, motors and generators are the same. If you turn a motor, it will generate electricity, and applying voltage to a generator, it will cause it to turn. However, most real motors and generators are optimized for only one function. In this device, alternating current, which changes direction many times per second, is sent through a coil wrapped around a magnetic core. This produces a changing magnetic field in the core, which in turn induces a current in second coil wrapped around a different part of the same magnetic core. For instance, if we take a transformer with turns on the input side and 50 turns on the output side, and we input an alternating current at volts, the output will be volts. According to Hyperphysics, a transformer cannot increase power, which is the product of voltage and current, so if the voltage is raised, the current is proportionally lowered and vice versa. In our example, an input of volts at 10 amps, or 2, watts, would produce an output of volts at 20 amps, again, 2, watts. In practice, transformers are never perfectly efficient, but a well-designed transformer typically has a power loss of only a few percent, according to the University of Texas. Transformers make possible the electric grid we depend on for our industrial and technological society. Cross-country transmission lines operate at hundreds of thousands of volts in order to transmit more power within the current-carrying limits of the wires. This voltage is stepped down repeatedly using transformers at distribution substations until it reaches your house, where it is finally stepped down to and volts that can run your electric stove and computer.

DOWNLOAD PDF FARADAYS LAW AND INDUCTION

Chapter 6 : blog.quintoapp.com: Electricity & Magnetism: Faraday's Law

Faraday's law is a fundamental relationship which comes from Maxwell's blog.quintoapp.com serves as a succinct summary of the ways a voltage (or emf) may be generated by a changing magnetic environment.

The axial means the sensor measures the magnetic field along the axis of the probe. We opened the preset experiment file as directed on the whiteboard. The program will record and graph the current in the solenoid remember to calculated from voltage drop across the 10 W resistor, the magnetic field produced inside the solenoid and the voltage induced in the small pick-up coil. Part 1 We had to adjust the frequency of the signal generator to 50 Hz. Make sure the axis of the sensor is always parallel to the axis of the solenoid. Use this number to calculate the expected magnitude of the corresponding magnetic field of the solenoid eqn. Compare this value with the one recorded by the magnetic probe again, we have to consider the average of the absolute maximum and minimum. Repeat this procedure for a couple more location of the magnetic field sensor inside the solenoid. Part 2 We Carefully measure the diameter of the pick-up coil and calculate its cross sectional area. Compare your measured value with the one given in the sample calculation below. Insert the pick-up coil into the solenoid in such way that both axes are parallel. With the magnetic field sensor held next to the pick-up coil inside the solenoid, record the data for different frequencies put out by the signal generator. Be aware that because of the alternating current principles the magnitude of the current in the circuit hence the magnetic field depends on the frequency. For better results you may want to make some small adjustments in the output signal amplitude to keep the current amplitude constant. In Graphical Analysis make a graph Vemf. Is the graph linear? What does that mean? Part 3 from part 2 we have to look at one should deduce that by increasing the frequency of the current in the solenoid making the changing magnetic field faster , we can proportionally make the induced emf bigger. Also, an increase in magnetic field and the magnetic flux will result in increasing the emf. A common way to increase the magnetic field of a solenoid is to put an iron rod inside it. Conduct such an experiment and comment on the effect.

Chapter 7 : Faraday's Laws of Electromagnetic Induction

This relationship is known as Faraday's law of blog.quintoapp.com units for emf are volts, as is usual. The minus sign in Faraday's law of induction is very important. The minus means that the emf creates a current I and magnetic field B that oppose the change in flux â€"this is known as Lenz's law.

Chapter 8 : Maxwell's Equations: Faraday's Law

Faraday's second law of electromagnetic induction states that, the magnitude of induced emf is equal to the rate of change of flux linkages with the coil. The flux linkages is the product of number of turns and the flux associated with the coil.

Chapter 9 : Faraday's Law - Magnetic Field | Magnets - PhET Interactive Simulations

Faraday was a scientist experimenting with circuits and magnetic coils way back in the s. His experiment setup, which led to Farday's Law, is shown in Figure 1.