

# PHY101

## AN INTRODUCTION TO PHYSICS

### Important subjective

#### Lec 23 - Electrostatics – I

What is electric charge, and what are the two types of charges?

Answer: Electric charge is a fundamental property of matter that arises from the presence of charged particles. The two types of charges are positive and negative.

What is Coulomb's law, and how is it related to electric charges?

Answer: Coulomb's law states that the force of attraction or repulsion between two charged particles is proportional to the product of their charges and inversely proportional to the square of the distance between them. This law describes the relationship between electric charges.

What is an electric field, and how is it represented?

Answer: An electric field is a vector field that describes the force that would be exerted on a charged particle placed at any point in space. It is represented by electric field lines, which are drawn in the direction of the force on a positive test charge.

What is Gauss's law, and how is it useful in electrostatics?

Answer: Gauss's law relates the electric field to the charge distribution in space. It states that the electric flux through any closed surface is proportional to the total charge enclosed by that surface. This law is useful in calculating the electric field in various situations.

What is the potential difference, and how is it measured?

Answer: The potential difference is the amount of work done per unit charge in moving a test charge from one point to the other against the electric field. It is measured in volts (V).

What is the electric potential energy, and how is it related to the potential difference?

Answer: The electric potential energy of a charged object in an electric field is defined as the amount of work done in bringing the object from infinity to that point in the field. It is related to the potential difference by the equation  $\Delta U = q\Delta V$ , where  $\Delta U$  is the change in electric potential energy,  $q$  is the charge, and  $\Delta V$  is the

potential difference.

What is capacitance, and how is it related to the charge and potential difference of a capacitor?

Answer: Capacitance is the ratio of the charge on each plate of a capacitor to the potential difference between the plates. It is related to the charge and potential difference by the equation  $C=q/V$ , where  $C$  is the capacitance,  $q$  is the charge, and  $V$  is the potential difference.

What is dielectric constant, and how does it affect the capacitance of a capacitor?

Answer: Dielectric constant is a measure of the ability of a material to store electrical energy in an electric field. It affects the capacitance of a capacitor by increasing it, as it reduces the electric field between the plates and allows more charge to be stored.

What is the difference between an insulator and a conductor?

Answer: An insulator is a material that does not conduct electricity, while a conductor is a material that allows electricity to flow through it.

How is the electrostatic force different from other fundamental forces of nature?

Answer: The electrostatic force is the strongest of the four fundamental forces of nature, and it has an infinite range. It is also different from the other forces because it can be both attractive and repulsive, depending on the charges involved.

## **Lec 24 - Electrostatics – II**

**What is the relationship between the electric field and the electric potential?**

**Answer:** The electric field is the negative gradient of the electric potential.  $E = -\nabla V$ .

**What is an electric dipole?**

**Answer:** An electric dipole is a pair of opposite charges of equal magnitude separated by a distance  $d$ .

**Define electric flux.**

**Answer:** Electric flux is the number of electric field lines passing through a given surface.

**What is Gauss's law?**

**Answer:** Gauss's law relates the electric flux through a closed surface to the charge enclosed within the surface. It states that the electric flux through a closed surface is proportional to the charge enclosed within the surface.

**What is meant by the term electric potential energy?**

**Answer:** Electric potential energy is the energy associated with the position of a charged object in an electric field.

**Define capacitance.**

**Answer:** Capacitance is the ability of a system to store electrical charge.

**What is an electric field?**

**Answer:** An electric field is a region of space around a charged object in which a force would be exerted on other charged objects.

**What is an electric potential?**

**Answer:** Electric potential is the electric potential energy per unit charge.

**What is the formula for the electric field between two charged plates?**

**Answer:**  $E = V/d$ , where  $E$  is the electric field,  $V$  is the potential difference between the plates, and  $d$  is the distance between the plates.

**What is the difference between conductors and insulators?**

**Answer:** Conductors allow electricity to flow through them easily, while insulators do not. Conductors have free electrons that can move through the material, while insulators do not.

## Lec 26 - Electric Potential

Define electric potential.

Answer: Electric potential at a point in an electric field is defined as the amount of work done in bringing a unit positive charge from infinity to that point.

What is the unit of electric potential?

Answer: The unit of electric potential is Volt (V).

What is the difference between electric potential and electric potential energy?

Answer: Electric potential is the electric potential energy per unit charge, whereas electric potential energy is the energy required to move a charge from one point to another against an electric field.

What is equipotential surface?

Answer: An equipotential surface is a surface in an electric field where all points have the same electric potential.

Why is electric potential a scalar quantity?

Answer: Electric potential is a scalar quantity because it has only magnitude and no direction.

What is the relation between electric potential and electric field?

Answer: The electric field at a point is the negative of the gradient of electric potential at that point.

What is the work done in moving a charge from a lower potential to a higher potential?

Answer: Work is done by an external agent in moving a charge from a lower potential to a higher potential.

What is the work done in moving a charge on an equipotential surface?

Answer: No work is done in moving a charge on an equipotential surface because the electric potential at all points on the surface is the same.

What is the electric potential due to a point charge?

Answer: The electric potential due to a point charge at a point in space is given by  $V = kq/r$ , where  $k$  is the Coulomb's constant,  $q$  is the charge, and  $r$  is the distance from the point charge.

What is the electric potential due to a dipole?

Answer: The electric potential due to an electric dipole at a point in space is given by  $V = k(p/r^2)\cos\theta$ , where  $k$  is the Coulomb's constant,  $p$  is the dipole moment,  $r$  is the distance from the dipole, and  $\theta$  is the angle between the dipole moment and the line joining the dipole to the point.

## **Lec 27 - Capacitors and Currents**

**What is the definition of capacitance?**

**Answer:** Capacitance is the ability of a capacitor to store electric charge per unit voltage.

**Define the time constant of a capacitor.**

**Answer:** The time constant of a capacitor is the time taken by the capacitor to discharge to 63.2% of its initial charge or voltage.

**What is the energy stored in a capacitor?**

**Answer:** The energy stored in a capacitor is given by the formula:  $E = \frac{1}{2} CV^2$ , where E is the energy stored, C is the capacitance, and V is the voltage across the capacitor.

**What happens when a capacitor is connected in series with a resistor and a battery?**

**Answer:** A capacitor connected in series with a resistor and a battery forms a simple RC circuit, where the capacitor charges and discharges through the resistor.

**Define the current in a capacitor.**

**Answer:** The current in a capacitor is the rate of change of charge stored in the capacitor with respect to time.

**What is the unit of capacitance?**

**Answer:** The unit of capacitance is farad (F).

**How can you increase the capacitance of a capacitor?**

**Answer:** The capacitance of a capacitor can be increased by increasing the area of the plates, decreasing the distance between the plates, or by using a material with a high dielectric constant between the plates.

**What is the charge on a capacitor when it is fully charged?**

**Answer:** The charge on a capacitor when it is fully charged is equal to the product of its capacitance and the voltage across it.

**What is the difference between a capacitor and a battery?**

**Answer:** A capacitor stores energy in an electric field, while a battery stores energy in a chemical form.

**What is the formula for the time constant of a capacitor in an RC circuit?**

**Answer:** The formula for the time constant of a capacitor in an RC circuit is given by the product of the resistance and the capacitance, i.e.,  $\tau = RC$ .



## **Lec 28 - Currents and Circuits**

**What is an electric current, and what are its units?**

**Answer:** Electric current is the flow of electric charges through a conductor. It is measured in amperes (A).

**What is Ohm's Law, and how is it used in circuits?**

**Answer:** Ohm's Law states that the current flowing through a conductor is directly proportional to the voltage applied across it and inversely proportional to its resistance. It is commonly used to calculate the resistance, current or voltage of a circuit.

**What is the difference between AC and DC current?**

**Answer:** AC (alternating current) changes direction periodically, while DC (direct current) flows in only one direction.

**What is a circuit diagram, and how is it useful?**

**Answer:** A circuit diagram is a graphical representation of an electrical circuit that shows how the various components are connected. It is useful for understanding the functioning of the circuit and troubleshooting it if any problem arises.

**What is a series circuit, and how does it differ from a parallel circuit?**

**Answer:** In a series circuit, the components are connected in a single loop, while in a parallel circuit, the components are connected in separate branches.

**What is a resistor, and how does it affect the flow of current in a circuit?**

**Answer:** A resistor is an electrical component that resists the flow of current in a circuit. It is used to regulate the amount of current flowing through a circuit.

**What is a capacitor, and how is it used in a circuit?**

**Answer:** A capacitor is an electrical component that stores electric charge. It is commonly used in circuits to block DC current and pass AC current.

**What is an inductor, and how does it affect the flow of current in a circuit?**

**Answer:** An inductor is an electrical component that stores energy in a magnetic field. It is used to oppose changes in current flow in a circuit.

**What is a diode, and what is its purpose in a circuit?**

**Answer:** A diode is an electrical component that allows current to flow in only one direction. It is used to regulate the flow of current in a circuit and prevent reverse current.

**What is a transistor, and how is it used in electronic devices?**

**Answer:** A transistor is an electrical component that is used to amplify or switch electronic signals. It is a fundamental building block of modern electronic devices such as computers and smartphones.

## Lec 29 - The Magnetic Field

### 1. What is the magnetic field?

The magnetic field is a region in space around a magnet or a current-carrying conductor where the magnetic force can be detected. It is a vector field that exerts a force on moving charged particles.

### 2. What is a magnetic field line?

Magnetic field lines are the paths that a hypothetical magnetic north pole would follow if it were placed in a magnetic field. The direction of the magnetic field is tangent to the field line at any point.

### 3. What is the right-hand rule in magnetism?

The right-hand rule is a mnemonic used to determine the direction of the magnetic force on a moving charged particle or a current-carrying conductor in a magnetic field. If you point your right thumb in the direction of the particle's velocity or current, and your fingers in the direction of the magnetic field, then your palm points in the direction of the magnetic force.

### 4. What is the magnetic field inside a solenoid?

The magnetic field inside a solenoid is uniform and parallel to the axis of the solenoid. The strength of the magnetic field is proportional to the number of turns per unit length of the solenoid and the current flowing through it.

### 5. What is the difference between diamagnetic, paramagnetic, and ferromagnetic materials?

Diamagnetic materials are those that have no permanent magnetic moment and are slightly repelled by a magnetic field. Paramagnetic materials have a small, positive magnetic susceptibility and are weakly attracted by a magnetic field. Ferromagnetic materials have a large, positive magnetic susceptibility and can be magnetized, retaining their magnetization even when the external magnetic field is removed.

### 6. What is the Hall effect?

The Hall effect is a phenomenon in which a magnetic field perpendicular to a current-carrying conductor creates a transverse electric field, resulting in a voltage across the conductor perpendicular to both the current and the magnetic field. This effect is used in Hall effect sensors to measure magnetic fields.

### 7. What is Lenz's law?

Lenz's law states that the direction of an induced electromotive force (EMF) in a conductor is always such that it opposes the change in magnetic flux that produced it. This law is based on the principle of conservation of energy.

### 8. What is electromagnetic induction?

Electromagnetic induction is the process of generating an electromotive force (EMF) in a conductor by exposing it to a changing magnetic field. This effect is the basis of many electrical devices, such

as generators and transformers.

#### 9. **What is the difference between AC and DC?**

AC stands for alternating current, which periodically reverses direction and changes magnitude. DC stands for direct current, which flows in one direction and maintains a constant magnitude. AC is used for long-distance power transmission, while DC is used for electronic devices and batteries.

#### 10. **What is an electromagnet?**

An electromagnet is a magnet created by running an electric current through a coil of wire wrapped around a magnetic core. The strength of the magnetic field generated by an electromagnet can be controlled by adjusting the current flowing through the coil. Electromagnets are used in a variety of applications, such as in electric motors, speakers, and MRI machines.

## **Lec 30 - Electromagnetic Induction**

### **What is electromagnetic induction?**

Electromagnetic induction is the phenomenon of generating an electromotive force (emf) or voltage in a closed circuit due to the change in magnetic flux through the circuit.

### **What is Faraday's law of electromagnetic induction?**

Faraday's law states that the emf induced in a circuit is proportional to the rate of change of magnetic flux through the circuit.

### **What is Lenz's law?**

Lenz's law states that the direction of the induced emf is such that it opposes the change that produced it.

### **What is self-induction?**

Self-induction is the phenomenon of inducing an emf in a coil due to the change in current flowing through it.

### **What is mutual induction?**

Mutual induction is the phenomenon of inducing an emf in a coil due to the change in magnetic flux linked with it, produced by a current flowing in another nearby coil.

### **What is an induced current?**

An induced current is a current that is produced in a closed circuit due to the presence of an induced emf.

### **What is an inductor?**

An inductor is a passive electrical component that is designed to store energy in its magnetic field. It is typically made up of a coil of wire.

### **What is an inductance?**

Inductance is a measure of the ability of an inductor to store energy in its magnetic field. It is measured in units of henries.

**What is a transformer?**

A transformer is a device that is used to transfer electrical energy from one circuit to another through the principle of electromagnetic induction.

**What is eddy current?**

Eddy currents are the currents that are induced in a conductor due to the change in magnetic field linked with it. They are often seen as unwanted effects in electrical machines and can cause energy loss in the form of heat.

## **Lec 31 - Alternating Current**

### **What is meant by alternating current?**

Answer: Alternating current is an electric current that periodically reverses direction, constantly changing its magnitude and direction.

### **What is the frequency of AC current in India?**

Answer: The frequency of AC current in India is 50 Hz.

### **Define RMS value of AC current.**

Answer: RMS (Root Mean Square) value of AC current is the value of the current which when passed through a resistor for a given time produces the same amount of heat as produced by the corresponding DC current when passed for the same time through the same resistor.

### **What is the phase difference between the voltage and current in a purely resistive circuit?**

Answer: In a purely resistive circuit, the voltage and current are in phase with each other, i.e., there is no phase difference between them.

### **What is an inductor in an AC circuit?**

Answer: An inductor is a passive electrical component that stores energy in a magnetic field when electric current flows through it in an AC circuit.

### **What is the reactance of a capacitor in an AC circuit?**

Answer: The reactance of a capacitor in an AC circuit is given by  $X_c = 1/(2\pi fC)$ , where  $f$  is the frequency of the AC signal and  $C$  is the capacitance of the capacitor.

### **What is the power factor of a purely resistive circuit?**

Answer: The power factor of a purely resistive circuit is unity or 1.

### **What is meant by the resonance frequency of an AC circuit?**

Answer: The resonance frequency of an AC circuit is the frequency at which the circuit offers maximum impedance to the flow of current.

**What is the phase difference between the voltage and current in an inductive circuit?**

Answer: In an inductive circuit, the current lags behind the voltage by 90 degrees.

**What is an LC circuit?**

Answer: An LC circuit is a resonant circuit consisting of an inductor (L) and a capacitor (C) connected together. It can store electrical energy oscillating at its resonant frequency.



## Lec 33 - Electromagnetic Waves

What are electromagnetic waves?

Answer: Electromagnetic waves are transverse waves consisting of electric and magnetic fields that propagate through space at the speed of light.

What is the relationship between electric and magnetic fields in electromagnetic waves?

Answer: In electromagnetic waves, the electric and magnetic fields are perpendicular to each other and to the direction of wave propagation.

What is the electromagnetic spectrum?

Answer: The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation.

How are the different types of electromagnetic waves distinguished from each other?

Answer: The different types of electromagnetic waves are distinguished from each other based on their frequency, wavelength, and energy.

How are electromagnetic waves produced?

Answer: Electromagnetic waves are produced by oscillating charges or currents.

What are some common applications of electromagnetic waves?

Answer: Electromagnetic waves are used in a wide range of applications, including communication (radio, television, and cell phones), medical imaging (MRI), cooking (microwave ovens), and many others.

How do electromagnetic waves travel through a vacuum?

Answer: Electromagnetic waves can travel through a vacuum because they do not require a medium for propagation.

What is the speed of electromagnetic waves in a vacuum?

Answer: The speed of electromagnetic waves in a vacuum is approximately  $3.00 \times 10^8$  m/s.

What is the relationship between the frequency and energy of an electromagnetic wave?

Answer: The energy of an electromagnetic wave is directly proportional to its frequency.

How do electromagnetic waves interact with matter?

Answer: Electromagnetic waves can be absorbed, reflected, or transmitted by matter, depending on the properties of the material and the frequency of the wave.

## **Lec 34 - Physics of Light**

### **What is the visible spectrum?**

**Answer:** The visible spectrum is the range of wavelengths of light that can be seen by the human eye, ranging from approximately 400 nanometers (nm) to 700 nm.

### **What is the speed of light?**

**Answer:** The speed of light is approximately 299,792,458 meters per second in a vacuum.

### **What is the wave-particle duality of light?**

**Answer:** The wave-particle duality of light means that light behaves like both a wave and a particle, depending on the situation.

### **What is refraction of light?**

**Answer:** Refraction of light is the bending of light as it passes through a material with a different refractive index, such as from air to glass or water.

### **What is absorption of light?**

**Answer:** Absorption of light is the transfer of the energy of light to atoms or molecules within a material, which can cause them to become excited and emit light of their own.

### **What is fluorescence?**

**Answer:** Fluorescence is the emission of light by a material that has absorbed light of a different wavelength, such as when a fluorescent dye is excited by a light source.

### **How is light used in fiber optic cables?**

**Answer:** Light is used to transmit information through fiber optic cables by sending pulses of light down the cable, which can carry a large amount of information over long distances.

### **What is an X-ray?**

**Answer:** An X-ray is a type of high-energy electromagnetic radiation that is used in medical imaging to produce images of the inside of the body.

**What is an LED?**

**Answer:** An LED, or light-emitting diode, is a type of semiconductor device that emits light when an electric current is passed through it.

**How is light used in astronomy?**

**Answer:** Light is used in astronomy to study the properties of stars and galaxies, and to detect objects such as planets and black holes, by analyzing the light that they emit or reflect.

## **Lec 35 - Interaction of Light with Matter**

**What is absorption and how does it occur when light interacts with matter?**

**Answer:** Absorption is the process by which the energy of light is transferred to the atoms or molecules within a material, causing them to become excited and potentially emit light of their own. This occurs when the photons of light are absorbed by the electrons within the material.

**What is reflection and how does it occur when light interacts with matter?**

**Answer:** Reflection is the process by which light bounces off a surface without being absorbed. This occurs when the angle of incidence of the light wave is equal to the angle of reflection, according to the law of reflection.

**What is refraction and how does it occur when light interacts with matter?**

**Answer:** Refraction is the process by which light passes through a material with a different refractive index, causing it to bend. This occurs when the angle of incidence of the light and the refractive index of the material are different.

**What is scattering and how does it occur when light interacts with matter?**

**Answer:** Scattering is the process by which light is redirected in many different directions as it passes through a material. This occurs when the photons of light are deflected by the atoms or molecules within the material.

**What is the role of optics in the interaction of light with matter?**

**Answer:** Optics is the study of the behavior of light, including its interaction with lenses, mirrors, and other optical devices. The principles of optics are used in a wide range of applications, from the design of eyeglasses to the creation of advanced telescopes.

**What is photovoltaics and how does it relate to the interaction of light with matter?**

**Answer:** Photovoltaics is the study of the conversion of light energy into electrical energy, which is the principle behind the operation of solar cells. When light is absorbed by a solar cell, the energy of the light is used to create an electric current.

**What is spectroscopy and how does it use the interaction of light with matter?**

**Answer:** Spectroscopy is the study of the interaction of light with matter to learn about its properties. By analyzing the way that light is absorbed or emitted by a material, scientists can learn about the composition, structure, and behavior of that material.

**What is the difference between transparent and opaque materials in terms of their interaction with light?**

**Answer:** Transparent materials allow most of the light that passes through them to go through unaffected, while opaque materials absorb most of the light that hits them.

**How does the refractive index of a material affect the way that light is refracted?**

**Answer:** The refractive index of a material determines how much the light is bent when it passes through it. Materials with a higher refractive index will cause light to bend more than materials with a lower refractive index.

**What is the significance of the interaction of light with matter in our daily lives?**

**Answer:** The interaction of light with matter is essential for many aspects of our daily lives, from the formation of images in our eyes to the functioning of electronic devices. Understanding the interaction of light with matter is important for the development of new technologies and the advancement of scientific knowledge.

## **Lec 36 - Interference and Diffraction**

**What is interference in the context of waves?**

**Answer:** Interference is the interaction of two or more waves resulting in a pattern of alternating bright and dark regions called an interference pattern.

**What is the difference between constructive and destructive interference?**

**Answer:** Constructive interference occurs when waves add up to produce a higher amplitude, resulting in a bright region. Destructive interference occurs when waves cancel each other out, resulting in a dark region.

**What is the double-slit experiment?**

**Answer:** The double-slit experiment is an experiment that demonstrates interference of light waves. A beam of light is passed through two narrow slits, which act as two sources of coherent waves. The waves interfere with each other, creating an interference pattern on a screen placed behind the slits.

**What is diffraction in the context of waves?**

**Answer:** Diffraction is the bending of waves around an obstacle or through an aperture.

**What is the relationship between the size of an obstacle or aperture and the amount of diffraction?**

**Answer:** The amount of diffraction depends on the size of the obstacle or aperture relative to the wavelength of the wave. The larger the obstacle or aperture, the greater the diffraction.

**What is X-ray diffraction?**

**Answer:** X-ray diffraction is a technique used to determine the atomic structure of crystals. X-rays are passed through a crystal, and the diffraction pattern produced by the crystal is analyzed to determine the arrangement of atoms.

**What is the difference between interference and diffraction?**

**Answer:** Interference occurs when waves from different sources interact with each other, while diffraction occurs when waves encounter an obstacle or aperture.

**What is the principle behind the operation of optical devices such as lenses and mirrors?**

**Answer:** Optical devices manipulate the behavior of light by using different combinations of lenses and mirrors to create interference or diffraction patterns.

**Can sound waves diffract around corners? Why or why not?**

**Answer:** Yes, sound waves can diffract around corners because their wavelength is much larger than that of light waves.

**Can light waves diffract around corners? Why or why not?**

**Answer:** Light waves cannot diffract around corners because their wavelength is much smaller than that of sound waves.



## **Lec 37 - The Particle Nature of Light**

**What is the particle nature of light?**

**Answer:** The particle nature of light refers to the idea that light consists of tiny packets of energy called photons.

**Who first proposed the idea of the particle nature of light?**

**Answer:** Albert Einstein first proposed the idea of the particle nature of light in 1905.

**What is the photoelectric effect?**

**Answer:** The photoelectric effect is a phenomenon in which electrons are emitted from a material when light of a certain frequency is shone on it.

**How does the photon theory explain the photoelectric effect?**

**Answer:** The photon theory explains the photoelectric effect by suggesting that photons transfer their energy to electrons in the material, allowing them to escape.

**What is the Compton effect?**

**Answer:** The Compton effect is an experiment that showed that X-rays scattered off a material have a longer wavelength than the incident radiation, which can be explained by the X-rays interacting with the electrons in the material as if they were particles.

**What is the wave-particle duality?**

**Answer:** The wave-particle duality refers to the idea that particles, such as photons, can exhibit both wave-like and particle-like behavior depending on the experiment.

**How does the wave-particle duality of light challenge our understanding of the nature of reality?**

**Answer:** The wave-particle duality challenges our understanding of the nature of reality by suggesting that particles can exist in multiple states simultaneously.

**What is the practical application of the particle nature of light in photovoltaic cells?**

**Answer:** The particle nature of light is used in photovoltaic cells to convert light energy into electrical energy.

**How do lasers work?**

**Answer:** Lasers work by creating a population inversion in a material, where more atoms are in an excited state than in the ground state. When these atoms decay to the ground state, they emit photons with the same frequency and phase, resulting in a coherent beam of light.

**Why is the discovery of the particle nature of light important?**

**Answer:** The discovery of the particle nature of light revolutionized our understanding of the fundamental nature of light and has practical applications in modern technology.

## **Lec 38 - Geometrical Optics**

### **What is the principle of rectilinear propagation?**

**Answer:** The principle of rectilinear propagation states that light travels in a straight line in a homogeneous medium.

### **What is the law of refraction?**

**Answer:** The law of refraction states that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant and is known as the refractive index of the medium.

### **What is the principle of reflection?**

**Answer:** The principle of reflection states that the angle of incidence is equal to the angle of reflection, and the reflected ray and the incident ray are on the same plane perpendicular to the reflecting surface.

### **What is the principle of least time?**

**Answer:** The principle of least time states that light travels between two points in such a way that the time taken is minimized.

### **What is lens imaging?**

**Answer:** Lens imaging is the process of forming images of objects by focusing the light rays that pass through lenses.

### **What is the difference between a virtual image and a real image?**

**Answer:** A virtual image is an image that is formed by the apparent intersection of light rays that appear to come from the image location, while a real image is an image that is formed by the actual intersection of light rays that come from the image location.

### **What are optical aberrations?**

**Answer:** Optical aberrations are deviations from ideal optical behavior, caused by factors such as lens imperfections, temperature changes, and atmospheric conditions.

### **What is spherical aberration?**

**Answer:** Spherical aberration occurs when light rays passing through the edges of a lens are refracted differently from those passing through the center, causing the image formed to be blurred and distorted.

**What is chromatic aberration?**

**Answer:** Chromatic aberration is caused by the different refractive indices of different wavelengths of light, which results in color fringes around the edges of an image.

**What is coma?**

**Answer:** Coma occurs when light rays entering a lens at an angle are not focused on the same point as those entering at the center of the lens, causing the image to be distorted.

## **Lec 39 - Heat – I**

### **What is thermal expansion?**

**Answer:** Thermal expansion refers to the expansion or contraction of materials due to changes in temperature.

### **How does thermal conductivity differ from thermal resistance?**

**Answer:** Thermal conductivity is the ability of a material to transfer heat, while thermal resistance is the measure of how well a material can resist heat transfer.

### **What is the difference between heat and temperature?**

**Answer:** Heat is the transfer of energy from a hotter object to a cooler object, while temperature is a measure of the average kinetic energy of the particles in a substance.

### **Define the term 'specific heat.'**

**Answer:** Specific heat is the amount of heat required to raise the temperature of one unit of mass of a substance by one degree Celsius or Kelvin.

### **What is the difference between a conductor and an insulator?**

**Answer:** A conductor is a material that allows heat to pass through it easily, while an insulator is a material that resists the flow of heat.

### **What is thermal radiation?**

**Answer:** Thermal radiation is the transfer of heat energy through electromagnetic waves, such as infrared radiation.

### **What is the first law of thermodynamics?**

**Answer:** The first law of thermodynamics states that energy cannot be created or destroyed, only transferred or transformed from one form to another.

### **What is the relationship between heat and work in thermodynamics?**

**Answer:** In thermodynamics, heat and work are both forms of energy and can be converted from one to the other.

**What is a heat engine?**

**Answer:** A heat engine is a device that converts thermal energy into mechanical energy.

**What is the difference between an adiabatic process and an isothermal process?**

**Answer:** In an adiabatic process, no heat is transferred into or out of the system, while in an isothermal process, the temperature of the system remains constant.

## Lec 40 - Heat – II

**What is thermal expansion? Give an example of a material that shows significant thermal expansion.**

**Answer:** Thermal expansion is the tendency of a substance to expand or contract in response to changes in temperature. An example of a material that shows significant thermal expansion is metal. Metals expand when heated and contract when cooled, which can cause problems in machinery and structures.

**What is thermal conductivity? Explain how it is related to heat transfer.**

**Answer:** Thermal conductivity is the ability of a material to conduct heat. It is related to heat transfer in that materials with higher thermal conductivity transfer heat more easily than materials with lower thermal conductivity. This is because materials with higher thermal conductivity allow heat to flow through them more easily.

**What is the difference between specific heat and heat capacity?**

**Answer:** Specific heat is the amount of heat required to raise the temperature of one gram of a substance by one degree Celsius. Heat capacity, on the other hand, is the amount of heat required to raise the temperature of an entire object by one degree Celsius. Heat capacity is therefore dependent on the mass of the object, while specific heat is not.

**What is convection? Give an example of convection in action.**

**Answer:** Convection is the transfer of heat through the movement of fluids. An example of convection in action is the heating of a room through a radiator. The warm air rises from the radiator and is replaced by cooler air, creating a cycle of hot and cold air that circulates through the room.

**What is the greenhouse effect? How does it relate to heat transfer?**

**Answer:** The greenhouse effect is the process by which certain gases in the Earth's atmosphere trap heat, causing the Earth's surface to become warmer. This is similar to how a greenhouse works, as it traps heat inside to keep plants warm. The greenhouse effect relates to heat transfer because it involves the transfer of heat from the Earth's surface to the atmosphere.

**What is the difference between a conductor and an insulator?**

**Answer:** A conductor is a material that easily conducts heat, while an insulator is a material that does not conduct heat well. This means that conductors allow heat to flow through them easily, while insulators resist the flow of heat.

**What is a thermocouple? How is it used to measure temperature?**

**Answer:** A thermocouple is a device that measures temperature by producing a voltage proportional to the temperature difference between two points. It consists of two wires made of different metals that are joined at one end. When the joined end is exposed to heat, it produces a voltage that can be measured to determine the temperature.

**What is the difference between conduction, convection, and radiation?**

**Answer:** Conduction is the transfer of heat through direct contact between two objects. Convection is the transfer of heat through the movement of fluids. Radiation is the transfer of heat through electromagnetic waves.

**What is the first law of thermodynamics?**

**Answer:** The first law of thermodynamics, also known as the law of conservation of energy, states that energy cannot be created or destroyed, only transferred or converted from one form to another.

**What is an adiabatic process?**

**Answer:** An adiabatic process is a process in which no heat is exchanged between the system and its surroundings. This means that the temperature of the system changes without any input or output of heat. An example of an adiabatic process is the compression or expansion of a gas in a closed container.



## **Lec 41 - Heat – III**

### **What is thermal equilibrium?**

**Ans:** Thermal equilibrium is a state where there is no net flow of heat between two systems in contact. The temperature of the two systems becomes equal at this point.

### **Define specific heat capacity.**

**Ans:** Specific heat capacity is the amount of heat energy required to raise the temperature of one unit mass of a substance by one degree Celsius.

### **What is the difference between a conductor and an insulator?**

**Ans:** A conductor is a material that allows the transfer of heat easily, while an insulator is a material that does not allow the transfer of heat easily.

### **What is the difference between conduction and convection?**

**Ans:** Conduction is the transfer of heat energy through a material due to the transfer of kinetic energy from one particle to another. Convection, on the other hand, is the transfer of heat energy due to the movement of fluids or gases.

### **What is the first law of thermodynamics?**

**Ans:** The first law of thermodynamics states that energy cannot be created or destroyed, only converted from one form to another.

### **How does the rate of heat transfer vary with distance?**

**Ans:** The rate of heat transfer decreases with distance. This is because the heat energy is dispersed over a larger area as it moves away from the source.

### **What is the difference between heat and temperature?**

**Ans:** Heat is a form of energy, while temperature is a measure of the average kinetic energy of the particles in a substance.

### **Define latent heat.**

**Ans:** Latent heat is the amount of heat energy required to change the state of a substance without changing its temperature.

**What is thermal expansion?**

**Ans:** Thermal expansion is the tendency of materials to expand when heated and contract when cooled.

**What is a thermocouple?**

**Ans:** A thermocouple is a device used to measure temperature by utilizing the voltage generated by the junction of two different metals at different temperatures.

## Lec 42 - Special Relativity – I

### What is the principle of relativity?

**Answer:** The principle of relativity states that the laws of physics are the same for all observers in uniform motion relative to one another.

### What is the difference between Galilean relativity and special relativity?

**Answer:** Galilean relativity is based on the principle of relativity, but it does not take into account the constant speed of light. Special relativity includes the constant speed of light as a fundamental aspect of the theory.

### What is time dilation?

**Answer:** Time dilation is the effect that occurs when the time interval between two events is perceived to be different by two observers who are moving relative to one another.

### How does time dilation arise in special relativity?

**Answer:** Time dilation arises from the fact that the speed of light is always constant, regardless of the motion of the observer. As a result, time appears to be slower for a moving observer than for a stationary observer.

### What is the twin paradox?

**Answer:** The twin paradox is a thought experiment that involves two identical twins, one of whom travels at high speed in space while the other stays on Earth. When the space-traveling twin returns, he or she will have aged less than the twin who stayed on Earth.

### What is length contraction?

**Answer:** Length contraction is the effect that occurs when the length of an object is perceived to be shorter in the direction of motion by an observer who is moving relative to the object.

### What is the Lorentz factor?

**Answer:** The Lorentz factor is a quantity that appears in special relativity and is defined as  $1/\sqrt{1-v^2/c^2}$ , where  $v$  is the velocity of an object and  $c$  is the speed of light.

### How does the concept of simultaneity change in special relativity?

**Answer:** In special relativity, the concept of simultaneity is relative to the observer's frame of reference. Two events that are simultaneous in one frame of reference may not be simultaneous in another frame of reference.

**What is the energy-momentum relationship in special relativity?**

**Answer:** The energy-momentum relationship in special relativity is given by the equation  $E^2 = (pc)^2 + (mc^2)^2$ , where  $E$  is the energy of a particle,  $p$  is its momentum,  $m$  is its mass, and  $c$  is the speed of light.

**What is the significance of the speed of light in special relativity?**

**Answer:** The speed of light is a fundamental constant in special relativity and plays a crucial role in determining the behavior of objects moving at high speeds. It is the ultimate speed limit in the universe, and nothing can travel faster than it.

## Lec 43 - Special Relativity – II

### What is the postulate of special relativity?

**Answer:** The postulate of special relativity states that the laws of physics are the same for all observers in uniform motion relative to each other.

### What is time dilation?

**Answer:** Time dilation is a phenomenon where time appears to run slower for an object in motion relative to an observer, as compared to an object at rest.

### What is length contraction?

**Answer:** Length contraction is a phenomenon where the length of an object in motion appears shorter to an observer as compared to an object at rest.

### What is the twin paradox in special relativity?

**Answer:** The twin paradox refers to a situation where one twin travels to a distant star at near-light speeds while the other twin remains on Earth. The traveling twin experiences time dilation and returns to Earth younger than the twin who stayed on Earth.

### What is the mass-energy equivalence?

**Answer:** The mass-energy equivalence, expressed by Einstein's famous equation  $E=mc^2$ , states that mass and energy are interchangeable and are two forms of the same thing.

### What is the Lorentz transformation?

**Answer:** The Lorentz transformation is a set of equations that describe how space and time coordinates of events appear to observers in relative motion with respect to each other.

### What is the concept of simultaneity in special relativity?

**Answer:** Simultaneity is relative in special relativity, meaning that two events that appear simultaneous to one observer may not appear simultaneous to another observer in relative motion.

### What is the meaning of the term "relativistic" in special relativity?

**Answer:** The term "relativistic" refers to the fact that the laws of physics in special relativity are relative to the observer's motion, rather than being absolute.

**How does special relativity explain the constancy of the speed of light?**

**Answer:** Special relativity explains the constancy of the speed of light by postulating that the speed of light is the same for all observers in uniform motion relative to each other, regardless of the motion of the light source or the observer.

**What is the role of the Lorentz factor in special relativity?**

**Answer:** The Lorentz factor, represented by the symbol  $\gamma$ , appears in many equations of special relativity and accounts for time dilation, length contraction, and the mass-energy equivalence. It is a measure of how "relativistic" an object's motion is, and approaches infinity as the object approaches the speed of light.

## Lec 44 - Matter as Waves

**What is the de Broglie wavelength of a particle of mass  $m$  and velocity  $v$ ?**

**Answer:** The de Broglie wavelength is given by  $\lambda = h/mv$ , where  $h$  is Planck's constant.

**What is the significance of the de Broglie wavelength?**

**Answer:** The de Broglie wavelength is significant because it shows that matter has wave-like properties, just like light. This wave-particle duality is a fundamental concept in quantum mechanics.

**What is the Heisenberg uncertainty principle?**

**Answer:** The Heisenberg uncertainty principle states that it is impossible to simultaneously determine the exact position and momentum of a particle. The more accurately we know one of these properties, the less accurately we can know the other.

**What is wave function collapse?**

**Answer:** Wave function collapse is the phenomenon where a quantum system that is in a superposition of states collapses into a definite state when it is measured or observed.

**What is the double-slit experiment?**

**Answer:** The double-slit experiment is a classic experiment in physics that demonstrates the wave-like nature of matter. In this experiment, a beam of particles, such as electrons, is directed at a screen with two slits. The resulting interference pattern on a detector behind the slits shows that the particles exhibit wave-like behavior.

**What is the Schrödinger equation?**

**Answer:** The Schrödinger equation is the fundamental equation of quantum mechanics that describes the time evolution of a quantum state. It is a differential equation that relates the wave function of a system to its energy.

**What is the wave function of a particle?**

**Answer:** The wave function of a particle is a mathematical function that describes the probability amplitude of finding the particle in a particular state or location.

**What is a probability density function?**

**Answer:** A probability density function is a mathematical function that describes the probability density of a particle being found in a particular region of space. It is related to the square of the wave function.

**What is quantum tunneling?**

**Answer:** Quantum tunneling is the phenomenon where a particle can pass through a barrier that it would not be able to pass through according to classical physics. This is due to the wave-like nature of matter, which allows it to "tunnel" through the barrier.

**What is an electron microscope?**

**Answer:** An electron microscope is a type of microscope that uses a beam of electrons instead of light to image samples. Since electrons have a much smaller wavelength than visible light, electron microscopes can achieve much higher resolution than optical microscopes.



## Lec 45 - Quantum Mechanics

### What is the uncertainty principle in quantum mechanics?

**Answer:** The uncertainty principle in quantum mechanics states that it is impossible to simultaneously determine certain pairs of physical properties, such as position and momentum, with arbitrary precision.

### What is a wave function in quantum mechanics?

**Answer:** A wave function in quantum mechanics is a mathematical function that describes the behavior of a quantum system. It is used to calculate the probability of finding a particle in a particular state.

### What is the difference between a classical and a quantum system?

**Answer:** A classical system is one that follows classical mechanics, which describes the behavior of macroscopic objects. A quantum system, on the other hand, follows quantum mechanics, which describes the behavior of microscopic objects such as atoms and subatomic particles.

### What is the Schrödinger equation?

**Answer:** The Schrödinger equation is a fundamental equation in quantum mechanics that describes the evolution of a wave function over time. It is used to predict the behavior of a quantum system.

### What is quantum entanglement?

**Answer:** Quantum entanglement is a phenomenon in which the properties of two or more particles become correlated in such a way that the state of one particle cannot be described independently of the other particles.

### What is a quantum state?

**Answer:** A quantum state is a mathematical description of the state of a quantum system. It includes information about the properties of the system, such as its energy, momentum, and spin.

### What is a quantum superposition?

**Answer:** A quantum superposition is a state in which a quantum system can exist in multiple states simultaneously. For example, an electron can be in a superposition of spin-up and spin-down states.

### What is a quantum measurement?

**Answer:** A quantum measurement is a process by which the properties of a quantum system are observed. When a quantum system is measured, its wave function collapses to a single state, and the properties of the system are determined with a certain probability.

### **What is quantum tunneling?**

**Answer:** Quantum tunneling is a quantum mechanical phenomenon in which a particle can pass through a potential barrier even if its energy is less than the height of the barrier. This is due to the wave-like nature of the particle.

### **What is the Heisenberg uncertainty principle?**

**Answer:** The Heisenberg uncertainty principle is a fundamental principle in quantum mechanics that states that the more precisely the position of a particle is known, the less precisely its momentum can be known, and vice versa. This principle sets a fundamental limit on the precision with which certain pairs of physical properties can be determined.

