Physics

What is the course code?
Phy 1214

What is the title of the course?
Physics Sessional

State the name of the experiments you have conducted

1. Determination of the refractive index of the material of a prism by a spectrometer
2. Determination of the frequency of a tuning fork by Melde's apparatus
3. Determination of the specific sugar solution by the means of polarimeter

Experiment Specific Question

Determination of the Value of Acceleration Due to Gravity (g) by Means of A Compound Pendulum

What is a compound pendulum?
A compound pendulum is a rigid body that oscillates freely about a horizontal axis that does not pass through its center of mass.

How does a compound pendulum differ from a simple pendulum?
In a simple pendulum, the mass is concentrated at a point, while in a compound pendulum, the mass is distributed throughout the body.

What is the principle of a compound pendulum?
Even though a compound pendulum is a rigid body with distributed mass, it's oscillatory motion is mathematically identical to that of a simple pendulum.

What factors affect the time period of a compound pendulum?

- Distribution of mass (Moment of inertia)
- Distance of center of mass from axis
- Acceleration due to gravity
- Mass of the pendulum

Determination of the Refractive Index of the Material of a Prism by a Spectrometer

How does light refract on a prism
When a ray of light enters the prism, it passes from air to glass (rarer medium to denser medium). By Snell's law it bends towards the normal.
The ray travel inside the prism. On leaving the prism, the light goes from glass to air (denser to rarer) medium. Again, by Snell's law, the light bends away from the normal.

What is interference?
Interference is a wave phenomenon that occurs when two or more waves of the same kind meet and overlap in space. The result is that the wave combine to form a new wave patter due to superposition.

Keyword: Crest (top part of the wave sin graph), Trough (bottom part)

What is the formula of interference?
For constructive interference(bright fringe):

$$\Delta x = n\lambda$$

For destructive interference(dark fringe):

$$\Delta x = (2n+1)\frac{\lambda}{2}$$

What is the angle of minimum deviation (δ_m)?
When light passes through a prism, the incident ray and emergent ray are not parallel, they are inclined. The angle between them is called the angle of deviation. Normally, as the angle of incidences changes, the deviation first decreases, reaches a minimum value, and then increase again. The least or minimum value is called the angle of minimum deviation.

What is the condition for minimum deviation
The light ray travels symmetrically inside the prism meaning the angle of incidence is equal to the angle of emergence.

What does refractive index of a prism depend on?

- Material of the prism
- Wavelength of the ray
- Medium

Relation between wavelength and refractive index

$$n \propto \frac{1}{\lambda}$$

How does a spectrometer helps in calculating the refractive index of a prism?
A spectrometer allows precise measurement of angles of light incidence and emergence on a prism. By using it we can determine the angle of the prism and the angle of minimum deviation, and we can calculate refractive index from it.

Write the formula of angle of prism

$$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$

What is a collimator?
A collimator is a device used in optical experiments to produce a narrow, parallel beam of light.

Determination of the Frequency of a Tuning Fork by Melde's Apparatus

What is resonance?
Resonance is when the natural frequency of the vibrating segment of the string is equal to the frequency of the fork.

What is stationary wave?
A stationary wave, also known as a standing wave, is a wave pattern that remains in a constant position. This phenomenon occurs when two identical waves travel in opposite direction and superimpose each other.

Node and antinode in a stationary wave
In a stationary wave, the point of no amplitude is called nodes and the point of maximum amplitude is called antinodes.

Write down the formula of determination of frequency
For transverse arrangement,

$$N = n = \frac{1}{\lambda}\sqrt{\frac{T}{M}}$$

For longitudinal arrangement,

$$N = 2n = \frac{2}{\lambda}\sqrt{\frac{T}{M}}$$

What is transverse arrangement?
In the transverse arrangement, the tuning fork vibrates perpendicular to the length of the string.

What is longitudinal arrangement?
In the longitudinal arrangement, the tuning fork vibrates parallel to the length of the string.

Determination of the Radius of Curvature of A Plano Convex Lens by Newton's Ring Method

What is the formula for radius of curvature?

$$R = \frac{D_{n+p}^2 - D_n^2}{4p\lambda}$$

How does Newton's ring form?
The plano convex lens is placed on a flag glass plate and a thin layer of air exists between them. Due to reflection and refraction of light in this layer, interference of light occurs, resulting in Newton's ring.

Why is the center dark?
At the point of contact, the air film thickness is zero. The path difference is half a wavelength because of the phase change of π which causes destructive interference, making the center dark.

Why is sodium light used in the experiment?
Sodium light is monochromatic. Using monochromatic light gives clear, sharp rings.

What happens if we use the while light instead of monochromatic light?
We get a series of colored centric rings (each color corresponding to different wavelength), but the fringes overlap and are not sharp, making measurement difficult.

What type of interference is produced in Newton's Rings?
Interference due to reflected light.

Determination of the Wavelength of Sodium Light by A Plan Diffraction Grating with the Help of A Spectrometer

What is a diffraction grating?
A diffraction grating is an optical element that has numerous small, equally spaced parallel slits or lines on its surface. When light falls on grating, it is diffracted in different direction, producing a diffraction pattern. From this pattern, the wavelength of the light can be determined.

What is diffraction?
Diffraction is the phenomenon by which a wave bends, spreads, or changes direction when it passes through a narrow slit, around an obstacle, or across an edge, instead of strictly moving in a straight line.

What is the principle of the experiment?
Based on diffraction and interference from many equally spaced slits (a grating). For maxima (bright lines) the grating equation holds

$$d \sin \theta = n\lambda$$

where d is grating spacing, θ is the diffraction angle, n is the order, and λ is the wavelength

What is grating constant / grating element / grating spacing?
The distance between consecutive slits is called grating constant. If a grating has N lines per mm, then $d = \frac{1}{N}$

What is the difference between diffraction and interference?
Interference is the superposition effect of waves (two or more coherent sources); diffraction refers to spreading and interference of a wave when it encounters obstacles or apertures. A grating uses diffraction from many slits to produce interference.

Determination of the Specific Rotation of Sugar Solution by Means of Polarimeter

What is meant by specific rotation?
Specific rotation is the angle of rotation produced by an optically active substances for a solution of 1 decimeter length and 1 gram per mL concentration of sugar.

What is an optically active substance?
A substance that can rotate the plan of polarization of polarized light when light passes through its solution or crystal.

What is a polarimeter?
A polarimeter is an instrument used to measure the angle of rotation of the plane of polarized light caused by an optically active substance.

What are the main parts of a polarimeter?

- Light source
- Polarizer (to produce plane polarized light)
- Sample tube (containing sugar solution)
- Analyzer (to detect and measure rotation)
- Scale / Vernier scale

What is the difference between polarizer and analyzer?
Polarizer: Produces plane-polarized light from unpolarized light
Analyzer: Detects and measure the rotation of that polarized light after passing through the optically active substance.

Why is water used as a reference in the experiment?
Pure water is optically inactive, thus it is used as a blank or reference to eliminate instrumental errors.

What is the unit of specific rotation
Degrees per decimeter per (g/ml)

Formula for specific rotation

$$\text{specific rotation} = \frac{10\theta}{lc}$$

What factors affect specific rotation

- Wavelength of light used
- Temperature
- Concentration of solution

What is the difference between dextrorotatory and laevorotatory substances?

- Dextrorotatory substances rotate the plane of polarized light to the right (clockwise)
- Laevorotatory substances rotate the plane of polarized light to the left (anticlockwise)

Why must the tube be filled carefully without air bubbles?
Air bubbles cause refraction and scattering, leading to incorrect rotation readings.

What is the difference between normal and half-shade polarimeter?

- Normal polarimeter: Uses a simple polarizer and analyzer
- Half-shade polarimeter: Uses a half-shade device for finer adjustments, giving more sensitive and accurate measurements

Measurement of e/m of an electron using an electron beam deflection tube

What is thermionic emission?
When a current is passed through the filament it becomes hot, and the electrons gain enough energy to escape the filament. This process is called thermionic emission.

What is Lorentz force law?

$$\overrightarrow{F} = q\left(\overrightarrow{E} + \overrightarrow{v} \times \overrightarrow{B}\right)$$

What is the condition to achieve circular path of electron?
The angle between velocity vector and magnetic field vector should be 90°

What does an electron beam tube consists of?

- Electron gun (cathode + anode)
- Fluorescent screen (to see the path of electrons)
- Deflecting coils (to produce magnetic field)
  Electrons emitted from the cathode are accelerated by voltage V and forma visible beam on the screen

What is the role of Helmholtz coils?
Helmholtz coils produce a uniform magnetic field in which the electron beam moves in a circular trajectory. The magnetic field is proportional to the current through the coils.

Why must the electron tube be evacuated?
To prevent electrons from colliding with air molecules, ensuring a clear path for measurement.

What happens if the magnetic field is not perpendicular to the electron beam?
The beam path will become helical instead of circular, making accurate measurement impossible.

Determination of Plank's Constant

What is photo-electric effect?
When electromagnetic radiations such as lights fall on a metallic surface, electrons are emitted from the surface. This phenomenon is known as photo-electric effect.

Explain photo-electric effect
Light acts as particle having energy of hv where h is the Planck's constant and v is the frequency of the particle. The particles of light, called photons or quanta collide with the metal surface and transfer energy to the electrons in the metal. The emitted electrons then use part of this energy to migrate to the surface of the metal and part of this energy to free themselves from the electrostatic attraction; the remainder goes into the kinetic energy of the electrons. This can be expressed mathematically as

$$hv = \Phi + K_{max}$$

What is the stopping potential?
The minimum reverse potential applied to stop the fastest photoelectrons from reaching the anode.

What is work function?
The minimum energy required to remove an electron from the surface of the metal is called the work function.

What is threshold frequency?
The minimum frequency of particle to generate the same energy as the work function.

Why must light be monochromatic?
To ensure single frequency, giving precise stopping potential readings.

Unit of Planck's Constant
Joule-second

EEE

Diode

What is a diode?
A diode is a two-terminal semiconductor device that allows current to flow in one direction only

What is the basic structure of a diode?
A diode is typically made of a p-n junction, which is a region of a semiconductor material where p-type and n-type materials meet.

How does a diode work?
When a diode is forward biased, the depletion region narrows, allowing current to flow. When a diode is reverse biased, the region widens, preventing current flow.

What is the depletion region
A region around the p-n junction devoid of free electrons and hole, forming a potential barrier.

Conduction band
The conduction band is the energy range where electrons are free to move through the material, contributing to electrical conduction

Valence band
The valence band is the energy range where electrons are bound to atoms. Electrons here cannot move freely unless they again enough energy to jump to the conduction band.

Forbidden region
The gap between conduction band and valence band is called the forbidden region

Fermi Level
The highest energy level that an electron can occupy at the absolute zero temperature is known as the Fermi level. In a diode, the conduction band of n-side is close to Fermi level and valence band of p-side is close to Fermi level.

What is the breakdown voltage?
The reverse voltage at which a diode starts conducting in reverse.

Types of diodes
PN junction diode, Zener diode, LED.

What is the Zener diode used for?
Voltage regulation and maintaining a constant voltage in circuits.

Why is there a depletion region in a diode?
Because electrons and holes diffuse and recombine, leaving fixed ions, forming a potential barrier.

Difference between an ideal diode and a practical diode

- Ideal diode: zero forward resistance, infinite reverse resistance, zero forward voltage drop
- Practical diode: finite forward voltage drop (0.7V for Si), small leaked current in reverse bias.

What is the reverse saturation current?
The tiny current that flows in reverse bias due to minority carriers.

Modes of diode

1. Forward Bias (Active Region):
   - Conditions: When the anode is positive relative to the cathode.
   - Behavior: The diode conducts current freely.
2. Reverse Bias (Cutoff Region):
   - Condition: When the anode is negative relative to the cathode.
   - Behavior: The diode blocks current flow
3. Breakdown (Saturation Region):
   - Conditions: When the reverse voltage exceeds the breakdown voltage
   - Behavior: The diode conducts heavily in the reverse direction

Application of diodes

- Rectification from AC to DC
- Voltage regulators and managing constant voltage level
- LEDs for lighting and display

Zener Diode

What is a Zener diode?
A special type of diode designed to operate in the reverse breakdown region without damage

What is the main application of a Zener diode?
Voltage regulation

Draw the symbol of Zener diode

How is Zener diode biased in voltage regulator circuits?
Reverse biased.

What is the difference between a PN junction diode and a Zener diode?

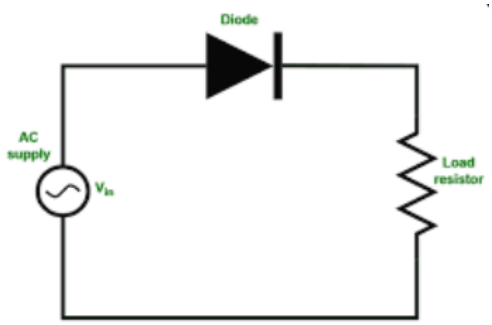
- PN junction: Used mainly in forward bias for rectification
- Zener: Used mainly in reverse bias for regulation

What is dynamic resistance in a Zener diode?
The small resistance offered by the diode in the breakdown region is called dynamic resistance.

Why is a Zener diode heavily doped?
To create a thin depletion region and achieve breakdown at a well defined low voltage.

Half-Wave Rectifier

Draw the circuit of Half-Wave Rectifier



What is a rectifier?
A device that converts AC into DC

What is half-wave rectifier?
A rectifier that allows only one half-cycle of AC to pass through, blocking the other half.

What happens during the positive half cycle of AC input?
The diode is forward biased, it conducts, and the output follows the input.

What happens during the negative half cycle of AC input?
The diode is reverse biased, it blocks, and the output is zero

What is the average(DC) values of output voltage?

$$V_{dc} = \frac{V_m}{\pi}$$

where, V_m is the peak input voltage.

What is the RMS values of the output voltage?

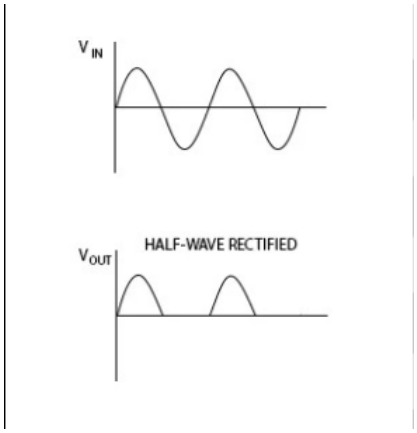
$$V_{rms} = \frac{V_m}{2}$$

What is the rectification efficiency of a half-wave rectifier?
About 40.6%

How do we improve half-wave rectifier?
By using filters like capacitors, which will reduce ripples and provide smoother DC output.

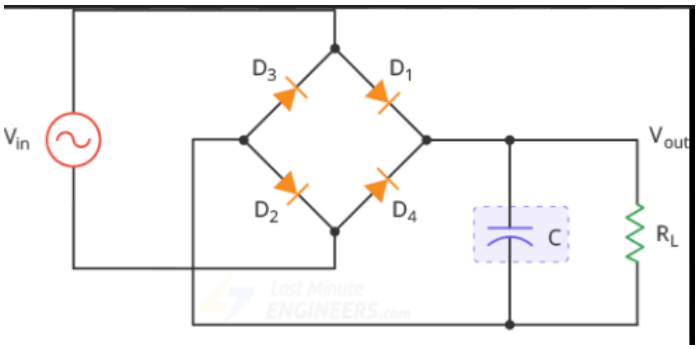
What is ripple?
Ripple is the undesired AC component present in the output of a rectifier along with the DC voltage.

Draw the output waveform of a HWR



Full-Wave Rectifier

Draw the circuit diagram of FWBR



What is a FWR
A rectifier that converts the entire AC waveform (both positive and negative half cycles) into DC.

How many diodes are required in a FWR?

- 2 diodes in center-tap configuration
- 4 diodes in bridge configuration

What is the average (DC) output voltage of a FWR?

$$V_{dc} = \frac{2V_m}{\pi}$$

What is the RMS output voltage of a FWR?

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

What is the efficiency of a FWR?
81.2%

Clipper Circuit

What is a clipper circuit?
A circuit that removes or clips off a portion of the input waveform without distorting the remaining part.

What components are used in a clipper?
Diodes, resistors, and sometimes DC sources.

Types of clippers

- Series clipper (diode in series with load)
- Shunt clipper (diode in parallel with load)

What is a biased clipper?
A clipper that uses an additional DC voltage source to shift the clipping level above or below zero.

What is the difference between a clipper and a clamper?

- Clipper: Removes part of the waveform
- Clamper: Shifts the entire waveform up or down

Application of clipper

- Waveform shaping: To create specific waveforms or modify existing waveforms.
- Signal protection: To protect sensitive components from excessive voltage
- Audio amplifiers
- Power supplies: To limit the output voltage of a power supply

Clamper Circuit

What is a clamper circuit?
A circuit that shifts the entire input signal up or down to a difference DC level without changing its shape

What are the basic components of a clamper?
Diode, capacitor and resistor.

Transistor

What is a transistor?
A transistor is a three-terminal semiconductor device used to amplify or switch electronic signals.

What are the different type of transistor?

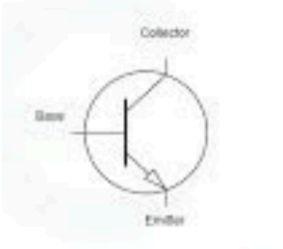
- Bipolar Junction Transistor (BJT): Uses both electrons and holes as charge carriers
- Field-Effect Transistor (FET): Uses only one type of charge carrier (either electrons or holes).

Bipolar Junction Transistor

What is a BJT
A three-terminal semiconductor device that uses both electrons and holes for conduction

What are the types of BJT?
NPN and PNP transistor

Draw an NPN BJT diagram



Why is it called "bipolar"?
Because current conduction involves both majority and minority charge carriers.

What are the terminals of a BJT?
Emitter, Base and Collector

How does a BJT work?
A small input current at the base controls a larger current flowing between collector and emitter.

What are the modes of operation of a BJT?

- Active mode (amplification)
- Cutoff mode (OFF)
- Saturation mode (ON, like a switch)
- Reverse-active mode

What are the applications of BJTs
Amplifiers, switches, oscillators, logic circuits

Cutoff Region of a BJT

- Conditions: The BE junction is reverse biased, and the BC junction is also reverse biased
- Behavior: The transistor acts as an open switch, no current flows through the collector-emitter junction

Active Region a BJT

- Conditions: The BE junction is forward biased, and the BC junction is reverse biased.
- Behavior: The transistor amplifies the input signal. The collector current is proportional to the base current.

Saturation Region of a BJT

- Conditions: The BE junction is forward biased, and the BC junctions is also forward biased.
- Behavior: The transistor acts as a closed switch, and the collector current reached its maximum value.

Field-Effect Transistors (FET)

What is a Field-Effect Transistor (FET)?
A transistor that controls current using an electric field and is voltage controlled rather than current-controlled.

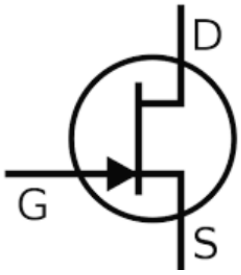
What are the terminals of an FET?
Gate, Drain, Source

What are the main types of FETs?

- Junction FET (JFET)
- Metal-Oxide-Semiconductor FET (MOSFET)
  Both can be the type of N-channel or P-channel

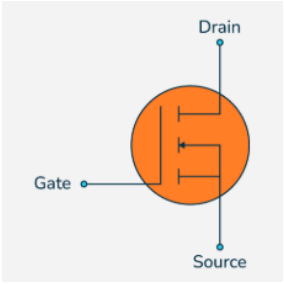
Why is FET called a unipolar device?
Because current conduction is due to only one type of carrier (electrons in n-channel, holes in p-channel)

Draw the symbol of JFET (N-channel)



How does a JFET work?
The gate-source voltage (V_{GS}) controls the drain-source current (I_D) by changing the channel width.

Draw the symbol of MOSFET



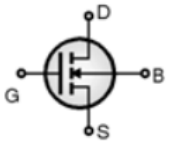
What is pinch-off in a JFET?
The channel become completely constricted at a certain V_{DS}, but current saturates and does not increase with further V_{DS}.

What is the cutoff voltage?
The gate-source voltage at which the drain current becomes zero.

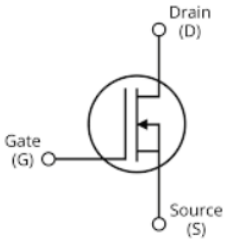
What are the types of MOSFET based on gate operation

- Enhancement MOSFET
  - Normally OFF at $V_{GS} = 0$
  - Requires a gate-source voltage to create a conducting channel
- Depletion MOSFET
  - Normally ON at $V_{GS} = 0$
  - Applying gate voltage opposite to channel type reduces or depletes current

Draw the symbol of Enhancement MOSFET



Draw the symbol of Depletion MOSFET



Cutoff region of FET

- Conditions: The gate-source voltage is below the threshold voltage
- Behavior: The channel between the source and drain is closed, and no current flows.

Ohmic region of FET

- Conditions: The gate-source voltage is slightly above the threshold voltage
- Behavior: The FET acts as a resistor, and the drain current is proportional to the drain-source voltage

Active region of FET

- Conditions: The gate-source voltage is well above the threshold voltage
- Behavior: The FET amplifies the input signal, and the drain current is controlled by the gate voltage

Application of FET
Amplifiers, switching circuits.

Operational Amplifiers (op-amp)

What is an Op-Amp?
A high-gain electronic voltage amplifier with differential input and usually a single-ended output

Characteristics of an idea Op-Amp

- Infinite open-loop gain
- Infinite input impedance
- Zero output resistance
- Infinite slew rate
- Infinite bandwidth
- Zero offset voltage

What is the difference between inverting and non-inverting input?

- Inverting: Output is 180° out of phase with input
- Non-inverting: Output is in phase with input

Applications of Op-Amps
Amplifiers, filters, integrators, differentiators, comparators

Output for a differentiator

- Sine wave to cosine wave
- Triangular wave to square wave
- square wave to positive and negative spikes

Output for integrator

- Sine wave to cosine wave
- Triangular wave to parabolic wave
- Square wave to triangular wave

Filter

Dissect the word "First-Order Active Low-Pass Butterworth Filter

- First-Order: Indicates filters consists of RC components and roll-off is 20 dB/decade
- Active: meaning filter uses devices such an Op-Amp
- Low-Pass: Types of filter that allows low-frequency signals and attenuates high-frequency signals
- Butterworth: refers to flat magnitude response in the passband.

Data Structure

What are the types of data structures?

- Primitive Data Structures: integers, floats, characters
- Non-Primitive Data Structures
  - Linear Data Structures: Arrays, Linked Lists, Stacks, Queues
  - Non-Linear Data Structures: Trees, Graphs, Hash Tables

Object Oriented Programming

What is Object Oriented Programming(OOP)?
Object-Oriented Programming (OOP) is a programming paradigm based on the concept of "objects", which can contain data (attributes) and methods (functions). OOP enables concepts such as inheritance, encapsulation, polymorphism, and abstraction.

What is a class in OOP?
A class is a blueprint or template for creating objects. It defines properties (attributes) and behaviors (methods) that the created objects will have.

What is an object in OOP?
An object is an instance of a class. It is a concrete entity that has the attributes and methods defined by the class.

What are the four main principles of OOP?

1. Encapsulation: Building of data (attributes) and methods that operate on the data within a single unit or class.
2. Abstraction: Hiding the internal implementation details and showing only the functionality to the user.
3. Inheritance: Mechanism by which a class can inherit properties and methods from another class
4. Polymorphism: Ability to take many forms, allowing objects to be treated as instances of their parent class, often achieved through method overriding or overloading.

What is encapsulation?
Encapsulation is the principle of bundling data (attributes) and methods that operate on that data into a single unit or class. It also restricts access to the internal details of the class and provided controlled access via public methods. For example, private data members can only be accessed or modified through getter and setter methods.

What is abstraction?
Abstraction is the concept of hiding the complexity of a system and only exposing the essential details. It simplifies the interaction with objects by providing a clear interface while keeping implementation details hidden. Abstract classes and interfaces are commonly used to implement abstraction in OOP.

What is inheritance in OOP?
Inheritance allows one class (the child class) to inherit properties and behaviors (methods) from another class (the parent class). This promotes code reuse and establishes relationship between classes.

What is polymorphism?
Polymorphism refers to the ability of an object to take on many forms. In OOP, polymorphism is mainly implemented through method overloading (same method name, different parameters) and method overriding (child class redefines a parent class's method)

What is method overloading?
Method overloading is a form of polymorphism where multiple methods in the same class share the same name but have different parameter lists (type, number, or both). This allows the same method to perform different actions based on the arguments passed to it.

What is method overriding?
Method overriding occurs when a subclass provides its own implementation of a method that is already defined in its parent class. The

method in the subclass must have the same name, return type, and parameters as the one in the parent class, but the implementation can differ.

What is a constructor in OOP?
A constructor is a special method in a class that is automatically called when an object of that class is created. It is used to initialize the object's attributes. In most OOP languages, constructors have the same name as the class and do not return a value.

What is a destructor in OOP?
A destructor is a method that is automatically called when an object is destroyed or goes out of scope. It is used to free up resources that the object may have acquired during its lifetime.

What is an abstract class?
An abstract class is a class that cannot be instantiated directly and is designed to be subclassed. It may contain abstract methods (methods without implementation) that must be implemented by any derived class. Abstract classes provide a way to define a common interface for subclasses

What is an interface in OOP?
An interface is a contract that specified a set of methods that a class must implement. Unlike abstract classes, interfaces do not provide any implementation details; they only define the method signatures. A class that implements an interface agrees to provide concrete implementations of all the methods in the interface

What is multiple inheritance?
Multiple inheritance occurs when a class inherits from more than one parent class. While not supported directly in all languages, it can be achieved through interfaces in such languages.

What is `this` keyword in OOP?
The `this` keyword is a reference to the current instances of the class. It is used within a class to refer to the calling object's attributes and methods, especially in cases where parameter names might clash with attribute names.

What is difference between a class and an object?

- Class: A blueprint or template for creating objects. It defines attributes and methods that objects will have.
- Object: An instance of a class, which contains the actual data and methods defined by the class

What is static binding and dynamic binding in OOP?

- Static Binding: Occurs at compile time and is associated with method overloading. The method call is resolved by the compiler based on the method signature.
- Dynamic Binding: Occurs at runtime and is associated with method overriding. The method call is resolved at runtime based on the object type, not the reference type.

What are getters and setter in OOP?
Getters are method used to retrieve or access the values of an object's attribute, while setter are methods used to set or update the value of an object's attribute. They are used to implement encapsulation.

What is the significance of the `super` keyword in OOP?
The `super` keyword is used in a subclass to refer to its parent class. It can be used to call the parent class's methods or constructors and is particularly useful when the child class overrides methods but needs to access the parent class's implementation.

What are the types of inheritance in OOP?

- Single inheritance: A subclass inherits from one superclass
- Multiple inheritance: A subclass inherits from more than one superclass
- Multilevel inheritance: A class inherits from another class, which in turn inherits from another class
- Hierarchical inheritance: Multiple subclasses inherit from a single superclass.
- Hybrid inheritance: A combination of two or more types of inheritance, such as multiple and multilevel.

What are the benefits of inheritance?

- Code reusability
- Modularity
- Extensibility
- Maintainability

What is the role of access modifiers in inheritance?

- Private members: Not accessible outside the class, including subclasses.
- Protected members: Accessible within the same package and by subclasses
- Public members: Accessible from inside and outside of the class

What is the role of the `final` keyword in inheritance?
If a class is marked as `final`, it cannot be extended or inherited by any other class. If a method is marked as `final`, it cannot be overridden by subclasses.

What are two types of polymorphism?

- Compile-time polymorphism: Achieved through method overloading or operator overloading. The method to be called is determined at compile time based on the method signature.
- Runtime polymorphism: Achieved through method overriding. The method to be called is determined at runtime based on the object's actual type, not the reference type.

What is the role of the `virtual` and `override` keywords in polymorphism?
the `virtual` keyword is used in a base class method to indicated tat it can be overridden in the derived classes. The `override` keyword is used in the derived class to indicate that a method is overriding a base class method.

What is a pure virtual function?
A pure virtual function declared in a base class that has no implementation and is specified by assigning `0` in its declaration. It indicates that derived classes must provide an implementation for this function.

What is aggregation in OOP?
Aggregation is a type of associate that represent a relationship between two classes, where one class contains a reference to another class. It's a weaker form of relation, meaning the contained object can exist independently of the container class. If the container object is destroyed, the contained object does not necessarily get destroyed.

What is composition in OOP?
Composition is a design principles that models a strong relationship between two classes, where the lifetime of the contained object depends on the lifetime of the container. If the container object gets destroyed, the contained object also get destroyed at the same time.

What is friend function in OOP?
A friend function is a special function that is not a member of a class but has the right to access private and protected members of that class. It helps when to classes need to work closely together

What is a static data member?
Static data member is a data member of a class which belongs to the class itself, not to any object.

What is static member functions
Static member functions or static function is a type of function that can be called without creating an object.