SOP of New Experiments Physics

1. Observing sky using Astronomical Telescope.

- Align the finder scope: During the day, point the telescope at a nearby object, such as a tree, chimney, or streetlight. Center the object in the field of view, then adjust the finder scope so the cross-hair or red dot is centered on the object.
- Focus the telescope: Point the telescope at a bright object and turn the focusing knobs until the object is in focus.
- Find and identify celestial objects: Use the lowest powered eyepiece to find and identify the object.
- Zoom in: Switch to a higher powered eyepiece with a lower focal length to zoom in.
- Adjust the telescope: Loosen the lock for the Dec and set its value to the object's coordinates. Then, tighten the lock again. To set the R.A., disengage the motor, loosen the R.A. setting circle screw, and move the telescope until the R.A. pointer points to the new value.
- Center the object: Use the fine adjustment knobs to center the object in the field of view.
- Re-engage the drive motor: Re-engage the drive motor.

2. To Study Hall Effect and measurement of Hall voltage.

- Ensure the apparatus is set up correctly. The Hall probe should be securely placed within the electromagnet. The sample under investigation should be mounted properly so that it can be subjected to both an electric current and a perpendicular magnetic field.
- Calibrate the Gauss meter to accurately measure the magnetic field strength.
- Calibrate the voltmeter and ammeter if necessary.
- Connect the sample to the power supply and ensure that a current flows through the sample along one axis (say, the x-axis).
- Measure and record the value of the current passing through the sample using an
- Switch on the electromagnet and apply a magnetic field perpendicular to the direction of the current (in the z-axis if the current is in the x-axis).
- Measure the strength of the magnetic field using the Gauss meter.
- Use the voltmeter to measure the Hall voltage across the width of the sample (along the y-axis).

- Record the Hall voltage for different values of current and magnetic field strengths.

3. Preparation of thin film by using CILAR method.

Substrate Preparation:

- **Cleaning:** Clean the substrates thoroughly to ensure good film adhesion. Use the following steps:
    1. **Sonicate** the substrate in acetone for 10 minutes to remove any organic contaminants.
    2. Rinse with ethanol, and then sonicate for another 10 minutes in ethanol.
    3. **Rinse with deionized water** and dry using nitrogen gas or by placing on a hot plate.
    4. Optionally, treat the surface with oxygen plasma for enhanced surface cleanliness and reactivity.

Preparation of Precursor Solution:

- Prepare a solution containing the desired metal or organic precursor for the thin film.
- Adjust the concentration of the solution depending on the desired film thickness and deposition rate.
- Add surfactants or interfacial agents as needed to promote uniform film formation.

Interface Layer Formation (if applicable):

- **Optional Step**: A molecular interfacial layer may be deposited on the substrate to enhance the control of the reaction at the interface.
- This can be achieved by dipping the substrate into a solution containing surfactants or interfacial agents for a set time, then rinsing with deionized water.

Chemical Deposition (CILAR Process):

- Submerge the cleaned substrate into the precursor solution.
- The substrate can be oriented vertically or horizontally in the solution depending on the reactor setup.
- Allow the reaction to proceed at a controlled temperature and pH, depending on the chemical system used.
    - **Temperature**: Room temperature or elevated (e.g., 60-90°C) based on the reaction kinetics.
    - **Time**: Varies from a few minutes to several hours depending on film thickness.

- During deposition, the interfacial layer (if present) promotes uniform film formation at the solid-liquid interface.

Film Growth and Monitoring:

- Monitor the growth of the thin film using in-situ techniques if available (e.g., spectroscopic ellipsometry).
- Alternatively, after a set period, remove the substrate and check for film quality and uniformity.

Post-Deposition Washing:

- After the deposition process, carefully remove the substrate from the precursor solution.
- Rinse the substrate with deionized water or the appropriate solvent to remove unreacted chemicals.
- Dry the substrate by nitrogen blow or place on a hot plate.

Post-Treatment (Optional):

- **Annealing:** Place the deposited film in an oven or furnace to anneal the film, which can improve the crystallinity, mechanical properties, or electrical properties.
    - Typical annealing temperatures: 100°C to 500°C depending on the material system.
    - Annealing time: 30 minutes to 2 hours.
- **UV Treatment**: For organic films, UV light can be used to enhance cross-linking or degradation of unwanted organic residues.

4. To study optical activity of different solutions.

Objective: To determine the optical activity (or specific rotation) of various optically active solutions using a polarimeter. Optical activity is a property of chiral molecules that rotate the plane of polarized light. The degree of rotation can help determine concentration, purity, or molecular identity in certain compounds.

Procedure:

Calibration of the Polarimeter:

- Turn on the polarimeter and allow it to warm up (for light sources such as sodium lamps, this may take 5-10 minutes).
- **Zero the Instrument**: Use distilled water or the pure solvent as a blank sample to calibrate the instrument to 0° rotation.
- Follow the manufacturer’s instructions for zeroing the instrument, and ensure the light beam is aligned properly.

Preparation of Solutions:

- **Concentration:** Prepare different concentrations of the optically active substance in the appropriate solvent using volumetric flasks. Common concentrations might range from 1% to 10% weight/volume (w/v) depending on the sensitivity of the substance.
- Ensure solutions are homogeneously mixed.

Filling the Polarimeter Tube:

- Clean the polarimeter tube thoroughly before each measurement using ethanol or isopropanol and dry it completely.
- Use a calibrated pipette to fill the polarimeter tube with the solution to be tested, ensuring there are no bubbles inside the tube as these can interfere with measurements.
- Cap the tube tightly, and if necessary, ensure the ends are clean and clear.

Measurement:

- Place the filled polarimeter tube in the polarimeter.
- Align the sample tube correctly based on the instrument's design (e.g., parallel to the light beam and polarizer).
- **Record the Rotation Angle**:
    - For manual polarimeters, rotate the analyzer until you reach the darkest or brightest point, or until you observe the sharpest contrast.
    - For digital polarimeters, the instrument will automatically provide the angle of rotation.
- Record the observed optical rotation angle (α) for each concentration of the solution.

Measurement at Different Temperatures (if applicable):

- The optical rotation of a solution can change with temperature. If temperature variation is a concern, measure the optical rotation at different temperatures (e.g., 20°C, 25°C, 30°C).
- Maintain and record the temperature using a thermometer.

Calculate the Specific Rotation [α]:

- The specific rotation of a compound is calculated using the formula:

[α]=αobsl·c[\alpha] = \frac{\alpha_{\text{obs}}}{l \cdot c}[α]=l·cαobs

Where:

- αobs\alpha_{\text{obs}}αobs is the observed rotation in degrees.
- lll is the path length of the polarimeter tube in **dm** (1 dm = 10 cm).
- ccc is the concentration of the solution in g/mL or g/100 mL.
- For multiple concentrations, plot optical rotation (α) against concentration to observe the trend and ensure consistency.

5. Measuring the Electrical Properties of Thin Films

Objective: To measure the electrical properties of thin films, such as resistivity, conductivity, and carrier mobility. These properties are critical for evaluating thin films in electronic, optoelectronic, and sensor applications.

Procedure:

Sample Preparation:

- Ensure the thin film sample is properly cleaned and dried. Dust or contaminants can affect electrical contacts and measurements.
- Apply conductive contacts (such as gold or silver) at specific points on the thin film where electrical probes will be connected.
    - **Methods for Applying Contacts:**
        - Thermal evaporation or sputtering (for clean, well-defined contacts).
        - Conductive paint or paste (for simpler applications).

Measurement of Sheet Resistance Using Four-Point Probe Method:

1. **Setup:**
    - Place the sample on the four-point probe stage, ensuring proper alignment.
    - Lower the four tungsten or gold-coated probes onto the surface of the thin film.
2. **Measurement:**
    - Pass a current (I) through the outer two probes and measure the voltage (V) across the inner two probes.
    - Use the measured voltage and current to calculate the sheet resistance (RsR_sRs) using the formula:

      Rs=VI·πln(2)R_s = \frac{V}{I} \cdot \frac{\pi}{\ln(2)}Rs=IV·ln(2)π

    - **Note**: For films with non-ideal shapes (non-square), apply correction factors.
3. **Calculation of Resistivity:**
    - Once the sheet resistance RsR_sRs is determined, the resistivity ρ\rhoρ of the film can be calculated if the film thickness ttt is known:

      ρ=Rs·t\rho = R_s \cdot tρ=Rs·t

      Where:

        - RsR_sRs is the sheet resistance in ohms per square (Ω/□).

- ttt is the thickness of the thin film in cm.

I-V Characterization Using Two-Point Probe Method:

1. **Setup:**
   - Connect two micromanipulator probes or contacts on opposite ends of the thin film (typically on pre-deposited conductive contacts).
   - Connect the probes to the source measure unit (SMU) or a digital multimeter.
2. **Measurement:**
   - Sweep a voltage across the thin film while measuring the resulting current, or vice versa, depending on the desired analysis.
   - Plot the I-V curve to analyze the electrical behavior of the thin film (e.g., ohmic, diode-like, etc.).
3. **Resistance Calculation:**
   - For an ohmic material (linear I-V relationship), calculate the resistance RRR using Ohm's law:

     R=VIR = \frac{V}{I}R=IV

   - The slope of the linear portion of the I-V curve will give the resistance. For non-ohmic materials, more advanced modeling may be required to extract electrical parameters.

6. Study of Mounting and Focusing telescope on astronomical objects

Objective: To safely mount and properly align a telescope for observing astronomical objects such as stars, planets, and deep-sky objects. The goal is to achieve a stable, focused view of these objects for visual observation or astrophotography

Procedure:

Mount and Tripod Setup:

1. **Level the Tripod**:
   - Set up the tripod on a stable, flat surface.
   - Use a bubble level to ensure the tripod is perfectly level, which is especially important for equatorial mounts.
2. **Attach the Mount**:
   - Securely attach the telescope mount to the tripod.
   - For **Alt-Azimuth Mounts**, ensure the mount is level.
   - For **Equatorial Mounts**, align the mount's polar axis roughly toward the North Celestial Pole (in the Northern Hemisphere, this is near Polaris, the North Star).

3. **Secure the Telescope to the Mount**:
   - Attach the telescope tube to the mount using the dovetail bar or mounting rings.
   - Ensure that the telescope is balanced on the mount to prevent strain on the gears and motors. For this:
     - Move the telescope in the horizontal and vertical axes and adjust the balance if necessary.

Align the Mount (Equatorial Mounts Only):

1. **Rough Polar Alignment**:
   - Point the mount's polar axis toward Polaris.
   - For fine polar alignment, use a polar alignment scope (if available) and adjust the altitude and azimuth of the mount.
2. **Balance the Telescope**:
   - With the mount clutch loosened, balance the telescope by adjusting the position of counterweights and the telescope tube until it stays level without tipping in any direction.

Insert the Eyepiece and Finderscope:

1. **Eyepiece**:
   - Start with a **low-power eyepiece** (e.g., 25mm) to give a wide field of view. This makes it easier to locate objects.
2. **Finderscope or Red Dot Finder**:
   - Attach and align the finderscope to match the telescope's field of view. This alignment can be done by focusing the telescope on a distant object during the day (e.g., a distant building or tree), centering it in the main telescope, and then aligning the finderscope so it points at the same object.

Focusing the Telescope on Astronomical Objects:

1. **Point the Telescope at a Bright Object**:
   - For initial alignment, point the telescope toward a bright object, like the Moon or a planet such as Jupiter or Saturn.
   - Use the **finderscope** to center the object in the field of view.
2. **Adjust the Focus**:
   - Look through the eyepiece and turn the focus knob until the object comes into sharp focus. It may take some trial and error to get it perfect.
   - If the image is blurry or faint, check if the eyepiece is securely inserted and the finderscope is properly aligned.
3. **Center the Object**:
   - Once the object is focused, use the slow-motion controls or manually move the telescope (depending on the mount) to center the object in the eyepiece's field of view.

Tracking Objects (Equatorial Mounts or Motorized Alt-Azimuth Mounts):

1. **Equatorial Mount**:
   - Once polar aligned, the equatorial mount allows you to track celestial objects by adjusting only one axis (the right ascension axis). This will compensate for Earth's rotation, keeping the object in the eyepiece for a longer time.
2. **Motorized Mount**:
   - For motorized mounts, turn on the tracking function. The mount will automatically adjust to keep the object centered.

Focusing on Different Astronomical Objects:

1. Focusing on Planets:

- **Start with a low-power eyepiece** (25mm or 32mm) to locate the planet.
- Once the planet is centered, switch to a **higher-power eyepiece** (e.g., 10mm) for a closer view.
- Fine-tune the focus using the focus knob until the planet appears sharp.
- For planets like Jupiter or Saturn, increasing magnification (using a 5mm or 6mm eyepiece) can reveal cloud bands, moons, or rings.

2. Focusing on the Moon:

- The Moon is large and bright, so a low-power eyepiece will show large sections of it.
- Use a **higher magnification** to zoom in on craters or specific features.
- Avoid over-magnifying as the brightness of the Moon can cause glare. A **Moon filter** can reduce brightness and improve contrast.

3. Focusing on Stars:

- Stars are point sources of light, so they should appear as sharp, tiny points when focused properly.
- If the star appears bloated or fuzzy, adjust the focus until it becomes a small, sharp point.

4. Focusing on Deep-Sky Objects (Galaxies, Nebulae, Star Clusters):

- Use a low-power eyepiece to locate the faint object, as deep-sky objects are often dim and spread out.
- Once located, fine-tune the focus and avoid using too much magnification, as this can make the object appear fainter.

7. <u>To study Magnetic Properties of material.</u>

Objective: To measure and analyze the magnetic properties of materials, such as magnetization, susceptibility, coercivity, and remanence, using various experimental techniques. Understanding these properties is essential in material science, physics, and engineering for applications in magnetic storage, sensors, and electronic devices

Procedure:

1. Sample Preparation:

1. **Material Selection**:
    - Select the material sample based on the magnetic property you wish to study (e.g., ferromagnetic materials for coercivity, paramagnetic materials for susceptibility, etc.).
    - The sample should be uniform in shape (typically a thin film, pellet, or bulk piece) and free from impurities or defects that could affect the measurement.
2. **Sample Mounting**:
    - Mount the sample securely in the holder provided by the magnetometer (e.g., in VSM or SQUID).
    - Ensure the sample is centered and aligned properly to avoid erroneous readings.
3. **Sample Weight and Dimensions**:
    - Record the sample's weight, dimensions, and volume, as these are necessary for normalizing magnetization values (e.g., converting from magnetic moment to magnetization in A/m or emu/cm^3).

2. Magnetic Field Setup:

1. **Generate Magnetic Field**:
    - Turn on the electromagnet, which will produce a magnetic field.
    - Set the desired range of magnetic field strength, typically starting from zero to a maximum value (e.g., ±2 Tesla, depending on the instrument's capability).
2. **Zero the Instrument**:
    - For instruments like VSM or SQUID, zero the system to account for any background noise or magnetic field interference before inserting the sample.
    - Calibrate the instrument if needed using a standard sample with known magnetic properties (e.g., a nickel sphere or a calibration magnet).

3. Measurement of Magnetic Properties:

A. Hysteresis Loop Measurement (Ferromagnetic and Ferrimagnetic Materials):

1. **Hysteresis Loop**:
    - Slowly sweep the magnetic field from negative to positive (e.g., -2T to +2T) while measuring the magnetization (MMM) at each point.
    - Plot the hysteresis loop, which shows the relationship between magnetization (MMM) and applied magnetic field (HHH).
2. **Key Parameters from the Hysteresis Loop**:
    - **Saturation Magnetization (MsM_sMs)**: The maximum magnetization achieved when the material is fully magnetized.
    - **Coercivity (HcH_cHc)**: The magnetic field required to reduce the magnetization to zero after the material has been saturated.
    - **Remanence (MrM_rMr)**: The residual magnetization left in the material when the applied magnetic field is reduced to zero.
    - **Area of the Hysteresis Loop**: Represents the energy loss due to magnetic hysteresis, significant in soft/hard magnetic materials.

B. Magnetic Susceptibility Measurement (Paramagnetic and Diamagnetic Materials):

1. **Susceptibility Measurement**:
    - Place the sample in a weak magnetic field and measure the magnetization induced in the sample.
    - The magnetic susceptibility (χ\chiχ) is defined as:

    χ=MH\chi = \frac{M}{H}χ=HM

    Where:

        - MMM is the induced magnetization.
        - HHH is the applied magnetic field.
2. **Temperature-Dependent Susceptibility**:
    - If studying temperature-dependent magnetic properties (e.g., Curie-Weiss behavior in paramagnetic materials), measure the susceptibility at different temperatures.
    - Use the Curie-Weiss law to analyze the data:

    χ(T)=CT−θ\chi(T) = \frac{C}{T - \theta}χ(T)=T−θC

    Where:

        - CCC is the Curie constant.
        - TTT is the temperature.
        - θ\thetaθ is the Curie-Weiss temperature.
3. **Identify Type of Material**:
    - **Diamagnetic materials** will have a small, negative susceptibility.
    - **Paramagnetic materials** will have a small, positive susceptibility.
    - **Ferromagnetic materials** will have a large, positive susceptibility.

8. Preparation of thin film by using Spin Coating method.

Objective: To prepare uniform thin films of materials (e.g., polymers, metal oxides, semiconductors) on a substrate using the spin coating technique. The process involves depositing a liquid solution on a substrate, which is then spread evenly by spinning at high speeds.

Substrate Preparation

- Clean the substrate (e.g., glass, silicon wafer) thoroughly to remove any impurities that could affect the uniformity of the thin film.
- Common cleaning steps:

- Rinse the substrate with deionized (DI) water.
- Clean with organic solvents like **acetone** and **isopropanol** to remove organic residues.
- Optionally, use **piranha solution** (a mixture of sulfuric acid and hydrogen peroxide) to clean substrates used in semiconductor processes. Be cautious when handling this solution.

- After cleaning, dry the substrate using a **nitrogen gun** or air drying.
- Ensure the substrate is free from dust or any contaminants before proceeding.

Preparation of the Coating Solution:

1. **Prepare the Solution**:
   - Dissolve the material (e.g., polymer or metal oxide precursor) in a suitable solvent at the desired concentration.
   - Concentration and viscosity of the solution play a significant role in determining the final thickness of the film.
     - **Higher concentration** produces thicker films.
     - **Lower concentration** produces thinner films.
2. **Filter the Solution**:
   - Filter the solution through a **0.22 µm syringe filter** to remove any particles that may cause defects in the coating.
3. **Optional Degassing**:
   - Degas the solution by leaving it in a vacuum chamber for a few minutes to remove trapped air bubbles, which could affect the film quality.

Spin Coating Process:

1. **Mount the Substrate**:
   - Place the cleaned substrate at the center of the spin coater's vacuum chuck and secure it by turning on the vacuum to hold it in place.
2. **Apply the Coating Solution**:
   - Use a **pipette or dropper** to dispense a small amount (typically 1–2 mL) of the coating solution onto the center of the substrate.

    - Ensure that the solution covers the entire surface when spinning starts.
3. **Spin Coating**:
    - Program the spin coater with desired speed and duration settings.
        - Example parameters: Start at a low speed (~500 RPM) for 10–15 seconds to spread the solution across the substrate.
        - Increase the speed to a higher rate (e.g., 2000–5000 RPM) for 30–60 seconds to achieve the desired film thickness by thinning out the solution through centrifugal force.
4. **Thickness Control**:
    - Adjust the spin speed and time to control the film thickness:
        - Higher speeds and longer durations produce **thinner films**.
        - Lower speeds and shorter times result in **thicker films**.

Drying and Annealing:

Soft Baking (Drying):

- After spin coating, dry the film by placing the substrate on a **hot plate** or in a **vacuum oven** at a moderate temperature (e.g., 60–100°C) for a few minutes.
- This step evaporates the solvent and solidifies the film.

9.<u>To Study G.M. Counter</u>

1. Equipment Setup:

1. **G.M. Tube Positioning**:
    - Secure the G.M. tube in a holder, ensuring it is properly connected to the high-voltage power supply and the counter unit.
    - Check the power supply and ensure the tube is grounded.
2. **Set the Voltage**:
    - Turn on the power supply and set the voltage to the recommended starting point for the specific G.M. tube (usually around 300–400V).
    - Slowly increase the voltage to the operating range (typically 400–900V) while monitoring the count rate.
3. **Background Radiation Measurement**:
    - With no radioactive source nearby, measure the **background radiation** count rate for a set period (e.g., 60 seconds). This will serve as a baseline for further experiments.

2. Measurement of Radiation from a Source:

1. **Place the Radioactive Source**:

    - Place the selected radioactive source (alpha, beta, or gamma emitter) at a fixed distance (e.g., 5 cm) from the G.M. tube.
2. **Measure the Radiation Count**:
    - Start the timer and measure the count rate (counts per minute or per second) for a set duration (e.g., 60 seconds).
    - Repeat the measurement for different distances (e.g., 5 cm, 10 cm, 15 cm) to observe how the count rate changes with distance (following the inverse square law for gamma rays).
3. **Repeat for Different Sources**:
    - Perform the same measurement for different radioactive sources (if available) to observe the different behaviors of alpha, beta, and gamma radiation.

3. Determining the Plateau Region:

1. **Increase the Voltage**:
    - Gradually increase the voltage in small increments (e.g., 10–20V) and record the count rate at each voltage.
    - Plot a graph of **count rate vs. applied voltage** to identify the plateau region, which is the range of voltage where the count rate remains relatively constant.
2. **Determine Operating Voltage**:
    - The operating voltage is usually selected in the middle of the plateau region to ensure stable operation of the G.M. counter.

4. Measurement of Dead Time:

1. **Two-Source Method**:
    - Place two identical radioactive sources close to the G.M. tube and measure the count rate for one source (R1R_1R1), the second source (R2R_2R2), and both sources together (R12R_{12}R12).

10. To study refractive index of liquids

Objective: To measure the refractive index of various liquids using a refractometer or other methods, and to understand the principles of refraction and light behavior in different media.

Procedure:

1. Calibration of Refractometer:

1. **Check Calibration**:
    - Ensure the refractometer is clean and free from any residues. Use a lint-free cloth to clean the prism surface.

    - Place a few drops of distilled water on the prism and close the cover.
    - Look through the eyepiece and adjust the calibration screw (if available) until the boundary line between light and dark fields is at zero or the known refractive index value (1.333 for distilled water).
2. **Record the Calibration Reading**:
    - Note the refractive index reading for distilled water to ensure accurate measurements.

2. Measurement of Refractive Index of Liquids:

1. **Prepare the Liquid Sample**:
    - Use a pipette or dropper to apply a few drops of the liquid sample onto the prism of the refractometer.
2. **Take the Reading**:
    - Close the cover of the refractometer gently to avoid spilling the liquid.
    - Look through the eyepiece and read the refractive index value at the boundary line between the light and dark fields.
3. **Record the Measurement**:
    - Write down the refractive index value and the temperature of the liquid sample.
4. **Repeat for Multiple Samples**:
    - Clean the prism thoroughly with a lint-free cloth and a suitable solvent after each measurement to avoid cross-contamination.
    - Repeat the measurement process for all liquid samples.
5. **Temperature Consideration**:
    - If the temperature of the liquid is significantly different from the calibration temperature (usually 20°C), note this, as the refractive index may change with temperature.

3. Additional Measurements (Optional):

- **Comparative Measurements**:
    - If available, use a known refractive index liquid (e.g., glycerin) for comparative measurements to verify the accuracy of your readings.
- **Calculating Average Values**:
    - If multiple measurements are taken for the same liquid, calculate the average refractive index for increased accuracy.