**NATIONAL CURRICULUM 2023**

**PHYSICS SUGGESTED GUIDELINES**

**GRADES 9-12**

**Table of Contents**

[**Pedagogical Principles 4**](#_heading=h.44qb2blr7kcj)

[**Classroom Assessment Guidance 5**](#_heading=h.gjdgxs)

[**Formative Assessment Plan 5**](#_heading=h.30j0zll)

[**Sample Activities** 8](#_heading=h.1fob9te)

[**GRADE 9-10** 9](#_heading=h.lr77hxeoyqmv)

[Domain : Mechanics 9](#_heading=h.c6pdo17wgcnv)

[Topic: Perpetual energy Mechanics; Energy, Work & Power 9](#_heading=h.2t8jqcl0e5hy)

[Domain: Heat and Thermodynamics 12](#_heading=h.3znysh7)

[Topic: Analyze consequence of heat radiation 12](#_heading=h.2et92p0)

[Domain: Electricity and Magnetism 14](#_heading=h.tyjcwt)

[Topic: Potential Divider 14](#_heading=h.3dy6vkm)

[Domain: Modern Physics Topic: Dark Matter 16](#_heading=h.oulqguwtb0bm)

[Domain: Mechanics 18](#_heading=h.1t3h5sf)

[Topic: Energy Conversions 18](#_heading=h.4d34og8)

[Domain: Work, Energy and Power 20](#_heading=h.2s8eyo1)

[Topic: Energy Conversions 20](#_heading=h.17dp8vu)

[Domain: Nature of Science 23](#_heading=h.3rdcrjn)

[Topic: Reasoning and Argumentation 23](#_heading=h.26in1rg)

[**GRADE 11-12** 26](#_heading=h.lnxbz9)

[Domain: Mechanics 26](#_heading=h.5a9gbjxdfw0d)

[Topic: Projectile Motion 26](#_heading=h.35nkun2)

[Domain: Heat and Thermodynamics 29](#_heading=h.4cj0c3m8pgiw)

[Topic: Degeneration of matter 29](#_heading=h.1ksv4uv)

[Domain: Modern Physics 30](#_heading=h.44sinio)

[Topic: Luminosity 30](#_heading=h.2jxsxqh)

[Domain: Modern Physics 32](#_heading=h.z337ya)

[Topic: Quantum Physics 32](#_heading=h.3j2qqm3)

[Domain: Waves 34](#_heading=h.o4l8dvemoz4q)

[Topic: Standing Waves 34](#_heading=h.1y810tw)

[**Lesson Plans on Conducting Experiments in the Lab** 36](#_heading=h.4i7ojhp)

[Topic: Principle of Moments 36](#_heading=h.2xcytpi)

[Topic: Specific Heat Capacity 39](#_heading=h.1ci93xb)

[Topic: Resistance of a Wire 42](#_heading=h.3whwml4)

[Topic: Capacitors and Capacitance 45](#_heading=h.2bn6wsx)

[**List of Practical for Grade 9 48**](#_heading=h.qsh70q)

[**List of Practical for Grade 10 49**](#_heading=h.3as4poj)

[**List of Practical for Grade 11 50**](#_heading=h.1pxezwc)

[**List of Practical for Grade 12** 51](#_heading=h.49x2ik5)

# Pedagogical Principles

The purpose of this curriculum is to both train students in theoretical and experimental skills, while releasing their scientific imagination and instilling in them scientific critical consciousness. Every class has a different dynamic, and different cultures have different norms about the relationship between teachers and students. This curriculum celebrates this diversity, and makes an effort to make it a chief strength. Teachers know their contexts best, and this curriculum does not try to enforce a rigid teaching model. However, there are four principles that are great guides for success:

* **Dialogue:** In order to inculcate scientific critical consciousness, earnest, respectful dialogue in a warm environment is important. Teachers should make every effort to ensure that students have a voice, and are able to express their views on critical issues. Such an environment is key to encouraging earnest self-reflection, and nurturing receptivity to different points of view. Teachers should present ideas in this curriculum as being open to debate and the understanding that our views about science and its impact in the world are never simply ‘neutral’, but are influenced by the narratives we are most familiar with.
* **Inclusive Classrooms:** Classes should be conducive to the learning of all students, regardless of any disabilities, to the maximum extent possible. A detailed guide on differentiating for students with disabilities is provided in the Appendices section. For all students, information should be presented in more than one form (i.e. through a combination of mediums such as multimedia, lecturing, lab demonstrations etc.), and they should be allowed to demonstrate their understanding in more than one way (i.e. not just through written tests, but also through presentations, project work, class conversation etc.).
* **Build on Existing Knowledge**: Each student has their own prior experiences and existing knowledge base, which should be incorporated into teaching by building upon them. This will not only help with learning, but also help students from marginalised identities feel more like science is something they can relate to and fully participate and excel in.
* **Hands-on Learning**: Scientific concepts should, to the maximum possible given resource constraints, be taught through structured hands-on experience and experiments with the phenomena being studied. Modelling socio-scientific issues through activities such as role play and presentations in front of community leaders are also very effective in helping inculcate scientific critical consciousness, and in motivating students to take social action.

# Classroom Assessment Guidance

Teachers are encouraged to use a variety of methods to assess student learning. These should include both formative (ongoing; in every class) and summative (at the end of each topic or a group of topics) assessments. It is important to emphasise here that, as this curriculum values inclusive education, that students should be given opportunities to demonstrate their understanding through different mediums as well (e.g. through a combination of writing, speaking, artistic expression, project work etc.).

**Formative Assessment:** In each class, teachers should gauge how students are doing through their participation in class and their engagement and performance with class work. In order to assess their developing critical consciousness skills, in addition to a combination of other mediums, it might be good to have students keep a reflection journal which they spend 5 minutes at the end of class writing in. The learning experience bank in the Appendices section can all be used as means of formative assessment, since they allow for many quality opportunities to observe students as they gauge with the materials, and to even create a work portfolio.

**Summative Assessment:** Teachers should also regularly formally assess students after covering an appropriate number of topics. Assessment does not have to be a written test, rather assessment should ideally be an educational experience in and of itself as well. Performance tasks are assessments that involve students carrying out tasks that mirror how they would be expected to use what they have learned in the real world. For example, the integrative project is a performance task as it requires students to convey an argument about a socio-scientific issue to an actual external audience. An activity that they are likely to repeat in future in one job or another.

# Formative Assessment Plan

The learning activities given in the Curriculum Guide can be used as formative assessments to gather evidence of student learning and give students the opportunity to measure their own growth and reflect and articulate key ideas. Here is a sample formative assessment plan that can be adapted by teachers, consisting of multiple assessment strategies. Teachers can pick a few from these for each unit that they cover.

* **Pre-assessment:** Before starting a new topic, administer a pre-assessment to gauge students' current understanding and identify areas where they may need extra support. This can take the form of a diagnostic quiz, exit ticket, or quick poll.
* **Classroom Discussions:** Encourage students to participate in regular class discussions, either in small groups or as a whole class. Ask questions, listen to students' responses, and provide feedback on their understanding. These discussions provide an opportunity to check for understanding, encourage critical thinking, and identify areas where students need further clarification.
* **Quizzes:** Give quizzes or short assessments on the material covered in class. These can be conducted either once or twice within a unit to assess individual student’s understanding of the mathematical ideas across lessons. These quizzes should consist of different types of questions that assess different levels of cognitive demand to push students to think, create, connect, and analyse. A rubric can be provided to students with the quizzes and can be used by the teacher to assess these quizzes. The scores will help inform what misconceptions the students have, or what is some idea they are lacking a proper understanding of, so that the teacher can revise or revisit them during the unit.
* **Group project:** Occasionally, at the end of a unit, students can be given group projects that require them to apply their knowledge and work together to solve problems. For example, one project might consist of presenting and comparing the three ways to solve systems of equations. Provide the students a rubric before assigning each project and make sure they understand it. Halfway through the project, ensure that the students use the rubric to check their progress. Then use the rubric to score the projects after they have completed them, and provide them with the scores they earned based on the rubric. Offer them opportunities to earn more points by correcting any mistakes.

**Performance Assessment:** During the lesson, give students open-ended and authentic tasks to demonstrate their mathematical understanding. These tasks will be either individual assessments or group tasks that will be cognitively demanding but low floor and high ceiling problems that will allow students to apply the knowledge they learnt during the lesson and further their understanding. Do not collect this work but instead monitor what the students are doing. Students can be given a rubric to help them self-assess or peer-assess these tasks.

* **Classroom observations:** While the students are solving tasks and having discussions within groups, roam around the class observing their written work and listening to their conversations. Use a monitoring sheet with student’s names on them to record which student is using which strategy and keep a check of the different ideas that are being formulated. Help direct the students’ thinking by asking them questions that will push them to critically think. The notes can then be used to sequence ideas and pick particular students to present strategies to discuss in a whole-class discussion to help all students connect between different ideas.
* **Science Journals:** Encourage students to reflect on their learning and set goals for improvement by writing them in their journals. Have students answer an open-ended question in a journal (like what did you learn today? Or what questions would you like me to answer tomorrow?) and select a few students to share. Reflection helps students see their progress, identify areas for improvement, and take ownership of their learning.
* **Gallery walk:** Have students respond to questions about the classroom and respond to the ideas of others. Have students work on different tasks in groups and then create a visual display that summarises their work and understanding of the topic. These displays can be placed around the classroom and have students walk around and interact with each display. They can ask questions, make observations, and give feedback to their peers using post-it notes. After the gallery walk, lead a discussion to debrief the experience. Students reflect on what they learned from their peers, what they found most helpful, and what areas they still need to work on. Instead of student work displays, myths about a certain topic can also be placed around the classrooms and students asked to walk around and respond to the prompts as a group.
* **Jigsaw:** Have students work in groups to solve a mathematics problem or concept. Each group is responsible for a specific part of the problem or concept, and then mx students up and have them share their findings and ideas to their new group. This process allows students to practise their problem-solving and critical thinking skills, as well as their ability to collaborate and communicate effectively with their peers. The teacher can observe and listen to the students during the activity, and use the information gathered to assess their understanding of the topic being covered and make any necessary adjustments to their instruction.
* **Exit Tickets:** At the end of most lessons, have students individually complete and hand in an exit ticket. The exit ticket will consist of 1-3 questions ranging from closed questions to assess student’s procedural fluency, open-ended questions to assess student’s conceptual understanding, questions similar to the tasks done in class to allow students to apply the knowledge they learnt and questions to have them inform the teacher about any confusions/questions that they might still have. These exit tickets will be used to inform the teacher about individual student’s current understandings and help him/her tailor the content of the next lesson to suit the students’ needs.
* **Homework:** Occasionally, give students homework to allow them to practise what they learnt during class. The homework questions will also be tasks that allow a deeper level of thinking instead of closed questions that have only one accurate answer. Students can choose a homework buddy to ask for help with homework assignments and they will be encouraged to identify concepts they are struggling with. Homework might only be given a couple of times in a unit to not overburden students, but it will help students self-assess themselves and revisit the concepts discussed in class. At the beginning of the class following a class where a HW was assigned, have a brief discussion that draws connections across HW problems, talks about the challenges students faced, or asks students the justification behind their solving techniques.

# 

# Sample Activities

**Notes:**

1. The CG is arranged Domain wise; Domains for Grades 11-12 are covered before, followed by Domains of Grades 9-10
2. ‘Perspectives’ are not compulsory content to be taught, but are intended to be suggested topics for exploratory discussion, research and project activities that enrich student learning and further promote critical thinking
3. Different National and International Curricula were consulted while developing the NCP for this subject.
4. The mention of all websites and links, from which content for activities was adapted, will be referenced properly and cited after finalisation of the Curriculum Guidelines.
5. There are certain links given here for videos, websites and documents. All links were checked for authenticity on 7th April, 2023, it has been established that they are valid. Since these are third party links, NCC will not be responsible if they are changed or do not work in the future. NCC is working on creating a repository of information which will be sustainable and accessible, all information from links will be downloaded and made available in due time to avoid this issue in the future.

# GRADE 9-10

Guidance for the reader:

| **Standard:**  Here the relevant parts of the appropriate standard from the Physics Progression Grid ( <https://ncc.gov.pk//SiteImage/Misc/files/Physics%20Printable.pdf> ) will be listed, including the relevant benchmarks under that standard | |
| --- | --- |
| **Student Learning Outcomes:**  Here only the relevant SLOs from the Progression Grid will be outlined | |
| **Knowledge:**  Here the main important concepts that students should become familiar with are summarised | **Skills:**  Here the main important applications of concepts (whether experimental or in the form of solving analytical problems) that students should become skilled with are summarised |
| **Perspectives:**  These are some (not exhaustive) suggested (not compulsory) topics/prompts for discussion in classes that help students think more critically and in an interdisciplinary fashion about the physics concepts they are learning. Perspectives will not be assessed in any exams; they are only intended to help enrich learning for students. | |
| **Activities**  Here the details of suggested activities for the chosen topic are elaborated on. These activities are not compulsory and they are not meant to be followed rigidly step by step. They are only intended to help inspire teachers to develop engaging lessons that help students unpack the concepts with hands-on learning. | |

# Domain : Mechanics

## Topic: Energy, Work & Power

| ***Standard:***  Students will be able to:   * Differentiate between different kinds of forces and their effects * differentiate between work, energy and power * use the law of conservation of energy to analyse the viability and efficiency of systems   **Benchmark V:** Describe and analyse the effects of energy transfers and energy transformations on a body, along with the advantages and disadvantages of harnessing energy from natural resources | |
| --- | --- |
| ***Student Learning Outcomes***   * Justify why perpetual energy machines do not work * Differentiate between and list renewable and non-renewable energy sources * Define and calculate power * Define and calculate efficiency * Apply the concept of efficiency to simple problems involving energy transfer | |
| ***Knowledge:***  *Students will be able to…*  *State the law of conservation of energy*  *Recall the relationships between force, work, energy, power and efficiency* | ***Skills:***  *Students will be able to…*  *Apply the law of conservation of energy to problems to solve problems and to identify why perpetual energy machine designs do not work*  *Calculate the efficiency of mechanical systems given relevant information*  *Conduct basic experiments to investigate energy losses in simple mechanical systems* |
| ***Perspectives***   * Historical attempts to defy the classical law of conservation of energy * How do energy conversions in systems help maintain balance in the world, such as in the world’s climate systems? * How does research on developing more efficient devices (such as batteries and vehicles) work to change society around us? | |
| ***Learning Activities***  **Activity 1**  **Title:** Investigating the Conservation of Mechanical Energy  Purpose**:** to demonstrate and validate the conservation of mechanical energy in a simple pendulum system.  **Materials:**  1. A string (approximately 1 metre long)  2. A small weight (such as a metal or wooden ball)  3. A ruler or measuring tape  4. Stopwatch or timer  **Procedure:**  1. Set up the pendulum: Tie one end of the string securely to a fixed support, such as a hook or a pole. Attach the small weight (ball) to the other end of the string.  2. Establish the reference point: Measure and mark the equilibrium position of the pendulum when it is at rest (directly below the fixed support). This position will serve as the reference point.  3. Measure the amplitude: Pull the pendulum to one side, away from the reference point, and release it. Measure the distance (amplitude) from the reference point to the starting position of the pendulum.  4. Release and measure time: Release the pendulum from the amplitude you measured in the previous step. Use a stopwatch or timer to measure the time it takes for the pendulum to complete ten full swings back and forth. Record this time in seconds.  5. Calculate potential and kinetic energies: The mechanical energy of the pendulum is the sum of its potential energy (PE) and kinetic energy (KE). The potential energy at the starting position (amplitude) is given by PE = mgh, where m is the mass of the weight, g is the acceleration due to gravity, and h is the height from the starting position to the reference point. The kinetic energy at the starting position is zero, as the weight is momentarily at rest.  6. Compare energies: At any point during the pendulum's motion, its mechanical energy should remain constant (assuming no energy loss due to friction or air resistance). Calculate the potential and kinetic energies at various points during the pendulum's swing and compare them to the energy at the starting position. Check if the mechanical energy is conserved throughout the swing.  7. Repeat and analyze: Repeat the experiment for different amplitudes and observe if the mechanical energy remains constant for each swing.  **Discussion and Interpretation:**  **·**  Discuss the results of your investigation. Did the mechanical energy remain constant during the pendulum's motion?  · If the mechanical energy didn't remain constant, what could be the sources of energy loss in the system (e.g., friction, air resistance)?  · Discuss the significance of the conservation of mechanical energy and how it applies to other systems and real-life scenarios**.**  **Note:** Ensure that the weight is not too heavy and that the pendulum's amplitude is not too large to avoid potential hazards. Always maintain safety precautions during the experiment.  **Activity 2**  **Title:** Investigating the Efficiency of Simple Machines  **Objective:** To determine the efficiency of a simple machine by comparing the input and output energies.  **Materials:**  · Lever (e.g., a metre stick or a wooden plank)  · Fulcrum (e.g., a wooden block)  · Weights (e.g., small objects with known masses)  · String or rope  · Pulley (optional)  · Stopwatch or timer  · Measuring tape or ruler  · Notebook and pen  **Procedure:**  1. Set up the ramp: Prop up one end of the ramp to create an inclined plane. Ensure the ramp is smooth and free from any obstructions.  2. Measure the ramp height: Measure and record the height (h) of the ramp from the base to the elevated end.    3. Calculate potential energy: Calculate the potential energy (PE) of the cart at the top of the ramp using the formula PE = m \* g \* h, where m is the mass of the cart and g is the acceleration due to gravity (approximately 9.81 m/s²). Use a known mass for the cart.  4. Release the cart: Place the cart at the top of the ramp, allowing it to roll down the incline freely. Ensure the cart starts from rest.  5. Measure the time of travel: Use a stopwatch or timer to record the time it takes for the cart to reach the bottom of the ramp. Repeat this process three times and calculate the average time.  6. Measure the distance: Measure the horizontal distance (d) the cart traveled along the ground from the base of the ramp to the stopping point. Repeat this process three times and calculate the average distance.  7. Calculate kinetic energy: Calculate the kinetic energy (KE) of the cart at the bottom of the ramp using the formula KE = (1/2) \* m \* v^2, where m is the mass of the cart and v is the final velocity of the cart at the bottom of the ramp. Use the measured time and distance to determine the final velocity.  8. Analyze efficiency: Compare the potential energy (PE) calculated at the top of the ramp with the kinetic energy (KE) calculated at the bottom. Calculate the efficiency of the energy conversion using the formula Efficiency = (KE / PE) \* 100%.  9. Repeat with varying masses: Repeat steps 4 to 8 with different masses for the cart to observe how the efficiency of energy conversion varies with different loads.  **Discussion and Analysis:**  1. Discuss the results of the experiment and the efficiency of energy conversion for different masses.  2. Analyze the factors that may affect the efficiency of energy conversion, such as friction and air resistance.  3. Relate the findings to real-world applications, such as mechanical systems and energy storage technologies.  4. Discuss ways to improve the efficiency of energy conversion in simple machines.  **Note:** Ensure the safety of the participants and keep the ramp and surrounding area clear of obstacles during the activity.  **Activity 3:**  **Title:** Investigating the Efficiency of a ***Perpetual Motion Machine Prototype***  **Objective:** To examine and analyse the efficiency of a perpetual motion machine prototype in order to appreciate why perpetual energy machines do not work according to the law of conservation of energy  **Materials:**  · Perpetual motion machine prototype  · Stopwatch or timer  · Masses (weights) of various sizes  · Ruler or measuring tape  · Table or flat surface  · Safety goggles (optional, depending on the prototype design)  **Procedure:**  1. Set up the perpetual motion machine prototype on a flat surface or table. Make sure it is stable and secure.  2. Measure and record the height (H) of the tabletop from the ground.  3. Identify the driving mechanism of the perpetual motion machine. This could be a rolling ball, a pendulum, or any other mechanism that is claimed to generate perpetual energy.  4. Set the prototype in motion by giving it an initial push or activating the driving mechanism.  5. Use the stopwatch to time the duration the prototype remains in motion without any additional intervention.  6. Measure and record the distance the prototype traveled during this time.  7. Repeat steps 4-6 for a total of three trials to ensure accuracy and consistency of data.  8. Add masses of different sizes to the prototype (if applicable) and repeat steps 4-6 for each trial, recording the time and distance traveled for each additional mass.  **Questions:**  1. Define perpetual energy in your own words and explain why it is considered impossible according to the laws of thermodynamics.  2. Describe the driving mechanism of the perpetual motion machine prototype you are testing.  3. Compare the distances traveled by the prototype in the trials with and without additional masses. Did adding masses affect the motion of the prototype? Explain.  4. Calculate the average time the prototype remained in motion without any additional intervention for each set of trials (with and without masses).  5. Calculate the average speed of the prototype for each set of trials (with and without masses). Speed is the distance traveled divided by the time taken.  6. Based on the average speed, discuss whether the perpetual motion machine prototype achieves perpetual motion. If not, what factors might be causing the decrease in speed over time?  7. Analyze the efficiency of the perpetual motion machine prototype by comparing the work done on the prototype (force x distance) with the energy output claimed by the machine. Are they equal or different? Explain your findings.  **Note:** The concept of perpetual motion violates the laws of thermodynamics, specifically the conservation of energy and the idea that energy cannot be created or destroyed. This experiment is designed to help students understand the limitations and principles of energy conservation. It is essential to approach this topic critically and use it as a learning opportunity to discuss the scientific principles involved  **Activity 4:**  **Title:** Investigating the Dependence of Work on the Angle of Inclination  **Objective:** The objective of this practical activity is to experimentally demonstrate and analyze how the angle of inclination affects the amount of work done when lifting an object along a ramp.  **Materials:**  1. Ramp (a smooth, inclined surface)  2. Small wheeled cart or a toy car with wheels  3. String or rope  4. Masses (e.g., weights) of known values  5. Pulley (optional, for easy measurement of the force)  **Procedure:**    1. Set up the ramp: Prop up one end of the ramp to create an inclined plane. The angle of inclination can be adjusted by changing the height of the elevated end. Ensure the ramp is smooth and free from any obstructions.  2. Measure the angle: Use a protractor to measure and record the angle of inclination (θ) of the ramp.  3. Attach the cart to the string: Tie one end of the string to the cart and pass it over the pulley (if available) at the top of the ramp. The other end of the string should be connected to the masses (weights) that will be used to pull the cart up the ramp.  4. Calculate the force: Determine the force (F) applied to the cart by the hanging masses. This force can be calculated using the formula F = m \* g, where m is the mass of the hanging masses, and g is the acceleration due to gravity (approximately 9.81 m/s²).  5. Release the cart: Release the cart from rest at the bottom of the ramp, and let it travel up the incline due to the force applied by the hanging masses.  6. Measure the distance: Measure and record the distance (d) traveled by the cart along the ramp. You can use a measuring tape or ruler to determine the horizontal displacement.  7. Calculate work done: Calculate the work (W) done on the cart using the formula  W = F \* d \* cos(θ), where θ is the angle of inclination measured in Step 2.  8. Repeat with different angles: Repeat the experiment with different angles of inclination by adjusting the height of the elevated end of the ramp. Keep the force (applied by the hanging masses) constant throughout the experiment.  9. Analyze the results: Plot a graph with the angle of inclination (θ) on the x-axis and the work done (W) on the y-axis. Analyze how the work done varies with the angle of inclination.  **Discussion and Analysis:**  · Discuss the relationship between the angle of inclination and the work done. How does the work done change as the angle of inclination increases or decreases?  · Explain the physical significance of the cosine function in the work formula and how it affects the work done at different angles.  · Discuss any sources of error in the experiment and potential improvements for future investigations.  **Note:** Ensure the safety of participants during the activity, especially when dealing with hanging masses or using a pulley system. Always maintain a safe environment during the practical.  **Activity 5:**  **Title:** Investigating the Dependence of Power on Force and Angle  **Objective:** The objective of this practical activity is to experimentally investigate the relationship between power, force, and angle of inclination using a simple inclined plane setup.  **Materials:**  1. Inclined plane (a smooth, adjustable ramp)  2. Small wheeled cart or a toy car with wheels  3. String or rope  4. Masses (e.g., weights) of known values  5. Pulley (optional, for easy measurement of the force)  6. Stopwatch or timer  7. Protractor or angle measuring tool  8. Measuring tape or ruler  **Procedure:**  1. **Set up the inclined plane:** Adjust the height of the elevated end of the inclined plane to vary the angle of inclination. Ensure the ramp is smooth and free from any obstructions.  2. **Measure the angle:** Use a protractor or an angle measuring tool to measure and record the angle of inclination (θ) of the ramp.  3. **Attach the cart to the string:** Tie one end of the string to the cart and pass it over the pulley (if available) at the top of the ramp. The other end of the string should be connected to the masses (weights) that will be used to pull the cart up the ramp.  4. **Calculate the force:** Determine the force (F) applied to the cart by the hanging masses. This force can be calculated using the formula F = m \* g, where m is the mass of the hanging masses, and g is the acceleration due to gravity (approximately 9.81 m/s²).  5. **Release the cart:** Release the cart from rest at the bottom of the ramp, and let it travel up the incline due to the force applied by the hanging masses.  6. **Measure the time:** Use a stopwatch or timer to record the time (t) taken for the cart to travel a known distance (d) along the inclined plane. Measure the distance using a measuring tape or ruler.  7. **Calculate work done and power:** Calculate the work (W) done on the cart using the formula W = F \* d \* cos(θ), where θ is the angle of inclination measured in Step 2. Then, calculate the power (P) using the formula  8. P = W / t.  9. **Repeat with different angles and forces:** Repeat the experiment with different angles of inclination and different masses (forces) for the hanging masses. Keep the distance (d) and the time (t) constant for each trial.  Analyze the results: Plot separate graphs for power (P) versus force (F) and power (P) versus angle (θ). Analyze how power varies with force and angle.  **Discussion and Analysis:**  1. Discuss the relationship between power, force, and angle based on the experimental data.  2. Explain how changes in force and angle affect the power output in the inclined plane setup.  3. Discuss the physical significance of the cosine function in the work formula and its influence on power calculations at different angles.  4. Analyze any sources of error in the experiment and suggest potential improvements for future investigations.  **Note:** Ensure the safety of participants during the activity, especially when dealing with hanging masses or using a pulley system. Always maintain a safe environment during the practical. | |
| ***Objective:*** understand the difference between renewable and non-renewable energy sources  ***Materials needed:***   * Whiteboard or blackboard * Markers or chalk * Chart paper or large paper sheets * Printed cards with energy source names (renewable and non-renewable)   ***A. Differentiating renewable and non-renewable sources***   * Divide the class into small groups (4-5 students per group). * Provide each group with chart paper or large paper sheets and markers. * Ask each group to draw a Venn diagram on the paper, labeling one circle as "Renewable Energy Sources" and the other as "Non-Renewable Energy Sources." * Instruct the groups to brainstorm and list energy sources they know in the appropriate circles of the Venn diagram. * Circulate around the class to facilitate discussions and answer any questions.   ***B. Sorting Energy Source Cards***   * After completing the Venn diagrams, distribute printed cards with the names of various energy sources to each group. * Instruct the groups to sort these energy source cards into the correct section of the Venn diagram (renewable or non-renewable). * Encourage them to discuss and debate among themselves to ensure the accurate placement of the cards. * After the sorting is complete, ask each group to share their Venn diagrams with the class, explaining their choices.   ***C. Group Presentations***   * Give each group a few minutes to present their Venn diagrams and explain their reasoning behind classifying specific energy sources as renewable or non-renewable. * As a class, discuss any differences in classification among the groups and come to a consensus on the correct placements. * Emphasise the importance of considering sustainability and environmental impact when categorising energy sources. | |

# Domain: Heat and Thermodynamics

## Topic: Analyse consequence of heat radiation

| ***Standard:***  Students should be able to describe and analyse:   * the effects of heat on the physical properties of matter by making reference to the kinetic theory of matter * how heat can be transferred through different modes   **Benchmark I:** Use the kinetic theory of matter to explain the physical properties of matter and how these transform upon changes in state  **Benchmark II:** Explain how heat can be transferred through convection, conduction and radiation and the effects and applications of these modes of transfer | |
| --- | --- |
| ***Student Learning Outcomes***   * Analyse the consequence of heat radiation in the greenhouse effect and its effect in global warming * Analyse everyday applications of conduction, convection and radiation * Justify experiments to distinguish between good and bad thermal conductors * Explain thermal conduction in all solids * Explain convection in liquids and gases. | |
| ***Knowledge:***  *Students will be able to…*  *Explain the factors that determine whether a material will be a good or bad absorber and emitter of heat*  *Explain the Greenhouse Effect*  *Describe how conductive, convection and radiation occur in everyday observed phenomena* | ***Skills:***  *Students will be able to…*  *Analyse and identify what materials would be appropriate in situations for use as thermal radiation emitters or absorbers*  *Apply the ideas of Greenhouse Effect, as well as general conduction, convection and radiation to given scenarios to determine what are the causes of heating up or cooling down inside a system*  *Set up and conduct experiments to investigate the effectiveness of materials as conductors, convectors and radiators* |
| ***Perspectives***   * How does global warming affect the Earth’s climate systems, as well as society? * What kind of problems are today’s engineers and scientists working on in order to develop materials that are perfect conductors, convectors and radiators in required physical conditions for temperature and pressure? | |
| ***Learning Activities***   1. **Modes of transfer of heat:** a. Students will be asked to use a heat source (Burner etc) and a metallic rod. b. Put the metallic rod on the flame by keeping it in your left hand and put your right hand at the same distance from the flame. c. Ask the students to share the feeling of the temperature of both hands, they can feel both transfer of heat by conduction through metallic rod in left hand and convection through the air on their right hand. d. Ask the students to share their observations to the other students. 2. **Greenhouse Gas Role-Play:** a. Assign each student or small group a specific greenhouse gas (e.g., carbon dioxide, methane, nitrous oxide) to research and represent in a role-play activity. b. Have students act out the behaviour (like increasing temperature and humidity due to CO2) of their assigned greenhouse gas in trapping heat and contributing to global warming.   c. Encourage creativity in showcasing (Project or Presentation) the different greenhouse gases and their impact on the climate.   1. **Mitigation Strategies:** a. Facilitate a class discussion on possible mitigation strategies to reduce the greenhouse effect and global warming. b. Brainstorm ideas such as using renewable energy, reducing carbon emissions, and promoting sustainable practices. 2. **Greenhouse Effect Simulation:**   Materials Needed: Two large clear plastic containers with lids (e.g., fish tank or storage container); Thermometer; Heat lamp or strong light source; Black construction paper; Aluminum foil; Water spray bottle; Stopwatch or timer; Access to research materials and resources  a. Divide the students into small groups and provide each group with two large clear plastic containers and a thermometer. b. Instruct one group to keep black construction paper inside of their container, representing increased heat absorption. c. Instruct another group to keep aluminum foil inside of their container, representing a reflective surface that prevents heat absorption. d. Place the containers side by side and position them under a heat lamp or strong light source.e. Use the thermometer to measure the initial temperature inside each container and record it. f. Keep the containers under the heat lamp for 10 minutes. g. After 10 minutes, measure and record the temperature inside each container again.  **Observations and Analysis:** a. Have each group share their observations and temperature measurements with the rest of the class. b. Lead a discussion on how the container with black construction paper (representing greenhouse gases) experienced a more significant temperature increase compared to the container with aluminum foil (representing a less effective greenhouse effect). c. Guide students to make connections between the simulation and the greenhouse effect in the Earth's atmosphere. D. Ask students to reflect on the strengths and limitations of modelling greenhouse gases through this experiment.  **Title:** Investigating the Degeneration of Matter through Heating    **Objective:** To observe and analyse the changes in matter due to heating and examine the concept of degeneration.  **Materials:**   * Bunsen burner or heat source * Tripod stand and wire gauze * Heat-resistant mat * Test tubes * Test tube holder or tongs * Thermometer * Water * Various substances (e.g., sugar, salt, chalk, paper)     **Procedure:**  1. Set up the Bunsen burner or heat source on a heat-resistant mat.  2. Place the tripod stand over the heat source and ensure it is stable.  3. Place the wire gauze on top of the tripod stand.  4. Fill three test tubes with equal amounts of water.  5. Select three different substances (e.g., sugar, salt, chalk, paper) and place a small amount of each substance into a separate test tube.  6. Use a thermometer to measure and record the initial temperature of each test tube.  7. Carefully hold each test tube with the test tube holder or tongs and place them, one at a time, on the wire gauze above the heat source.  8. Observe the changes occurring in each substance as it is heated and record any observations. Pay attention to changes in physical appearance, such as color, texture, and state (solid, liquid, or gas).  9. Monitor and record the temperature of each test tube at regular intervals during the heating process.  10. Remove the test tubes from the heat source once significant changes in the substances are observed or when the temperature reaches a specific value (e.g., 100°C).  11. Allow the test tubes to cool down to room temperature.  12. Measure and record the final temperature of each test tube.  13. Compare the initial and final temperatures of each substance, noting any differences.  14. Analyze and discuss the observed changes in the substances, focusing on the concept of degeneration.  **Questions:**  **1.** Define the term "degeneration" as it relates to matter and explain why heating is often associated with this concept.  2. What physical changes did you observe in each substance as it was heated? Describe any changes in color, texture, or state (solid, liquid, or gas).  3. Did all substances undergo degeneration when heated? Explain your answer based on the observations.  4. Compare the initial and final temperatures of each substance. Did the temperature change for each substance? If so, what might have caused the temperature change?  5. Discuss the relationship between temperature and the degeneration of matter. How does increasing temperature affect the degeneration process?  6. Based on your observations, propose a hypothesis or explanation for why matter undergoes degeneration when exposed to heat.  7. How can the concept of degeneration through heating be applied or related to real-life scenarios or industries?  **Note:** Ensure proper safety precautions are followed during the experiment, such as wearing safety goggles, handling heated objects with care, and using appropriate heat sources. Use substances that are safe and suitable for heating, and consult with a teacher or lab supervisor if needed.  **Title:** Investigating the Degeneration of Matter in a Closed System  **Objective:** To observe and analyse the changes in matter within a closed system under controlled conditions.  **Materials:**  **·** Sealed glass container or flask  · Thermometer  · Hot plate or Bunsen burner  · Water  · Ice  · Stopwatch or timer  **Procedure:**  1. Fill the glass container or flask with a known amount of water, and seal it tightly to create a closed system.  2. Measure and record the initial temperature of the water inside the closed system using the thermometer.  3. Place the closed system on a hot plate or Bunsen burner and heat it for a specific duration (e.g., 5 minutes).  4. After the heating period, remove the closed system from the heat source and allow it to cool down naturally for the same duration as the heating time.  5. Measure and record the final temperature of the water inside the closed system after the cooling period.  6. Repeat steps 3-5 for a total of three trials, ensuring consistency in the duration of heating and cooling periods.  7. Prepare a separate closed system with ice inside instead of water and measure its initial temperature.  8. Leave the closed system with ice to melt at room temperature for a specific duration (e.g., 10 minutes).  9. Measure and record the final temperature of the water inside the closed system after the melting period.  10. Repeat steps 7-9 for a total of three trials, ensuring consistency in the duration of the melting period.  **Questions:**  1. Describe the closed system used in this experiment and explain why it is necessary to ensure the system remains isolated from the external environment.  2. Compare the initial and final temperatures of the water inside the closed system after the heating period. Did the temperature change? If so, explain the reasons for the change.  3. Calculate the average temperature change for each set of trials (heating and cooling). Discuss any discrepancies or variations observed in the results.  4. Describe the initial and final states of the water inside the closed system after the cooling period. What conclusions can you draw from these observations?  5. Analyze the effect of the heating and cooling process on the matter within the closed system. Does the experiment demonstrate the degeneration of matter? Why or why not?  6. Compare the initial and final temperatures of the ice inside the closed system after the melting period. Did the temperature change? If so, explain the reasons for the change.  7. Calculate the average temperature change for the ice during the melting process. Discuss any discrepancies or variations observed in the results.  8. Discuss the concept of latent heat of fusion and how it relates to the temperature change observed during the ice melting process.  9. Based on the experimental results, can you draw any general conclusions about the degeneration of matter in a closed system? Are there any limitations or sources of error in this experiment?  **Note:** The concept of the degeneration of matter is related to the idea of the conservation of mass in thermodynamics. This experiment aims to observe changes in matter within a closed system and discuss relevant scientific principles. Students should approach the topic critically and use it as an opportunity to learn about thermodynamics and the conservation laws**.**  **Title:** Investigating the Consequences of Heat Radiation on Different Materials    **Objective:** To observe and analyse the effects of heat radiation on various materials and evaluate their thermal conductivity.  **Materials:**     * Heat source (e.g., Bunsen burner, hot plate) * Three different materials (such as metal, wood, and plastic) of equal size and thickness * Thermometer * Stopwatch or timer * Safety goggles * Heat-resistant gloves     **Procedure:**  1. Put on safety goggles and heat-resistant gloves for personal protection during the experiment.  2. Place the heat source (e.g., Bunsen burner or hot plate) on a stable surface and ensure a safe distance from flammable materials.  3. Measure and record the initial temperature of each material using the thermometer.  4. Position one material at a time, equidistant from the heat source, ensuring that the same surface area is exposed to the heat.  5. Start the stopwatch or timer and allow the material to absorb heat radiation for a specific duration (e.g., 5 minutes).  6. After the heating period, measure and record the final temperature of the material using the thermometer.  7. Repeat steps 4-6 for each material, ensuring consistency in the heating duration.  8. Calculate the temperature change (∆T) for each material by subtracting the initial temperature from the final temperature.  9. Calculate the average temperature change for each material.  **Questions:**  1. Define heat radiation in your own words and explain how it differs from conduction and convection.  2. Discuss the importance of thermal conductivity in different materials and how it affects their ability to transfer heat.  3. Compare the initial and final temperatures of each material after the heating period. Did the temperature change? If so, which material showed the greatest temperature change? Explain your observations.  4. Calculate and compare the average temperature changes (∆T) for the different materials. Which material demonstrated the highest average temperature change? What does this indicate about its thermal conductivity?  5. Based on the experimental results, rank the materials from highest to lowest thermal conductivity.  6. Explain why certain materials, such as metals, are commonly used for heat transfer applications compared to materials with lower thermal conductivity.  7. Discuss any limitations or sources of error in this experiment and suggest improvements to enhance the precision of the results.  8. In real-world scenarios, why is it crucial to consider heat radiation and its consequences when designing and selecting materials for specific applications?    **Note:** This experiment aims to explore the concept of heat radiation and its effects on different materials. The emphasis should be on understanding thermal conductivity and its significance in various practical situations. Students should also consider the implications of heat radiation in everyday life and engineering applications.  **Title:** Investigating the Effects of Heat Radiation on Different Surfaces  **Objective:** To observe and analyse the consequences of heat radiation on different surfaces.  **Materials:**   * Two identical metal containers (e.g., aluminium cans) * Black spray paint * White spray paint * Thermometer * Water * Stopwatch or timer * Heat source (e.g., Bunsen burner or hot plate) * Safety goggles   **Procedure:**  1. Start by preparing the two metal containers. Paint one container entirely with black spray paint and the other container entirely with white spray paint. Let them dry completely.  2. Fill both containers with the same amount of water at room temperature.  3. Measure and record the initial temperature of the water in each container using a thermometer.  4. Place both containers at the same distance from the heat source (Bunsen burner or hot plate) and start the timer.  5. Observe and record the changes in temperature of the water in each container every minute for a total of five minutes.  6. After five minutes, turn off the heat source and allow both containers to cool down to room temperature.  7. Measure and record the final temperature of the water in each container.  **Questions.**  1. Describe the setup used in this experiment and explain the role of the black and white spray paint on the metal containers.  2. Compare the initial temperatures of the water in the black-painted and white-painted containers. Are they the same or different? Provide a reason for any observed differences.  3. Plot a graph showing the changes in temperature of the water in each container over the five-minute period.  4. Analyze the data from the graph. Which container showed a faster increase in temperature, and why? What does this reveal about the consequences of heat radiation on different surfaces?  5. Explain the concept of heat absorption and heat reflection in relation to the observations in the experiment.  6. What conclusions can you draw from the experiment about the effect of different surface colors (black vs. white) on heat absorption and radiation?  7. Discuss practical applications of this phenomenon in everyday life or specific industries.  8. Suggest improvements to the experiment's design to enhance the accuracy and reliability of the results.  9. Investigate how other surface colors or materials may influence heat absorption and radiation differently. Propose additional experiments to explore this aspect.    **Note:** Heat radiation and the effects of surface colors on heat absorption and radiation are essential concepts in thermodynamics and the study of energy transfer. Students should be encouraged to apply critical thinking and connect the experimental results to real-world scenarios. Safety precautions, such as wearing safety goggles during the experiment, should be followed at all times.  **Title:** Investigating the Consequences of Heat Radiation on Different Surfaces  **Objective:** To analyse and compare the consequences of heat radiation on various surfaces.    **Materials:**  **·** Heat source (e.g., hot plate or Bunsen burner)  · Thermometer  · Three identical metal objects (e.g., metal rods or metal plates)  · Three identical non-metal objects (e.g., wooden blocks or plastic containers)  · Stopwatch or timer  **Procedure:**  1. Set up the heat source (hot plate or Bunsen burner) on a stable surface.  2. Measure and record the initial temperature of each metal and non-metal object using the thermometer.  3. Place one metal object and one non-metal object at a distance of approximately 10 cm from the heat source.  4. Start the stopwatch or timer and allow the objects to be exposed to the heat radiation for a specific duration (e.g., 5 minutes).  5. After the heating period, carefully measure and record the final temperature of each object.  6. Repeat steps 3-5 for the remaining metal and non-metal objects, ensuring consistency in the duration of the heating period.  7. Calculate the temperature change for each metal and non-metal object by subtracting the initial temperature from the final temperature.  8. Compare the temperature changes between the metal and non-metal objects. Analyze and discuss the consequences of heat radiation on different surfaces.  **Questions:**  1. Define heat radiation in your own words and explain how it differs from conduction and convection.  2. Describe the setup used in this experiment to observe the consequences of heat radiation on different surfaces.  3. Compare the initial and final temperatures of the metal objects after exposure to heat radiation. Did the temperature change? If so, explain the reasons for the change.  4. Compare the initial and final temperatures of the non-metal objects after exposure to heat radiation. Did the temperature change? If so, explain the reasons for the change.  5. Analyze and compare the temperature changes between the metal and non-metal objects. Discuss the differences in the consequences of heat radiation on these surfaces.  6. Based on the observations and analysis, discuss the efficiency of heat radiation on metal surfaces compared to non-metal surfaces. Explain the reasons for any differences observed.  7. Explain how heat radiation is related to energy transfer and the laws of thermodynamics.  8. Discuss real-life examples where the consequences of heat radiation are significant, and explain their practical implications.  **Note:** The concept of heat radiation is an important aspect of thermodynamics and energy transfer. This experiment allows students to observe and analyze the consequences of heat radiation on different surfaces. It is essential to provide clear explanations and connect the experiment to real-life applications to enhance understanding. | |

# Domain: Electricity and Magnetism

## Topic: Potential Divider

| ***Standard:***  Students will be able to:   * describe mathematically the nature of static magnetic and electric fields * analyse and account for the distribution of current, voltage and resistance in simple DC circuit * explain how power can be generated through electromagnetic induction * account for how motors make use of electromagnetism to generate kinetic energy * analyse AC circuits in terms of current, resistance, reactance, voltage, and impedance   **Benchmark II:** Apply knowledge of the relationships between electric current, voltage, resistance and power in simple circuits to describe their applications (in technology and in nature) and the need for safety measures in electric appliances | |
| --- | --- |
| ***Student Learning Outcomes***   * Analyse the function of variable potential dividers in circuits * Use common rules regarding current and voltage distribution in circuits to solve problems * Calculate current, voltage and resistance in parts of a circuit or in the whole circuit * Draw circuit diagrams [with cells, batteries, power supplies, generators, potential dividers, switches, resistors (fixed and variable), heaters, thermistors (NTC only), light-dependent resistors (LDRs), lamps, motors, ammeters, voltmeters, transformers, fuses, relays, diodes and light-emitting diodes (LEDs)] | |
| ***Knowledge:***  *Students will be able to…*  *Identify the voltage distributions in simple series and parallel circuits*  *Recall Ohm’s Law*  *Describe the uses of potential dividers in circuits and electrical appliances*  *Explain how resistivity of the resisting material is an important factor to consider in designing a potential divider* | ***Skills:***  *Students will be able to…*  *Design simple circuits that make use of potential dividers to control the voltage across a load*  *Determine the resistance of a material by making use of relevant data regarding its cross-section area, length and resistivity*  *Calculate the voltage distribution across a potential divider circuit* |
| ***Perspectives:***  *Why are there conservation laws (such as conservation of charge and energy) in Physics, how do they help us solve problems and how do they help keep nature in balance?*  *How realistic/helpful are assumptions made in theoretical physics such as that a material has ‘uniform resistance’ for practical applications?* | |
| ***Learning Activities***  **Activity 1:**  Title: Investigating the Output Voltage of a Potential Divider Circuit  **Objective:** To explore the relationship between the input voltage and the output voltage in a potential divider circuit.  **Materials:**  · Power supply or battery (with variable voltage control)  · Resistors of different resistance values (e.g., R1 = 100 ohms, R2 = 200 ohms)  · Multimeter or voltmeter  · Connecting wires  · Breadboard or circuit board  · Safety goggles (optional)  **Procedure:**  1. Set up the potential divider circuit on the breadboard or circuit board by connecting the resistors in series with each other.  2. Connect the positive terminal of the power supply or battery to one end of the series resistors.  3. Connect the negative terminal of the power supply or battery to the other end of the series resistors.  4. Measure and record the resistance values of each resistor (R1 and R2) using the multimeter.  5. Set the power supply or battery to a specific voltage value (e.g., 10 volts).  6. Use the multimeter or voltmeter to measure and record the output voltage (Vout) across one of the resistors (R2).  7. Repeat steps 5-6 for different voltage values (e.g., 6 volts, 8 volts, 12 volts) while keeping the resistance values constant.  8. Repeat steps 5-7, changing the resistance values (e.g., R1 = 200 ohms, R2 = 300 ohms) while keeping the voltage constant.  9. Tabulate the recorded voltage values for each combination of voltage and resistance.  10. Analyze the relationship between the input voltage, output voltage, and resistance values in the potential divider circuit.  **Questions:**  1. Define a potential divider circuit and explain its purpose in an electrical circuit.  2. Describe the setup used in this experiment to investigate the output voltage of a potential divider circuit.  3. What is the role of each resistor in the potential divider circuit? How does their arrangement affect the output voltage?  4. Discuss the concept of voltage division in a potential divider circuit and explain the mathematical relationship between the input voltage, resistance values, and output voltage.  5. Analyze the recorded voltage values for different input voltages while keeping the resistance values constant. Describe any patterns or trends observed.  6. Analyze the recorded voltage values for different resistance values while keeping the input voltage constant. Describe any patterns or trends observed.  7. Based on your observations, discuss how the resistance values in the potential divider circuit affect the output voltage. Provide examples to support your explanation.  8. Explain how the potential divider circuit can be used in practical applications. Provide at least two examples of its uses in electrical devices or circuits.  9. Discuss any limitations or potential sources of error in this experiment and suggest ways to improve its accuracy and reliability.  10. Explain the importance of understanding the concept of potential dividers in the context of electrical circuit design and analysis.  **Note:** The potential divider experiment aims to provide students with hands-on experience in understanding the relationship between input voltage, output voltage, and resistance values in a potential divider circuit. Encourage students to think critically about the experiment's outcomes and apply their knowledge to real-world applications.  **Activity 2:**  **Title:** Investigating the Output Voltage of a Potential Divider  **Objective:** To analyse the behaviour of a potential divider circuit and how the output voltage changes with different resistor values.  **Materials:**  · Power supply (DC voltage source)  · Two resistors of different resistance values (e.g., 1kΩ and 10kΩ)  · Breadboard or circuit board  · Connecting wires  · Multimeter (voltmeter mode)  · Safety goggles (optional)  **Procedure:**  1. Set up the potential divider circuit on the breadboard or circuit board. Connect the positive terminal of the power supply to one end of the circuit and the negative terminal to the other end.  2. Place the two resistors in series within the potential divider circuit. Connect the output terminal (junction between the two resistors) to the voltmeter.  3. Adjust the power supply to a specific voltage (e.g., 10V).  4. Use the multimeter in voltmeter mode to measure and record the output voltage (Vout) across the two resistors.  5. Note the resistance values of both resistors used in the circuit (R1 and R2).  **Questions:**  1. Define the potential divider circuit and explain its principle of operation in your own words.  2. Calculate the theoretical output voltage (Vout\_theoretical) using the formula: Vout\_theoretical = Vin × (R2 / (R1 + R2)), where Vin is the input voltage (power supply voltage), R1 is the resistance of the first resistor, and R2 is the resistance of the second resistor.  3. Compare the theoretical output voltage with the measured output voltage for each resistor combination. Discuss any differences observed and possible sources of error.  4. Analyze the relationship between the output voltage and the resistor values in the potential divider circuit. How does changing the resistor values affect the output voltage?  5. Investigate the concept of voltage division and explain how the potential divider circuit achieves it.  6. Suggest a way to increase the output voltage of the potential divider without changing the power supply voltage. Provide a theoretical explanation for your suggestion.  7. Experimentally determine the equivalent resistance (Req) of the two resistors in series using the formula: Req = R1 + R2. Compare the measured value of Req with the sum of the individual resistances.  8. Propose a practical application of the potential divider circuit and explain its significance in real-life electronic devices or systems.  **Note:** The potential divider circuit is a fundamental concept in electronics, and this experiment allows students to gain hands-on experience with voltage division and resistor behavior. Encourage students to discuss the theoretical and practical aspects of the potential divider circuit and its relevance in various electronic applications.  **Activity 3:**  **Title:** Investigating the Relationship Between Resistance Ratios and Voltage Output in a Potential Divider Circuit  **Objective:** To examine the effect of resistance ratios on the voltage output in a potential divider circuit.  **Materials:**  · Power supply  · Variable resistors (potentiometers)  · Resistors of different values (e.g., 1kΩ, 2kΩ, 5kΩ)  · Multimeter  · Connecting wires  · Breadboard or circuit board  **Procedure:**  1. Set up a potential divider circuit by connecting a power supply to a series circuit containing two resistors.  2. Choose a specific resistance value (e.g., 1kΩ) for one of the resistors and leave the other resistor variable.  3. Connect the voltmeter across the variable resistor to measure the voltage output (Vout).  4. Adjust the resistance of the variable resistor and record the corresponding voltage output.  5. Repeat steps 3-4 for two additional resistance values, changing the ratio between the fixed resistor and the variable resistor.  6. Calculate the resistance ratio (R1:R2) for each set of resistors.  7. Repeat the entire experiment using different resistance values to investigate the relationship between resistance ratios and voltage output.  **Questions:**  1. Explain the concept of a potential divider circuit and its function in an electrical circuit.  2. Describe the setup used in this experiment to investigate the relationship between resistance ratios and voltage output.  3. Analyze the effect of changing the resistance ratio (R1:R2) on the voltage output (Vout). How does the voltage output change with different resistance ratios?  4. Calculate the resistance ratio (R1:R2) for each set of resistors used in the experiment.  5. Plot a graph of the resistance ratio on the x-axis against the voltage output on the y-axis. Analyze the shape of the graph and draw conclusions about the relationship between resistance ratios and voltage output.  6. Discuss the practical applications of potential dividers in real-world scenarios.  7. Explain the concept of voltage division and how it applies to the potential divider circuit.  8. Discuss any sources of error or limitations in the experimental setup and suggest possible improvements to enhance accuracy.  9. Investigate the effect of changing the fixed resistor value while keeping the variable resistor constant. How does this affect the voltage output in the potential divider circuit?  **Note:** The potential divider experiment allows students to understand the principles of voltage division and the relationship between resistance ratios and voltage output. Students should focus on interpreting the experimental results, analyzing the data, and drawing meaningful conclusions based on their observations. Emphasize the practical applications of potential dividers in various electrical circuits.  **Activity 4:**  **Title:** Investigating the Relationship Between Resistance and Voltage in a Potential Divider Circuit  **Objective:** To explore the behaviour of a potential divider circuit and investigate the relationship between resistance and voltage.  **Materials:**  1. Power supply or battery (e.g., 9V battery)  2. Resistors of different values (e.g., 1kΩ, 2kΩ, and 4kΩ)  3. Breadboard or circuit board  4. Connecting wires  5. Multimeter or voltmeter  6. Safety goggles  **Procedure:**  1. Set up the circuit on the breadboard or circuit board by connecting the resistors in series. The positive terminal of the power supply or battery should be connected to the junction between the resistors, and the negative terminal should be connected to the ground.  2. Connect the multimeter or voltmeter in parallel across one of the resistors to measure the voltage across it.  3. Ensure all connections are secure and free from short circuits.  4. Turn on the power supply or connect the battery to energize the circuit.  5. Measure and record the voltage across each resistor using the multimeter or voltmeter.  6. Repeat steps 2-5 for the remaining resistors, ensuring consistency in the setup and connections.  7. Calculate the ratio of the voltage across each resistor to the total voltage supplied by the power source. Record the ratios for each resistor.  **Questions:**  1. Explain the concept of a potential divider circuit and how it is used to obtain a specific voltage output.  2. Describe the setup used in this experiment to investigate the relationship between resistance and voltage in a potential divider circuit.  3. Compare the measured voltages across the resistors. Analyze and discuss how the voltage across each resistor changes as the resistance increases.  4. Calculate the ratio of the voltage across each resistor to the total voltage supplied by the power source. Plot a graph of the resistance (x-axis) against the voltage ratio (y-axis). Analyze the relationship between resistance and voltage based on the graph.  5. Discuss the concept of voltage division in a potential divider circuit and how it relates to the resistance values used.  6. Explain the principle of proportionality between resistance and voltage in a potential divider circuit based on the experimental results.  7. Calculate the expected voltage across each resistor using the formula V = (R / R\_total) × V\_total, where V is the voltage across the resistor, R is the resistance of the resistor, R\_total is the total resistance of the circuit, and V\_total is the total voltage supplied by the power source. Compare the expected voltages with the measured values. Discuss any discrepancies observed.  8. Suggest modifications or variations to the experiment that could provide additional insights into the behavior of potential divider circuits.  **Note:** The potential divider experiment allows students to understand the relationship between resistance and voltage in a circuit. Emphasize the importance of accurate measurements and calculations to draw meaningful conclusions. Additionally, remind students to follow safety guidelines and ensure proper handling of electrical components. | |
| ***Materials needed:***  · Breadboard or circuit board  · Resistors (at least three different values)  · Potentiometer (variable resistor)  · Battery or power supply  · Connecting wires  · LED  · Multimeter (optional, for measurements)  ***Circuit Setup***  · Divide students into small groups and provide each group with the necessary materials.  · Instruct the groups to connect the battery or power supply to the breadboard.  · Guide them to set up a simple series circuit with two resistors in series and the potentiometer connected as the third resistor.  ***Predictions and Observations***  · Before proceeding, ask students to predict what will happen to the brightness of an LED (connected across the resistors) as they vary the potentiometer's resistance.  · Have the students rotate the knob of the potentiometer and observe the effect on the LED's brightness.  · Ask them to record their observations and compare them with their predictions.  ***Analysis and Discussions***  ***·***  Gather the students together and discuss their observations as a class.  · Explain the role of the potentiometer as a variable potential divider, and how changing its resistance affects the distribution of voltage across the resistors in the circuit.  · Discuss the relationship between the potentiometer's resistance and the brightness of the LED, as well as the impact on the current flowing through the circuit.   * ***Practical Applications***   Introduce practical applications of variable potential dividers in real-life devices, such as audio volume controls, light dimmers, and sensor calibration circuits.  Encourage students to think of other scenarios where variable potential dividers could be utilised for voltage control and adjustment.   * ***Activity***   For an extension activity, students can design more complex circuits that involve multiple potentiometers or experiment with different types of loads (e.g., motors, speakers) to see how the variable potential dividers affect them | |

## 

## Domain: Modern Physics Topic: Dark Matter

| ***Standard:***  Students will be able to:  - Describe the standard model of particle physics  - Analyse radioactive decay processes  - Explain the processes of nuclear fusion and fission  - Explain the postulates and implications of special relativity  - Use the quantum mechanical model of photons to explain phenomena  **Benchmark I:**  Describe and explain, with reference to broad qualitative ideas from relativity, quantum mechanics and particle physics:  (1) the structure of atoms and atomic nuclei  (2) the origin of radioactivity and its uses and hazards. | |
| --- | --- |
| ***Student Learning Outcomes***   * Describe that it is hypothesised that most of the matter in the universe is made up of dark matter * Explain the nature of the Sun [as a star of medium size it consists mostly of hydrogen and helium, and that it radiates most of its energy in the infrared, visible and ultraviolet regions of the electromagnetic spectrum] | |
| ***Knowledge:***  *Students will be able to…*  *Explain why there is a need to hypothesise the existence of dark matter* | ***Skills:***  *Students will be able to…*  *Suggest from provided simplified data and basic maps of galaxy clusters as to the presence of dark matter providing a source of gravity* |
| ***Perspectives:***  *If dark matter were experimentally discovered, what impact would that have on our understanding of the universe and would it potentially affect society on Earth?*  *What assumptions do astrophysicists make about the universe while conducting research, and on what basis do they justify those assumptions (e.g. that the distribution of matter across the universe is homogeneous in all directions from Earth)?* | |
| ***Learning Activities***  **Topic: Dark Matter Lab: Measuring Mass using Circular Motion**  An object moving at a constant speed in a circular path is accelerating (i.e., the direction of the velocity vector is constantly changing). This acceleration is caused by an unbalanced force acting towards the centre of the circle (centripetal force). Any change in the unbalanced force will produce a change in the orbital motion of the object.  **Predict:**  How will the speed of an orbiting body change as the applied force increases, if we keep the orbital radius constant?  **Materials**  Rubber stopper; 16 washers; string; stopwatch; glass or plastic tube; electronic balance; paper clip; unknown mass  **Procedure**  1.Measure and record the mass of (i) the stopper and (ii) all of the washers combined.  2.Your teacher will show you how to construct the apparatus.  3.Set the radius of revolution of the stopper between 40 and 80 cm by keeping the paper clip just below the bottom of the tube. Record the distance from the top of the tube to the middle of the stopper.  4.Attach eight washers to a second paper clip tied to the free end of the string. Spin the stopper in the horizontal plane, keeping the ﬁrst paper clip suspended just below the bottom of the tube. Once you have the stopper orbiting at a constantrate, record the time taken for 10 cycles.  5.Increase the number of washers by two, keeping the radius constant. Record the time for another 10 cycles. Repeat until you have results for at least ﬁve different masses.    **Application**  You are given an object of unknown mass. Follow the procedure described above and record the time taken for 10 cycles.    **Analysis**  1. Draw free-body diagrams for the washers and the stopper.  2. Use these free-body diagrams to derive an expression that relates *v*2 to *m*w. The angle between the string and the horizontal should be relatively small for all your results so it will be ignored in any calculations.  3. Use the geometry of a circular path to convert the period of motion to linear speed for the stopper.  4. Plot the square of the speed of the stopper *v*2 against the mass of the washers *m*w. Calculate the slope of the line (remembering to include the correct units).  5. Use the expression derived in Step 2 to give a physical interpretation for the slope of the plot of *v*2 against *m*w. Compare the slope calculated in Step 4 with the slope generated by your free-body diagram model in Step 2.  6. Use the results to calculate the unknown mass. Compare your answer to the value obtained using a balance.    **Questions**  1. Two students are spinning identical stoppers at equal orbital radii. One of the stoppers is moving noticeably faster than the  other. What can you infer about the number of washers attached to the faster stopper?  2. Earth orbits the Sun because of gravitational attraction. How could you use Earth’s orbital data to measure the mass of the Sun? Find the relevant data and calculate the Sun’s mass.  3. The Sun orbits the centre of the Milky Way galaxy at a radius of 8.33 kpc (1 parsec = 3.26 light years) and at a speed of 220 km/s. Determine the mass of the Milky Way contained within the Sun’s orbit.  4. Physicists estimate the mass of luminous matter in a galaxy by measuring the galaxy’s brightness. They have observed that stars within many galaxies orbit around their galactic centres at speeds higher than expected. Using ideas from this lab, give an explanation for these observations.  **Reference:** [**https://resources.perimeterinstitute.ca/**](https://resources.perimeterinstitute.ca/) | |

## 

# Domain: Mechanics

## Topic: Energy Conversions

| ***Standard:***  Students will be able to:   * Differentiate between different kinds of forces and their effects * Use Newton's laws to analyze motion and equilibrium * Analyze circular and rotational motion in terms of forces and momentum * Use the law of conservation of energy to analyze the viability and efficiency of systems   ***Benchmark II:*** *Describe and analyze the effects of forces and momentum on the translational and rotational motion of bodies in one dimension*  ***Benchmark IV:*** *Describe and analyze in one dimension, analytically and graphically, how forces can cause solids to stretch and compress* | |
| --- | --- |
| ***Student Learning Outcomes***   * Apply the principle of the conservation of momentum to solve simple problems in one dimension * Define resultant force in terms of momentum * Analyse the dynamics of an object reaching terminal velocity * Define and calculate impulse * Apply the principle of the conservation of momentum to solve simple problems in one dimension | |
| ***Knowledge:***  *Students will understand…*   * Terminal velocity is a kind of dynamic equilibrium in which the resistive force equals the weight * Changes in momentum can be used to predict the forces of collisions * Momentum in a system is conserved provided there are no external resultant forces applied   *Students will know…*   * The terms Momentum, Energy, Work and Torque. | ***Skills:***  *Students will be able to…*   * Use free body diagrams to determine the resultant forces and momentum * Calculate the resultant force on a system of objects by making using of the momentum formulation of Newton’s 2nd Law * Apply the law of conservation of momentum to situations involving collisions and explosions |
| ***Perspectives***   * Can substantial knowledge of physics help practitioners such as martial artists and sports players improve their crafts? * Why are quantities such as momentum, charge and energy conserved in the universe? * Is the universe deterministic i.e. can its future be predicted through Newtonian mechanics? | |
| ***Learning Activities***  **Conservation of Momentum**   1. The purpose of this activity is to apply the concepts learnt about the conservation of momentum. As a game, have students sit on chairs with wheels and have their legs raised so that they do not touch the ground. Give them instructions and let them figure how to use the law of conservation of momentum to carry them out: 2. If you are at rest, without touching the ground get yourself to move in a line (ans. The student can throw his/her bag away from him/herself in order to create a backwards thrust) 3. If you are moving in a line, get yourself to turn 90 degrees (ans. The student will need to throw something of appropriate mass in the direction to which he/she wants to turn) 4. If you are spinning about the axis of your chair, make yourself spin faster (ans. By either through something in a direction that is tangential and opposite to the motion, or by withdrawing one’s arms and legs close to the body; taking advantage of angular momentum conservation)   **Forces and Momentum in Martial Arts**  The purpose of this activity is to apply concepts of forces and momentum to understand martial arts techniques. Students should in groups research martial arts of their choice (see for example this [video](https://www.youtube.com/watch?v=lCm5WiHda-0) for how techniques are related to Physics), and study how the moves or weapons make use of concepts of forces and momentum to maximise their effectiveness. The groups should be ready to then present their findings, try to simulate the moves if safe, and explain using scientific language.  **Terminal Velocity**  The purpose of this activity is to practise applying knowledge of air resistance and terminal velocity. Students should design parachutes out of available materials such as paper or plastic bags. The challenge is to develop a parachute that will help a typical pen fall from a height of 3 metres (say from the window of a 2nd or 3rd floor of a building). They should first pilot their designs, and be able to justify why they chose their materials and the shape of their parachute in order to maximise air resistance.  **Car Crashes**  The purpose of this activity is to help students apply their concepts of forces and momentum to a real world context. Students should in groups research the data for what kind of injuries and what mechanism of collision is most common in car crashes. They should explain, in terms of inertia, momentum, forces and the position of the passengers in relation to the vehicle, how the physics agrees (or disagrees) with the data from research. Next they should present on what safety features and practices are most important for the top 5 most popular vehicles in their city. | |

## 

## B. Topic: Energy Conversions

| ***Standard:*** *Students will be able to:*   * *Differentiate between different kinds of forces and their effects* * *Use Newton's laws to analyze motion and equilibrium* * *Analyze circular and rotational motion in terms of forces and momentum* * *differentiate between work, energy and power* * *use the law of conservation of energy to analyze the viability and efficiency of systems* * *differentiate between and mathematically analyze kinetic and gravitational potential energy*   ***Benchmark II:*** *Describe and analyze the effects of forces and momentum on the translational and rotational motion of bodies in one dimension*  ***Benchmark III:*** *Describe and analyze the dynamics of rotational motion quantitatively and circular motion qualitatively in terms of forces in one dimension*  ***Benchmark V:*** *Describe and analyze the effects of energy transfers and energy transformations on a body, along with the advantages and disadvantages of harnessing energy from natural resources* | |
| --- | --- |
| ***Student Learning Outcomes***   * Define energy as the ability to do work * Use the formulas for kinetic and gravitational potential energy to solve problems involving simple energy conversions * Justify why perpetual energy machines do not work * State and apply the principle of the conservation of energy * Differentiate between and list renewable and non-renewable energy sources | |
| ***Knowledge:***  *Students will understand…*   * Different kinds of energy and their sources. * The conversion of energy between different forms in the context of the law of energy conservation. * That work done transforms into energy and vice versa, in accordance with the law of conservation of energy * The mechanisms of generation, along with the general pros and cons, of electricity from renewable and non-renewable resources   *Students will know…*   * The terms power, work, and frequency. | ***Skills:***  *Students will be able to…*   * Advocate, through use of knowledge of energy generation, in favour of green, sustainable energy. * Apply the law of conservation of energy to solve problems, and to disprove pseudo-scientific claims * Apply knowledge of methods of electrical power generation to assess the pros and cons of harnessing various energy sources in given geographical contexts |
| ***Perspectives***   * Politics of energy in today’s global economies and in the context of climate change * Political and environmental implications of nuclear weapons and nuclear energy * Modern ideas about mass- energy, including ‘strings’ and the Higgs Boson * Historical attempts to defy the classical law of conservation of energy * Philosophical views over modern non- classical notions of energy * Philosophical views over modern notions of dark matter and energy | |
| ***Learning Activities***   1. **Debunking Perpetual Energy Machines**   The purpose of this activity is to help students understand how to apply the law of conservation of energy to problems. Research and find memes from the internet that seem to contradict the law of conservation of energy. For example (retrieved from [here](https://i.stack.imgur.com/lbFah.jpg)):    Post these around the classroom and ask students to in pair walk around and brainstorm how they violate the law of conservation of energy. Have a whole-class discussion in which students then provide their justifications.  Conclusion: The magnet used here is a permanent magnet with fixed energy, if it pulls a machine its magnetic energy will convert into mechanical and hence its energy decreases which cannot move the car further.   1. **Pakistan’s Energy Future**   The purpose of this activity is to help students apply their knowledge of renewable and non-renewable energy to an authentic situation. Ask students in groups do a research project, where they need to:   1. Identify an energy sub-sector of Pakistan (e.g. solar energy) 2. Identify the pros and cons of investing further in that sub-sector of energy. They should be ready to express their arguments in terms of kilowatts, kilowatt hours and currency. 3. Suggest a plan for optimising the energy sub-sector, keeping in mind new advancements in sustainable energy technology as well as the prevailing politics around the issue   Have the groups present, but also build upon each other’s ideas and reflect on where they disagree with each other.  **3. Studying the Law of Conservation**  The purpose of this activity is to help students quantitatively verify the law of conservation of energy. Students can either work in groups or individually. Thru should drop balls from fixed heights (that are not so high as to make air resistance significant). The students should record the amplitude of the bounce of the ball after each bounce. If they are allowed cell phones with integrated cameras, they can use that to record videos of the motion. Ask them to justify through their experiment how the KE of the ball is largely being conserved. | |

# 

# Domain: Nature of Science

## Topic: Reasoning and Argumentation

| **Standard:**   * Students should be able to explain, with examples, what philosophical assumptions underpin the practice of science   **Benchmark I:** Students should able to:  - identify common sources of argumentative fallacies  - explain the broad schools of thought about the relationship between physics and metaphysics  - give examples of ethical dilemmas that emerge from research and practice of science  - explain the broad schools of thought about how science is distinguished from other fields of inquiry | |
| --- | --- |
| **Student Learning Outcomes**   * Explain, with examples in Physics, falsifiability as the idea that a theory is scientific only if it makes assertions that can be disproven * Illustrate, with examples of achievements made by scientists in both theoretical and experimental physics, that the 'scientific method' in practice is not a linear process that goes from hypothesis to theory to law | |
| * Explain how the below thought experiments helped convey important physics concepts that would have been impractical to investigate empirically:   (i) Einstein's teenager chasing a beam of light  (ii) Olber’s paradox (Night Sky paradox)   * Explain, with reference to the below examples, that a paradox is a statement that, despite apparently valid reasoning from true premises, leads to a seemingly self-contradictory or a logically unacceptable conclusion:   (i) The Grandfather paradox (ii) Achilles and the tortoise | |
| ***Knowledge:***  *Students will understand…*   * The components of logical arguments (propositions, premises, conclusions) * The reasons why common argumentative fallacies are not logically sound * The differences between deductive, inductive and abductive reasoning   *Students will know…*   * The terms fallacy, deduction, abduction, induction, propositions, premises, conclusions | ***Skills:***  *Students will be able to…*   * Deconstruct scientific arguments into propositions, premises, and conclusions * Identify, with justification, whether a given argument is deductive, inductive, abductive or a combination of them * Identify argumentative fallacies in a given text about science |
| ***Perspectives***   * In public scientific discourse, argumentative fallacies are often prevalent and can mislead society * Sound science requires sound arguments * All types of reasoning have pros and cons | |
| ***Learning Activities***   1. **False Advertising** The purpose of this activity is to help students recognise argumentative fallacies in authentic situations. Using an online video platform like YouTube, the instructor should screen commercials on products like toothpaste and soap, which often are backed by seemingly scientific arguments. Students should be put in teams, with each competing in a Buzzer Round quiz format. The team that buzzes first and gives the correct answer regarding the kinds of fallacies, with correct justifications for their answers, in the advertisement get the points. Here is an [example of argumentative fallacies in advertising](https://www.youtube.com/watch?v=65lWgXye1_M). 2. **Is the Earth Flat?**   The purpose of this activity is to help students understand the advantages and limitations of inductive, deductive and abductive reasoning. Have volunteers from the class opt to take part in a [parliamentary style debate](https://www.oxfordscholastica.com/blog/what-is-british-parliamentary-style-debate/). One team should argue that the Earth is flat (they will provide the opening arguments), and the other team will then try to argue that the Earth is round. The teams should be allowed time to prepare their arguments in advance, and each speaker should have a fixed amount of time. After the debate, the class should identify by creating a mindmap of the arguments of both sides of the teams when deductive, abductive and inductive logic being used, and how convincing the arguments were and why.   1. **Proof of a Physics Equation**   The purpose of this activity is to help students distinguish between inductive, deductive and abductive arguments. Ask students to work in pairs to derive the formula for gravitational potential energy (GPE = mgh), and then identify:   * What are your initial assumptions/premises? * Do your initial assumptions require further arguments to justify? How would you justify them? * What is your claim? * What are your arguments?   Through these above questions students should be able to identify what elements of their argument they would categorise as inductive, deductive or abductive. These should be discussed and debated in a whole-class discussion.   1. **Climate Change Fallacies**   The purpose of this activity is to help students recognise argumentative fallacies in authentic situations. The [below arguments against climate change](https://www.wwf.org.uk/updates/here-are-10-myths-about-climate-change) should be put up on chart papers around the classroom (one argument per chart paper). Students should counter the arguments after doing their research (from the internet or through their books). They should write their counterclaims on sticky notes, and identify what is the argumentative fallacy behind each of the climate denial claims. These sticky notes should then be posted on the corresponding chart papers, and then the students should examine each other’s answers.  MYTH 1. THE EARTH’S CLIMATE HAS ALWAYS CHANGED  MYTH 2. PLANTS NEED CARBON DIOXIDE  MYTH 3. GLOBAL WARMING ISN'T REAL AS IT'S STILL COLD  MYTH 4. CLIMATE CHANGE IS A FUTURE PROBLEM  MYTH 5. RENEWABLE ENERGY IS JUST A MONEY-MAKING SCHEME  MYTH 6. POLAR BEAR NUMBERS ARE INCREASING  MYTH 7. RENEWABLE ENERGY CAN ONLY WORK WHEN IT'S NOT CLOUDY OR WINDY  MYTH 8. ANIMALS WILL ADAPT TO CLIMATE CHANGE  MYTH 9. GETTING RID OF HUMANS WILL FIX THIS | |
| **Case Study Review**  **Case 1:**  **Einstein's Theory of General Relativity (Theoretical Physics)**   * Observations: Discrepancies in the orbit of Mercury and the constant speed of light (observed in the Michelson-Morley experiment). * Hypotheses: Einstein hypothesised that space and time were interwoven into a single continuum known as space-time, and that gravity was a result of an object's mass causing a curvature in this space-time. * Experiment/Analysis: Einstein did not conduct a physical experiment, but used mathematical calculations to test his hypotheses, demonstrating the non-linear path of the scientific method. * Theory: His hypotheses led to the formulation of the theory of General Relativity, which was later confirmed by Eddington's 1919 solar eclipse experiment.   **Case 2:**  **The Discovery of the Higgs Boson (Experimental Physics)**   * Observations: Certain particles had mass, but the mechanism of how they attained it was unclear. * Hypotheses: Peter Higgs and other scientists hypothesised the existence of a field (the Higgs field) that would interact with particles to give them mass. * Experiment/Analysis: Decades later, scientists at CERN conducted experiments using the Large Hadron Collider to search for evidence of the Higgs field by trying to detect the Higgs boson, a particle associated with the field. * Theory/Law: After many experimental runs and data analyses, the Higgs boson was finally discovered in 2012, confirming the hypotheses put forth in the 1960s and leading to a significant update of the Standard Model of Particle Physics.   **Interactive Discussion**   * In this segment, students should actively discuss the non-linearity of the scientific method illustrated in the case studies. They should recognize that hypotheses can lead to theory development without physical experiments, as seen in the General Relativity case. Also, they should understand that experiments can take decades to confirm a hypothesis, as with the Higgs Boson case.     **Summary and Reflection**   * The instructor will conclude the activity by summarising the key takeaways regarding the nonlinear nature of the scientific method. This includes the understanding that the process can loop back and forth between stages and that the development of a theory does not require its subsequent evolution into a law. | |
| **Title:** Develop understanding of the Linear & non-Linear process in Scientific Investigation  In scientific investigation, a non-linear process refers to an approach that does not follow a strict, sequential pattern or a straight line from beginning to end. Unlike a linear process, where one step follows the next in a logical and orderly manner, a non-linear process might involve revisiting previous stages, making iterative changes, and allowing for flexibility and adaptation.  **Case Studies of Non-linear Scientific Discoveries:**   1. **Development of Medications:** The process of drug development often involves an iterative, non-linear approach. Researchers might go back and forth between laboratory studies, clinical trials, and even marketing phases, learning and adapting the process as new information becomes available.   **Thought-Provoking Question:** How might the non-linear nature of drug development impact the efficiency and effectiveness of bringing a new medication to market?   1. **Climate Change Research:** Understanding climate change requires a multidisciplinary, non-linear approach. It involves constantly updating models and predictions based on new data from various fields such as meteorology, oceanography, geology, and biology.   **Thought-Provoking Question:** How does the complexity and non-linear process of climate change research affect our ability to make precise predictions and take effective action?   1. **The discovery of radioactivity:** Describe how Marie Curie's accidental findings while investigating uranium led to the discovery of radioactivity and a profound shift in the understanding of atomic structure.   Marie Curie's investigation into uranium led her to accidentally discover radioactivity, a finding that prompted a profound shift in the understanding of atomic structure. Analyze how this discovery represents a non-linear process in scientific research. Consider how Curie's initial hypotheses, the unexpected observations, the iterative experimentation, and the ultimate reinterpretation of atomic theory contribute to this non-linear progression. How did this non-linear approach pave the way for further discoveries and technological advancements in nuclear physics?  **Instruction for Teachers:**   * While doing activities with students, Encourage them to embrace curiosity, open-mindedness, and critical thinking in their scientific explorations. * Teachers can challenge students to design their own experiments on different topics or phenomena, allowing them to experience the iterative nature of the scientific method firsthand. They can present their findings and reflect on any revisions or adjustments made to their hypotheses during the process. This work will further solidify their understanding of how the scientific method evolves and adapts through experimentation and observation. | |

# GRADE 11-12

# Domain: Mechanics

## Topic: Projectile Motion

| ***Standard: Students will be able to:***   * Differentiate between and mathematically manipulate scalar and vector quantities * Describe and analytically and graphically analyze distance, displacement, speed, velocity, and acceleration * Differentiate between different kinds of forces and their effects * Use Newton's laws to analyze motion and equilibrium * Analyze circular and rotational motion in terms of forces and momentum * differentiate between work, energy and power * use the law of conservation of energy to analyze the viability and efficiency of systems * differentiate between and mathematically analyze kinetic and gravitational potential energy   **Benchmark II**: Explain events in terms of Newton’s laws, including the Law of Gravitation, and the law of conservation of momentum in up to two dimensions  **Benchmark V**: Describe and analyze analytically and graphically the effects of energy transfers and energy transformations on a body | |
| --- | --- |
| ***Student Learning Outcomes***   * Predict qualitatively how air resistance affects projectile motion * Evaluate and analyse projectile motion in the absence of air resistance | |
| ***Knowledge:***  *Students will be able to…*  *State the equations of uniform motion*  *Explain that projectile motion can be broken up into separate vertical and horizontal components*  *Explain the concepts of range, domain, launch angle, and time of flight*  *Recall that air resistance decelerates motion and acts opposite to the direction of resultant motion* | ***Skills:***  *Students will be able to…*  *Solve problems on projectile motion by resolving forces, velocities and displacements into x and y components and using the equations of motion*  *Sketch and analyse velocity-time and displacement-time graphs of projectile motion*  *Qualitatively predict how projectile motion in a given scenario will be affected by the introduction of resistive forces* |
| ***Perspectives:***  ***Newton’s Cannonball thought experiment***  ‘What is motion’ and ‘what causes motion’ remain philosophically interesting problems e.g. Xeno’s paradox, Achille’s Tortoise paradox, and Al Ghazali’s explanation for burning fire  Engineering ever-more precice rockets and missiles with larger range and maximum flight remains an active area of research today | |
| **Learning Activities**  **Activity 1:**  **Aim:** To investigate the projectile motion of a launched object.  **Apparatus:**  1. A launcher with adjustable angle  2. A set of steel balls  3. A measuring tape  4. A protractor  5. Safety goggles  6. Graph paper  7. Stopwatch  **Procedure:**  1. Set up the launcher on a flat surface and adjust the angle to 45 degrees using the protractor.  2. Measure the distance between the launcher and the target point using the measuring tape and record it as "d".  3. Put on the safety goggles to protect your eyes.  4. Load a steel ball into the launcher.  5. Launch the ball and start the stopwatch simultaneously.  6. Observe the ball's trajectory and record the time it takes for the ball to hit the ground as "t".  7. Repeat steps 4-6 for two more trials.  8. Use the measuring tape to measure the maximum height reached by the ball during its flight and record it as "h".  9. Use the graph paper to sketch the trajectory of the ball for each trial, marking the launch point, the highest point, and the point of impact.  10. Calculate the average time of flight (T) by summing up the times for each trial and dividing by the number of trials.  11. Calculate the average horizontal range (R) by multiplying the average time of flight (T) by the initial horizontal velocity (v₀).  12. Calculate the average initial vertical velocity (v₀y) using the formula v₀y = h / (T/2).  13. Calculate the average initial horizontal velocity (v₀x) using the formula  v₀x = R / T.  **Analysis:**   * Plot a graph of the ball's horizontal distance (x-axis) against the time of flight (y-axis) for each trial. Draw the best-fit line and determine its slope. * Calculate the average acceleration of the ball using the formula a = 2d / T². * Calculate the average initial velocity of the ball using the formula v₀ = (d - 0.5aT²) / T. * Compare the calculated values of v₀x and v₀y with the initial velocity of the ball obtained from the launcher's specifications. Comment on the consistency of the results. * Discuss any sources of error and suggest improvements to the experiment.   **Conclusion:** Provide a conclusion based on your observations and calculations, summarizing the key findings of the experiment, and relating them to the principles of projectile motion.  **Activity2:**  **Title:** Projectile Motion - Determining the Launch Angle  **Objective:** To investigate the relationship between the launch angle and the range of a projectile.  **Materials**:  1. Projectile launcher (spring-loaded launcher)  2. Range scale (marked in meters)  3. Protractor (angle measurement tool)  4. Tape measure  5. Table or flat surface  6. Safety goggles  **Procedure**  1. Set up the projectile launcher on a flat surface or table, ensuring that it is stable and secure.  2. Put on safety goggles to protect your eyes during the experiment.  3. Measure and record the height of the tabletop from the ground (H) using a tape measure.  4. Set the projectile launcher to the maximum power setting.  5. Choose five different launch angles (θ1, θ2, θ3, θ4, θ5) for the projectile, such as 15°, 30°, 45°, 60°, and 75°.  6. Launch the projectile at each angle, making sure the launcher is pointed away from any obstructions or people. Take extra caution during launch.  7. Measure and record the horizontal distance (range) traveled by the projectile for each angle (d1, d2, d3, d4, d5) using the range scale.  8. Repeat steps 4-7 for a total of three trials for each angle to ensure accuracy and consistency of data.  9. Calculate the average range (d\_avg) for each launch angle.  10. Plot a graph of launch angle (x-axis) against average range (y-axis).  **Activity3:**  **Title:** Investigating the Relationship Between Launch Angle and Projectile Range  **Objective:** To explore how the launch angle affects the range of a projectile.  **Materials:**  1. Projectile launcher (e.g., a slingshot or a catapult)  2. Projectile (e.g., a small ball or a rubber ball)  3. Measuring tape or measuring device  4. Stopwatch or timer  5. Safety goggles (optional)    **Procedure:**  1. Set up the projectile launcher on a flat surface, ensuring it is stable and securely positioned.  2. Measure and record the height of the launcher from the ground as the reference point for measuring the range.  3. Choose a specific launch angle (e.g., 30 degrees) and set the launcher to that angle using a protractor or angle indicator.  4. Load the projectile into the launcher, making sure it is positioned correctly and securely.  5. Aim the launcher horizontally and activate the launching mechanism to release the projectile.  6. Use the measuring tape or measuring device to measure and record the horizontal distance traveled by the projectile as the range.  7. Repeat steps 3-6 for two additional launch angles (e.g., 45 degrees and 60 degrees) to investigate how the launch angle affects the projectile's range.  **Activity 4:**  **Title:** Investigating the Range of Projectile Motion  **Objective:** To explore the factors influencing the range of a projectile in a controlled experiment.  **Materials:**  1. Launcher (e.g., a spring-loaded launcher or a rubber band launcher)  2. Balls of different masses (e.g., tennis balls, table tennis balls, or marbles)  3. Meter ruler or measuring tape  4. Protractor  5. Stopwatch or timer  6. Flat surface or open field (outdoor location with ample space)  **Procedure:**  1. Set up the launcher on a flat surface or open field with enough space for the projectile to travel freely.    2. Measure and record the height (H) of the launcher from the ground.  3. Choose one type of ball and measure its mass (m) using a scale or balance. Record the mass.  4. Adjust the angle of the launcher to a specific value (e.g., 30 degrees) and keep it fixed throughout the experiment.  5. Load the chosen ball onto the launcher, aiming it at the predetermined angle.  6. Launch the ball and use the stopwatch or timer to measure the time of flight from the launch to the landing point.  7. Measure and record the horizontal distance (range) traveled by the ball from the launcher to the landing point.  8. Repeat steps 5-7 for a total of three trials to ensure accuracy and consistency of data.  9. Repeat the entire experiment, changing the angle of the launcher to two additional values (e.g., 45 degrees and 60 degrees) and using the same ball for all angles.  10. Repeat steps 3-9 for each type of ball to investigate how different masses affect the range of the projectile.  **Questions:**  1. Define projectile motion in your own words and explain the factors that influence the path of a projectile.  2. Based on the experimental setup, describe the initial conditions under which the projectile is launched and the forces acting on it during its flight.  3. Compare the ranges obtained for the same ball at different angles. Analyze the relationship between the angle of projection and the range.  4. Plot a graph of the range on the y-axis against the angle of projection on the x-axis. Analyze the shape of the graph and draw conclusions about the optimum angle for maximum range.  5. Compare the ranges obtained for different balls of various masses. Discuss the impact of mass on the projectile's range.  6. Calculate the average range for each angle and ball type based on the three trials. Compare and analyze the average ranges.  7. Discuss the effect of air resistance on the projectile's motion and its potential impact on the experimental results.  8. Suggest improvements to the experiment that would enhance its accuracy and reliability.  9. Investigate the concept of vertical motion during projectile motion. Explain how the vertical and horizontal components of motion are related.  **Note:** The projectile motion experiment provides an opportunity for students to explore the concepts of range, angle of projection, and the factors affecting the motion of a projectile. Emphasize the importance of conducting multiple trials and recording accurate data to draw meaningful conclusions from the experiment. | |

# Domain: Heat and Thermodynamics

## Topic: Degeneration of matter

| ***Standard:***  Students should be able to describe and analyse:   * the effects of heat on the physical properties of matter by making reference to the kinetic theory of matter * how heat can be transferred through different modes   **Benchmark I:**  Use the kinetic theory of matter to account for the properties of an ideal gas | |
| --- | --- |
| ***Student Learning Outcomes***   * State that under extreme physical conditions, atoms can break down into sub-atomic particles that can form unusual states of matter * Illustrate that the model of ideal gases is used as a base from which the field of statistical mechanics emerged * Derive and use the formula for the average translational kinetic energy of a gas * Explain qualitatively, in terms of particles, the relationship between the pressure, temperature and volume of a gas | |
| ***Knowledge:***  *Students will be able to…*  *Describe the factors that affect whether a material is a good or poor absorber and emitter of heat*  *Give examples of unusual states of matter*  *Recall the effects of temperature on expansion of matter*  *Use the kinetic theory of ideal gases to explain the properties of ideal gases* | ***Skills:***  *Students will be able to…*  *Distinguish between good and bad absorbers and emitters of heat radiation*  *Suggest in scenarios where matter is subject to extreme physical conditions (such as high temperature), it may degenerate and have different physical properties*  *Use the ideal gas equation to solve problems* |
| ***Perspectives:***  *Extreme physical conditions can help uncover more fundamental physical relationships between matter and energy*  *To enable discoveries in outer space, engineers and physicists are working to develop materials and technology that can withstand ever more extreme physical conditions*  *Statistical mathematical modelling of matter can help us predict its properties under various physical conditions, and help us research objects such as stars and the Earth’s core*  *Whether the physical world can be best understood through logic and reason (such as through mathematical modelling) or through experiments (such as through exposing matter to extreme conditions) is a debate with a long philosophical history, going back to Aristotle vs Plato on rationalism vs empiricism* | |
| **Title:** Exploring Extreme Conditions: DIY Particle Collisions  **Objective:** To understand how extreme physical conditions can lead to the breakdown of atoms into sub-atomic particles and explore the formation of unusual states of matter through hands-on activity.  **Materials:**   * Table tennis balls or small plastic balls (representing atoms) * Rubber bands or small elastic bands (representing strong forces within the atoms) * Plastic gloves (to ensure cleanliness and safety) * Safety goggles (optional but recommended for eye protection) * Open space (e.g., classroom floor or a clear area)   **Preparing the "Atoms":**   * Divide the class into small groups and provide each group with a set of table tennis balls and rubber bands. * Instruct the students to wear plastic gloves and safety goggles for safety reasons. * Demonstrate to the students how to assemble the "atoms" by connecting the table tennis balls with rubber bands. Explain that the rubber bands represent the strong forces within the atoms.   **Simulating Extreme Physical Conditions:**   * Explain that the students will now simulate extreme physical conditions to observe the breakdown of atoms. * Instruct the groups to hold their "atoms" tightly and apply increasing pressure by squeezing them together. * Ask the students to observe and describe what happens to the "atoms" under extreme pressure.   **Forming Unusual States of Matter:**   * Guide the students to continue applying pressure until the "atoms" begin to break down into sub-atomic particles. * Discuss the changes observed as the "atoms" transform into unusual states of matter (e.g., plasma-like structures).   **Reflection and Discussion:**   * After the activity, gather the students and facilitate a discussion about their observations and the significance of the activity. Part of this discussion should be students suggesting what are the limitations of modelling atoms as table tennis balls. * Encourage students to relate their observations to real-life phenomena and applications in science and technology. | |
| **Title: Gas Pressure and Temperature Relationship**  **Material:**  · Large syringe (without the needle)  · Small container of hot water  · Small container of cold water  · Thermometer  · Stopwatch or timer  · Rubber gloves (optional, for safety)    **Procedure:**  **1.Setup:**   * Fill the syringe with air by pulling the plunger fully out and then pushing it back in to fill the syringe with air. * Make sure the syringe is clean and dry.   **2.Initial Measurements:**   * Push the plunger of the syringe all the way in to compress the air. * Note the initial volume reading on the syringe scale. * Measure and record the initial temperature of the room.   **3.Baseline Pressure Measurements:**   * While keeping the syringe plunger compressed, note the pressure reading on the syringe. * You can estimate this pressure by using the force needed to keep the plunger compressed.   **4.Hot Water Bath:**   * Place the syringe in the container of hot water, ensuring the plunger remains compressed. * Wait for about 2-3 minutes to allow the air inside the syringe to reach the temperature of the water.   **5.Hot Water Bath:**   * Place the syringe in the container of cold water, still keeping the plunger compressed. * Wait for about 2-3 minutes again to allow the air inside the syringe to reach the temperature of the water.     **6. Pressure Measurements:**   * After each water bath, note the pressure reading on the syringe while keeping the plunger compressed. b. Estimate the pressure similarly to the baseline measurement.   **Observation and Analysis:**  **1.Volume and Pressure:**  Compare the initial, hot water, and cold water pressure readings for the compressed air in the syringe. How does the pressure change with temperature?  **2.Temperature and Kinetic Energy:**  According to the kinetic theory of gases, how does temperature affect the average kinetic energy of gas molecules?  **3.Gas Behavior:**  How can you explain the changes in pressure observed in the syringe using the kinetic theory of gases? How do the gas molecules behave at different temperatures?  **4.Gas laws:**  How does this experiment relate to the ideal gas law (PV = nRT)?  Can you interpret the changes in pressure as the temperature changes in terms of the ideal gas law?  **Conclusion:**  Summarize your observations and findings from the experiment. Discuss how the results support the kinetic theory of gases and the relationship between temperature, kinetic energy, and pressure. Reflect on any potential sources of error or limitations in the experiment and suggest improvements for a more accurate investigation.  **Ideal Gas Law:**  As a reinforcement activity, teachers can assign research projects where students investigate the differences between ideal gases and real gases. They can explore deviations from ideal behaviour under different conditions and how these deviations are accounted for in various scenarios. This work will allow students to delve deeper into the topic and understand the limitations of the ideal gas law. | |
| **Title:** Exploring Statistical Mechanics through the Ideal Gas Model  **Materials:**   * Balloons (preferably transparent or semi-transparent) * Air pump or compressed air source * Small beads or balls (representing gas particles) * Transparent container (e.g., a clear plastic box or glass container) * Ruler or measuring tape * Thermometer   **Preparing the "Gas"**   * Divide the students into small groups. * Distribute balloons, small beads (representing gas particles), and the transparent container to each group. * Each group should fill their balloons with air using the air pump or compressed air source until the balloons are inflated but not too tight. Also, put some small beads to each balloon. * Instruct the students to place the inflated balloons inside the transparent container.   **Macroscopic Observables**   * Have students measure the volume (V) of the container using a ruler or measuring tape. * Record the temperature (T) of the room using a thermometer. * Discuss with the students how these macroscopic observables (V and T) can be related to the ideal gas model.   **Microscopic Behaviour**   * Instruct the students to gently shake the container to observe the motion of the small beads (representing gas particles) inside the balloons. * Encourage the students to discuss and draw connections between the macroscopic observables and the microscopic behaviour of the gas particles.   **Statistical Mechanics**   * Introduce the concept of statistical mechanics as a way to bridge the gap between macroscopic and microscopic behaviour. * Explain how statistical mechanics uses the principles of probability and statistics to derive macroscopic properties from the behaviour of individual particles. | |

## 

# Domain: Modern Physics

## Topic: Luminosity

| **Standard:** Students will be able to:   * Describe the standard model of particle physics * Analyse radioactive decay processes * Explain the processes of nuclear fusion and fission * Explain the postulates and implications of special relativity * Use the quantum mechanical model of photons to explain phenomena   **Benchmark I**: Explain and apply knowledge of the basic inter-related postulates of and discoveries from:  (1) the special theory of relativity  (2) the standard model of particle physics  (3) quantum theory  **Benchmark II:** Describe and explain, with reference to broad qualitative ideas from relativity, quantum mechanics and particle physics:  (1) the structure of atoms and atomic nuclei  (2) the origin of radioactivity and its uses and hazards. | |
| --- | --- |
| ***Student Learning Outcomes***   * Apply the inverse square law for radiant flux intensity [ F in terms of the luminosity L of the source ] * Explain the term luminosity [ as the total power of radiation emitted by a star] * Explain blackbody radiation and apply Wien’s displacement law to solve problems * Apply the Stefan–Boltzmann law to solve problems [ L = to solve problems] * Estimate the radius of a star | |
| ***Knowledge:***  *Students will know…*   * The terms Luminosity, Flux and Standard Candles. * What kind of objects serve as standard candles and how we can estimate distances using them.   *Students will understand…*   * How to relate the Luminosity of a star with its radius and surface temperature. * Wien’s Law and the inverse relation between wavelength emitted and the temperature of a surface. * The relation between Blackbody radiation and the radiation intensity of the light emitted by stars. | ***Skills:***  *Students will be able to…*   * Apply the equations of the Stephen-Boltzmann and Wein’s Displacement laws to determine properties like distances to galaxies and the physical properties of stars * Apply the concept of redshift to critically appraise data from emission and absorption spectra of interstellar objects |
| ***Perspectives***   * There have been many paradigm shifts in models of the universe. For example, Why was it so counter- intuitive to believe that the Earth was not the centre of the universe? Consider:   + Ptolemy to Copernicus   + Arab, Indian and Chinese historical astronomical beliefs   + Tycho Brahe, Galileo and the Church | |
| ***Learning Activities***  **Origins of the Stephen-Boltzmann Law and Wien's Displacement Law**  After learning and becoming comfortable with using these laws, students should investigate the origins of their formulation. The Stephen-Boltzmann law was analytically formulated through combining Statistical Mechanics, Quantum Physics and Thermodynamics. It was also first empirically discovered. Similarly Wien's displacement law has an inter-field origin with formulations both theoretical and empirically confirmed. After researching this for themselves, students should have a reflective discussion on:   * How classical reasoning (pre quantum mechanics) can often agree with later quantum mechanical derivations up to certain physical parameters * There is beauty in how different mathematical constants can interrelate with each other in equations to entail new discoveries * Often equations in physics can be derived from more one line of argument and reasoning   **What Would We Look Like to Them?**  As a perspective and awe building exercise, students should identify their favourite stars and calculate how someone at that star would see the Earth as being millions or billions of years in the past. They could calculate the luminosity of the Sun and judge whether life on Earth would be viewable to a hypothetical observer near their favourite state. Students could also identify the constellations in the night sky, and put time stamps on how far back in time the light that we on Earth receive from them. This could lead to a discussion on whether those stars would still actually be there now, and realisation of the dramatic age difference between the constellations seen in the sky.  **Explore the work of some scientist on Luminosity**  The purpose of this activity is to bring attention of students towards the work of any Nobel laureate, who made major contributions to the properties of stars. A group of students should be asked to research his life and accomplishments, and share their findings with the rest of the class as a presentation. | |

## Topic: Quantum Physics

| **Standard: Students will be able to:**  **-** Describe the standard model of particle physics  - Analyze radioactive decay processes  - Explain the processes of nuclear fusion and fission  - Explain the postulates and implications of special relativity  - Use the quantum mechanical model of photons to explain phenomena  **Benchmark I:** Explain and apply knowledge of the basic inter-related postulates of and discoveries from:  (1) the special theory of relativity  (2) the standard model of particle physics  (3) quantum theory  **Benchmark II:** Describe and explain, with reference to broad qualitative ideas from relativity, quantum mechanics and particle physics:  (1) the structure of atoms and atomic nuclei  (2) the origin of radioactivity and its uses and hazards. | |
| --- | --- |
| ***Student Learning Outcomes***   * state that electromagnetic radiation has a particulate nature * Explain and apply the photonic model of light to solve problem [use to solve problems, and use the electronvolt (eV) as a unit of energy] * describe the significance of Einstein’s assumption of the constancy of the speed of light. * State the postulates of Special relativity * Explain qualitatively and quantitatively the consequences of special relativity [Specifically in the case of:   a– the relativity of simultaneity.  b– the equivalence between mass and energy.  c– length contraction.  d– time dilation.  e– mass increase] | |
| ***Knowledge:***  *Students will understand…*   * The particle nature of light and photons as quanta of light. * The wave-particle duality for matter and energy. * Distinct experiments that prove the wave and matter nature of light.   *Students will know…*   * The terms: Photoelectric effect, Compton’s Scattering, Pair Production, de Broglie Wavelength, and Emission and Absorption Spectra * How electron microscopes use the wave nature of electrons to provide higher precision than light microscopes. | ***Skills:***  *Students will be able to…*   * Apply Plank’s law to determine the energy of photons of different frequencies. * Interpret energy differences between lasers/lights of different colours. * Interpret the double-slit experiments and posit and demonstrate various different scenarios of the experiment. * Use the uncertainty principle to propose the maximum theoretical precision with which a phenomenon can be studied * Calculate the de Broglie wavelength of macroscopic objects and compare them with microscopic objects. |
| ***Perspectives***   * Historical notions of the nature of light, including luminous ether, corpuscles, Newton’s wave model, Huygen’s constructs, and De Broglie’s wave- particle duality * Is light a wave or a particle or a ‘wavicle’? * Schrodinger’s Cat, the uncertainty principle and the quantum mechanical picture of the electron cloud around an atom * How has cause and effect in the context of motion been conceived historically? Consider:   + Ancient conceptions of cause and effect such as Aristotle's   + Al Ghazali, Galileo and Newton   + The paradigm shift from classical to quantum thinking | |
| ***Learning Activities***  **The Past and Present of Light**  The purpose of this activity is to help students put the knowledge they have gained of light’s dual nature into context. In this activity, students will be divided into groups and will present on various paradigms throughout history (after researching them) about the nature of light e.g. the outdated concept of aether, and the historical swaying back and forth between being viewed as a particle or as a wave. One group of students should present on what is still not known about the nature of light.  **Quantum World situation**  Students should, in groups, work to develop a comic strip story of someone who has imaginarily shrunk down to the size of a subatomic particle, and through the illustrations convey their understanding of how different things are at the quantum level compared to human size. (Teacher may refer some story, video or kids movie about such situation)  **Flipping the Classroom on Compton Scattering**  The purpose of this activity is to encourage students to apply their concepts of quantum physics to new scenarios as they do their own research. After being introduced to the idea of Compton Scattering, a group of students should be challenged to present to the class on its medical usage. The group of students presenting should pay special regards to its applications to detecting cancer.  **Discovering With the Electron Microscope**  The purpose of this activity is to help students appreciate the power of the electron microscope. Students should be tasked with each finding an inspiring or interesting image of the nanoworld that has been taken with an electron microscope. They should each, in Show and Tell style, present briefly what they found and explain how the unprecedented precision of the electron microscope makes it possible. They should also explain (they should research before) how electron microscope images are then processed by computers and coloured in. | |
| **Title:** Visualising Special Relativity Postulates  **Materials:**   * Two toy cars or carts with wheels * Measuring tape or ruler * Stopwatch or timer * Large open space (e.g., a hallway or a classroom with cleared desks) * Whiteboard or blackboard * Markers or chalk     **First Postulate: Principle of Relativity:**   * Divide the class into small groups and provide each group with a toy car or cart. * Instruct the groups to measure the length of their toy cars using a ruler or measuring tape and record it as "L."   **Simultaneous Movement:**   * Have each group position their toy car at the same starting point on a straight path in the large open space. * Instruct the students to start their timers simultaneously and push their toy cars forward at a constant speed for a fixed time interval (e.g., 10 seconds). * Ask each group to measure the distance their toy car covered during the time interval and record it as "d."   **Discussion:**   * Gather the groups and ask them to share their data on the board. * Lead a class discussion on how all the toy cars moved at constant speeds relative to each other and covered different distances ("d") depending on their initial velocities. * Explain that this observation supports the principle of relativity, which states that the laws of physics are the same for all observers moving at a constant velocity relative to one another.   **Second Postulate: Speed of Light:**   * Introduce the concept of the speed of light being constant in all inertial reference frames, regardless of the observer's motion. * Ask the students to imagine a scenario where they observe a light source emitting a beam of light horizontally while standing still and then observe the same light source while moving at a constant speed in a cart or car. * Have a discussion about how, according to the second postulate of special relativity, all observers will measure the speed of light to be the same value "c" (approximately 299,792,458 m/s) regardless of their motion.   **Visual Representation:**  Use the whiteboard or blackboard to draw diagrams and represent the postulates of special relativity, explaining the concept of time dilation and length contraction. | |
| **Explore, Research & Discussion:**  Teachers can assign a research project where students delve deeper into the broader contributions of Al-Ghazali to Islamic philosophy and theology. They can explore how his ideas influenced subsequent scholars and the impact of his writings on the development of science and philosophy in the Islamic world. This activity will provide a more comprehensive understanding of Al-Ghazali's intellectual legacy.  **Reflective Writing:**   * Ask students to individually write a short reflective essay or response to the following questions: a. How did Al-Ghazali attempt to reconcile the ideas of philosophers and theologians regarding cause and effect in motion? b. What aspects of Al-Ghazali's perspective do you find most interesting or relevant to contemporary discussions in science and philosophy? * Encourage critical thinking and open discussion among the groups, allowing them to compare and contrast Al-Ghazali's perspective with the viewpoints of philosophers and theologians. | |

# Domain: Waves

## Topic: Standing Waves

| **Standard:**  Students should be able to  ● mathematically describe how waves propagate and the general properties of reflection, refraction and diffraction  ● explain how the wave theory of light can help explain various optical phenomena  **Benchmark I:** Analytically and graphically explain the nature and effects of simple harmonic motion, the doppler effect, and attenuation of sound wave intensity in media  **Benchmark II:** Use wave theory to analyse diffraction patterns, interference and polarisation in the context of light and sound and other waves | |
| --- | --- |
| ***Student Learning Outcomes***   * explain and use the principle of superposition * understand how wavelength may be determined from the positions of nodes or antinodes of a stationary wave * show an understanding of experiments that demonstrate diffraction including the qualitative effect of the gap width relative to the wavelength of the wave; for example diffraction of water waves in a ripple tank * understand the terms interference and coherence * explain beats as the pulsation caused by two waves of similar frequencies interfering with each other * recognise that beats are generated in musical instruments | |
| ***Knowledge:***  *Students will understand…*   * The mathematical description of waves in terms of amplitude, wavelength, frequency and phase * The difference between nodes and antinodes * Standing waves are generated through the superposition of two or more component waves * Diffraction is the spreading of a wave through an aperture and depends on the wavelength and the aperture width * Waves can interfere and the extent of interference depends on coherence, phase difference and amplitude * Beats are a pulsations caused by two waves of slightly different frequency interfering with each other   *Students will know…*   * The terms: Interference, Diffraction, Beats, and Stationary Waves. | ***Skills:***  *Students will be able to…*   * Construct and interpret graphs of oscillatory disturbances (for both travelling and standing waves) with respect to time and with respect to displacement from the source * Apply general wave theory to interpret natural phenomena produced by various kinds of longitudinal and transverse waves * Use the principle of superposition to recognise beats in wave forms * Use the principle of superposition to construct standing waves from component waves and vice versa * Imagine the real-world applications of waves in the industry, military, businesses etc. |
| ***Perspectives***   * Implications of waves for wars, surveillance and technological advancement of society in the last century * Debates about recent advancements in the understanding of waves, including wave- particle duality and gravitational waves, and how they help answer fundamental questions about the very tiny, and the distant edges of the universe * Should we implement promising technology if we do not know all of its potential implications for our health and the environment? * Should we alert potential aliens to our existence on Earth? | |
| ***Learning Activities***  **Rubens Tube**  The purpose of this activity is to help students visually appreciate how standing waves are generated, and how to study their properties empirically.. A group of students can be given the challenge of [creating a Rubens Tube;](https://www.instructables.com/How-to-make-a-Rubens-Tube/) this a pipe with equally spaced holes in it. Gas is made to pass through one end of the pipe, and the other end of the tube is kept closed. The gas escapes through the holes, and these can be set alight with a lighter or matchstick. By sending sound waves of the correct frequency through the tube, [the flame columns oscillate as a standing wave is produced](https://www.youtube.com/watch?v=HpovwbPGEoo) in the tube. By then passing music and various controlled frequencies, the behaviour of standing waves can be studied.  **Chladni Plate**  The purpose of this activity is to help students visually appreciate how standing waves are generated, and how to study their properties empirically. A Chladni Plate is simply a membrane with grains on it e.g. of rice, that sits on top of a sound speaker. As sound of the right frequency is produced, the Chladni Plate goes into resonance and this causes the grains to shape up into regular 3D patterns. Students can [create their Chladni Plates](https://www.instructables.com/Easy-Chladni-Plate/) as a project, and then research the properties of sound waves through them.  **Resonance in Musical Instruments**  The purpose of this activity is to help students visualise how resonance occurs in musical instruments. Students can choose any musical instrument of their choice, and then video record the resonance occurring (whether that is in a string or on a membrane). The video should ideally be recorded in slow motion so that the harmonic vibrations and beats can be easily seen. Students should take videos for each of the musical notes of the instrument and then present to the classroom their findings; inferring the relationship between resonance and the different musical notes.  **Resonance of Non-Newtonian Fluid (e.g. ketchup) on a Speaker**  The purpose of this activity is to help students visualise how resonance occurs in musical instruments. [Place a non-Newtonian fluid on the cone of a sound speaker,](https://www.facebook.com/watch/?v=1261297427236683) and slowly increase the frequency signal sent to the speaker. The fluid will begin to rise in resonance, and this provides a interesting 3D visual to studying resonance. | |

# 

# 

# Lesson Plans on Conducting Experiments in the Lab

| **Physics Experiment – Grade 09** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Subject:** Physics | | **Level:** Grade 09 | | Topic: Principle of Moments | |
| **Practical:** To verify the 2nd condition of equilibrium by using a metre rod. | | | | | |
| **Name of teacher:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | **Duration:** 85 min. | |
| **Objectives**  By the end of this lab students will be able to;   * Understand the concept of moments * Demonstrate the effect of increasing and decreasing the moment arm * Understand equilibrium and its types * Use the principle of moments to solve for an unknown variable * Differentiate between mass and weight * Take steps to avoid parallax error * Understand the importance of multiple readings to average out errors * Verifying results by theoretical calculations | | | | | |
| **Materials and Apparatus** | | | | | |
| * 1-5 kg weights * Wooden metre rule or rod * apparatus stand * wooden wedge * string or thread | | | * a small metal cube * an irregular uniform object | | |
| **Methodology**  **Introduction:**   1. Introduction to the practical: The teacher will begin the lesson by asking the students to recall moment or torque and its formula. The teacher will lead the discussion by asking what would make a ruler or rod pivoted at a wedge stay horizontal. Answer: equilibrium through principle of moments. 2. The teacher will discuss equilibrium with the students and the conditions required for equilibrium. The teacher can ask what types of equilibrium are achieved when a ruler is balanced on a wedge. 3. Demonstration: The teacher will perform a demonstration of balancing a ruler or rod on a wedge by fixing a weight on one side and adjusting the weights on the other side. 4. Discussion: The students will discuss the clockwise and counterclockwise moments acting on the ruler. Are they equal? 5. Objective: The teacher will explain the objective of the experiment, which is to use the principle of moments to determine the mass of an unknown object by balancing it on a metre rod.   **Main Activity:**   1. Materials: The teacher will provide each group with a set of materials, including a rod or ruler, a wedge, a weight box, a cube of unknown weight, and string. 2. Procedure: The teacher will ask the students to attach the unknown weight on one side of the rule and, using loops of strings, tie the known weight on the other side. Move the weight around until the ruler is balanced and stable. Measure the distances from the pivot or centre of rotation. The teacher will ask the students to reattach the unknown weight to another part of the ruler/rod and adjust the known weight(s) to balance the ruler/rod. Take the readings again. Repeat again. 3. Discussion: As the students are setting up the experiment, the teacher will ask questions to encourage critical thinking and discussion. They may ask how the mass of the object can be calculated theoretically, what information about the object do they need to calculate that mass. Answer: volume and density. 4. Analysis: Once the students have completed three repetitions of the experiment and have taken all the readings, the teacher can ask which equation will be used to calculate the mass of the unknown object.  Important note: this will be the time to discuss the difference between the mass and weight of the object. The teacher will ask the students to calculate the mass based on each of the three repetitions. They will discuss why the mass is slightly different for each calculation and why multiple iterations are required in practical experiments. They will discuss why taking an average is an important aspect of experimental readings and procedures. 5. Homework: the teacher will tell the students the density of the object and its volume. The students have to calculate its mass and research what material it is made of.   **Wrap-up:**   1. Conclusion: The teacher will ask the students to share their findings and discuss what they learned. They will summarise the main concepts of the experiment, including the difference between mass and weight, how increasing or decreasing the moment arm affects the moment or rotation. 2. Applications: The teacher will discuss how this method is used to calculate the mass or weight of objects in a balance scale. The teacher will also discuss other examples of moments and why it is important to consider it during any sort of construction by discussing cantilever bridges and balconies etc. 3. Clean-up: The students will clean up their workstations, dispose of any materials according to safety procedures, and return any equipment to the teacher. | | | | | **Duration and Resources**  15 minutes  05 Minutes  25 Minutes  15 Minutes  15 Minutes  10 Minutes |
| **Assessment** | Students will be assessed based on their participation in the experiment and their ability to accurately determine the mass of the object.  Students will be asked to write a short reflection on the experiment, highlighting the areas where there could be errors that lead to different readings in each repetition. | | | | |
| **Extensions** | The students can verify the density of the unknown object by submerging it in water in a beaker, measuring the displaced water, and calculating the density based on the experimentally determined mass. Using this information, the students can identify what the object is by cross-referencing against a list of materials and their densities. | | | | |
| **Teacher’s Reflections** | | | | | |
| What went as planned? | | | What needs Improvements? | | |

| **Physics Experiment – Grade 10** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Subject:** Physics | | **Level:** Grade 10 | | Topic: Specific Heat Capacity | |
| **Practical: To verify that different species have different specific heat capacities.** | | | | | |
| **Name of teacher:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | **Duration:** 85 min. | |
| **Objectives**  By the end of this lab students will be able to;   * Understand the concept of specific heat capacity of a substance * Demonstrate the comparatively large specific heat capacity of water * Understand that melting or freezing pauses change in temperature until the process is completed * Understand how specific heat capacity changes in mixtures * Take steps to avoid parallax error * Verifying results by theoretical calculations * Draw straight lines of best fit or curves to show the trend of a graph | | | | | |
| **Materials and Apparatus** | | | | | |
| * Polystyrene cups with lids and stirrers * Thermometers * Ice * Water * salt | | | * Ethanol * Stopwatch * Electronic balance | | |
| **Methodology**  **Introduction:**   1. Introduction to the practical: The teacher will begin the lesson by asking the students to recall the definition of specific heat capacity and its formula. The teacher will lead the discussion by asking about the comparative specific heat capacity of water and whether it is likely to be greater than the specific heat capacity of ethanol. Answer: water has a relatively large specific heat capacity. 2. The teacher will discuss what happens to its temperature when a substance is changing state and why it is possible to have a mixture of ice and water maintain a constant temperature until all the ice has melted. 3. Demonstration: The teacher will demonstrate how to move liquids from one cup to another and quickly cover the cup with the lid to minimise heat loss to the environment. 4. Discussion: The students will discuss whether water, salt water, or ethanol will have the lowest temperature after it is mixed with cold water from the mixture of ice and water. Are they equal? 5. Objective: The teacher will explain the objective of the experiment, which is to determine the specific heat capacity of water, salt water, and ethanol.   **Main Activity:**   1. Materials: The teacher will provide each group with a set of materials, including polystyrene cups with lids and stirrers, a stopwatch, and thermometers. Also provided to the class will be a cooler of water mixed with ice (to keep at 0 degrees Centigrade), a beaker/bucket filled with salt water, and a bottle filled with ethanol. 2. Procedure: Each group has to maintain and oversee, and measure temperatures of 6 cups: 2 each of water, salt water, and ethanol. Students will fill 2 cups each with water, salt water, and ethanol and measure the mass of the liquids using an electronic balance (will need to subtract mass of cup and lid). In each of the cups the students will add a measured mass of ice water (make sure no ice is added) and start the stopwatch. The students will record the temperature of each cup after every 5 minutes until thermal equilibrium is reached. 3. Discussion: As the students are setting up the experiment, the teacher will ask questions to encourage critical thinking and discussion. They may ask (i) why it is important that no pieces of ice are added to the cups, (ii) at which steps of the experiment there is the greatest possibility of exchanging heat with the surroundings, (iii) why it is important to prevent that. 4. Analysis: Once thermal equilibrium has been achieved in all the cups, the students will take the average of the readings of the two cups of each substance. Students will then plot and draw the graphs of temperature against time for each substance. They will note when the graph flattens and what this means.  The students will use the given specific heat capacity of water to calculate the heat capacity of ethanol and saltwater. Do the results match their initial hypothesis of water having a larger heat capacity? What effect does adding salt to water have on its heat capacity?   **Wrap-up:**   1. Conclusion: The teacher will ask the students to share their findings and discuss what they learned. They will summarize the main concepts of the experiment, including the difference between specific heat capacities of water, saltwater, and ethanol. They will explain why equilibrium temperatures of the three substances are different from each other. 2. Applications: The teacher will discuss how the relatively large specific heat capacity of water is utilised by humans and its effects in nature. They will discuss how adding or removing salt from water can change its specific heat capacity and why it changes. 3. Clean-up: The students will clean up their workstations, dispose of any materials according to safety procedures, and return any equipment to the teacher. | | | | | **Duration and Resources**  15 minutes  05 Minutes  25 Minutes  15 Minutes  15 Minutes  10 Minutes |
| **Assessment** | Students will be assessed based on their participation in the experiment and their ability to create accurate plots of temperature vs time. They will also be assessed on the value of *c* of ethanol.  Students will be asked to write a short reflection on the experiment, highlighting the areas where there could be errors that lead to different readings in each repetition. | | | | |
| **Extensions** | The students can take a beaker of ice water, put it above a bunsen burner, and measure its temperature against time. They can verify that the temperature does not rise until all of the ice is melted, thus verifying that the heat energy provided to the ice water is first all used up to melt the ice (latent heat of fusion) before the temperature, of the now liquid water, begins to rise. | | | | |
| **Teacher’s Reflections** | | | | | |
| What went as planned? | | | What needs Improvements? | | |

| **Physics Experiment – Grade 11** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Subject:** Physics | **Level:** Grade 11 | | | Topic: Resistance of a Wire | | |
| **Practical: To verify that resistance of a wire depends upon various factors.** | | | | | | |
| **Name of teacher:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | **Duration:** 85 min. | |
| **Objectives**  By the end of this lab students will be able to;   * Understand the concept of resistance * Understand the resistance in a piece of wire * Demonstrate that resistance is directly proportional to the length of the wire * Understand the working of an ohmmeter * Learn to set up apparatus correctly without assistance from a supervisor * Express the uncertainty in a measurement as an absolute or percentage uncertainty, and translate between these forms * Draw straight lines of best fit or curves to show the trend of a graph | | | | | | |
| **Materials and Apparatus** | | | | | | |
| * Wires * Ohmmeter * Wires of varying diameters * Crocodile clips | | | * Wire cutters * Micrometer | | | |
| **Methodology**  **Introduction:**   1. Introduction to the practical: The teacher will begin the lesson by asking the students to recall the definition of resistance and its formula. The teacher will lead the discussion by asking the students whether conducting wires themselves have any resistance and the factors that affect this resistance. *Answer: temperature, length, diameter or cross-sectional area*. 2. The teacher will discuss what happens to the flow of current through wires of the same material but different lengths and diameters. What role the resistivity of a material plays in this relationship. Why keeping temperature constant is important. 3. Demonstration: The teacher will demonstrate how to (i) connect the given electrical components together: the wire to be investigated and the ohmmeter using crocodile clips, (ii) cut a wire safely and with appropriate precautions, (iii) how to use a micrometer to measure the diameter of a wire. 4. Discussion: The students will discuss the implications of temperature changes in conduction of wires. Also the implications of energy losses in wires, starting from extensions up to the power supply chain for our homes and industry. 5. Objective: The teacher will explain the objective of the experiment, which is to determine the effect in overall resistance of a wire based on its length and cross-sectional area.   **Main Activity:**   1. Materials: The teacher will provide each group with a set of electrical components, including the items mentioned above. . 2. Procedure: Each group has to cut the wires of different diameters in equal lengths. After each of the wires of different diameters is cut, they need to measure and record their diameters. Then the wires are to be connected to the ohmmeter and the readings need to be recorded. 3. Discussion: As the students are setting up the experiment, the teacher will ask questions to encourage critical thinking and discussion. They may ask (i) why it is important that there is no considerable difference in temperature when carrying out the experiment with the different wires, (ii) at which step(s) of the experiment an uncertainty is introduced into the readings , (iii) why it is important to acknowledge and calculate uncertainty in an experiment’s findings. 4. Analysis: Once the students have taken the readings of the resistance of each piece of wire and noted them against the measured diameters of the wires, they will begin the analytical calculations. First, the students need to find the absolute uncertainty in the diameter of the wires according to the limitations of the micrometer screw gauge. Then they need to calculate the cross-sectional area of the wires and their uncertainties. They need to look at the equation of resistivity of a wire and determine what to keep on the x and y axis so that there is a straight line. The gradient of the graph will provide an expression through which the value of *resistivity (rho)* can be calculated.   **Wrap-up:**   1. Conclusion: The teacher will ask the students to share their findings and discuss what they learned. They will summarize the main concepts of the experiment, including the relationship of diameter and cross-sectional area of a wire with its resistance. 2. Applications: The teacher will discuss how the diameters of wires for different purposes is chosen in a way to minimise resistance and energy loss. The teacher will discuss why it is inefficient to transport electricity from far off power stations and how it wastes energy. 3. Clean-up: The students will clean up their workstations, dispose of any materials according to safety procedures, and return any equipment to the teacher. | | | | | | **Duration and Resources**  25 minutes  25 Minutes  15 Minutes  15 Minutes |
| **Assessment** | | Students will be assessed based on their participation in the experiment and their ability to create accurate plots of resistance vs inverse of area. They will also be assessed on the value of *resistivity(rho)* calculated by the students from the gradient of their graphs.  Students will be asked to write a short reflection on the experiment, highlighting the areas where there could be errors that lead to different readings in each repetition. | | | | |
| **Extensions** | | The students can take a wire of constant diameter and cut it in different lengths to gauge the relationship between length and resistance of a wire. The same can be done by measuring resistance at room temperature and then in a room with very high temperature or very low temperature, to gauge the effect of temperature on resistivity of a wire/material. | | | | |
| **Teacher’s Reflections** | | | | | | |
| **What went as planned?** | | | **What needs Improvements?** | | | |

| **Physics Experiment – Grade 12** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Subject:** Physics | **Level:** Grade 12 | | | Topic: Capacitors and Capacitance | | |
| **Practical:**   * To find the capacitance of a capacitor. * To verify charging and discharging of capacitors. * To verify that capacitors can store charge. | | | | | | |
| **Name of teacher:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | Duration: 85 min. | |
| **Objectives**  By the end of this lab students will be able to;   * Understand the concept of capacitors and capacitance * Understand that capacitors store electrical energy that is used up when the capacitor is discharged * Demonstrate that the electrical energy stored in a capacitor is a function of capacitance and voltage * Design the set up of an experiment involving circuit components * Learn to set up apparatus correctly without assistance from a supervisor * Express the uncertainty in a measurement as an absolute or percentage uncertainty, and translate between these forms * Identify the usage of a CRO and its applications | | | | | | |
| **Materials and Apparatus** | | | | | | |
| * Capacitor * Resistors with known resistances * Voltmeter * Ammeter * Adjustable power supply with a switch * Wires | | | * Crocodile clips * Circuit board | | | |
| **Methodology**  **Introduction:**   1. Introduction to the practical: The teacher will begin the lesson by asking the students to recall the working of capacitors and the definition of capacitance. Discuss how capacitors save energy and that energy is discharged. 2. Objective of the practical: The teacher will explain to the students that they have been provided with the given materials and they need to (i)find the capacitance of the capacitor (ii) investigate experimentally the curve of discharge of the capacitor against time (iii) the effect of increasing or decreasing resistance on the discharge curve (iv) calculate the energy stored in the capacitor.   **Main Activity:**   1. Materials: The teacher will provide each group with a set of electrical components, including the items mentioned above. 2. Procedure: The teacher will divide the students into groups and have them create a circuit diagram of their proposed set up and advise corrections. Once the design has been approved, the students will set up the equipment and begin taking readings and doing calculations. They will be encouraged to pursue efficiency and assign tasks to group members appropriately according to their strengths. 3. Discussion: As the students are setting up the experiment, the teacher will ask questions to encourage critical thinking and discussion. They may ask (i) why it is important to get multiple readings, (ii) at which step(s) of the experiment an uncertainty is introduced into the readings , (iii) why it is important to acknowledge and calculate uncertainty in an experiment’s findings, (iv) what role will the CRO have in this experiment. 4. Analysis: Once the students have taken the readings from the ammeter and voltmeter and recorded the discharge of the capacitor against time with the use of CROs, they will begin calculating uncertainties and then the potential energy stored in the capacitor and its percentage uncertainty. The students will then analyse their graphs with the discharge of the capacitor against difference resistances and compare them. They will analyse the relationship between resistance and capacitance and calculate the time constant for each set up.   **Wrap-up:**   1. Conclusion: The teacher will ask the students to share their findings and discuss what they learned. They will summarize the main concepts of the experiment, including the difference in discharge rates of the capacitor through different resistors/resistances. 2. Applications: The teacher will discuss how capacitors are used to create that smooth discharge curve to protect equipment from sudden surge and loss of power. They will discuss why capacitors are important in this regard and ask students what other applications they can have based on their properties examined in this experiment. 3. Clean-up: The students will clean up their workstations, dispose of any materials according to safety procedures, and return any equipment to the teacher. | | | | | | **Duration and Resources**  25 minutes  25 Minutes  15 Minutes  15 Minutes |
| **Assessment** | | Students will be assessed based on their participation in the experiment and their ability to design appropriate setups for the experiment. They will be assessed on the corresponding calculations identified by the students to achieve the desired investigation of the experiment. The accuracy of their results and the comparative analyses of the graphs and its implications will also be evaluated. | | | | |
| **Extensions** | |  | | | | |
| **Teacher’s Reflections** | | | | | | |
| **What went as planned?** | | | **What needs Improvements?** | | | |

# List of Practical for Grade 9

1. Analyze the motion of a supported copper wire.
2. Explore the equilibrium of a system of three identical springs.
3. A student examines the rate of cooling, in air, of heated blocks made of different metals.
4. Considering the temperature rise of water in beakers heated by different methods.
5. Inspection of electromagnets.
6. Perform and analyze into how the strength of an electromagnet depends on the number of coils of wire.
7. Investigation of a ‘puzzle box’ containing a single electrical component connected between the terminals A and B. The box is sealed and the component inside is hidden.
8. Perform and consider that the frequency of vibration depends on the length of the string.
9. Using the circuit study how the potential difference V across a resistance wire depends upon its length x.
10. Review the effect of the size of the air gap on the rate of cooling of hot water.
11. A student measures the resistance R of a lamp for different values of the potential difference V across it.
12. Determines the acceleration of free-fall by timing the oscillations of a pendulum.
13. Use a ray box to investigate the refraction of a ray of red light as it passes through a semi-circular glass block.
14. Measure the density of a sample of modelling clay.
15. How to measure the refractive index of oil.
16. To determine the area of cross-section by measuring the diameter of a solid cylinder with Vernier Callipers.
17. To determine the volume of a solid cylinder by measuring length and diameter of a solid cylinder with Vernier callipers.
18. To measure the thickness of a metal strip or a wire by using a micrometre screw gauge.
19. To find the acceleration of a ball rolling down an inclined angle iron by drawing a graph between 2 s and t2.
20. To find the value of “g” by free fall method (using electronic timer).
21. To determine the value of “g” by a wood's machine.
22. To determine the resultant of two forces graphically using a horizontal force table.
23. To find the weight of an unknown object by using vector addition of forces.
24. To verify the principle of moments by using a metre rod balanced on a wedge.
25. To find the weight of an unknown object by using principle of moments.
26. To find the density of a liquid using a plastic medical syringe (instead of density bottle).
27. To study the relationship between load and extension (helical spring) by drawing a graph.
28. Verify the two conditions of equilibrium using a suspended metre rod.

# List of Practical for Grade 10

1. Investigating whether the type of container affects the time taken for water to be heated from room temperature to boiling point.
2. Investigate how the resistance of a lamp varies with the current in it.
3. Measure the volume V of the glass prism by displacement method.
4. Measure the frequency and peak voltage of an a.c. supply by using cathode-ray oscilloscope (CRO).
5. Measures the time T for one oscillation of the chain of paper-clips.
6. Measure the terminal velocity of a metal sphere falling through oil.
7. Using a long vertical wire passing through a horizontal white card show the shape of the magnetic field around the wire.
8. Inspect the distance travelled by a block of wood along a bench when the block is fired by a rubber band.
9. Compare the combined resistance of lamps arranged either in series or in parallel.
10. Determine the focal length of a lens and its relationship with the thickness.
11. Exploring the insulation around a container affects the rate at which water cools.
12. Study the Effect of voltage on the combined resistance of lamps arranged either in series or in parallel.
13. Determine the spring constant k of a spring by two methods.
14. Determine the refractive index n of the material of a transparent block.
15. In this experiment, you will investigate combinations of resistors in an electrical circuit.
16. A student is investigating the factors that affect the size of the crater (hole) a ball makes when it is dropped into sand.
17. To find the specific heat by the method of mixture using polystyrene cups (used as containers of negligible heat capacity).
18. To draw a graph between temperature and time when ice is converted into  
     water and then to steam by slow heating.
19. To measure the specific heat of fusion of ice using polystyrene cups as calorimeters.
20. To verify the laws of refraction by using a glass slab.
21. To find the refractive index of water by using a concave mirror.
22. To determine the critical angle of glass using a semicircular slab and a light ray box or by prism.
23. To trace the path of a ray of light through a glass prism and measure the angle of deviation.
24. To find the focal length of a convex lens by parallax method.
25. To set up a microscope and telescope.
26. Verify ohm’s law (using wire as conductor).
27. To study resistors in series circuits.
28. To study resistors in parallel circuits.
29. To find the resistance of the galvanometer by half deflection method.
30. To trace the magnetic field using a bar magnet.
31. To trace the magnetic field due to a current carrying circular coil.
32. To make a burglar alarm / fire alarm using an appropriate gate.

# List of Practical for Grade 11

1. Design an experiment to study the relationship between the diameter of the wire and the resistance.
2. Design an experiment to study the relationship between the length of the wire and the resistance.
3. Design a laboratory experiment to test the relationship between f (frequency) and V (voltage)while considering simple harmonic motion using an electric vibrator.
4. Two students are having a discussion about an experiment in which the air inside a bell jar is gradually removed. The sound of a ringing bell inside the jar is heard to decrease in intensity during this process.
5. A student is investigating the heating of metal blocks immersed in water.
6. In this experiment you will consider the motion of a sphere launched from a ramp.
7. A student is reviewing how the extension e of an elastic cord depends on the diameter d of the cord when a force is applied.
8. A student is exploring monochromatic light passing through a double slit. Bright and dark fringes are produced on a screen.
9. A student is studying the force between two charged metal spheres.
10. A student is examining monochromatic light passing through a diffraction grating.
11. Study the current in a coil
12. Explore the stationary sound waves in a cylindrical tube which is open at both ends.
13. Inspect the discharge of a capacitor in the circuit.
14. Review the current in a coil and a resistor connected in series.
15. Examine the vertical oscillations of a solid cylinder floating in cooking oil.
16. To find the density of a body heavier than water by archimedes principle.
17. Measure length and diameter of a solid cylinder and hence estimate its volume quoting proper number of significant figures using Vernier callipers.
18. Measure the diameters of a few ball bearings of different sizes using Screw Gauge and estimate their volumes. Mention the uncertainty in each result.
19. Determine the radius of curvature of convex lens and a concave lens using a spherometer
20. Determine the weight of a body by vector addition of forces.
21. Measure the free fall time of a ball using a ticker-timer and hence calculate the value of ‘g’. Evaluate your result and identify the source of error and suggest improvements.
22. Investigate the value of ‘g’ by free fall method using electronic timer
23. Investigate momentum conservation by colliding trolleys and ticker-timers for elastic and inelastic collisions.
24. Investigate the downward force, along an inclined plane, acting on a roller due to gravity and study its relationship with the angle of inclination by plotting a graph between force and sinθ.
25. Determine the moment of inertia of a flywheel.
26. Investigate the fall of spherical steel balls through a viscous medium and determine. (i) terminal velocity (ii) coefficient of viscosity of the fluid
27. Verify that the time period of the simple pendulum is directly proportional to the square root of its length and hence find the value of ‘g’ from the graph.
28. Determine the acceleration due to gravity by oscillating the mass-spring system.
29. Determine the value of ‘g’ by vibrating a metal lamina suspending from different points.
30. Determination of frequency of A.C by Melde’s apparatus / electric sonometer.
31. Investigation of the laws of vibration of stretched strings by sonometer or electromagnetic method.
32. Measure the diameter of a wire or hair using a laser.
33. Measure the mechanical equivalent of heat by electric method.
34. Determine the specific heat of a solid by electrical method.
35. Determine Young’s modulus of the material of a given wire using Searle’s apparatus.
36. Determine emf of a cell using potentiometer.
37. Determine the emf and internal resistance of a cell by plotting V against I graph.
38. Investigate the relationship between current passing through a tungsten filament lamp and the potential applied across it.
39. Convert a galvanometer into voltmeter of range 0 – 3 V.
40. Determine internal resistance of a cell using potentiometer.

# List of Practical for Grade 12

1. Variation of magnetic field along the axis of a circular coil.
2. Charging and discharging of a capacitor and measuring the time constant.
3. Relationship between current and capacitance when different capacitors are used in a.c circuit.
4. Characteristics of a semiconductor diode and calculation of forward and reverse current resistance.
5. Characteristics of a N.P.N. transistor.
6. Study of the variation of electric current with intensity of light using a photocell.
7. To make the burglar alarm using logic gates.
8. Investigate the amount of air needed to lift an underwater load.
9. Investigate stationary wave patterns.
10. Investigate the oscillations of a magnet.
11. Investigate a potential divider circuit.
12. Investigate the result of a collision between two cylinders.
13. Investigate the bending of a rod under a compressive force.
14. Investigates how the spring constant k varies with A.
15. Investigate stationary waves with an elastic cord of circular cross-section attached to a load.Also investigates how f varies with the cross-sectional area A of the cord**.**
16. To study the effect of the length of a simple pendulum on time and hence find “g” by calculation.
17. To prove that time period of a simple pendulum is independent of:
    * 1. Mass of the pendulum
      2. Amplitude of the vibration.
18. Determine the pick count of a nylon mesh by using a diffraction grating and a laser.
19. Determine the wavelength of sound in air using stationary waves and to calculate the speed of sound using resonance tube.
20. Determine the wavelength of light by using a diffraction grating and spectrometer.
21. Determine the slit separation of a diffraction grating by using laser light of unknown wavelength.
22. Determine time constant by charging and discharging a capacitor through a resistor.
23. Determine resistance of wire by slide Wire Bridge.
24. Determine resistance of voltmeter by drawing graph between R and I/V.
25. Determine resistance of voltmeter by discharging a capacitor through it.
26. Analyse the variation of resistance of thermistor with temperature. - 10
27. Determine the relation between current and capacitance when different capacitors are used in an AC circuit using different series and parallel combinations of capacitors.
28. Determine the impedance of a RL circuit at 50Hz and hence find inductance.
29. Determine the impedance of a RC circuit at 50Hz and hence find capacitance.
30. Draw characteristics of semiconductor diode and calculate forward and reverse current resistances.
31. Study the half and full wave rectification by semiconductor diodes by displaying on CRO
32. Study of the variation of electric current with intensity of light using a photocell.
33. Determine Planck’s constant using internal potential barrier of different light emitting diodes.
34. Observe the line spectrum of mercury with diffraction grating and spectrometer to determine the wavelength of several different lines, and hence, draw a conclusion about the width of visible spectrum.
35. Using a set of at least 100 dice, simulate the radioactive decay of nuclei and measure the simulated half-life of the nuclei.
36. Determine the amount of background radiation in your surrounding and identify their possible sources.