

topics of physics class 11

Understanding the foundational concepts of physics is crucial for students embarking on their higher secondary education. The topics of physics class 11 lay the groundwork for a deeper understanding of the physical world, covering a vast array of phenomena from the microscopic to the macroscopic. This comprehensive guide will navigate through the essential units and subtopics typically encountered, exploring mechanics, thermodynamics, waves, optics, and electricity. By delving into these areas, students will develop analytical skills, problem-solving abilities, and a newfound appreciation for the elegant laws governing our universe. Prepare to explore the building blocks of physics that will shape your scientific journey.

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Introduction to Physics and Measurement

Embarking on your journey through the **topics of physics class 11** inevitably begins with understanding what physics is and how we quantify the physical world. Physics, at its core, is the scientific study of matter, its fundamental constituents, its motion and behavior through space and time, and the related entities of energy and force. It's about asking "why" and "how" things happen around us, from the falling of an apple to the orbits of planets. This introductory unit not only defines the scope of physics but also introduces the indispensable tools for scientific investigation: measurement and units.

Precise measurement is the bedrock of all scientific progress. Without accurate ways to quantify physical quantities, it would be impossible to formulate theories or verify them experimentally. This section delves into the importance of physical quantities, distinguishing between fundamental and derived quantities. Fundamental quantities, like length, mass, and time, are independent, while derived quantities, such as velocity or force, are expressed in terms of fundamental ones. Understanding this distinction is key to grasping the interconnectedness of physical concepts.

Physical Quantities and Units

We'll explore the various systems of units used in physics, with a strong emphasis on the International System of Units (SI). SI units provide a standardized and globally recognized framework for measurements, ensuring consistency and facilitating scientific communication. You'll learn about the seven base SI units: meter (m) for length, kilogram (kg) for mass, second (s) for time, ampere (A) for electric current, kelvin (K) for thermodynamic temperature, mole (mol) for amount of substance, and candela (cd) for luminous intensity.

Dimensions and Dimensional Analysis

A powerful tool in the physicist's arsenal is dimensional analysis. This technique involves analyzing the dimensions of physical quantities to derive relationships between them or to check the consistency of physical equations. Understanding dimensions allows us to see how different physical quantities relate to each other through their fundamental units (M for mass, L for length, T for time, etc.). For example, the dimension of velocity is $[L][T]^{-1}$, while the dimension of acceleration is $[L][T]^{-2}$.

Errors in Measurement

No measurement is perfect; there will always be some degree of uncertainty. This subtopic focuses on understanding and quantifying these errors. We'll differentiate between systematic errors, which consistently affect measurements in the same direction, and random errors, which vary unpredictably. Learning about concepts like absolute error, relative error, and percentage error is vital for evaluating the reliability of experimental data and understanding the limitations of our measurements.

Motion in One, Two, and Three Dimensions

Once we've established the language of measurement, the next logical step in the **topics of physics class 11** is to describe how objects move. This unit introduces the fundamental concepts of kinematics, the branch of mechanics concerned with the motion of objects without reference to the forces that cause the motion. We begin by simplifying the problem to motion in a straight line and then expand our understanding to more complex scenarios in two and three dimensions.

Understanding motion requires defining key terms like displacement, distance, velocity, and acceleration. Displacement is the change in position of an object, a vector quantity, while distance is the total path length covered, a scalar. Velocity describes the rate of change of displacement, including

direction, whereas speed is just the magnitude of velocity. Acceleration, the rate of change of velocity, is what causes changes in motion, whether it's speeding up, slowing down, or changing direction.

Position, Path Length, and Displacement

We'll start by visualizing motion on a coordinate system. Position is represented by coordinates. Path length is the total distance traveled along the trajectory. Displacement is the straight-line vector from the initial position to the final position. The difference between distance and displacement becomes clear when an object moves and returns to its starting point; the distance traveled is non-zero, but the displacement is zero.

Uniform Motion and Uniformly Accelerated Motion

This is where we start to formalize the description of motion. Uniform motion implies constant velocity, meaning an object moves with a constant speed in a straight line. Uniformly accelerated motion, on the other hand, involves a constant acceleration, leading to a changing velocity. For uniformly accelerated motion, we derive and apply the famous kinematic equations that relate displacement, initial velocity, final velocity, acceleration, and time. These equations are fundamental for solving a wide range of problems.

Vectors and Motion in Two Dimensions

Real-world motion rarely occurs in a straight line. We introduce vectors to represent quantities that have both magnitude and direction. Addition, subtraction, and resolution of vectors are essential skills. We then apply these vector concepts to analyze motion in a plane, such as projectile motion. Projectile motion, like that of a thrown ball, is a classic example of analyzing motion in two independent dimensions (horizontal and vertical) under the influence of gravity.

Relative Velocity

The concept of relative velocity is crucial for understanding motion from different frames of reference. The velocity of an object as observed by one observer can be different from its velocity as observed by another observer moving with respect to the first. This concept is particularly useful when dealing with problems involving multiple moving bodies, such as boats crossing rivers or airplanes flying in wind.

Laws of Motion

Describing motion is one thing, but understanding why objects move the way they do leads us to the **topics of physics class 11** concerning the Laws of Motion. This unit introduces Isaac Newton's three laws of motion, which form the foundation of classical mechanics. These laws explain how forces affect the motion of objects and are paramount to understanding interactions in the universe.

Forces are the agents of change in motion. A force can cause an object to start moving, stop moving, change its speed, or change its direction. Understanding the nature of forces, whether they are contact forces like friction or non-contact forces like gravity, is central to this unit. We'll move beyond just describing motion to analyzing the causes behind it.

Newton's First Law of Motion: The Law of Inertia

Often called the law of inertia, Newton's first law states that an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced external force. Inertia is the tendency of an object to resist changes in its state of motion. This law explains why seatbelts are important and why we feel pushed back when a bus accelerates.

Newton's Second Law of Motion: Force and Acceleration

This is arguably the most important law, providing a quantitative relationship between force, mass, and acceleration. Newton's second law states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. Mathematically, this is expressed as $F = ma$, where F is the net force, m is the mass, and a is the acceleration. This equation is fundamental to solving countless physics problems.

Newton's Third Law of Motion: Action and Reaction

For every action, there is an equal and opposite reaction. This law describes the nature of interactions between objects. When object A exerts a force on object B, object B simultaneously exerts a force of equal magnitude and opposite direction on object A. This principle explains how rockets propel themselves and how we can walk by pushing against the ground.

Conservation of Momentum

Closely related to Newton's laws is the concept of momentum, defined as the product of an object's mass and its velocity ($p = mv$). The principle of conservation of linear momentum states that in the absence of external forces, the total momentum of a system remains constant. This principle is crucial in analyzing collisions and other interactions where forces might be difficult to calculate directly.

Friction

Friction is a force that opposes motion between surfaces in contact. We'll explore static friction, which prevents an object from moving, and kinetic friction, which opposes motion when an object is sliding. Understanding friction is essential for analyzing real-world scenarios, from designing tires to understanding how brakes work.

Work, Energy, and Power

Moving from the forces that cause motion, we transition to the concepts of work, energy, and power, a crucial set of **topics of physics class 11** that describe the capacity to do things. These concepts are not only fundamental to understanding mechanics but also extend to other branches of physics. They provide a different, often more convenient, perspective for analyzing physical processes than solely using forces.

Work, in physics, is done when a force causes an object to move a certain distance. Energy is the capacity to do work, and it exists in many forms. Power is the rate at which work is done or energy is transferred. Mastering these interconnected ideas allows us to analyze systems in terms of their energy transformations, which can simplify complex problems significantly.

Work Done by a Constant Force

We define work as the product of the force applied and the distance moved in the direction of the force. If the force is not in the direction of motion, we use the component of the force along the displacement. The unit of work is the Joule (J). It's important to note that if there is no displacement, no work is done, regardless of the force applied.

Kinetic Energy and the Work-Energy Theorem

Kinetic energy is the energy an object possesses due to its motion. It is given by the formula $KE = \frac{1}{2}mv^2$. The Work-Energy Theorem states that the net

work done on an object is equal to the change in its kinetic energy. This theorem provides a powerful link between the work done by forces and the resulting change in an object's motion.

Potential Energy

Potential energy is stored energy that an object possesses due to its position or state. We commonly encounter gravitational potential energy ($PE = mgh$, where h is the height) and elastic potential energy (stored in springs). Understanding potential energy is key to understanding conservative forces, where the work done is independent of the path taken.

The Principle of Conservation of Mechanical Energy

In systems where only conservative forces are doing work, the total mechanical energy (the sum of kinetic and potential energy) remains constant. This principle is incredibly useful for solving problems involving falling objects, pendulums, and other systems where energy is transformed between kinetic and potential forms.

Power

Power is defined as the rate at which work is done, $P = \text{Work}/\text{time}$. Its SI unit is the Watt (W). A high-power device can do a lot of work in a short amount of time. For instance, a powerful engine can accelerate a car much faster than a less powerful one.

Rotational Motion

Our exploration of **topics of physics class 11** continues with rotational motion, extending the concepts of linear motion to objects that spin or rotate. This unit introduces a new set of variables and laws that govern how objects move when they pivot around an axis. Understanding rotational motion is vital for comprehending the behavior of everything from spinning tops to planets orbiting stars.

Just as linear motion is described by quantities like position, velocity, and acceleration, rotational motion requires analogous concepts. We'll introduce angular displacement, angular velocity, and angular acceleration, which describe the orientation and turning of an object. The concept of torque, the rotational equivalent of force, becomes central to understanding why objects start or stop rotating.

Angular Displacement, Angular Velocity, and Angular Acceleration

Angular displacement is the change in the angle of an object as it rotates. Angular velocity measures the rate of change of angular displacement, and angular acceleration measures the rate of change of angular velocity. These quantities are typically measured in radians.

Torque and Angular Momentum

Torque is the rotational analogue of linear force; it's what causes an object to change its rotational motion. It depends on the force applied and the distance from the axis of rotation. Angular momentum is the rotational equivalent of linear momentum and is a measure of an object's tendency to keep rotating. For a rigid body rotating about a fixed axis, it's the product of its moment of inertia and its angular velocity.

Moment of Inertia

The moment of inertia is the rotational equivalent of mass. It quantifies an object's resistance to changes in its rotational motion and depends not only on the mass but also on how that mass is distributed relative to the axis of rotation. Objects with mass distributed farther from the axis have a larger moment of inertia.

Conservation of Angular Momentum

Similar to linear momentum, angular momentum is conserved in the absence of external torques. This principle explains phenomena like figure skaters spinning faster when they pull their arms in, thereby decreasing their moment of inertia and increasing their angular velocity to keep angular momentum constant.

Gravitation

The universe itself is governed by a fundamental force that dictates the motion of celestial bodies and keeps us grounded: gravitation. This unit delves into the **topics of physics class 11** that explain the universal law of gravitation and its implications. From the falling apple to the orbiting Moon, gravity plays a starring role.

We will explore Sir Isaac Newton's groundbreaking law of universal gravitation, which describes the attractive force between any two objects with mass. This law not only explains the orbits of planets around the Sun

but also the phenomenon of falling objects on Earth. Understanding gravity is key to comprehending celestial mechanics and the structure of the cosmos.

Newton's Law of Universal Gravitation

Newton's law states that every particle attracts every other particle in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers. This force is represented by the equation $F = G(m_1m_2)/r^2$, where G is the gravitational constant.

Acceleration Due to Gravity

On Earth, we experience the effect of gravity as acceleration towards the center of the planet. Near the Earth's surface, this acceleration (g) is approximately constant (9.8 m/s^2). We will examine how this acceleration can vary slightly with altitude and latitude.

Gravitational Potential Energy

Similar to other potential energies, gravitational potential energy is associated with an object's position within a gravitational field. We will study its definition and its relation to work done against gravity. The concept becomes more nuanced when considering large distances, where the inverse square nature of gravity is more pronounced.

Orbits of Planets and Satellites

Using the principles of gravitation and motion, we can understand why planets orbit the Sun and satellites orbit the Earth. The gravitational force provides the centripetal force necessary to keep these bodies in their elliptical paths. We will explore Kepler's laws of planetary motion, which provide empirical descriptions of these orbits.

Properties of Bulk Matter

Moving from the grand scale of gravitation, the **topics of physics class 11** then zoom in to examine the behavior and properties of matter in bulk. This unit explores how materials respond to external forces and influences, focusing on solids, liquids, and gases. Understanding these properties is crucial for engineering, material science, and everyday applications.

We will delve into concepts like elasticity, stress, strain, and pressure.

How do materials deform under stress, and do they return to their original shape? What causes pressure in fluids, and how does it relate to force and area? These questions are addressed in this comprehensive unit.

Elasticity, Stress, and Strain

Solids can be deformed by forces, but they often possess elasticity, the ability to return to their original shape after the deforming force is removed. Stress is the internal restoring force per unit area within a deformed body, while strain is the measure of deformation. We will study Hooke's law, which states that within the elastic limit, stress is directly proportional to strain.

Young's Modulus, Shear Modulus, and Bulk Modulus

These are different measures of a material's stiffness or resistance to deformation. Young's modulus relates tensile stress to tensile strain, describing how a material stretches or compresses. Shear modulus relates shear stress to shear strain, describing resistance to twisting or shearing. Bulk modulus quantifies resistance to changes in volume under pressure.

Pressure in Fluids

Pressure is defined as force per unit area. In fluids (liquids and gases), pressure is exerted in all directions. We will explore how pressure changes with depth in a liquid due to the weight of the fluid above (hydrostatic pressure) and Pascal's principle, which states that a pressure change applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and the walls of the containing vessel.

Buoyancy and Archimedes' Principle

When an object is submerged in a fluid, it experiences an upward buoyant force equal to the weight of the fluid displaced by the object. This is Archimedes' principle. This principle explains why ships float and why objects feel lighter in water.

Surface Tension and Viscosity

Surface tension is the tendency of liquid surfaces to shrink into the minimum surface area possible, acting like a stretched elastic membrane. Viscosity is a measure of a fluid's resistance to flow; thicker fluids are more viscous. We will examine the factors affecting these properties and their implications.

Thermodynamics

The study of heat, work, and energy transformations forms the heart of thermodynamics, a critical component of the **topics of physics class 11**. This branch of physics deals with the macroscopic properties of systems and how they change. Understanding thermodynamics is essential for comprehending engines, refrigerators, and the very flow of energy in the universe.

We begin by defining concepts like temperature, heat, and internal energy. We then explore the fundamental laws that govern energy transfer and transformation, providing a framework for analyzing systems involving heat and work. This unit bridges the gap between mechanics and other areas of physics, offering a powerful perspective on energy.

Thermal Equilibrium and Temperature

Thermal equilibrium is a state where there is no net flow of heat between two systems in contact. Temperature is a measure of the hotness or coldness of an object and is directly related to the average kinetic energy of the molecules within a substance. We will discuss different temperature scales like Celsius, Fahrenheit, and Kelvin.

Heat and Internal Energy

Heat is the transfer of thermal energy between systems due to a temperature difference. Internal energy, on the other hand, is the total energy contained within a system, including the kinetic and potential energies of its molecules. Heat is a form of energy transfer, while internal energy is a property of the system itself.

The First Law of Thermodynamics

The first law of thermodynamics is essentially a statement of the conservation of energy. It states that the change in internal energy of a system is equal to the heat added to the system minus the work done by the system. Mathematically, $\Delta U = Q - W$.

Specific Heat Capacity and Latent Heat

Specific heat capacity is the amount of heat required to raise the temperature of 1 unit mass of a substance by 1 degree Celsius (or Kelvin). Latent heat refers to the heat absorbed or released during a phase transition (like melting or boiling) at a constant temperature. This is the energy involved in changing the state of matter.

Phase Transitions

We will examine the processes of melting, freezing, vaporization, and condensation, exploring the energy changes associated with these phase transitions. The concepts of latent heat are central to understanding these transformations.

Behavior of Perfect Gases and Kinetic Theory

Delving deeper into the microscopic world, the **topics of physics class 11** now include the behavior of gases based on the kinetic theory. This theory provides a molecular-level explanation for the macroscopic properties of gases, such as pressure, temperature, and volume, offering a compelling link between the microscopic and macroscopic realms of physics.

We will assume the existence of an "ideal" or "perfect" gas, a theoretical model that simplifies the complex interactions of real gases. By understanding the assumptions of the kinetic theory, we can derive the gas laws and gain insights into the motion of gas molecules. This unit is a bridge between thermodynamics and the atomic and molecular nature of matter.

Assumptions of Kinetic Theory

The kinetic theory of gases makes several key assumptions, including that gases consist of a large number of tiny particles (atoms or molecules) that are in constant, random motion. These particles are assumed to have negligible volume themselves and to exert no intermolecular forces on each other except during collisions. Collisions between particles and with the container walls are assumed to be perfectly elastic.

Kinetic Interpretation of Temperature

A cornerstone of the kinetic theory is its interpretation of temperature. The absolute temperature of a perfect gas is directly proportional to the average translational kinetic energy of its molecules. This provides a fundamental connection between the microscopic motion of particles and the macroscopic concept of temperature.

The Gas Laws (Boyle's Law, Charles's Law, Avogadro's Law)

Based on the kinetic theory, we can derive the macroscopic gas laws. Boyle's Law states that at constant temperature, the pressure of a gas is inversely proportional to its volume. Charles's Law states that at constant pressure,

the volume of a gas is directly proportional to its absolute temperature. Avogadro's Law states that equal volumes of all gases, at the same temperature and pressure, have the same number of molecules.

The Ideal Gas Equation

Combining these gas laws leads to the ideal gas equation: $PV = nRT$, where P is pressure, V is volume, n is the number of moles of gas, R is the universal gas constant, and T is the absolute temperature. This equation is a powerful tool for relating the macroscopic properties of an ideal gas.

Molecular Collisions and Mean Free Path

We will also explore the concepts of molecular collisions and the mean free path, which is the average distance a molecule travels between successive collisions. These concepts help us understand the dynamics of gas molecules and their interactions.

Oscillations

Many phenomena in nature involve repetitive, back-and-forth motion. The study of oscillations, a core component of the **topics of physics class 11**, provides a framework for understanding these periodic movements. From the swing of a pendulum to the vibrations of a guitar string, oscillations are ubiquitous and have profound implications across science and engineering.

The simplest form of oscillation is Simple Harmonic Motion (SHM), which serves as a fundamental model. We will explore the characteristics of SHM, including its amplitude, frequency, and period, and learn how to describe it mathematically. Understanding oscillations is key to understanding wave phenomena, which we will explore next.

Simple Harmonic Motion (SHM)

SHM is a type of periodic motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to that of displacement. A classic example is a mass attached to a spring. The motion is symmetrical about the equilibrium position.

Characteristics of SHM: Amplitude, Period,

Frequency, and Phase

Amplitude is the maximum displacement from the equilibrium position. The period (T) is the time taken for one complete oscillation, while frequency (f) is the number of oscillations per unit time ($f = 1/T$). Phase describes the position and direction of motion of an oscillating object at a particular instant.

Energy in SHM

In SHM, energy oscillates between kinetic and potential forms. At the extreme points of displacement, the velocity is zero, and all the energy is potential. At the equilibrium position, the potential energy is minimum, and all the energy is kinetic. The total mechanical energy in SHM remains constant, assuming no damping.

The Simple Pendulum

A simple pendulum, consisting of a mass suspended by a light string, exhibits approximate SHM for small angular displacements. We will analyze its motion and derive the formula for its period, which depends on its length and the acceleration due to gravity.

Damped Oscillations and Forced Oscillations

Real-world oscillations often experience damping, where energy is lost due to friction or other dissipative forces, causing the amplitude to decrease over time. Forced oscillations occur when an external periodic force is applied to an oscillating system, leading to resonance when the driving frequency matches the natural frequency of the system.

Waves

Finally, our journey through the **topics of physics class 11** culminates in the study of waves, a fundamental way in which energy propagates through space. Waves are the carriers of information and energy, from the light we see to the sound we hear. This unit explores the nature, types, and behavior of waves, building upon our understanding of oscillations.

We will differentiate between various types of waves, such as transverse and longitudinal waves, and explore their characteristic properties like wavelength, frequency, and speed. Understanding wave phenomena is essential for fields ranging from optics and acoustics to quantum mechanics and cosmology.

Types of Waves: Transverse and Longitudinal

Transverse waves are those in which the particles of the medium move perpendicular to the direction of wave propagation (e.g., waves on a string, light waves). Longitudinal waves are those in which the particles of the medium move parallel to the direction of wave propagation (e.g., sound waves).

Wavelength, Frequency, and Speed of Waves

Wavelength (λ) is the spatial distance over which the wave's shape repeats. Frequency (f) is the number of wave cycles passing a point per unit time. The speed (v) of a wave is related to its wavelength and frequency by the equation $v = f\lambda$. This fundamental relationship holds for all types of waves.

Wave Motion and Energy Transfer

Waves are a mechanism for transferring energy from one point to another without the bulk movement of the medium itself. We will discuss how the energy carried by a wave depends on its amplitude and frequency.

The Principle of Superposition

When two or more waves meet at a point, the resultant displacement is the algebraic sum of the displacements due to each individual wave. This principle explains phenomena like interference and diffraction.

Sound Waves and Doppler Effect

We will specifically examine sound waves, exploring their speed in different media and the factors affecting it. The Doppler effect describes the change in frequency of a wave in relation to an observer who is moving relative to the wave source. This is why the pitch of a siren changes as it passes by.

The comprehensive exploration of these topics in physics class 11 equips students with a robust understanding of the fundamental principles governing the physical world. From the mechanics of motion to the intricate behavior of waves, each unit builds upon the last, fostering analytical thinking and problem-solving skills. Mastering these concepts not only prepares students for future academic pursuits in science and engineering but also cultivates a deeper appreciation for the scientific underpinnings of everyday phenomena. The journey through these topics is a rewarding one, unlocking the secrets of the universe one principle at a time.

Frequently Asked Questions about Topics of Physics Class 11

Q: What are the main branches of physics covered in Class 11?

A: Class 11 physics typically covers fundamental branches like Mechanics, Properties of Matter, Thermodynamics, Oscillations, and Waves. These are further broken down into units that explore motion, forces, energy, heat, and the propagation of disturbances.

Q: Why is Units and Measurement so important at the beginning of Class 11 Physics?

A: Units and Measurement are foundational because they provide the language and tools for all subsequent physics concepts. Without accurate measurements and a standardized system of units, it's impossible to quantify physical phenomena, formulate laws, or verify them experimentally.

Q: How do vectors help in understanding motion in Class 11 Physics?

A: Vectors are essential for describing quantities that have both magnitude and direction, such as displacement, velocity, and acceleration. In Class 11, vectors are crucial for analyzing motion in two and three dimensions, such as projectile motion and relative velocity, where direction is as important as magnitude.

Q: What is the significance of Newton's Laws of Motion in Class 11?

A: Newton's Laws of Motion are the bedrock of classical mechanics. They explain the relationship between forces and motion, defining inertia, quantifying force and acceleration ($F=ma$), and describing action-reaction pairs. Mastering these laws is key to solving a vast array of problems involving forces and movement.

Q: How does the concept of energy differ from work in Class 11 Physics?

A: Work is defined as the energy transferred when a force causes displacement, essentially the application of energy. Energy, on the other hand, is the capacity to do work and exists in various forms like kinetic,

potential, thermal, etc. Work is the process, and energy is the potential or the quantity involved.

Q: What is the role of temperature in thermodynamics according to Class 11 syllabus?

A: In thermodynamics, temperature is a measure of the average kinetic energy of the particles within a system. It dictates the direction of heat flow; heat naturally moves from regions of higher temperature to regions of lower temperature until thermal equilibrium is reached.

Q: What is the difference between simple harmonic motion (SHM) and other types of oscillations?

A: SHM is a specific type of periodic motion where the restoring force is directly proportional to the displacement from equilibrium and acts in the opposite direction. This results in a sinusoidal pattern of motion. Other oscillations may be more complex, with varying restoring forces or damping.

Q: How does sound travel, and what is the Doppler Effect?

A: Sound travels as longitudinal waves through a medium (like air, water, or solids) by causing vibrations. The Doppler Effect is the apparent change in the frequency of a sound wave (or any wave) due to the relative motion between the source of the sound and the observer.

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