

Based on National Curriculum of Pakistan 2022-23

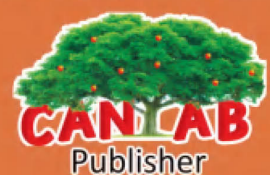
9

Model Textbook of

PHYSICS



Cantab Publisher
Lahore, Pakistan



PHYSICS

9th

Note: All rights of this book are reserved by Cantab Publisher, Lahore. Although proofreading of the book has been arranged, if there is any error in typography, printing, statement of facts or binding, please report it to official@ncc.gov.pk so that it can be corrected in the next publication.

Editor,
Cantab Publisher, Lahore

Cantab Publisher Lahore, Pakistan

All rights reserved. This volume may not be reproduced in whole or in part in any form (abridged, photocopy, electronic etc.) without prior written permission from Cantab Publisher.

A Textbook of
for Grade

Authors

Muhammad Azem Sharif
Muhammad Riaz Khan

Chief Editor

Prof. Dr. Naeem Khalid

Supervision

Dr. Mariam Chughtai
Director, National Curriculum Council
Ministry of Federal Education and Professional Training, Islamabad

Reviewed by Internal Review Committee

Hanifa Ubaid
Irmia Ijaz
Zeba Noreen
Muhammad Furqan
Saima Waheed
Muhammad Ikram
Muhammad Asghar
Beenish
Mrs Shafqat Tariq
Nazir Ahmed Malik
Adnan Rasool
Uzma Jamal
Muhammad Rizwan

Reviewed by National Review Committee

Tanveer Bhatti
Afshan Ali
Abdul Rauf
Dr Shafqat
Sajid Iqbal
Muhammad Salman
Nazir Ahmed Malik
Zaheer Hussain
Abbasi

Desk Officer (NCC)

Zehra Khushal

Management

Prof. Dr. Shazia Naeem
CEO Cantab Publisher

First Edition - First Impression

Price: PK 000/-

Code: , **ISBN:**

Printer:

Note: All the pictures, paintings and sketches used in this book are only for educational and promotional purpose in public interest.

For Information about other publications of Cantab Publisher,

Visit our Web site: www.cantabpublisher.com

or E-mail: info@cantabpublisher.com

to share feedback or correction, please send us an email to info@cantabpublisher.com
and textbooks@snc.gov.pk

Preface

This Grade 9th Physics textbook, crafted in accordance with the National Curriculum Council's guidelines, is a comprehensive educational tool. Its key features include: International Standards Compliance: Incorporates the International System of Units (SI) and scientific nomenclature. Emphasized Key Concepts: Key statements, definitions, and equations highlighted for ease of study. Real-Life Visuals: Includes images and diagrams connecting concepts to real-world scenarios. Additional Information: Provides extra facts and insights for broader understanding. Significant Figures Focus: Offers an in-depth look at significant figures to enhance accuracy in measurements and calculations. Advanced Topics in Appendices: Contains supplementary advanced material for extended learning opportunities. Chapter Summaries: Each chapter concludes with a summary for quick revision. Bibliography for Further Study: A comprehensive list of references for deeper exploration. Mathematics-Physics Bridge: An appendix dedicated to mathematical foundations in physics. Quick Reference Tools: Features a glossary and an index for easy navigation. Designed to elevate science and technology education in Pakistan, this textbook aims to align with global educational standards. It invites feedback from educators, students, and experts to facilitate continuous improvement. Gratitude is extended to Almighty Allah and the educational community for their support in this endeavor.



Section A Introduction to Dynamics

Dynamics is the branch of physics that deals with the study of forces and their effects on motion. It encompasses the analysis of objects in motion or at rest under the influence of external forces. In grade 9, students will learn about the different forces, like gravity, friction, air resistance, and thrust (driving force), and how they make things move or stay still. Every day, we see dynamics in action. When we drop something, it falls because of gravity and the air resistance opposes its motion. When we slide a book across a table, it stops because of friction. By understanding dynamics, students will get to know the science behind these everyday experiences. This knowledge is fundamental in physics and will help students understand more complex topics in the future.

Knowledge A5.1 Mass and its Measurement using Electronic Balance

To understand how objects move, we need to know how they behave when we apply a force. This behavior is influenced by a property that is inherent to objects, and it determines how much they resist acceleration. This property is essential to the laws of motion, and it plays a crucial role in the way objects move and interact in the physical world. As we learn more about dynamics, we will see how important this property is and how it affects the way objects move.

Mass

To understand mass, you will have to know about matter. Matter is anything that takes up space and consists of tiny particles called atoms. Gases, liquids, and solids are different states of matter. An object having a large number of particles in a small volume will have more quantity of matter.

Mass is a measure of the amount of matter in an object or substance. For example, you might note that a sponge, despite being large, has less mass than a smaller iron ball because an iron ball has more quantity of matter in it than a sponge. You can compare their masses using balances and scales.

Mass is an intrinsic property of physical objects and does not change regardless of the object's location. Your mass remains the same whether you are on Earth, the moon, or in deep space. Mass is a scalar quantity denoted by 'm' and is typically measured in SI units of kilograms (kg).

Knowledge A5.2 Measurement of Mass by Electronic Balance

Accurate measurement of an object's matter is vital for scientific experiments and industrial applications. Modern technology, like the electronic balance, offers precise and rapid measurements. This tool is essential in laboratories and other settings for its ease of use and accuracy in quantifying matter.

Student Learning Outcome

Illustrate that mass is a measure of the quantity of matter in an object. Justify and illustrate the use of electronic balances to measure mass (understanding the internal workings of the electronic balance is not required, just how to practically use the instrument in appropriate situations)

Important information

Imagine two boxes of the same size. One is filled with cotton while the other is filled with sand. Which one would have more mass than the other.

Student Learning Outcome

Justify and illustrate the use of electronic balances to measure mass (understanding the internal workings of the electronic balance is not required, just how to practically use the instrument in appropriate situations)

The purpose of a skill is to apply knowledge. Students and teachers can scan the provided QR code to access a worksheet that enhances their understanding.

Knowledge is information about a specific topic that helps clarify concepts. Students and teachers can scan the QR code provided with the knowledge to access lectures related to that topic.

Knowledge is information about a specific topic that helps clarify concepts. Students and teachers can scan the QR code provided with the SLO Tab to access lectures related to that topic.



Greenhouse Effect

Climate change is mostly happening because we are putting too many greenhouse gases, like CO₂ from burning oil and coal, and methane from farms, into the air. These gases act like a blanket, trapping heat from the Earth and warming up the air around us. It is like how the glass of a greenhouse keeps plants warm by holding in the heat.

Normally, some greenhouse effect is good because it keeps our planet warm enough for plants and animals to live. But because of things people are doing, like driving cars and running factories, there is now too much of this blanket effect, and that is making Earth warmer than it should be.

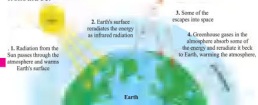


Figure 7.19. Green House Effect.

Test Yourself

1. Describe how a turbine and generator work together to produce electricity in a coal-fired power plant.
2. Explain the process of generating electricity using geothermal resources.

Multiple Choice Questions

- One disadvantage of solar power compared to fossil fuels is that solar power:
 - Is not renewable.
 - Produces greenhouse gases.
 - Is not always available.
 - Is more expensive to harness.
- The main environmental advantage of wind power over coal is:
 - It is more reliable.
 - It is cheaper.
 - It does not emit carbon dioxide.
 - It can be used everywhere.

Knowledge 7.6 Power

Power is a concept in physics that tells us how quickly work is done or energy is transferred. Imagine you have two identical sets of stairs and two people of the same fitness level. If one person climbs the stairs in 2 minutes and the other in 4 minutes, the first person is showing more power because he is doing the same work but in less time. So, power can be defined as "the rate of doing work or rate of transferring energy".

In science, we measure power in a unit called watt (W). One watt means you are doing one joule of work or transferring one joule of energy every second i.e., $1\text{ W} = 1\text{ J/s} = 1\text{ Js}^{-1}$. It is like you are lifting one small apple one meter up into the air every second.

Skill 7.6c

Investigate various sources of energy and their role in powering our world.

Student Learning Outcome

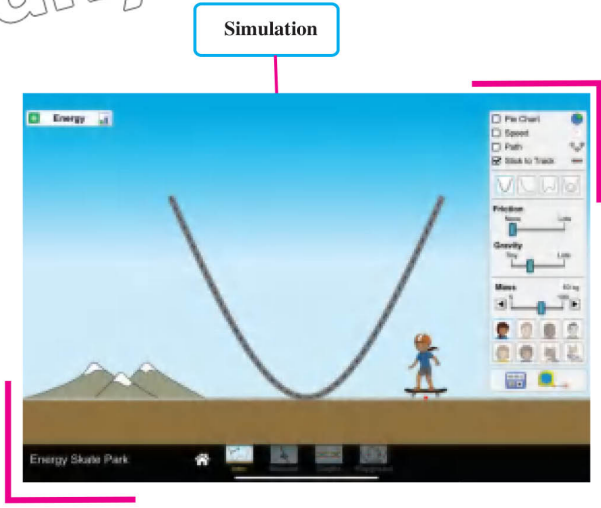
Define and calculate power as work done per unit time and also as energy transferred per unit time. This also includes applying the equations: $\text{power} = \frac{\text{work done}}{\text{time taken}}$ $P = \frac{W}{t}$ $\text{power} = \frac{\text{energy transferred}}{\text{time taken}}$ $P = \frac{E}{t}$ to solve simple problems]

SLO Based Model Video Lecture



Salient Features

- Comprehensive Learning**
Engage students with videos, simulations, and practical worksheets.
- Structured Lesson Plan**
Well-organized with clear objectives, PPTs, and a self-assessment questions.
- Engaging Multimedia**
Visual appeal through PPTs and interactive simulations.
- Assessment & Tracking**
Diverse question from daily life and progress monitoring.
- Adaptable & Accessible**
Scalable and accessible, suitable for all learners.




SLO No: P: 09 - A -18
SLO statement: Use all formulas for kinetic and gravitational potential energy to solve the problem involving simple energy conversions.

KNOWLEDGE


Knowledge 1.1 | Exploring the Universe Through Physics

Physics, derived from the Greek words "phusikos" (meaning natural) and "physis" (meaning nature), is fundamentally the study of nature. Getting into physics is like starting an exciting adventure that helps us understand the world and everything in it. It connects what we see and do every day with the big questions about the universe. Ready to explore how and why things work? Let us set off on this journey together, discovering the amazing rules that explain everything in the universe.


Why study physics?
 The goal of physics is to gain a better understanding of the world in which we live. Observe the things around you. Have you ever considered why and how things around you work?
 The laws of physics help us to answer questions like those given below.




How do fireworks work?
What is launched into the sky to make such beautiful displays?



How does email from your desktop get to a friend halfway around the world?



How does a mobile phone function without wires?
How do SMS get to our mobile phone?



How does a telescope function?
How can we see stars and galaxies, which are far beyond our vision?

What is Physics
 Physics is an exciting journey into understanding everything that exists, from the smallest particles to the vast stretches of the cosmos. At its heart, physics is about discovering how things are made (matter), what drives them (energy), where they happen (space), and when (time). These four pillars are closely linked, showing us how the universe operates. Matter, the substance of all physical objects, interacts through energy, the catalyst that initiates change and movement. These interactions occur within space, the vast expanse that hosts everything from particles to planets. Time measures the progression of events, allowing us to understand the sequence and duration of changes in the universe. The integration of matter, energy, space, and time forms the core of physics, providing a comprehensive framework to reveal the natural complexity of the world. So, physics is defined as "the branch of science that studies matter, energy, space, and time, along with how they interact and connect with each other". It, often regarded as the most fundamental

Important information

Quark matter is an extremely dense phase of matter made up of subatomic particles called quarks. This theoretical phase would occur at extremely high temperatures and densities. It may exist at the heart of neutron stars. It can also be created for brief moments in particle colliders on Earth, such as CERN's Large Hadron Collider.

INTERCOMPREHENSION OF ENERGY

APPLY KINETIC AND GRAVITATIONAL POTENTIAL ENERGY FORMULAS TO SOLVE PROBLEMS INVOLVING ENERGY CONVERSIONS, INCLUDING CASES WHERE ENERGY IS TRANSFERRED BETWEEN DIFFERENT FORMS, ACCOUNTING FOR LOSSES TO THE SURROUNDINGS.

Transformation of Energy

Use the following boxes of energy to fill in the table below. Use the terms: mechanical energy, kinetic energy, potential energy, electrical energy, and sound. The first one has been done for you.

Source	Converted energy	Final energy state
1. A battery that is being recharged	electrical	chemical energy
2. A battery that is being used	chemical energy	electrical energy
3. A person climbing a hill	mechanical energy	potential energy
4. A person pushing a cart	mechanical energy	kinetic energy
5. A hand holding a ball	mechanical energy	potential energy
6. A person on a roller coaster	mechanical energy	kinetic energy
7. A person on a roller coaster	mechanical energy	potential energy
8. A person on a roller coaster	mechanical energy	kinetic energy

Transformation of Energy II

Answer a question or write the following energy conversions. Use one suitable example from the table above.

- Electrical energy being converted into sound energy.
- Chemical energy being converted into sound energy.

Skills Sheet

CONTENTS

Chapter 1 Nature of Physics

01

- Knowledge 1.1 Exploring the Universe Through Physics
- Knowledge 1.2 Fields of Physics and Interdisciplinary Connections
- Knowledge 1.3 Who are Physicists?
- Knowledge 1.4 Fundamental Concepts in Physics Research
- Knowledge 1.5 Science, Technology, and Engineering

Chapter 2 Foundations of Measurement in Physics

20

- Knowledge 2.1 Foundation of Physics
- Knowledge 2.2 Mastering SI Units and Scientific Notation
- Knowledge 2.3 SI Prefixes and Estimation
- Knowledge 2.4 Analyzing and Correcting Measurement Errors
- Knowledge 2.5 Understanding Measurement concept
- Knowledge 2.6 Techniques of Measuring Length
- Knowledge 2.7 Measurement of Volume of liquid and solid
- Knowledge 2.8 Measurement of time Interval
- Knowledge 2.9 Data Interpretation and Rounding Off Calculations

Chapter 3 Scalars and Vectors

58

- Knowledge 3.1 Understanding Scalar and Vector Quantities
- Knowledge 3.2 Identifying Scalar and Vector Quantities
- Knowledge 3.3 Determining the Resultant of Two Vectors

Chapter 4 Kinematics

74

- Knowledge 4.1 Motion and its Various Types
- Knowledge 4.2 Concepts of Distance, Displacement, Speed, and Velocity
- Knowledge 4.3 Calculating Speed and understanding of its Types
- Knowledge 4.4 Uniform and Non-Uniform Velocity
- Knowledge 4.5 Acceleration and its Types
- Knowledge 4.6 Acceleration Due to Gravity
- Knowledge 4.7 Graphical Analysis in Motion
- Knowledge 4.8 Universal Speed Limit

Chapter 5 Dynamics

105

Unit 5. Dynamics I (Mass, Weight and Gravity)

- Knowledge A5.1 Mass and its Measurement using Electronic Balance
- Knowledge A5.2 Measurement of Mass by Electronic Balance
- Knowledge A5.3 Understanding and Calculating the Weight
- Knowledge A5.4 Force Meter
- Knowledge A5.5 Gravitational Field Strength

Unit 5. Dynamics II (Forces and Newton's Law of Motion)

- Knowledge B5.1 Forces
- Knowledge B5.2 Fundamental Forces in Nature
- Knowledge B5.3 Representing Forces
- Knowledge B5.4 Newton's Laws of Motion
- Knowledge B 5.5 Laws of Motion
- Knowledge B 5.6 Equilibrium

Unit 5. Dynamics III Friction

Knowledge C 5.1 Friction and its Dissipative Effect

Knowledge C 5.2 Terminal Velocity

Unit 5. Dynamics IV Momentum

Knowledge D 5.1 Momentum

Knowledge D 5.2 Impulse

Knowledge D 5.3 Conservation of Momentum

Chapter 6 Torque and Stability

170

Knowledge 6.1 Principles of Parallel Forces

Knowledge 6.2 Turning Effects and Moment of Forces

Knowledge 6.3 Equilibrium and Principle of Moments

Knowledge 6.4 Center of Mass and Gravity

Knowledge 6.5 Stability and Center of Gravity

Knowledge 6.6 Real-life Applications of Stability Physics

Knowledge 6.7 Motion of Rotating Bodies and Circular Motion

Knowledge 6.8 Planetary Motion

Chapter 7 Work, Energy and Power

202

Knowledge 7.1 Fundamentals of Work and Energy

Knowledge 7.2 Concept of Energy

Knowledge 7.3 Energy Conversion and Conservation

Knowledge 7.4 Power

Chapter 8 Deformation of Solids

230

Knowledge 8.1 Deformation and Hooke's Law

Knowledge 8.2 Spring Constant

Knowledge 8.3 Load-Extension Graphs and Limit of Proportionality

Knowledge 8.4 Applications of Hooke's Law

Chapter 9 Pressure

241

Knowledge 9.1 Understanding Pressure and Its Calculations

Knowledge 9.2 Principles of Pressure on Surfaces

Knowledge 9.3 Atmospheric Pressure

Knowledge 9.4 Measuring Pressure with Barometers and Manometers

Knowledge 9.5 Pascal's Law and Its Applications

Chapter 10 Heat and Thermodynamics

257

Knowledge 10.1 Density and its Measurement

Knowledge 10.2 Particle Theory of Matter

Knowledge 10.3 Temperature and Internal Energy

Knowledge 10.4 Measurement of Temperature

Chapter 11 Magnetism

273

Knowledge 11.1 Introduction of magnet

Knowledge 11.2 Magnetic Field and its Representation

Knowledge 11.3 Types of Magnets and their Uses

Knowledge 11.4 Domain theory of Magnetism

Knowledge 11.5 Earth's Magnetic Field

Knowledge 11.6 Application of Magnets

Glossary

293

Nature of Physics



Physics in the Natural Interconnectedness

The image suggests a visual metaphor for the interconnectedness of physical laws in nature. The spheres linked by lines could represent atomic or molecular structures, symbolizing the fundamental forces that hold matter together. The Earth adorned with foliage implies the growth and life that physics enables through processes like photosynthesis, which converts sunlight into chemical energy. The clear sky and floating paper planes may allude to the principles of aerodynamics and atmospheric physics. Overall, the image creatively captures how physics underpins the natural world, from the microscopic interactions within atoms to the global systems that support life and the environment.

Student Learning Outcomes

- Describe physics as the study of matter, energy, space, time and their mutual connection and interaction
- Explain with examples that physics have many sub-fields and in today's world involves interdisciplinary fields. students should be able to distinguish in terms of the broad subject matter that is studied between the fields: Biophysics, Astronomy, Astrophysics, Cosmology, Thermal physics, optics, classical mechanics, quantum mechanics, relativistic mechanics, nuclear physics, particle physics, electromagnetism, acoustics, computational physics, geo physics, climate physics.
- Explain with examples how physics is a subset of physical sciences and of the natural sciences
- State that the scientists who specialize in the research of physics are called physicists.
- Brief with examples that science is a collaborative field that requires interdisciplinary researchers working together to share knowledge and critique ideas
- Understand the terms 'hypothesis', 'theory' and 'law' in the context of research in the physics
- Explain, with examples in Physics, falsifiability as the idea that a theory is scientific only if it makes assertions that can be disproven.
- Differentiate the terms 'science', 'technology' and 'engineering' with suitable examples

All the above mentioned SLOs are classified into knowledge and skills for the better understanding of students.

After studying this Unit, the students will be able to understand:



Knowledge

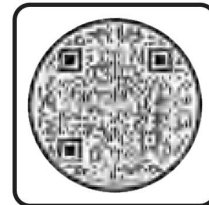
- ✓ Exploration of matter, energy, space, and time, and recognize its integral role within both the Physical and Natural Sciences.
- ✓ Identify diverse physics sub-fields like Biophysics, Astrophysics, and Quantum Mechanics, and comprehend their interdisciplinary nature. They will appreciate collaborative efforts in science, essential for knowledge exchange and idea critique.
- ✓ Knowing the Physicists as specialists who conduct research in the field of physics.
- ✓ Understanding the terms 'hypothesis', 'theory', and 'law' in physics, and grasping falsifiability as the criterion for scientific theories, wherein assertions must be testable and potentially disproven through experimentation or observation.
- ✓ Understanding the distinction between science, technology, and engineering: science explores natural phenomena, technology applies scientific knowledge for practical purposes, and engineering designs solutions to real-world problems.



Skill

- ✓ Science is a collaborative field that involves interdisciplinary researchers working together.
- ✓ They share knowledge and critique ideas to advance scientific understanding.
- ✓ Students understand the terms hypothesis, theory and law in the context of physics research.
- ✓ They can differentiate between these concepts and their roles in scientific inquiry.
- ✓ Students comprehend the concept of falsifiability, which states that a theory is scientific only if it makes assertions that can be disproven. Examples in physics are used to illustrate this idea.
- ✓ Students distinguish between science (the study of natural phenomena), technology (the application of scientific knowledge for practical purposes), and 'engineering' (the design and construction of complex systems). They use suitable examples to clarify these distinctions.

Knowledge 1.1 | Exploring the Universe Through Physics



Physics, derived from the Greek words "phusikos" (meaning natural) and "physis" (meaning nature), is fundamentally the study of nature. Getting into physics is like starting an exciting adventure that helps us understand the world and everything in it. It connects what we see and do every day with the big questions about the universe. Ready to explore how and why things work? Let us set off on this journey together, discovering the amazing rules that explain everything in the universe.

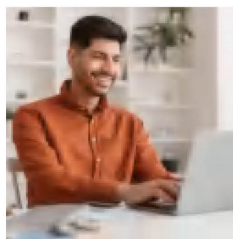
Why study physics?

The goal of physics is to gain a better understanding of the world in which we live. Observe the things around you. Have you ever considered why and how things around you work?

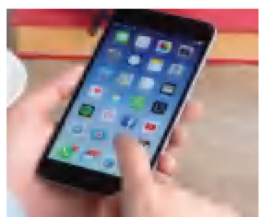
The laws of physics help us to answer questions like those given below.



How do fireworks work?
What is launched into the sky to make such beautiful displays?



How does email from your desktop get to a friend halfway around the world?



How does a mobile phone function without wires?
How do SMS get to our mobile phone?



How does a telescope function?
How can we see stars and galaxies, which are far beyond our vision?

Figure 1.1 applications of physics in our daily life

What is Physics?

Physics is an exciting journey into understanding everything that exists, from the smallest particles to the vast stretches of the cosmos. At its heart, physics is about discovering how things are made (matter), what drives them (energy), where they happen (space), and when (time). These four pillars are closely linked, showing us how the universe operates. Matter, the substance of all physical objects, interacts through energy, the catalyst that initiates change and movement. These interactions occur within space, the vast expanse that hosts everything from particles to planets. Time measures the progression of events, allowing us to understand the sequence and duration of changes in the universe. The integration of matter, energy, space, and time forms the core of physics, providing a comprehensive framework to reveal the natural complexity of the world. So, physics is defined as "the branch of science that studies matter, energy, space, and time, along with how they interact and connect with each other". It, often regarded as the most fundamental

Student Learning Outcome

- Describe physics as the study of matter, energy, space, time and their mutual connections and interactions
- Explain with examples how Physics is a subset of the Physical Sciences and of the natural sciences

Important information

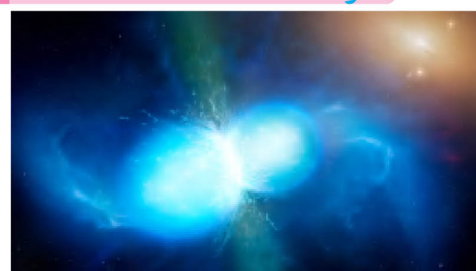
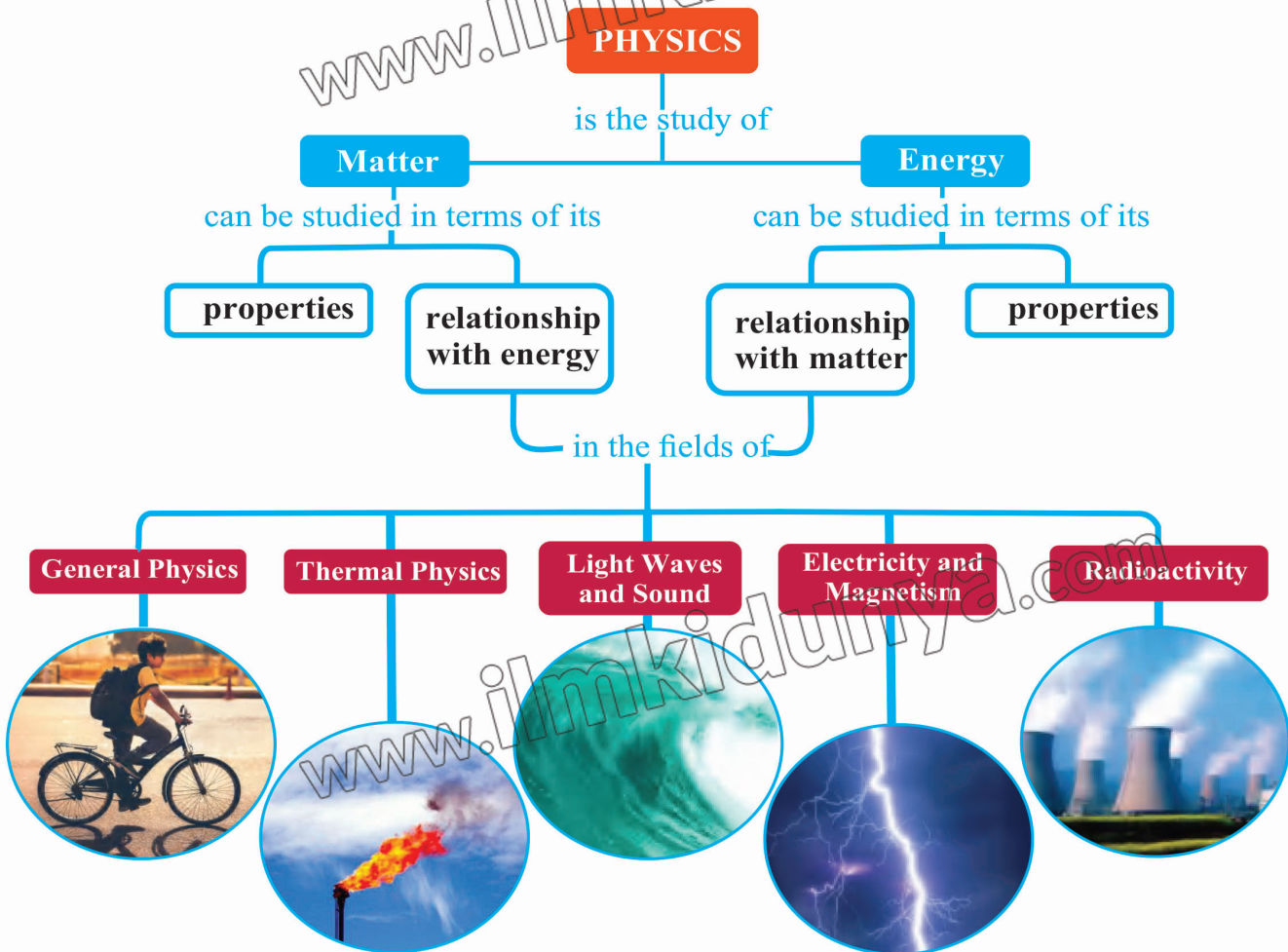


Figure 1.2 Quark matter is an extremely dense phase of matter made up of subatomic particles

Quark matter is an extremely dense phase of matter made up of subatomic particles called quarks. This theoretical phase would occur at extremely high temperatures and densities. It may exist at the heart of neutron stars. It can also be created for brief moments in particle colliders on Earth, such as CERN's Large Hadron Collider.

of the natural sciences, serves as the backbone of our understanding of the universe. Imagine throwing a ball, using a flashlight, or watching the stars at night. Each of these activities involves physics in action, revealing the invisible rules that govern how objects move, how light travels, and how gravity pulls things together. By exploring these connections, physics helps us make sense of the world and beyond, piecing together the intricacies of our universe in a way that is both fascinating and deeply informative.

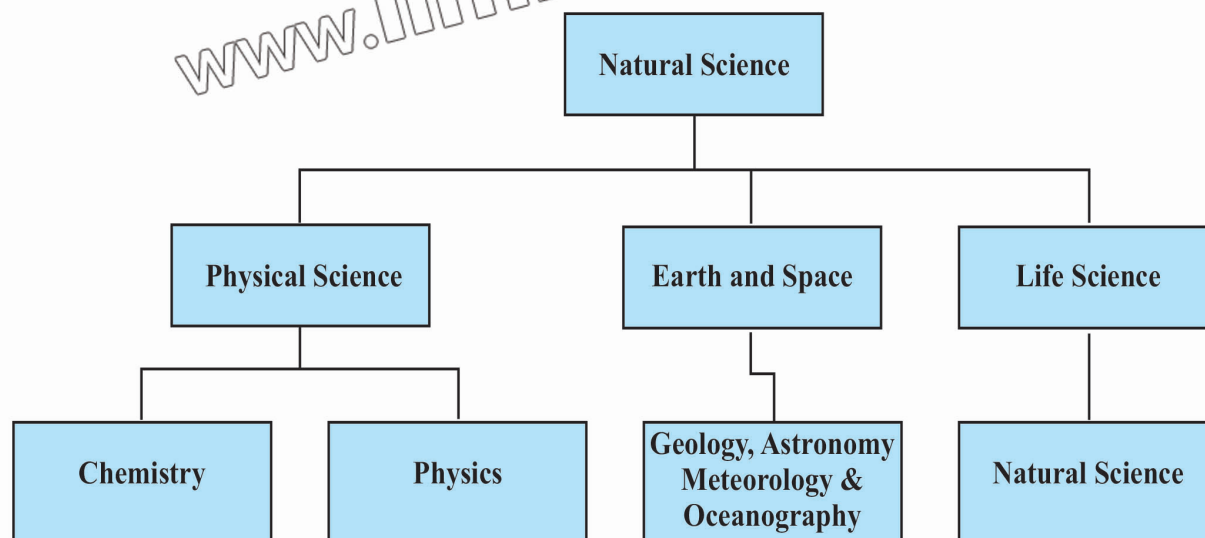


Physics as subset of Physical and Natural Sciences

Science, once called natural philosophy, covers the study of living things and nonliving things, split into life sciences and physical sciences. Life sciences, like biology, zoology, and botany, study living creatures. Physical sciences, including geology, astronomy, chemistry, and physics, explore nonliving aspects of the world. Physics is special because it is not just a part of physical sciences; it is the most fundamental science. It deals with the basics like how things move, forces, energy, matter, heat, sound, light, and structure of atom.

For example, when physicists study how gravity works, this helps us understand why things fall down instead of up. This is physics in action, and it is connected to other sciences too. Like, when we look at chemistry, we might explore how atoms bond together, which also

involves physics because it is about energy and forces, which are physics topics. And in earth science, when we learn about how mountains form or what causes earthquakes, physics is there too, explaining the forces and energy behind these events. So, you can see, physics is a key part of learning about everything in nature, working together with other sciences to help us understand the world better.



Mind map: Branches of Science

Knowledge 1.2 | Fields of Physics and Interdisciplinary Connections

Fields of Study in Physics

As we begin on this intellectual journey, it becomes evident that the realm of physics is not confined to a singular pathway but rather branches into a array of specialized fields, each with its unique focus and methodologies. These sub-disciplines, ranging from the study of the grand scale of universe in cosmology to the minute workings of subatomic particles in quantum mechanics, illustrate the vast scope of physics. Each field focuses on a specific area of study. Here are some of the major branches

Thermal Physics: This branch explores heat and temperature and their effects on matter. Students learn about the principles of heat transfer and the ways we can harness thermal energy in everyday life.

Optics: It focuses on the behavior of light and its interactions with different materials. This field explains phenomena like the formation of rainbows and the functioning of lenses in eyeglasses.

Classical Mechanics: This branch deals with the motion of visible objects and the forces that act upon them. It helps explain everyday occurrences, such as why a ball rolls down a hill or how a car accelerates.

Student Learning Outcome

- Explain with examples that physics has many sub-fields, and in today's world involves interdisciplinary fields. (Students should be able to distinguish in terms of the broad subject matter that is studied between the fields: Biophysics, Astronomy, Astrophysics, Cosmology Thermal Physics, Optics, Classical Mechanics, Quantum Mechanics, Relativistic Mechanics, Nuclear Physics, Particle Physics, Electromagnetism, Acoustics, Computational Physics, Geophysics, Climate Physics.)
- Brief with examples that science is a collaborative field that requires interdisciplinary researchers working together to share knowledge and critique ideas

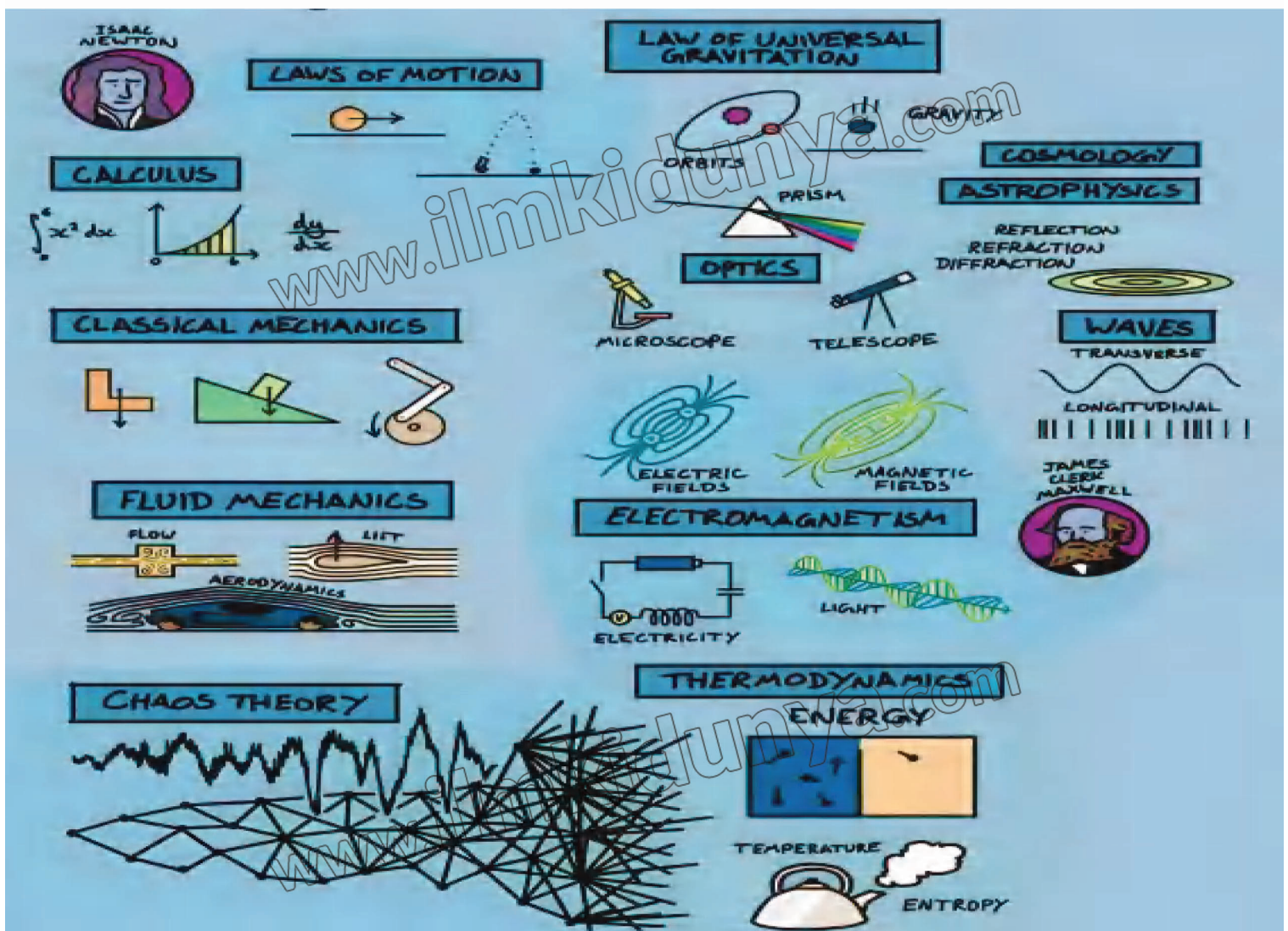
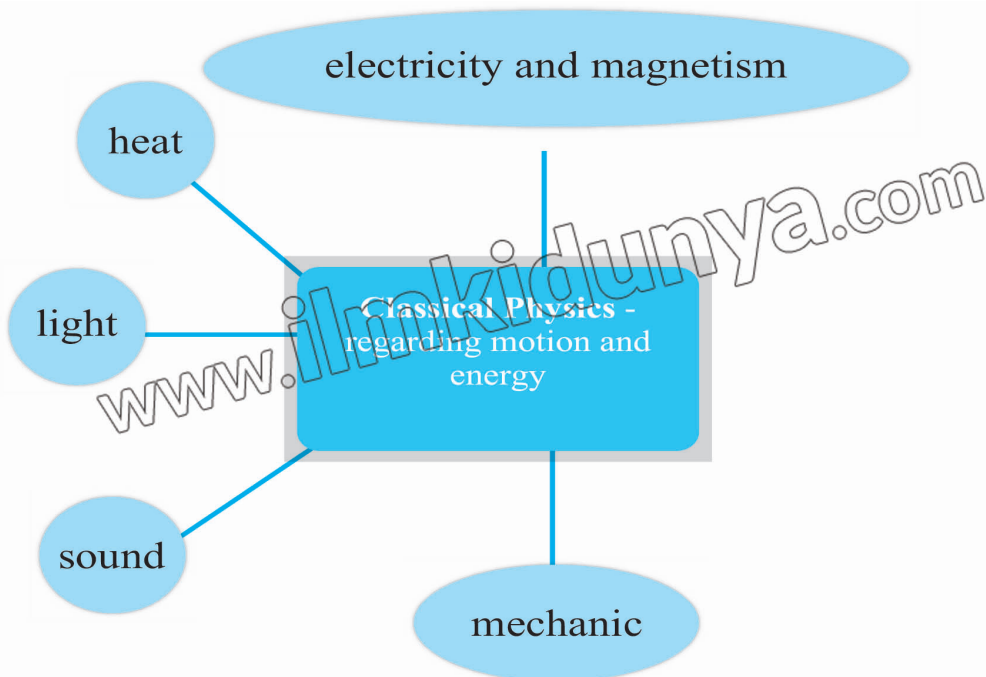


Figure 1.3 Field of study in classical Physics

Quantum Mechanics: It is a field which delves into the physics of the very small, such as atoms and subatomic particles. It introduces students to a world where traditional rules may not apply, revealing the peculiar behavior of matter at the smallest scales.

Relativistic Mechanics: Stemming from Einstein's theories, Relativistic Mechanics explores the relationship between time and space, especially at high speeds. It helps students understand phenomena like time dilation in fast-moving objects.

Nuclear Physics: This branch focuses on the nucleus of the atom and its components. Nuclear Physics is crucial for understanding nuclear energy, radiation, and applications.

Particle Physics: Particle Physics investigates the fundamental particles that make up the universe and the forces that govern them. It offers insights into the basic building blocks of matter and the interactions that shape the physical world.

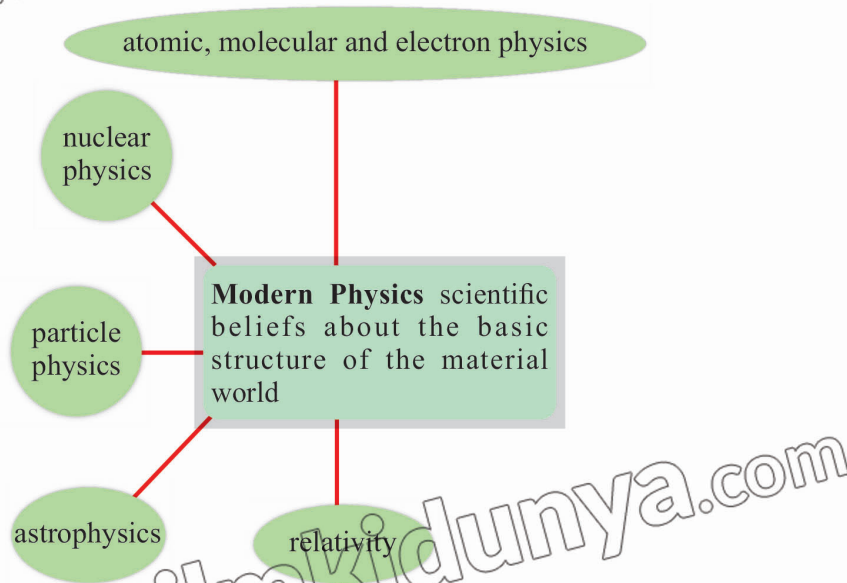


Figure 1.4 Modern Physics

Electromagnetism: In this field we study electric and magnetic fields and their interplay. It explains how magnets work and the principles behind the flow of electricity in circuits.

Acoustics: It is the science of sound, including its production, transmission, and reception. It covers topics like why some sounds are louder or higher-pitched than others and how sound is utilized in technology.

Each of these branches is like a different tool in a toolbox, helping us understand the world and universe in its own unique way. Physics is exciting because it lets us discover new things about everything from tiny atoms to the vast universe.

Science as a collaborative field of Research

Having explored physics and its branches, let us now consider how science advances. Science is a collaborative effort that flourishes when researchers from different disciplines join forces to exchange knowledge and evaluate ideas. Here is a brief explanation with examples:

Climate Change: Addressing climate change requires the combined efforts of climatologists, ecologists, engineers, and policy experts. They work together to understand its causes, effects, and potential solutions.

Medical Breakthroughs: Advances in medicine result from the collaboration of doctors, biologists, chemists, and engineers. For example, the development of MRI technology involved expertise in physics, engineering, and medicine.

Space Exploration: This field combines the skills of scientists, engineers, and mathematicians. Astronomers identify targets for study, engineers design spacecraft, and mathematicians calculate trajectories to explore the universe.

Environmental Conservation: Efforts to conserve the environment involve biologists, ecologists, sociologists, and policymakers. They collaborate to study ecosystems, human impacts, and develop strategies for biodiversity preservation.

Energy Innovation: Developing sustainable energy solutions requires the collaboration of physicists, chemists, engineers, and environmental scientists. Together, they work on renewable energy technologies like solar panels and wind turbines.

Artificial Intelligence: AI research is an interdisciplinary field involving computer scientists, cognitive psychologists, and linguists. They collaborate to create algorithms and models that simulate human intelligence.

Infectious Disease Control: During pandemics, epidemiologists, virologists, statisticians, and healthcare professionals work together to understand disease spread and devise containment strategies.

Archaeology and History: Unraveling historical mysteries often involves collaboration between archaeologists, historians, geologists, and anthropologists. This interdisciplinary approach helps reconstruct the stories of ancient civilizations.

Ten tips for developing interdisciplinary socio-ecological researchers

Interdisciplinary research is different disciplines working together to integrate their disciplinary knowledge and methods, to develop and meet shared research goals that achieve a true synthesis of approaches

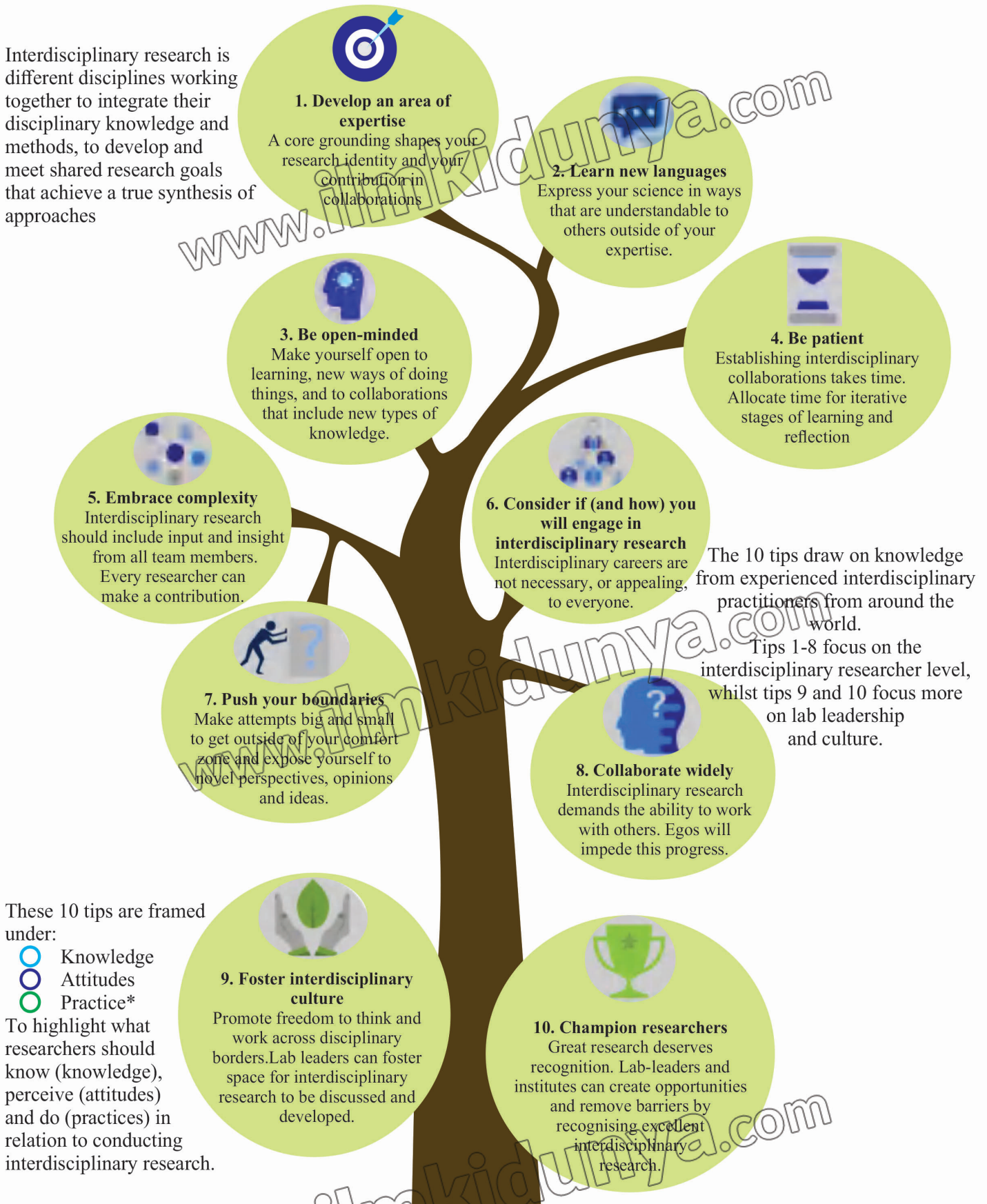


Fig 1.5. Tips for developing interdisciplinary socio-ecological researcher

Spheres of Influence in the Research-Implementation Space

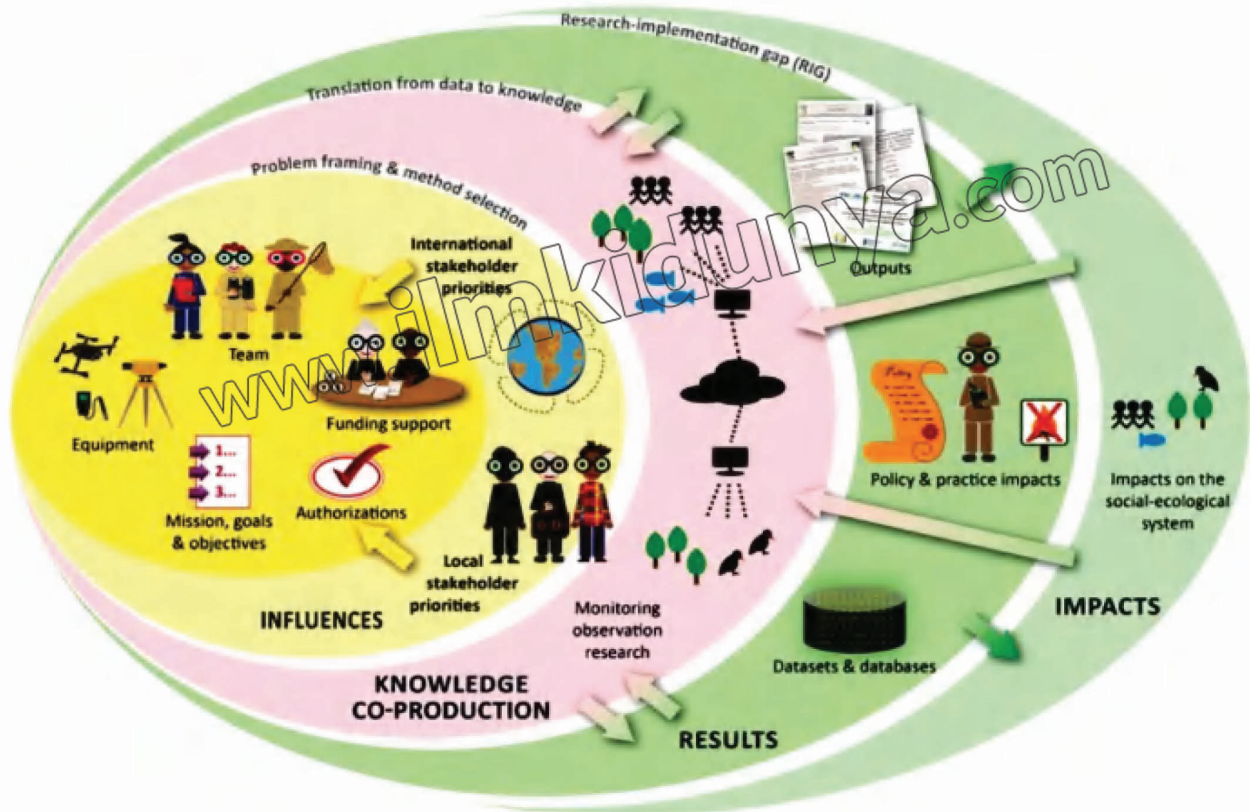


Fig: 1.6 Spheres of influence in the research-implementation space

These examples underscore the collaborative nature of science, where interdisciplinary teams share knowledge and critique ideas to advance our understanding of the world.

Interdisciplinary Areas of Physics

Physics also works together with other sciences to tackle complex problems that cover many topics. This vast network of knowledge not only shows how varied physics is but also emphasizes its key role as a fundamental science. It connects with many other fields, expanding what we know and how we apply this understanding to the world around us.

This blending of physics with other disciplines gives rise to new areas of physics. Let us look at what each of these interdisciplinary areas:

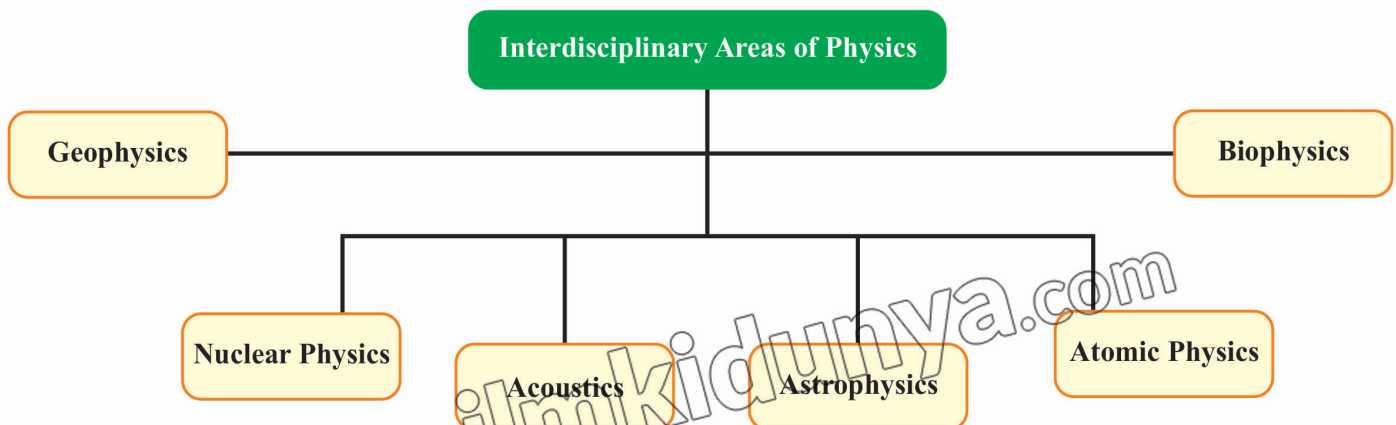


Fig 1.7 Interdisciplinary Areas of Physics

Biophysics: This field combines physics with biology to understand how physical principles govern living systems. Biophysicists study the structure and function of biological molecules, cells, and organisms using concepts from mechanics, thermodynamics, and quantum physics.

Astronomy: While traditionally considered a pure science, modern astronomy has become interdisciplinary, blending physics with other sciences to study celestial objects and phenomena. Astronomers use principles from physics to understand the behavior and properties of stars, planets, and galaxies.

Astrophysics: Astrophysics is a branch of astronomy that specifically applies the laws of physics to explain the physical properties of celestial bodies and phenomena. It encompasses the study of the life cycles of stars, the structure of galaxies, and the physics of the universe.

Cosmology: Cosmology is an interdisciplinary field that combines elements of physics and astronomy to study the origin, evolution, and large-scale structure of the universe. It involves theories from general relativity and quantum mechanics to understand the history of universe and its future.

Computational Physics: This area uses computational methods and algorithms to solve complex physical problems. Computational physicists develop simulations and models to study phenomena that are difficult or impossible to observe directly, making it a crucial tool in many areas of physics and engineering.

Geophysics: Geophysics applies physical principles to study the Earth and its environment. It encompasses areas such as seismology, magnetism, and gravitational studies to understand the Earth's internal structure, dynamics, and its interactions with the atmosphere and space.

Climate Physics: Climate physics, or atmospheric physics, focuses on the physical processes that govern the Earth's climate system. It combines principles from physics, meteorology, and oceanography to study weather patterns, climate change, and the interactions between the atmosphere and oceans.

Knowledge 1.3 | Who are Physicists?

In the vast and fascinating world of science, individuals who dedicate their careers to exploring, understanding, and expanding our knowledge of physics are known as physicists.

Physicists are curious minds who ask big questions like "Why do objects fall to the ground?" or "How can we harness the energy of atoms?" They use experiments, mathematical models, and observations to find answers. Their work involves a lot of problem-solving and creativity, as they develop theories and apply them to solve real-world problems. This could range from developing new medical imaging devices to improve healthcare, to designing more efficient energy sources to power our homes and cities.

Student Learning Outcome

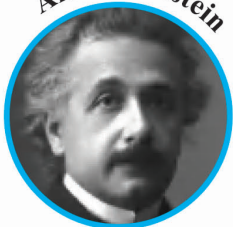
- State that scientists who specialize in the research of physics are called Physicists

Isaac Newton:



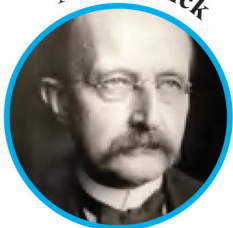
1. Isaac Newton:
First man to give an impression and empirical idea about the universe

Albert Einstein



2. Albert Einstein:
Originator of the First pillar of modern physics: General Relativity

Max Planck



3. Max Planck:
Originator of the Second pillar of modern physics: Quantum Theory

Niels Bohr



4. Niels Bohr:
Contribution to QT and explained atomic structure

Figure 1.8 Renowned Physicists

Being a physicist requires a strong foundation in mathematics and science, as these tools are essential for analyzing data and creating theoretical models. Physicists must also be proficient in critical thinking and have the ability to communicate complex ideas clearly and effectively. This is because sharing findings with the scientific community and the public is a crucial part of their job.

In short, physicists are scientists who specialize in the study of physics. They are essential for advancing our understanding of the universe and improving our quality of life through technological innovations. Their work is a evidence to human curiosity and our continuous search of knowledge.

Here are a few examples of the work of physicists:

Exploring the Subatomic World: Physicists investigate tiny particles like electrons and quarks to understand the building blocks of matter. They use particle accelerators to simulate conditions from the early universe and unravel the mysteries of the subatomic world.

Studying the Cosmos: Many physicists focus on astronomy and astrophysics, exploring stars, galaxies, and the universe's evolution. They aim to uncover the origins and fate of celestial bodies and the cosmos as a whole.

Developing Energy Solutions: Physicists play a crucial role in creating new energy sources and technologies. They work on nuclear power, renewable energy, and innovative materials for electronics, contributing to a sustainable future.

Advancing Technology: Physics is the foundation of many technological breakthroughs, from lasers to MRI machines. Physicists continually push the boundaries of technology, leading to improvements in various fields.

The journey of a physicist is a continuous quest for knowledge. They build on the discoveries of past scientists, and each new finding leads to more questions and further exploration. This cycle of discovery and inquiry is what drives the progress of physics and its impact on our world.

Student Learning Outcome

- > Understand the terms 'hypothesis', 'theory' and 'law' in the context of research in the physics
- > Explain, with examples in Physics, falsifiability as the idea that a theory is scientific only if it makes assertions that can be disproven

Knowledge 1.4 | Fundamental Concepts in Physics Research

In the context of research in physics, the terms "hypothesis," "theory," and "law" have specific meanings and roles in the scientific process. Let us clarify each of these terms:

Hypothesis:

A tentative and testable statement or educated guess that suggests a possible explanation for a specific phenomenon or observation is known as hypothesis. They are proposed at the beginning of a scientific investigation and serve as a starting point for research and experimentation. Scientists use hypotheses to make predictions about what might happen under certain conditions.

Theory:

In physics, theory is a well-substantiated and comprehensive explanation that has withstood extensive testing and experimentation. It represents a higher level of understanding compared to a hypothesis.

Theories are developed after extensive research, data collection, and experimentation. They provide a framework for explaining a wide range of related phenomena. A theory is not considered absolute truth but is the best current explanation based on available evidence. Einstein's Theory of Relativity is a well-known example in physics. It explains the behavior of objects in extreme gravitational fields and at near-light speeds, providing a more accurate description of gravity than Newton's Law of Universal Gravitation.

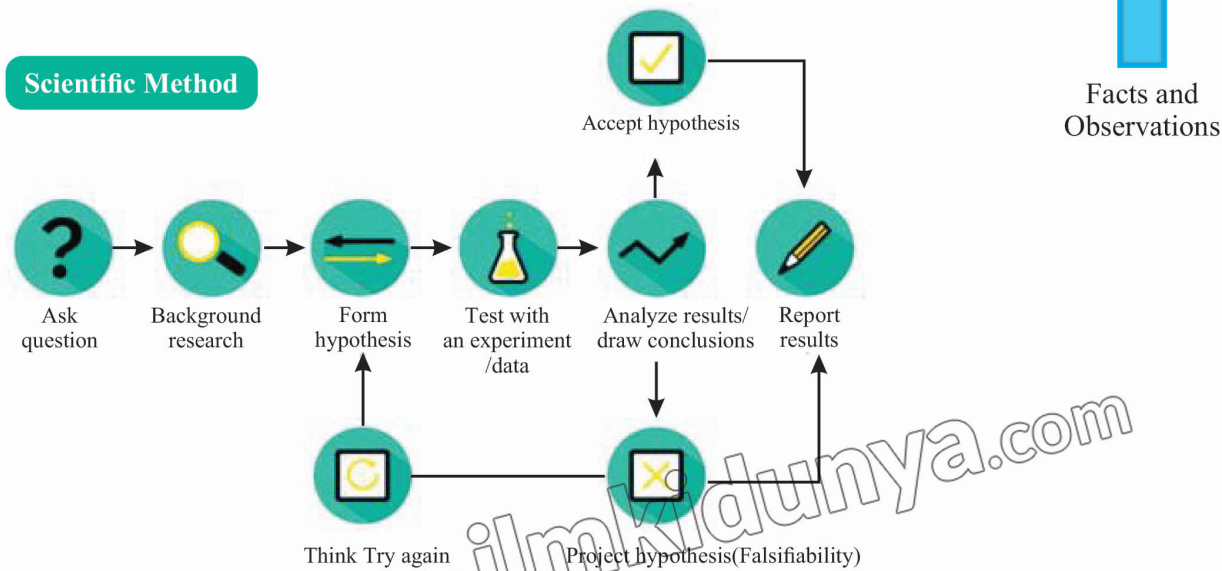


Figure 1.9 Scientific Method to develop a theory

Law:

On the other hand, a law in physics is a concise and descriptive statement that summarizes a consistent and universal relationship observed in nature. Laws describe "what" happens but do not necessarily explain "why" it happens. Laws are fundamental principles that have been observed to be true in a wide range of circumstances and experiments. They provide a basis for predicting and understanding physical phenomena.

Newton's Laws of Motion are classic examples of laws in physics. One of these laws states that the force applied to an object is equal to the mass of the object times its acceleration ($F = ma$).

To summarize, within the realm of physics research:

- A hypothesis is an initial statement or prediction that is tested through experimentation.
- A theory is a well-established and comprehensive explanation of natural phenomena, based on extensive evidence and experimentation.

Key Facts

- Scientific theories and methods change over time.
- The invention of the telescope led to new discoveries about the planets, moon, and stars.
- As telescope technology improved, new discoveries changed our understanding of the Universe.

Skill 1.1

Scientific Terminology

- Students understand the terms 'hypothesis,' 'theory,' and 'law' in the context of physics research. They can differentiate between these concepts and their roles in scientific inquiry.

A law is a concise and universally applicable statement that summarizes observed relationships in nature.

As scientific understanding evolves, hypotheses can lead to the development of theories, and laws can be derived from theories when certain relationships are consistently observed. These terms represent different stages in the scientific process, with each contributing to our understanding of the physical world.

Test Yourself

- How is a theory developed in physics?
- What is the relationship between a theory and a law in physics?

Multiple Choice Questions

- A hypothesis in physics research is:
 - A proven fact about a natural phenomenon
 - An educated guess or prediction that can be tested
 - A universally accepted principle that explains a large body of data
 - A mathematical formula used to calculate physical quantities
- In physics, a theory is:
 - A random guess
 - A well-tested explanation that unifies a broad range of observations
 - An untested idea
 - A law that has been proven incorrect
- A law in the context of physics research usually refers to:
 - A hypothesis that has been somewhat tested
 - A detailed report of an experiment
 - A statement based on repeated experimental observations that describes some aspects of the universe
 - A theory that is not widely accepted

Falsifiability

It is a fundamental concept in the philosophy of science, particularly in the context of scientific theories. This principle asserts that an idea or theory can only be considered scientific if it can be disproven through testing or observation. In the realm of physics, this translates to the notion that all scientific theories must be capable of making testable predictions. If the results of these tests contradict the predictions of theory, then there is reason to suspect the theory may be flawed.

Let us explore the concept of falsifiability in physics with some examples:

- The theory of gravity predicts that objects will fall towards the Earth at a specific rate. This can be tested by measuring how fast objects fall. If an object were found to fall at a different rate than predicted, this would challenge the theory of gravity. However, because all tests have supported predictions of gravity, it remains a strong scientific theory.
- Another example is Einstein's theory of relativity, which made predictions about how light bends around massive objects like the sun. This was tested during a solar eclipse and the



Figure 1.10 Inductive and deductive research methodology

observations matched predictions of Einstein, supporting his theory. If the light had not bent as predicted, Einstein's theory would have been proven false.

Thus, falsifiability is important because it allows scientists to test and challenge theories, helping to ensure that only the most accurate and reliable theories are considered true in physics

Test Yourself

1. How can a physics theory be tested for falsifiability?
2. What happens if a theory in physics is not falsifiable?

Multiple Choice Questions

1. Falsifiability in physics means a theory is scientific if it:
 - a. Can be proven true in all cases
 - b. Is based on unchangeable principles
 - c. Makes assertions that can be disproven
 - d. Is widely accepted by scientists
2. Which of the following is an example of falsifiability in physics?
 - a. A theory that can be tested by experiments and potentially disproven
 - b. A theory that explains all observed phenomena without exception
 - c. A theory based on metaphysical concepts
 - d. A theory that is supported by all scientists
3. A scientific theory in physics is not considered valid if it:
 - a. Cannot be disproven under any circumstances
 - b. Is complex and difficult to understand
 - c. Has been proven true in several experiments
 - d. Is supported by a majority of physicists

Knowledge 1.5 | Science, Technology, and Engineering

In our study of physics, we have learned about 'hypothesis,' 'theory,' and 'law,' as well as the significance of falsifiability, which dictates that a theory must be capable of being proven incorrect to be considered scientific. These concepts are essential for understanding the evolution of science, technology, and engineering."

Science, technology, and engineering are distinct but interconnected fields, each with its own focus and purpose. Let us differentiate these terms with suitable examples:

Science:

Science is primarily concerned with understanding the natural world, uncovering fundamental principles, and explaining natural phenomena. The primary goal of science is knowledge and understanding. It seeks to answer "why" and "how" questions about the universe.

Physicists study the fundamental forces of nature and the behavior of matter and energy. For example, they explore the laws of motion and gravity. Biologists investigate the structures and processes of living organisms. For instance, they study DNA and genetics to understand inheritance patterns.

Skill 1.2

Falsifiability in Physics

- Students comprehend the concept of falsifiability, which states that a theory is scientific only if it makes assertions that can be disproven.
- Examples in physics are used to illustrate this idea.

Important information

It involves making generalizations based on specific observations or experiments. It starts with specific instances and extrapolates to broader conclusions.

Observation: Suppose you observe that the sun has risen in the east every morning of your life.

Induction: Based on these observations, you generalize that the sun always rises in the east.

This is an example of inductive reasoning because you are making a general conclusion based on specific instances.

This example illustrates how inductive reasoning leads to the formulation of hypotheses, which are then subject to falsifiability through empirical

Student Learning Outcome

- Differentiate the terms 'science', 'technology' and 'engineering' with suitable examples.

Deductive reasoning

It starts with a general premise and deduces specific conclusions from it.

Imagine a theory that states: "All objects with mass attract each other." This theory is derived from Newton's law of universal gravitation, which describes the gravitational attraction between two masses. Through deductive reasoning, we can predict specific outcomes based on this theory. For instance, if we have two objects with known masses, we can calculate the gravitational force between them using Newton's law. If, upon measurement, the observed gravitational force does not match the predicted value, it would contradict the theory and demonstrate its falsifiability.

This showcases how deductive reasoning helps to test theories against specific predictions derived from established principles.

Key Facts

- Modern technology can have great benefits, but some technologies can also cause harm.
- The risks and benefits of different technologies need to be assessed before deciding whether or not to use them.

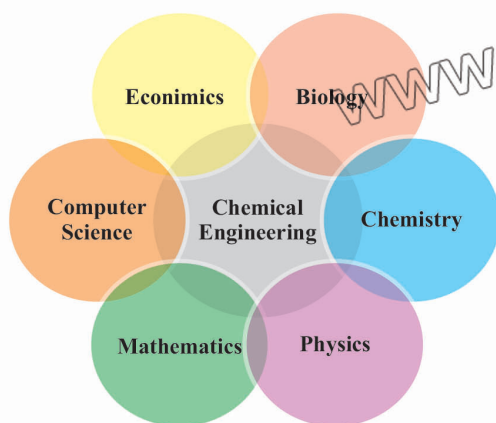


Figure 1.11 Chemical engineering consists of applications of mathematics, physics, chemistry, biology, computer science, and economics.

Technology:

Technology is concerned with the practical application of scientific knowledge to solve specific problems or meet human needs. The primary goal of technology is to create useful products, processes, or systems that improve the quality of life or enhance efficiency.

Smartphones are the result of technological innovation that combines advances in materials, electronics, and software to create versatile communication devices. Technologies like MRI (Magnetic Resonance Imaging) and CT scanners

Engineering:

It is the application of scientific and mathematical principles to design and build systems, structures, and devices. The primary goal of engineering is to bring practical solutions to real-world problems by designing, constructing, and optimizing products and processes.

Civil engineers design and build infrastructure like bridges, roads, and buildings. They ensure that structures are safe and meet specific requirements. Aerospace engineers develop aircraft and spacecraft, applying principles of physics and materials science to create vehicles for air and space travel.

Therefore, science seeks to understand the natural world, technology applies scientific knowledge to create useful tools, and engineering uses science and technology to design and build practical solutions.

These fields often work together in a collaborative manner. For example, scientific discoveries may lead to technological innovations, and engineers use both scientific knowledge and technology to create new systems and devices.

Role of Physics in Our Life

The knowledge gained from studying physics is crucial in various other scientific fields, including astronomy, biology, chemistry, and geology.

Physics is closely linked to practical advancements in engineering, medicine, and technology. Engineers, for instance, apply physics concepts and theories when designing vehicles and machinery.

The study of physics is rapidly expanding, resulting in technological advancements that benefit humanity. Fundamental physics laws and theories enable tasks like launching satellites, gathering data from space probes, and enhancing telecommunications.

Physics research has also facilitated the use of radioactive materials in the diagnosis and treatment of specific diseases.

Physics plays a pivotal role in the development of advanced medical equipment such as magnetic resonance imaging (MRI), X-ray machines, and computerized tomography (CT) scanners, contributing significantly to medical technology.

Physics contributes to enhancing the quality of life by explaining how modern household appliances, like televisions and microwave ovens, operate based on its theories and principles.

Many everyday objects we use, as shown in Table 1.1, function and operate according to the principles of physics, highlighting its widespread relevance in our daily lives.

Table 1.1 Object along with scientific work or principle behind the scene

Object	Principle of physics
Wristwatch	Elasticity, electricity, electronics
Bread toaster	Electrical energy, heat
Bicycle	Mechanics, dynamics, kinematics
Fan	Electromagnetism, mechanics
Computer	Electronics, electricity, electromagnetism
Air conditioner	Thermodynamics, electronics, mechanics
Mobile phone	Waves, electronics
Video camera	Optics, electronics

Malaysia's first satellites, MEASAT 1 and MEASAT 2, were built by Hughes Space and Communications International, Inc. of California. MEASAT 1 was launched on 12 January 1996 from Kourou, French Guiana, and MEASAT 2 was launched on 13 November 1996.

These two satellites serve as a communication network for telephone, television, and data transmission for trade, education, and other telecommunications services; with a coverage stretching from India to Hawaii and from Japan to Eastern Australia.

TiungSAT-1 is a micro satellite designed and fully built in Malaysia. It was successfully launched on 26 September 2000 from Baikonur Cosmodrome, Kazakhstan.

This satellite operates at a height of 1000 km from the Earth's surface and serves as a communication satellite with applications in telecommunications, education, fisheries, forestry, and pollution control. It contains scientific apparatus, cameras, and other equipment for relaying voice and data, signals from remote sensors and global positioning systems (GPS) for purposes of surveying, weather forecasting, detection of forest fires and oil spills.

Photograph of the Earth taken from the TiungSAT-1 at a height of 653 km, at a location with bearings $61^{\circ} 12' N$, $128^{\circ} 4' W$.

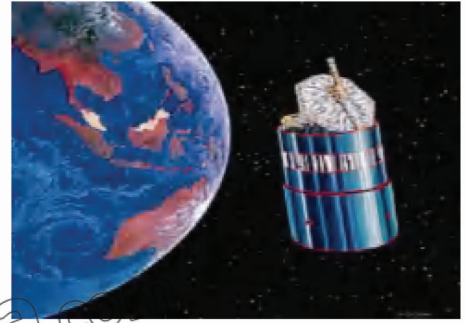


Figure 1.12 MEASAT-1

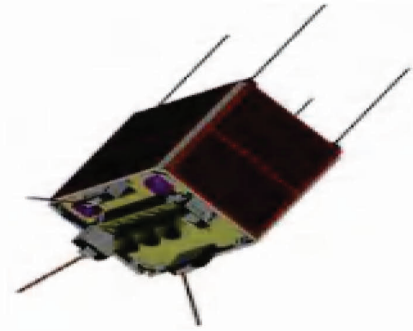


Figure 1.13 MEASAT-2

Test Yourself

1. Can you provide an example where technology and science intersect?
2. What role does engineering play in applying scientific principles?

Multiple Choice Questions

1. Which of the following is an example of technology?
 - a. Formulating a theory about black holes
 - b. Developing a new smartphone
 - c. Constructing a bridge over a river
 - d. Conducting a chemical experiment
2. Engineering is best described as:
 - a. The study of historical events
 - b. The use of scientific principles to design and build machines and structures
 - c. The exploration of space
 - d. The development of mathematical theories
3. Which example best illustrates the practice of science?
 - a. Inventing a new type of solar panel
 - b. Discovering the laws of thermodynamics
 - c. Designing a computer network
 - d. Launching a marketing campaign

Skill 1.3

- Students distinguish between 'science' (the study of natural phenomena), 'technology' (the application of scientific knowledge for practical purposes), and 'engineering' (the design and construction of complex systems).
- They use suitable examples to clarify these distinctions.

**A Multiple Choice Questions:**

- Optics is a branch of physics that investigates:
 - The behavior of animals
 - The properties of light
 - The composition of minerals
 - Cultural traditions
- Physics is considered a natural science because it:
 - Deals with the natural world and its phenomena
 - Focuses on artistic expressions
 - Studies social interactions
 - Analyzes historical events
- As a physical science, physics primarily involves:
 - Understanding societal norms
 - Researching biological organisms
 - Studying matter and energy
 - Examining economic principles
- An example of physics intersecting with other physical sciences is:
 - The study of Earth's geological layers
 - Analysis of historical civilizations
 - Investigation into political theories
 - Research in cultural anthropology
- Which term correctly identifies professionals dedicated to the study and research of physics?
 - Mathematicians
 - Biologists
 - Physicists
 - Geographers
- Interdisciplinary research in science is vital because it:
 - Focuses on individual achievement
 - Leads to isolated discoveries in one field
 - Enables combining expertise from various fields for comprehensive understanding
 - Discourages collaboration and sharing of ideas
- Which of the following best describes the progression from hypothesis to theory to law in physics?
 - Hypothesis → Law → Theory
 - Theory → Hypothesis → Law
 - Hypothesis → Theory → Law
 - Law → Theory → Hypothesis
- What differentiates a theory from a law in physics?
 - A theory is less reliable than a law
 - A law explains why a phenomenon occurs, while a theory describes how it occurs
 - A theory is a well-tested explanation, while a law is a concise statement that is universally accepted
 - There is no difference; they are interchangeable terms
- Which statement best aligns with the concept of falsifiability in physics?
 - Theories must be based on historical beliefs
 - Theories should make predictions that can be tested and potentially falsified
 - Theories are valid if they are old and established
 - Theories need to be universally accepted to be considered scientific
- What distinguishes technology from science and engineering?
 - Technology focuses on theoretical understanding
 - Technology involves the application of scientific knowledge for practical purposes
 - Technology is concerned with the construction of buildings
 - Technology is the same as science

11. An example of engineering is:
- Investigating the behavior of subatomic particles
 - Developing an efficient electric car
 - Creating a vaccine for a new virus
 - Writing a computer program

B Short Questions

- How does computational physics use computational methods to solve physical problems?
- What does particle physics study regarding the fundamental particles and the forces acting upon them?
- How does quantum mechanics describe the behavior of matter and energy at atomic and subatomic levels?
- Why is interdisciplinary research crucial in science?
- What role does critique play in collaborative scientific endeavors?
- How do different scientific disciplines work together to advance knowledge?
- What distinguishes science from technology and engineering?
- How does technology apply scientific knowledge?
- In what ways does engineering differ from science?

C Long questions.

- Physics integrates matter, energy, space, and time to understand phenomena like gravity and quantum behavior, essential for comprehending the universe's fundamental aspects.
- Physics underpins physical and natural sciences, with its principles enhancing understanding and innovations in chemistry, biology, and beyond, showcasing the interconnectedness of scientific disciplines.
- Physicists drive scientific progress by exploring theoretical and practical aspects across diverse fields, contributing to advancements from fundamental physics to applied technologies, highlighted by the achievements of notable individuals.
- Collaboration in physics fosters significant scientific breakthroughs, demonstrating the importance of interdisciplinary efforts in solving complex problems and advancing our understanding of the universe, supported by examples of collaborative achievements.