# UNIT 1

# PHYSICS AND HUMAN SOCIETY

## Introduction

Physics is a major driver of innovation and economic growth in world-wide in sectors ranging from energy, security, advanced manufacturing, data extraction and analysis to healt care and diagnostic, finance and communication for the benefit of society.

In this chapter you will understand the career opportunity of physics, the contribution of physics for every individuals and economic growth of a country. In addition to see you will practice the method of gaining knowledge, It is important in providing fundamental knowledge for understanding nature, in providing applied knowledge for the development of technology.

***After completing this unit, student will be able to:***

- *get acquainted with the impact of physics on society.*
- *familiarize themselves with physics communities and their roles.*
- *develop basic understanding of the making of physics knowledge.*
- *familiarize themselves with basic principles and applications of physics in various disciplines.*
- *acquire basic knowledge and understandings of nature and appreciate it.*
- *update themselves with the current status of physics.*

## 1.1 Importance of Physics to Society

***At the end of this section you will be able to:***

- *explain the importance of physics to society*

### ? Brainstorming

1. What is the benefit of physics for society?
2. What are the technologies directly related to physics that benefit society?

Physics is one of the sciences that generate fundamental knowledge needed for the future technological advances that will continue to drive the economic engines of the world. Physics contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries. Physics is an important element in the education of chemists, engineers and computer scientists, as well as practitioners of the other physical and biomedical sciences. The future of any country and its contribution to the global economy is linked to its ability to develop its human capital in the field of science and engineering. Through its scientists and engineers, it is able to develop infrastructure for trade and industry.

Physics extends and enhances our understanding of other disciplines, such as the earth, agricultural, chemical, biological, and environmental sciences, plus astrophysics and cosmology subjects of substantial importance to all peoples of the world.

Physics can play an important role in developing strategies to combat climate change, in the development of cleaner energies, and in the development of technological advancements.

Physics improves our quality of life by providing the basic understanding necessary for developing new instrumentation and techniques for medical applications, such as computer tomography, magnetic resonance imaging, positron emission tomography, ultrasonic imaging, and laser surgery.

Physics and technology must work together to resolve the need for new technologies that will decrease the damage to our planet, for strategies to ensure that the people of developing countries have the tools to progress, the need for solutions to deadly diseases that remain a threat, and the need for solutions to the increasing demands we place on our resources before they depleted. The role of physics in our modern world is more important than in any other time in history.

Society's reliance on technology represents the importance of physics in daily life. Many aspects of modern society would not have been possible without the important scientific discoveries made in the past. These discoveries became the foundation on which current technologies were developed. Discoveries such as magnetism, electricity, conductors and others made modern conveniences, such as television, computers, phones and other business and home technologies possible. Modern means of transportation, such as aircraft and telecommunications, have drawn people across the world closer together  all relying on concepts in physics.

### The Influence of Physics on Society

***Explain the important of physics in transport, electronics and health.***

Simple mechanical devices such as pulleys and levers, as well as complex modern machines like quantum computers and nuclear reactors, would be impossible to create without the use of physics.

Physics lies at the root of many inventions that have had an enormous impact on the everyday life of the average person. There are numerous ordinary objects that people use regularly that rely on the science of physics to function, including semiconductors, lasers, X-rays, GPS devices, radio transmitters and bar code scanners.

Transportation vehicles such as automobiles, airplanes and space shuttles could not be constructed without the help of physics experts. Physics is also useful for military purposes, informing the design of weapons. Many of the scientists responsible for inventing the atomic bomb were physicists, and today physicists are involved in the creation of nuclear weapons.

**Activity 1.1**

1. Explain the influence of physics on society in transport, health, economy, technology, etc

## 1.2 Physics Communities and Their Roles

***At the end of this section you will be able to:***

- *discuss about physics communities and their roles.*

**Brainstorming**

1. What is the purpose of establishment of physics communities? What are the technologies directly related to physics that benefit society?

Physics communities are an organized group of persons associated together for scientific purposes. This organization is established at the level of national, continent as well as worldwide based on their aims. For example, Ethiopian Physical Society (EPS) was established by Ethiopian physics professionals to enhance physics research and education, thereby contributing its share to the overall development of the country.

## Objectives of EPS

- To promote physics education and research in the country;
- To organize and coordinate various conferences on physics education and exchange of scientific information;
- To popularize physics in order to make students develop interest in physics;
- To promote active participation of Ethiopian physicists and the general public in the design and implementation of the physics curriculum;
- To create a means for disseminating scientific information; etc.

**Ethiopian Physics Society in North America (EPSNA)** was established to promoting physics education and research among Ethiopians in Ethiopia and North America. The mission of EPSNA was to promote and support the education and training of Ethiopian Physics professionals by donating educational materials, field equipment, computing facilities, provide scholarship…etc.

**African association of physics students (aaps)** is Student-run educational association. It comprises students and recent graduates who are interested in physics. The purpose of the organization is to encourage physics students in their scientific and professional work in an African and an international context as well as to promote relations between physics students from all over the world. The 'aaps' is committed to supplement physics education with an international scientific experience and it is affiliated with Physics societies and departments. 'aaps' is open to all persons committed to physics.

## Group Work

Make a group and do a project work on searching for detailed information about Ethiopian space science society (ESSS) mission, strategies, goals etc and present in the class.

### Activity 1.2

What are the benefits of physics communities?

## 1.3 Making of Physics Knowledge

***At the end of this section you will be able to:***

- *discuss how scientific knowledge is constructed.*
- *discuss the roles that the learning of physics plays to the individual intellectual satisfaction.*

### ? Brainstorming

1. What is the process of gaining knowledge in physics?

One way of understanding the concept of knowledge is to look at the different ways in which we acquire knowledge. There are two types of knowledge from two entirely different sources. First, there is knowledge through experience: seeing something, hearing about something, feeling something called *a posteriori* knowledge. Second, there is knowledge that does not come from experience, but perhaps instead is intuitively supplied from reason itself, such as logical and mathematical truths called *a priori* knowledge.

### Experimental knowledge

Experiential (*a posteriori*) knowledge is of many types. Four of them are sensory perception, introspection, memory, and testimony: these are the four main ways of acquiring knowledge through experience.

I. **Sensory perception:** sensory perception is perhaps the dominant source of experiential knowledge, it immediately raises a critical question. We gather knowledge by seeing, touching hearing, etc.

II. **Introspection:** Introspection is like a sixth sense that looks into the most intimate parts of our minds, which allows us to inspect how we are feeling and how our thoughts are operating. If I go to a doctor complaining of an aching back, she'll ask me to describe my pain. Through introspection I then might report, "Well, it's a sharp pain that starts right here and stops right here." The doctor herself cannot directly experience what I do and must rely on my introspective description.

III. **Memory:** a memory is like a recording device that captures events that one can experience more or less in the order that they occur.

IV. **Testimony:** Testimonies from written sources are usually more reliable than

oral sources, but much depends on the integrity of the author, publisher, and the methods of fact-gathering.

## Non-Experiential Knowledge

Turning next to non-experiential (*a priori*) knowledge, this source of information is more difficult to describe. We presumably gain access to this knowledge through rational insight. Usual examples of non-experiential knowledge are mathematics and logic. Take, for example, 2+2=4. Indeed, I might learn from experience that two apples plus two more apples will give me four apples.

## Scientific method

The **scientific method** is an ordered series of steps to acquire knowledge based on experimental evidence.

### Examples of Scientific Method in Physics

**Observation**: the water boiled at a lower temperature when I was visiting the mountains than when I was in other cities with low altitudes.

**Question:** Why does my water boil at different temperatures?

**Research:** In a chemistry book, you read that the boiling temperature of a substance depends on the strength of the molecular bonds of a substance and the pressure.

**Hypothesis:** Since the atmospheric pressure changes with altitude, the boiling temperature of water is different at different altitudes.

**Experiment:** You decide to heat water at different altitudes and record the boiling temperature.

**Analysis:**

| Altitude (m) | Boiling point of water ( C°) |
|---|---|
| 0 | 100 |
| 150 | 99.5 |
| 305 | 99 |
| 610 | 98 |
| 1524 | 95 |

Your measurements indicate that as the height increases, the boiling temperature of water decreases!


**Conclusion:** The original hypothesis was correct. The boiling temperature of water decreases approximately by one degree Celsius.

### Activity 1.3

1. Give some examples in the process of scientific method of knowledge gain.

## 1.4 The Mission of Physics and Career Awareness

***At the end of this section you will be able to:***

- *explain the job opportunities concerning to physics.*

### Brainstorming

1. Mansion lists of career related to physics.

The diversity of physics careers is an appealing aspect for prospective students. Physics graduates have skills that are in high demand in diverse sectors. These include skills relating to numeracy, problem-solving, data analysis and the communication of complex ideas, as well as a wider understanding of how the world works on a scientific and human level.

### Typical careers in physics

Whether you want to explore space, time, matter or the many other intriguing elements of the physical world, a physics degree can do wonders for your career path. While many physics graduates go on to work within research roles, these are spread across many different industries – including education, automotive and aerospace industries, defense, public sector, healthcare, energy, materials, technology, computing and IT.

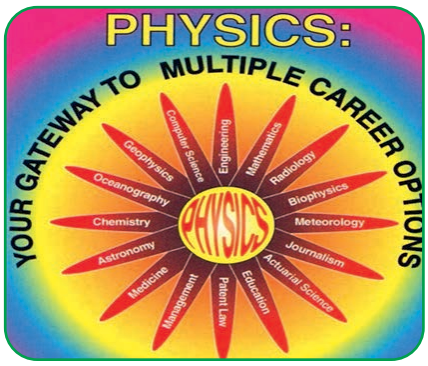



*Figure 1: Career opportunities*

## Physics careers in space and astronomy

As an astronomer, your job would be to study the universe, collecting data from global satellites and spacecraft and operating radio and optical telescopes. Other tasks within this sector include investigation and research of new materials and technologies, measuring performance of existing materials and technologies, and problem-solving at the design stage.

*Figure 2: A person observing stars through telescope*

## Physics careers in healthcare

*Figure 3: observing CT scan result*

Physics careers in the healthcare sector are numerous. Medical physics overlaps significantly with biomedical engineering, and physicists work alongside biomedical engineers to create, review and maintain medical technologies and equipment. Although cardiology and neurology are areas reserved for those with an additional medical degree, physicists are regularly employed within areas such as radiology, radiation oncology and nuclear medicine, in order to test and approve the latest technologies and equipment.

## Physics careers in engineering

The engineering sector provides many careers in physics, particularly within manufacturing and technology-based roles. Physics graduates are often tasked with improving and developing products and manufacturing processes, and benefit from a large range of potential employers spanning multiple industries such as medicine, energy, transport, defense, space exploration and telecommunications.

*Figure 4: engineers working place*

## Physics careers in energy

*Figure 5: wind energy production site*

Whether we're talking about renewable or non-renewable energy, there are plenty of careers in physics within the energy sector. Alongside the rise of renewable energy, oil and gas companies remain big players in the energy market and are major employers for physics graduates. Oneb area of focus is on extracting fossil fuel reserves in the most efficient way possible, using knowledge of the Earth's characteristics and the newest technologies.

With the prospect of fossil fuels running out, energy companies are also branching out into renewable alternatives such as wind and solar energy and are investing heavily in research and development in this area, offering much career potential. Your role here could be to collaborate with other scientists and engineers to develop efficient and functional energy systems which harness the Earth's energy sustainably and cost-effectively.

## Physics careers in technology

A broad arena of continual growth and innovation, the technology sector is a constant source of new opportunities, challenges and career paths. For physics graduates, there is scope to work alongside other specialists in order to develop new ideas and products. Fields with particularly high demand for research and development workers from various backgrounds include relatively young fields such as robotics, nanoscience and nanotechnology.

*Figure 6: application of machines*

Technology careers in physics may be based in public or private-sector research centers. Many opportunities for graduates are available within large technology companies, as these businesses are keen to attract innovative and talented researchers from around the world.

### Geophysics and meteorology careers

Those who study physics are also prime candidates for environmental careers, thanks to their scientific understanding of the ways in which the Earth functions. While geophysicists are more concerned with the prediction of natural disasters, meteorologists focus on areas such as daily weather forecasting, as well as researching the long-term effects of climate change.

*Figure 7: Metrological report*

### Research scientist careers

The main reason to study physics is to help you gain more in-depth, specialized knowledge to prepare you to work effectively in a specific field. Potential areas of specialization include astrophysics, particle physics, biotechnology, nanotechnology, meteorology, aerospace dynamics, atomic and laser physics, atmospheric, oceanic and planetary physics and climate science.

*Figure 8: Data scientist*

**The mission of physics is to** advance science, engineering, and innovation throughout the world for the benefit of all a*nd serving Society.*

## 1.5 Current Status of Physics

***At the end of this section you will be able to:***

- *list at least five recent new developments or discoveries in the fields of physics.*

**? Brainstorming**

Go to library and websites search out what are the newest discoveries in physics

Nowadays, there is a lot of discoveries and inventions in different parts of the world. Among this some are listed below.

## Major recent discoveries in Physics

Physics is the study of physical world from the smallest particles to the gigantic structures known to human; galaxies, clusters of galaxies and black holes. Some of them are,

### Discovery of Exoplanets:

Exoplanet or extrasolar planet is a planet outside our solar system. As of 1 October 2022, there are 5,197 confirmed exoplanets in 3,833 planetary systems.

Michel Mayor and Didier Queloz won the Nobel Prize in Physics in 2019.

*Figure 9: Artist's impressio of exo planet orbiting two stars*

https://www.nobelprize.org/interactive-visualisations-the-discovery-of-exoplanets/
https://en.wikipedia.org/wiki/Michel_Mayor
https://en.wikipedia.org/wiki/Didier_Queloz

### Black hole:

Black hole is a region of space-time the gravity of it so strong that nothing can escape. Not even, light (electromagnetic wave).

Roger Penrose, Reinhard Genze. And Andrea M. Ghez have won the Nobel Prize in 2020 for discovery black hole formation and discovery of supermassive compact object (Black hole) at the center of our Milky-way Galaxy.

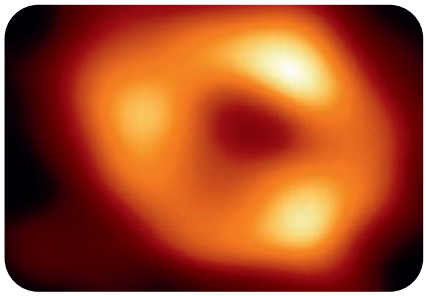


*Figure 10: Image of Black Hole*

https://en.wikipedia.org/wiki/Roger_Penrose,
https://en.wikipedia.org/wiki/Reinhard_Genzel
https://en.wikipedia.org/wiki/Andrea_M._Ghez

## Quantum cryptography:

Cryptography is a way of sending information and messages in secret. Think of your bank account number, password etc. without the secret encryption all these are at risk. Quantum cryptography is an application of quantum physics that enhances the security of the information exchange at higher level.

## High energy physics (Particle Accelerators)

July 4, 2012 EC, CERN scientists (thousands of them doing collaboratively from almost every corner of the world) discovered a particle called Higgs Boson. It is a subatomic particle like photons, protons and electrons but at the very basic level. The experiment took 60 years to prove the existence of this particle.

## Gravitational wave (Large scale structures)

Even more years have taken to prove Albert Einstein's theory of gravity that says gravity is a wave that travels with the speed of light $3.00 \times 10^8$ m /s. The hypothesis was formulated in 1916, it was proved to be right in 2016 by LIGO, it took again thousands of scientists' collaborative work. They use Laser Interferometer as shown in the figure.

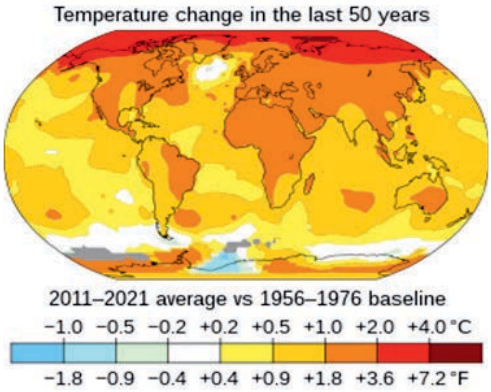
## Global warming:

Global warming is an increase in earth's temperature and its impact on earth's climate.

Climate is a long-term weather variability averaged over many years and decades. Some of the variables are temperature, humidity, atmospheric pressure and wind. According to World Meteorological Organization (WMO) a typical variability average year is 30.

Syukuro Manabe and Klaus Hasselmann have won the Nobel Prize in Physics in 2021 for modeling earth's climate and reliability predicting global warming. The following images from Wikipedia illustrate the effect of global warming.

*Figure 11: gravitational wave experimenting areas*



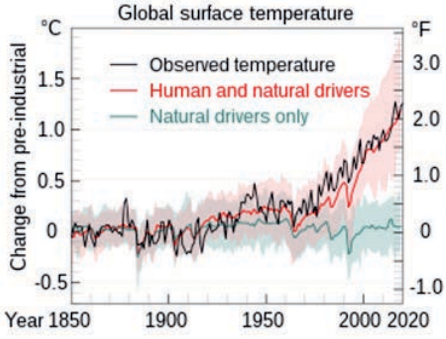




*Figure 12: illustrating the effect of global warming.*

https://en.wikipedia.org/wiki/Syukuro_Manabe
https://en.wikipedia.org/wiki/Klaus Hasselmann

## James Webb Space Telescope (JWST)

It is an infrared telescope located between earth and sun at a distance of 1,500,000 km beyond Earth's orbit around the Sun. It is operating at the temperature of (−223 °C) important for infrared detection of the galaxies and other large-scale structures.

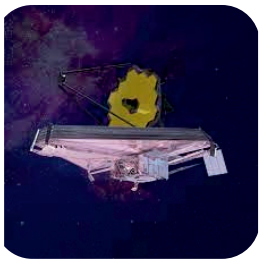


*Figure 13: image of JWST*

It will tell us about assembly of galaxies, birth of stars and atmospheres of exoplanets and objects in our solar system.

*Figure 14: Star formation in Carina Nebula.*

## Future perspectives.

Research at the forefront is very expensive (Billions of dollars), it is also needing a collaboration of scientists from many fields. It also involves many countries.

Rich countries have huge laboratories of their own with many physicists involved. Ethiopia as developing country must start doing physics at the highest level for its national security and sustainable growth. the Ethiopian Science and Art Museum inaugurated by PM Abiy Ahmed 4 October 2022 would stimulate and attract young students towards science. It is situated in Addis Ababa.

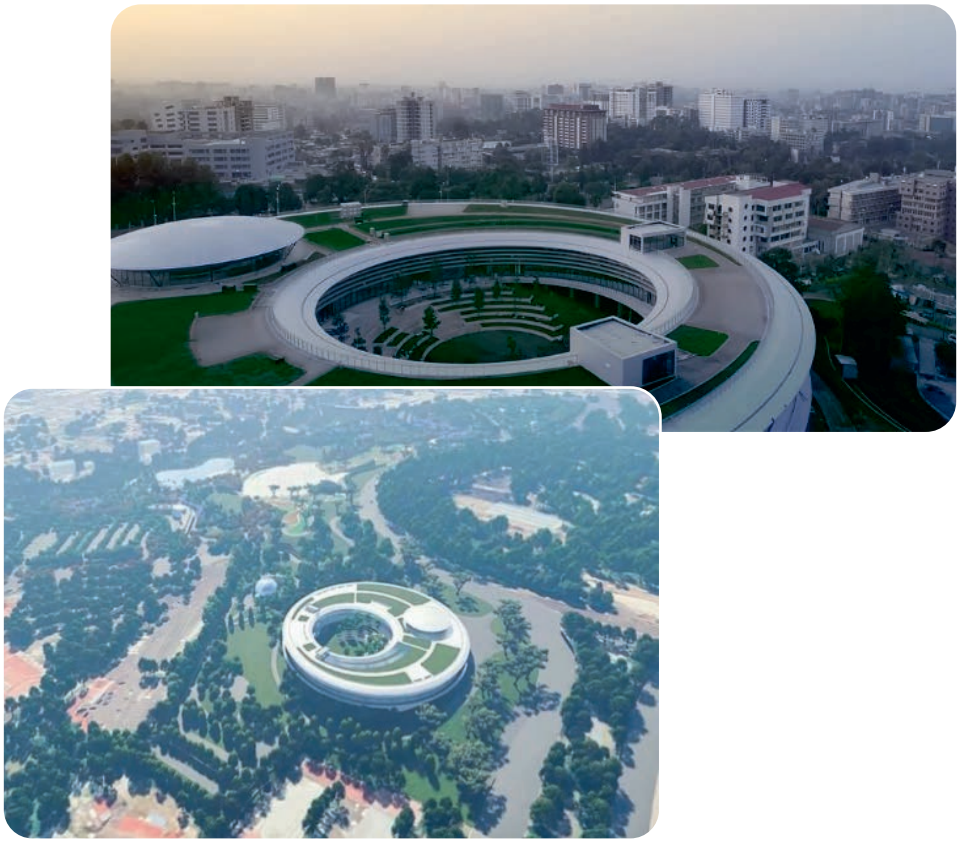


*Figure 15: Some photographs of the newly inaugurated Ethiopian Science and Art Museum.*

The museum holds exhibition hall dedicated to scientific and developmental research. It also includes several building complexes dedicated to interactive display screens, cyber security, geographical information system (GIS), data analysis, manufacturing, and robotics to name a few.

*Figure 16: Interior of the Dome-shaped Science and Art Museum*

Planetarium: Inside this dome you can seat and watch from our solar system to stars and galaxies. It is an amazing and inspiring place for young and old alike.

### Activity 1.4

1. Google the web or go to the library to find some information to find out what is going on https://en.wikipedia.org/wiki/Ethiopia_Museum_of_Art_and_Science.

## Questions 1.1

***Explain current status of physics.***

1. What do you think the future of physics looks like? Your opinions in one paragraph or two with justification.
2. What is the significances of the two discoveries- gravitational wave, and Higgs boson?

## UNIT SUMMARY

- Physics improves our quality of life by providing the basic understanding necessary for developing new instrumentation and techniques for medical applications, such as computer tomography, magnetic resonance imaging, positron emission tomography, ultrasonic imaging, and laser surgery.
- Transportation vehicles such as automobiles, airplanes and space shuttles could not be constructed without the help of physics experts.
- Physics is also useful for military purposes, informing the design of weapons. Many of the scientists responsible for inventing the atomic bomb were physicists, and today physicists are involved in the creation of nuclear weapons.
- Physics communities are an organized group of persons associated together for scientific purposes. This organization is established at the level of national, continent as well as worldwide based on their aims.
- The scientific method is an ordered series of steps to acquire knowledge based on experimental evidence.
- The mission of physics is to advance science, engineering, and innovation throughout the world for the benefit of all and serving Society.
- Physics have a lot of job opportunities in the fields of Astronomy, healthcare, engineering, energy, technology, meteorology, etc
- New discoveries of Exoplanets, Black hole, Quantum cryptography, High energy physics, Gravitational wave, Global warming, James Webb Space Telescope, etc have been seen in recent years.

## END OF UNITQUESTIONS

1. What is the importance of learning physics in your opinion?
2. What did you benefit from knowing physics at this level?
3. List at least ten technological benefits that physics has contributed for society.
4. What is the benefit of establishing physics communities?
5. Is there a physics community in your high school? If the answer is yes, what is it helpful for?
6. What process skills should you use investigating a phenomenon?
7. What are the process skills you are using in your in investigating a phenomenon?
8. What are the career opportunities physics have?
9. At the forefront in physics research, there are many countries collaborating. Why is that?