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ENTRANCE TRICKS**❖ The Foundational Role of Physics**

Physics is a fundamental science that generates the essential knowledge required for future technological advancements. These advancements, in turn, continue to drive the world's economic engines. The field contributes directly to the technological infrastructure of a society and provides the trained personnel—scientists and engineers—needed to capitalize on scientific discoveries.

A country's future and its contribution to the global economy are strongly linked to its ability to develop its human capital in science and engineering. This expertise is crucial for developing the infrastructure for trade and industry. Furthermore, physics extends and enhances our understanding of other disciplines, including:

- ✓ Earth sciences
- ✓ Agricultural sciences
- ✓ Chemistry
- ✓ Biological and environmental sciences
- ✓ Astrophysics and cosmology

❖ Physics in Technology, Daily Life, and Specialized Fields

The principles of physics are essential for creating everything from simple mechanical devices to complex modern machines.

- **Simple & Complex Machines:** Devices like pulleys and levers, as well as advanced technologies like quantum computers and nuclear reactors, are impossible to create without physics.
- **Everyday Inventions:** Physics is at the root of numerous inventions that impact our daily lives.

Common objects that rely on physics include:

- ✓ Semiconductors
- ✓ Lasers
- ✓ X-ray machines
- ✓ GPS devices
- ✓ Radio transmitters
- ✓ Bar code scanners

- **Transportation and Defense:** The construction of vehicles such as automobiles, airplanes, and space shuttles depends heavily on the expertise of physicists. Physics is also critical for military applications, informing the design of weapons, from the atomic bomb to modern nuclear weapons.

❖ **Physics Communities and Organizations**

Physics communities are organized groups of people associated for scientific purposes. These organizations can be established at national, continental, or worldwide levels. They play a key role in promoting research, education, and collaboration.

➤ **Ethiopian Physical Society (EPS)**

Established by: Ethiopian physics professionals.

Purpose: To enhance physics research and education, thereby contributing to the overall development of the country.

Objectives of EPS:

- ✓ To promote physics education and research in the country.
- ✓ To organize and coordinate conferences on physics education and the exchange of scientific information.
- ✓ To popularize physics and help students develop an interest in the subject.
- ✓ To promote the 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.

➤ **Ethiopian Physics Society in North America (EPSNA)**

Purpose: To promote physics education and research among Ethiopians in both Ethiopia and North America.

Mission: To promote and support the education and training of Ethiopian physics professionals by donating resources such as educational materials, field equipment, computing facilities, and providing scholarships.

➤ **African Association of Physics Students (AAPS)**

Structure: A student-run educational association comprising students and recent graduates interested in physics.

Purpose:

- ✓ To encourage physics students in their scientific and professional work within an African and international context.
- ✓ To promote relations between physics students from all over the world.
- ✓ To supplement physics education with an international scientific experience.

Affiliation: It is affiliated with physics societies and departments and is open to all persons committed to physics.

❖ **Understanding Knowledge and the Scientific Method**

Types of Knowledge

One way to understand the concept of knowledge is to look at the different ways we acquire it.

There are two primary types from different sources:

- **A Posteriori Knowledge (Experiential):** This is knowledge gained through experience, such as seeing, hearing, or feeling something.
- **A Priori Knowledge (Non-Experiential):** This is knowledge that does not come from sensory experience but is supplied by reason itself, such as logical and mathematical truths (e.g., $2+2=4$).

Sources of Experiential (A Posteriori) Knowledge

There are four main ways we acquire knowledge through experience:

I. Sensory Perception: The dominant source of experiential knowledge, gathered through seeing, touching, hearing, etc.

II. Introspection: A "sixth sense" that allows us to inspect our own minds, feelings, and thoughts. For example, describing the specific feeling of a pain to a doctor.

III. Memory: A recording device that captures events in the order they occur, allowing us to recall past experiences.

IV. Testimony: Knowledge gained from what others tell us, either orally or in writing. Written sources are often more reliable, depending on the integrity of the author, publisher, and fact-gathering methods.

❖ The Scientific Method

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

Example of the Scientific Method in Physics

- ✓ **Observation:** Water boiled at a lower temperature in the mountains than in cities at low altitudes.
- ✓ **Question:** Why does water boil at different temperatures?
- ✓ **Research:** A chemistry book explains that boiling point depends on molecular bond strength and atmospheric pressure.
- ✓ **Hypothesis:** Since atmospheric pressure changes with altitude, the boiling temperature of water is different at different altitudes.
- ✓ **Experiment:** Heat water at different altitudes and record its boiling temperature.

Analysis of Experimental Data

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

- ✓ **Conclusion:** The measurements indicate that as altitude (height) increases, the boiling temperature of water decreases. The original hypothesis was correct.

Careers in Physics

The diversity of physics careers is a major appeal for prospective students. Physics graduates possess high-demand skills, including numeracy, problem-solving, data analysis, communication of complex ideas, and a broad understanding of the world. These skills are valuable in education, automotive, aerospace, defense, public sector, healthcare, energy, materials, technology, computing, and IT.

➤ **Space and Astronomy**

Role: Study the universe by collecting data from satellites and spacecraft, and operating telescopes.

Tasks: Investigating new materials and technologies, measuring performance of existing ones, and solving design-stage problems.

➤ **Healthcare**

Role: Physicists work alongside biomedical engineers to create, review, and maintain medical technologies.

Key Areas: Radiology, radiation oncology, and nuclear medicine, where they test and approve new equipment.

➤ **Engineering**

Role: Focus on improving and developing products and manufacturing processes.

Industries: Medicine, energy, transport, defense, space exploration, and telecommunications.

➤ **Energy**

Renewable & Non-Renewable: Oil and gas companies employ physicists to extract fossil fuels efficiently. Simultaneously, the rise of renewable energy (wind, solar) offers roles in researching and developing sustainable and cost-effective energy systems.

➤ **Technology**

Role: Collaborate with other specialists to develop new ideas and products.

High-Demand Fields: Rapidly growing areas like robotics, nanoscience, and nanotechnology offer many opportunities in both public and private-sector research centers.

➤ **Geophysics and Meteorology**

Geophysicists: Concerned with understanding Earth's internal processes and predicting natural disasters.

Meteorologists: Focus on daily weather forecasting and researching the long-term effects of climate change.

➤ **Research Scientist**

Path: Studying physics provides specialized knowledge to work effectively in a specific field.

Specializations: Astrophysics, particle physics, biotechnology, nanotechnology, aerospace dynamics, atomic and laser physics, atmospheric science, and climate science.

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

❖ Major Recent Discoveries and Frontiers in Physics

Physics is the study of the physical world, from the smallest particles to the gigantic structures known to humanity, such as galaxies, clusters of galaxies, and black holes.

1. Astrophysics and Cosmology

Discovery of Exoplanets:

- ✓ **What it is:** An exoplanet (or extrasolar planet) is a planet outside our solar system.
- ✓ **Key Data:** As of October 1, 2022, there were 5,197 confirmed exoplanets in 3,833 planetary systems.
- ✓ **Nobel Laureates (2019):** Michel Mayor and Didier Queloz won the Nobel Prize in Physics for this discovery.

Black Holes:

- ✓ **What it is:** A region of space-time where gravity is so strong that nothing—not even light—can escape.
- ✓ **Nobel Laureates (2020):** Roger Penrose, Reinhard Genzel, and Andrea M. Ghez won the prize for the discovery of black hole formation and for the discovery of a supermassive compact object (a black hole) at the center of our Milky Way galaxy.

Gravitational Waves:

- ✓ **What it is:** A direct consequence of Albert Einstein's theory of gravity (General Relativity), which posits that gravity travels in waves at the speed of light (3.00×10^8 m/s).
- ✓ **The Discovery:** The hypothesis was formulated in 1916 but was proven correct 100 years later, in 2016, by the LIGO scientific collaboration. This achievement required the collaborative work of thousands of scientists.

James Webb Space Telescope (JWST):

- ✓ **What it is:** An infrared telescope located 1.5 million km beyond Earth's orbit, operating at a temperature of -223°C . This extreme cold is crucial for detecting infrared signals from distant galaxies.
- ✓ **Scientific Goals:** It will help us understand the assembly of galaxies, the birth of stars, and the composition of exoplanet atmospheres and objects within our solar system.

2. Quantum and Particle Physics

Quantum Cryptography:

- ✓ **What it is:** Cryptography is the practice of securing information (like bank account numbers and passwords). Quantum cryptography is an application of quantum physics that enhances the security of information exchange to a much higher level, making it virtually unhackable.

High Energy Physics (Particle Accelerators):

- ✓ **Discovery of the Higgs Boson:** On July 4, 2012, scientists at CERN (thousands of them collaborating from around the world) discovered a subatomic particle called the Higgs

Boson. This experiment confirmed a 60-year-long search for the particle that explains how other particles gain mass.

❖ Earth and Climate Science

Global Warming:

- ✓ **What it is:** Global warming is the increase in Earth's average surface temperature and its impact on climate. Climate is the long-term weather variability (temperature, humidity, pressure, wind) averaged over many years (typically 30 years, according to the WMO).
- ✓ **Nobel Laureates (2021):** Syukuro Manabe and Klaus Hasselmann won the Nobel Prize in Physics for physically modeling Earth's climate and reliably predicting global warming.

❖ Physics and other sciences

Science encompasses various disciplines that collectively enhance our understanding of the world. Each scientific field is interconnected, benefiting from advancements in others. Recognizing the contributions of each discipline is vital for collaborative scientific development and its impact on society and the environment.

➤ Physics and Chemistry

Physics is foundational to many scientific developments, particularly chemistry. The overlap occurs when studying matter composed of electrons and nuclei, where fundamental laws govern behavior. Both fields focus on matter and energy interactions, with atomic and subatomic physics explaining chemical principles.

Physics provides insights into covalent and ionic bonding processes. Heat energy physics informs chemists about reaction feasibility and equilibrium composition. Spectroscopy, a key tool in both fields, studies matter's interaction with electromagnetic radiation.

➤ Physics and Biology

Understanding life requires knowledge of physics, which explains various biological processes, including human motion, metabolism, and blood flow dynamics.

- ✓ **Newtonian mechanics** describes animal movement and stability.
- ✓ **Fluid dynamics** principles are crucial for understanding blood circulation.
- ✓ **Sound wave physics** explains vocalization and hearing mechanisms.
- ✓ **Electrical phenomena** govern the nervous system and muscle control.
- ✓ **Optical physics** is essential for vision and photosynthesis in plants.

➤ Physics and Astronomy

Astrophysics studies celestial objects and phenomena, utilizing physics principles to understand motion and radiation in space.

- ✓ **Newton's laws** describe planetary motion and gravitational interactions.
- ✓ **Electromagnetic** waves are used to gather information about stars and galaxies.
- ✓ **Light measurements** help determine distances in space using the inverse square law.
- ✓ **Atomic astrophysics** connects atomic physics with astronomical observations.

➤ Physics and Geology, a branch of Earth science, relies on physics to understand geological processes and properties of rocks and minerals.

- ✓ **Physics concepts** like force, optics, and waves are applied in geological studies.
- ✓ **Geologists** analyze properties such as density, magnetization, and radioactivity.

- ✓ **Geological** knowledge aids in locating economically valuable resources.

➤ **Physics and engineering**

Physics underpins various engineering disciplines, providing essential knowledge for solving complex problems.

- ✓ **Civil Engineering** Civil engineering involves designing infrastructure using principles of physics, such as forces and fluid pressure.
- ✓ **Mechanical Engineering**
 - Mechanical engineering applies physics to create systems like engines and vehicles, focusing on mechanics and thermodynamics.
- ✓ **Electrical Engineering**
 - Electrical engineering designs circuits and systems, requiring knowledge of electromagnetism and energy conversion.
- ✓ **Chemical Engineering**
 - Chemical engineering focuses on processes involving chemical reactions, governed by physical chemistry and thermodynamics

➤ **Medical physics**

Medical physics applies physics principles to diagnose and treat medical conditions, revolutionized by X-ray technology.

- ✓ **Medical imaging techniques** include MRI, CT scans, and ultrasound.
- ✓ **MRI utilizes** magnetic resonance to create detailed images of soft tissues.
- ✓ **CT scans** provide cross-sectional images using X-ray absorption differences.
- ✓ **Ultrasound** employs high-frequency sound waves to visualize internal structures.

➤ **Physics and defense technology**

Defense technology relies on physics for advancements in various military applications.

- ✓ **Radar technology** detects and tracks objects using electromagnetic signals.
- ✓ **Missiles utilize** Newtonian mechanics for accurate targeting.
- ✓ **Infrared detection** aids in night vision and object identification.

➤ **Physics in communication**

Communication technologies depend on physics for effective information transfer.

- ✓ **Wireless communication** utilizes radio waves and microwaves.
- ✓ **Wired communication** employs electrical circuits and optical fibers.

-Understanding wave phenomena is crucial for communication systems.

Worksheet

1. What is physics primarily responsible for driving, according to?
 - a) Cultural revolutions
 - b) Economic engines of the world
 - c) Political ideologies
 - d) Religious practices
2. Which common device relies on physics principles to function?
 - a) Handwritten letters
 - b) Bar code scanners
 - c) Wooden furniture
 - d) Organic fertilizers
3. The Ethiopian Physical Society (EPS) was established to:
 - a) Regulate international trade
 - b) Enhance physics research and education in Ethiopia
 - c) Promote religious studies
 - d) Manage agricultural development
4. What type of knowledge is gained through sensory experience (a posteriori)?
 - a) Mathematical truths
 - b) Introspection
 - c) Logical deductions
 - d) Ethical principles
5. In the scientific method example (water boiling), what was the hypothesis?
 - a) Water purity affects boiling point
 - b) Boiling temperature changes with altitude due to atmospheric pressure
 - c) Molecular bonds weaken at high temperatures
 - d) Altitude impacts water density
6. Which skill is NOT highlighted as a strength of physics graduates?
 - a) Data analysis
 - b) Culinary expertise
 - c) Problem-solving
 - d) Communication of complex ideas
7. Medical physicists primarily work in which healthcare area?
 - a) Cardiology (without a medical degree)
 - b) Radiology
 - c) Neurology (without a medical degree)
 - d) Pediatrics
8. What particle was discovered by CERN scientists in 2012?
 - a) Neutron
 - b) Higgs Boson
 - c) Quark
 - d) Photon

9. Gravitational waves travel at:

- a) The speed of sound
 - b) The speed of light
 - c) Mach 1
 - d) Subsonic speeds
10. The James Webb Space Telescope (JWST) operates in which spectrum?
- a) Ultraviolet
 - b) Infrared
 - c) X-ray
 - d) Gamma-ray
11. Physics contributes to the technological infrastructure by providing:
- a) Political advisors
 - b) Trained personnel
 - c) Religious leaders
 - d) Artistic inspiration
12. Which invention required physics expertise for its development?
- a) Hand loom
 - b) Nuclear reactor
 - c) Clay pottery
 - d) Manuscript illumination
13. EPSNA aims to support:
- a) European physicists
 - b) Ethiopian physics professionals in Ethiopia and North America
 - c) African political leaders
 - d) Global trade organizations
14. Knowledge gained through reason alone (e.g., mathematics) is called:
- a) A posteriori
 - b) A priori
 - c) Testimonial
 - d) Sensory perception
15. In the scientific method, what follows "Research"?
- a) Observation
 - b) Experiment
 - c) Hypothesis
 - d) Conclusion
16. Which sector employs physicists for renewable energy research?
- a) Textile manufacturing
 - b) Energy companies
 - c) Culinary arts
 - d) Literary publishing
17. Who shared the 2020 Nobel Prize for black hole discoveries?

- a) Michel Mayor and Didier Queloz
 - b) Roger Penrose, Reinhard Genzel, and Andrea Ghez
 - c) Svukuro Manabe and Klaus Hasselmann
 - d) Albert Einstein and Isaac Newton
18. Quantum cryptography enhances:
- a) Agricultural yield
 - b) Information security
 - c) Transportation speed
 - d) Artistic expression
19. The Ethiopian Science and Art Museum aims to:
- a) Replace universities
 - b) Stimulate interest in science among youth
 - c) Promote traditional crafts only
 - d) Fund political campaigns
20. Physics explains blood circulation in biology through:
- a) Fluid dynamics
 - b) Quantum entanglement
 - c) Thermodynamic cycles
 - d) Optical refraction
21. Newton's laws are applied in astronomy to study:
- a) Plant photosynthesis
 - b) Planetary motion
 - c) Human neurology
 - d) Chemical bonding
22. Geologists use physics to analyze:
- a) Literary texts
 - b) Rock density and magnetization
 - c) Political trends
 - d) Musical harmony
23. Civil engineering relies on physics principles for:
- a) Poetry composition
 - b) Designing infrastructure (e.g., bridges)
 - c) Painting techniques
 - d) Culinary recipes
24. MRI technology in medical physics is based on:
- a) Magnetic resonance
 - b) Gravitational waves
 - c) Quantum computing
 - d) Solar energy
25. Infrared detection in defense technology is used for:

- a) Night vision
 - b) Voice recognition
 - c) Soil analysis
 - d) Water purification
26. Optical fibers in communication rely on principles of:
- a) Light transmission
 - b) Fluid pressure
 - c) Magnetic levitation
 - d) Thermal conductivity
27. Physics is essential for practitioners of:
- a) Biomedical sciences
 - b) Medieval history
 - c) Abstract painting
 - d) Classical poetry
28. Which everyday object functions using physics principles?
- a) Feather quill
 - b) GPS device
 - c) Wool blanket
 - d) Stone sculpture
29. The African Association of Physics Students (aaps) is:
- a) A government agency
 - b) A student-run educational association
 - c) A religious group
 - d) A commercial enterprise
30. Introspection as a source of knowledge involves examining:
- a) Planetary orbits
 - b) Personal thoughts and feelings
 - c) Chemical reactions
 - d) Historical events
31. Boiling point data at different altitudes proved that temperature:
- a) Increases with height
 - b) Decreases with height
 - c) Is unaffected by altitude
 - d) Depends on water volume
32. Astronomers primarily use:
- a) Telescopes and satellites
 - b) Microscope
 - c) Stethoscopes
 - d) Seismographs
33. Physicists in healthcare collaborate closely with:

- a) Biomedical engineers
 - b) Political scientists
 - c) Chefs
 - d) Novelists
34. Oil and gas companies hire physicists to:
- a) Write company slogans
 - b) Extract fossil fuels efficiently
 - c) Design uniforms
 - d) Manage social media
35. Meteorologists study:
- a) Long-term climate change effects
 - b) Rock formations
 - c) Neural networks
 - d) Ancient manuscripts
36. The 2021 Nobel Prize in Physics recognized work on:
- a) Exoplanets
 - b) Climate modeling and global warming
 - c) Quantum teleportation
 - d) Laser technology
37. JWST is positioned:
- a) On Earth's surface
 - b) 1,500,000 km beyond Earth's orbit
 - c) On the Moon
 - d) In Earth's atmosphere
38. The planetarium in the Ethiopian Science Museum allows visitors to observe:
- a) Solar systems and galaxies
 - b) Bacterial cultures
 - c) Chemical explosions
 - d) Musical instruments
39. Spectroscopy in chemistry and physics studies interactions with:
- a) Electromagnetic radiation
 - b) Gravitational fields
 - c) Acoustic waves
 - d) Mechanical stress
40. Electrical engineering requires knowledge of:
- a) Electromagnetism
 - b) Genetic coding
 - c) Baroque art
 - d) Soil erosion
41. Radar technology in defense uses:

- a) Electromagnetic signals
 - b) Seismic waves
 - c) Thermal currents
 - d) Chemical reactions
42. Physics helps explain hearing in biology through:
- a) Sound wave principles
 - b) Quantum tunneling
 - c) Fluid viscosity
 - d) Nuclear fusion
43. The primary mission of physics is to:
- a) Advance science and serve society
 - b) Replace other sciences
 - c) Fund political systems
 - d) Preserve historical traditions
44. Exoplanets are:
- a) Planets outside our solar system
 - b) Asteroids in the Kuiper Belt
 - c) Artificial satellites
 - d) Black holes
45. LIGO experimentally confirmed:
- a) Gravitational waves
 - b) Dark matter
 - c) Quantum entanglement
 - d) String theory
46. Global warming is evidenced by:
- a) Rising Earth temperatures
 - b) Increased volcanic activity
 - c) Magnetic pole reversal
 - d) Oceanic salinity reduction
47. Physics careers in technology focus on fields like:
- a) Robotics and nanotechnology
 - b) Renaissance art
 - c) Classical literature
 - d) Culinary tourism
48. Geophysics careers involve predicting:
- a) Stock market trends
 - b) Natural disasters
 - c) Musical compositions
 - d) Fashion trends
49. Chemical engineering applies physics to understand:
- a) Chemical reactions and thermodynamics
 - b) Poetic meter
 - c) Political debates
 - d) Sculpture techniques

50. Wireless communication utilizes:

- a) Radio waves and microwaves
- b) Ocean currents
- c) Geothermal energy
- d) Kinetic friction

 Answer Key

- 1. **b**
- 2. **b**
- 3. **b**
- 4. **b**
- 5. **b**
- 6. **b**
- 7. **b**
- 8. **b**
- 9. **b**
- 10. **b**
- 11. **b**
- 12. **b**
- 13. **b**
- 14. **b**
- 15. **c**
- 16. **b**
- 17. **b**
- 18. **b**
- 19. **b**
- 20. **a**
- 21. **b**
- 22. **b**
- 23. **b**
- 24. **a**
- 25. **a**
- 26. **a**
- 27. **a**
- 28. **b**
- 29. **b**
- 30. **b**
- 31. **b**
- 32. **a**
- 33. **a**
- 34. **b**
- 35. **a**
- 36. **b**

- 37. **b**
- 38. **a**
- 39. **a**
- 40. **a**
- 41. **a**
- 42. **a**
- 43. **a**
- 44. **a**
- 45. **a**
- 46. **a**
- 47. **a**
- 48. **b**
- 49. **a**
- 50. **a**