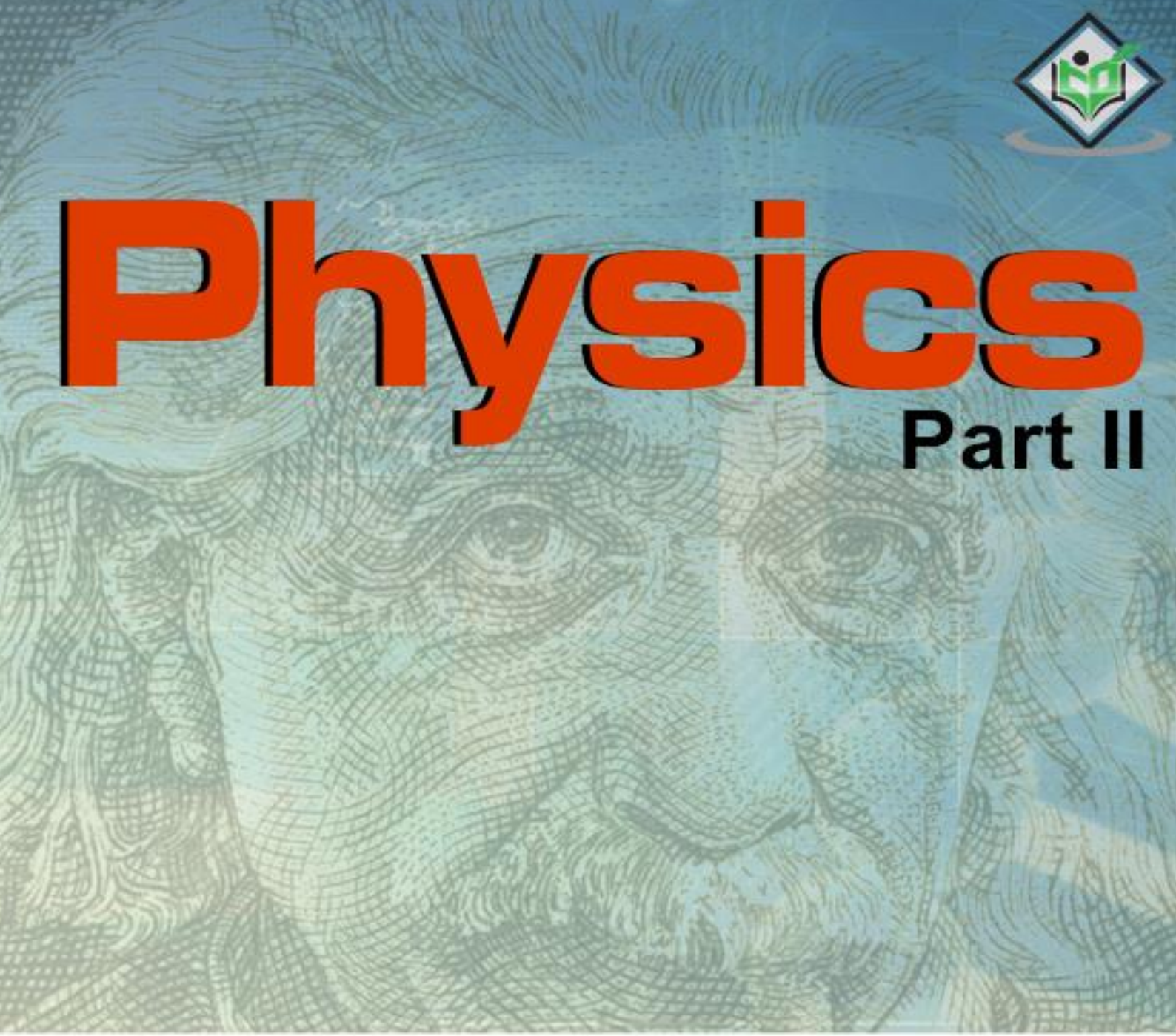

Physics

Part II

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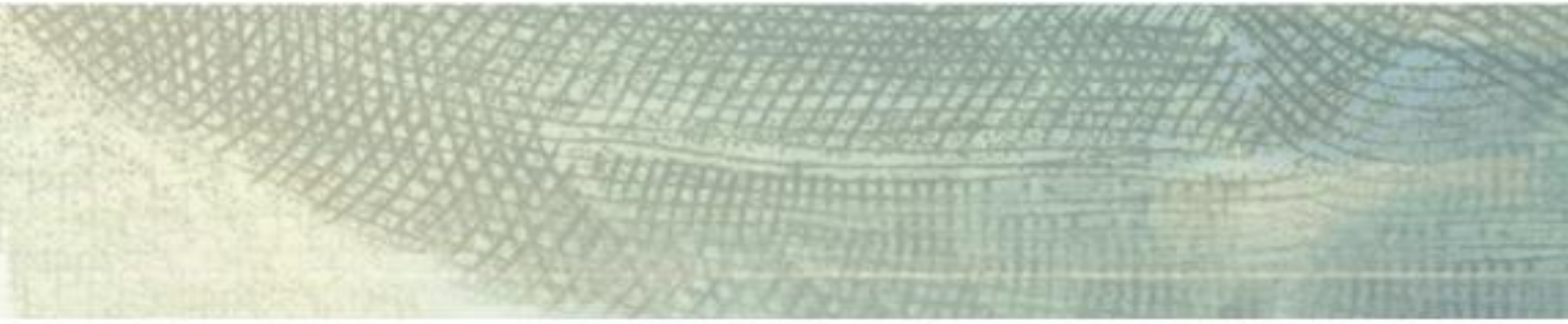

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About the Tutorial

Physics is one of the disciplines of natural science that studies about the various aspects of the matters and energy. The major topics those are studied in physics are mechanics, electricity, magnetism, heat, sound, light and other radiation, and the structure of atoms. In addition, physics also explains the evolution, structure, and functions of various elements of the universe.

Because of having wide range of topics, this tutorial is divided into two parts namely Physics Part 1 and Physics Part 2. Further, these two parts are divided into different chapters for an easy understanding.

Audience

This tutorial is designed exclusively for the students preparing for the different competitive exams including **civil services, SSC, banking**, **railway**, **eligibility test**, and all other competitive exams of such kind.

Prerequisites

This tutorial is partly based on **NCERT Physics** (class 8^{th} to 10^{th}) i.e. Part I and Part 2 is prepared from the different reliable sources and represents largely the significant facts and figures vital for the competitive exams.

This tutorial starts with the basic concepts of Physics; however, prior experience of reading the NCERT science (Physics) books is recommended for the easy understanding.

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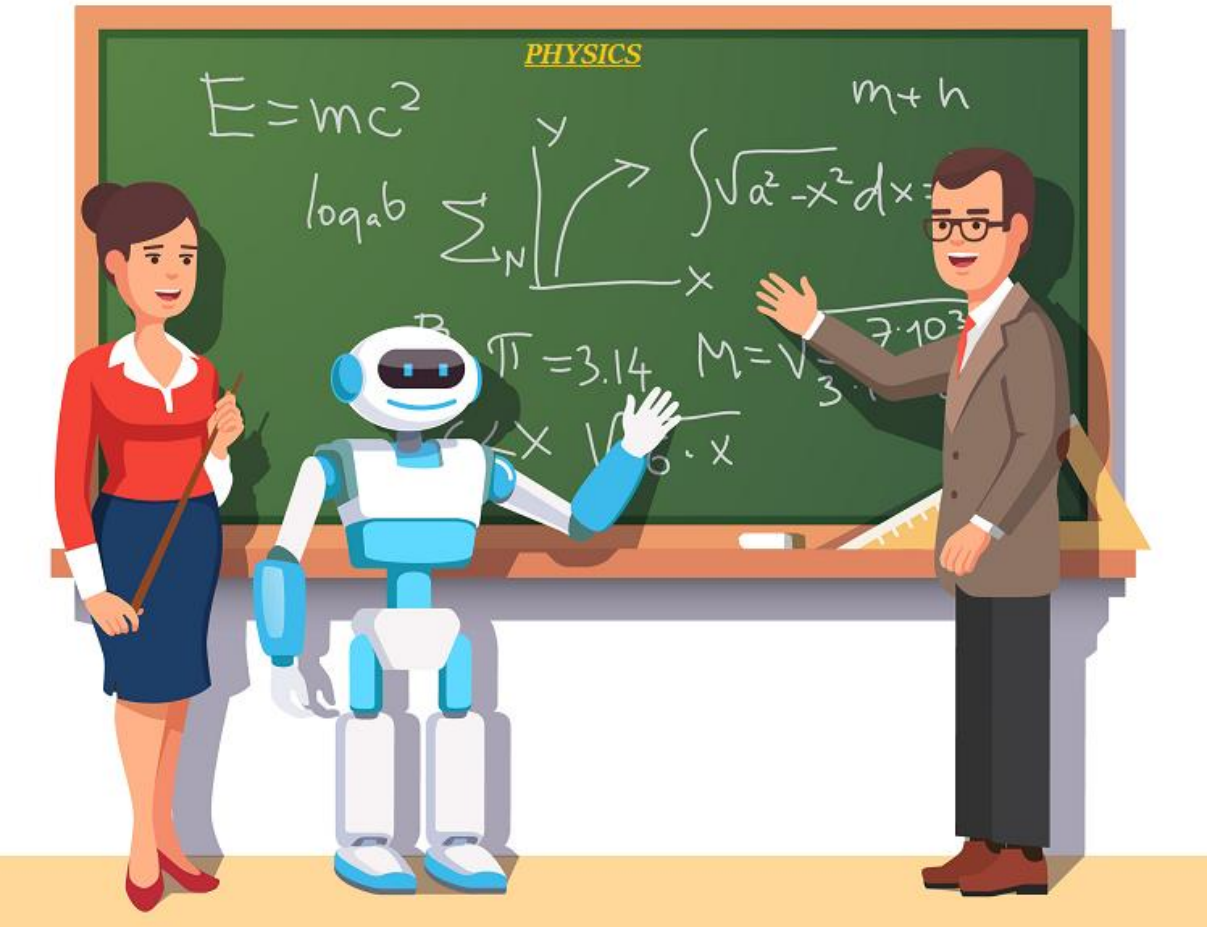
Table of Content

1. PHYSICS: INTRODUCTION

Introduction

- Physics is one of the most significant disciplines of natural science, which describe the nature and properties of matters.

- The term 'physics' is derived from the Ancient Greek word i.e. '***phusikḗ***' meaning '**knowledge of nature**'.



Definition

- Physics is the branch of natural science that studies the nature and properties of matter and energy.

- The significant subject matter of physics includes mechanics, heat & thermodynamics, optics, sound, electricity, magnetism, etc.

- Development of Physics also makes significant contributions in the field of technologies. For example, inventions of new technology such as television, computers, cell phone, advanced home appliances, nuclear weapons, etc.

Development of Physics

- During the ancient period, the development of physics took place with the development of astronomy.

- However, during the medieval period, a notable work of the Arab writer and scientist Ibn Al-Haitham revolutionized the concept of physics.

- Ibn Al-Haitham had written a book in seven volumes namely "Kitāb al-Manāẓir "also known as "The Book of Optics."

- In this book, Ibn Al-Haitham disprove the ancient Greek concept of vision and introduced a new theory.

- Ibn Al-Haitham had also introduced the concept of the pinhole camera.

- During the late medieval period, Physics became a separate discipline of the natural science.

- In making physics as a separate discipline, the major contributions were given by the European scientists.

- These modern European scientists had been introduced different concepts of physics and discovered and invented many new technologies.

- For example, Copernicus replaced the ancient view of geocentric model and introduced the heliocentric concept; Galileo invented the telescopes, Newton discovered the laws of motion and universal gravitation, etc.

- The era of modern physics came with the discovery of quantum theory by Max Planck and theory of relativity by Albert Einstein.

- After development of modern physics, the ear of applied physics commenced where emphasis is given on 'research' on a particular use.

- The particle physicists have been consistently designing and developing the high energy accelerators, detectors, and computer programs.

- Nuclear physics is another branch of modern physics that studies the constituents and interactions of the atomic nuclei.

- The most widely known inventions and applications of nuclear physics are the generation of nuclear power and the development of nuclear weapons technology.

- At present, the physic scientists are working on the concept of high-temperature superconductivity.

2. BRANCHES OF PHYSICS

The following table illustrates the major branches and their sub-branches) of physics:

Branch/Field	Sub-branch/Sub-field
Classical mechanics	Newtonian mechanics
	Analytical mechanics
	Celestial mechanics
Applied mechanics	Acoustics
	Analytical mechanics
	Dynamics (mechanics)
	Elasticity (physics)
	Fluid mechanics
	Viscosity
	Energy
	Geomechanics
Electromagnetism	Electrostatics
	Electrodynamics
	Electricity
Thermodynamics and statistical mechanics	Heat
Optics	Light
Condensed matter physics	Solid state physics
	High pressure physics

	Surface Physics
	Polymer physics
Atomic and molecular physics	Atomic physics
	Molecular physics
	Chemical physics
Astrophysics	Astronomy
	Astrometry
	Cosmology
	Gravitation physics
	High-energy astrophysics
	Planetary astrophysics
	Plasma physics
	Solar physics
	Space physics
	Stellar astrophysics
Nuclear and particle physics	Nuclear physics
	Nuclear astrophysics
	Particle physics
	Particle astrophysics
Applied Physics	Agrophysics
	Biophysics
	Chemical Physics
	Communication Physics

	Econophysics
	Engineering physics
	Geophysics,
	Laser Physics
	Medical physics
	Physical chemistry
	Nanotechnology
	Plasma physics
	Quantum electronics
Sound	

3. ACOUSTICS

Introduction

- Acoustics is an interdisciplinary science that studies different mechanical waves passing through solid, liquid, and gases.

- Basically, acoustics is the science of sound that describes the generation, transmission, and effects of sounds; it also, including biological and psychological effects sound

- Likewise, acoustics studies vibration, sound, ultrasound, infrasound.

- The term "acoustic" is a Greek word i.e. '*akoustikos*,' which means "of or for hearing, ready to hear."

- These days, acoustics technology is very much applicable in many industries specially to reduce the noise level.

Acousticians

- The person who is an expert in the field of acoustics is known as acoustician.

- There are a variety of acoustics fields of study. For example, the production sound, control of sound, transmission of sound, reception of sound, or effects of sound on human beings as well as on animals.

Types of Acousticians

- Following are the major types of acousticians:

- **Bioacoustician**: The expert of this field researches and studies birds of a given geographic region to determine that the man-made noise changes their behavior.

- **Biomedical Acoustician**: The expert of this field researches and develop medical equipment to treat kidney stone.

- **Underwater Acoustician**: The expert of this field research and design sophisticated sonar hardware that explores the ocean floor.

- **Audiologist**: The expert of this field diagnose hearing impairments.

- **Architectural Acoustician**: The expert of this field designs an opera house to manage the high pitch sound (inside the house).

Fields of Acoustics

- Following are the major fields of acoustics.

- **General Acoustics**: This field of acoustic studies about the sounds and waves.

- **Animal Bioacousticians**: This field of acoustic studies how animals create, use, and hear sounds.

- **Architectural Acoustics**: This field of acoustic studies about the building designs to have the pleasing sound quality and safe sound levels.

- **Medical Acoustics**: This field of acoustic researches and studies the use acoustics to diagnose and treat various types of illnesses.

- **Archaeoacoustics**: This field of acoustic studies sound systems of archaeological sites and artefacts.

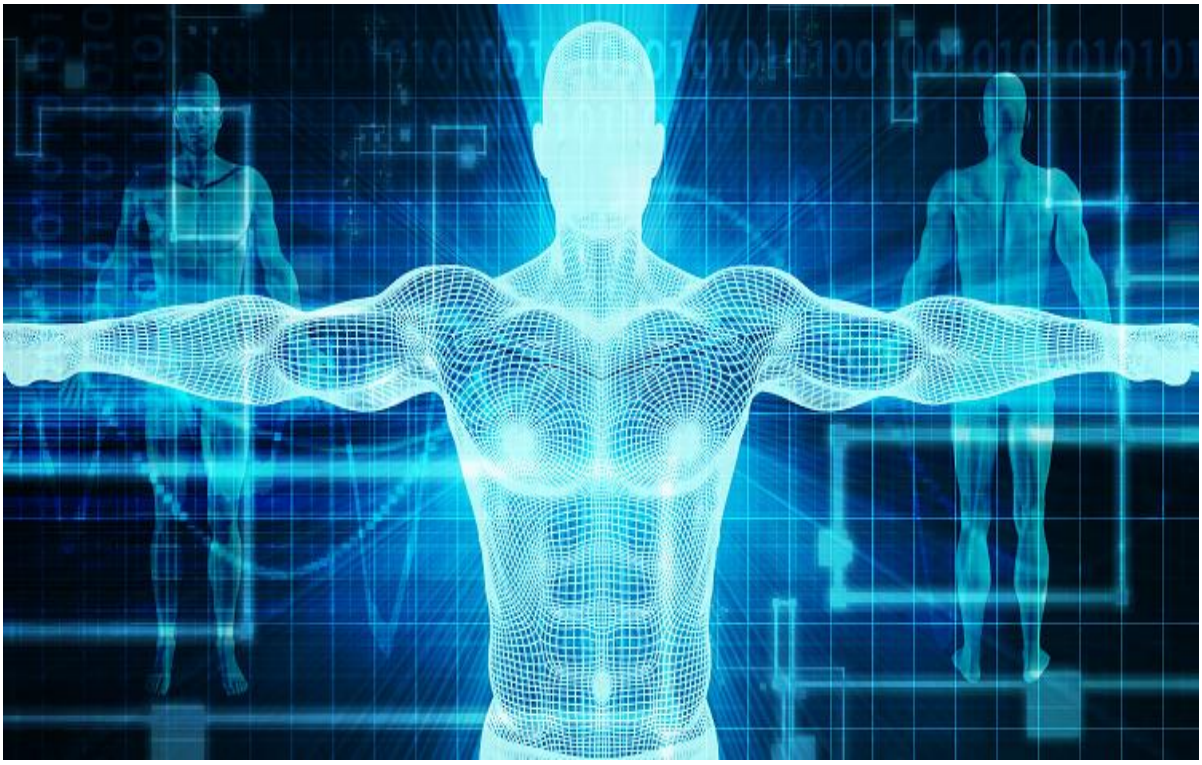
- **Psychoacoustics**: This field of acoustic studies – how human beings respond to a particular sound.

4. BIOPHYSICS

Introduction

- Biophysics is a fascinating term for the biology researchers as well as for the physics researcher, as it creates bridge between these two subjects of science.

- Biophysics (also known as biological physics) is basically an interdisciplinary approach to study the biological systems. It is uses physics technology to understand the biological systems.



- Likewise, biophysics integrates all levels of biological organization, i.e. from molecular level to organismic and population level.

- In 1892, first time Karl Pearson used the term 'Biophysics.'

Subject Matter of Biophysics

- Biophysicists study the life (basically human life); starting from the cellular organs (such as ribosome, mitochondria, nucleus, etc.) to organisms, and their environment.

- With the advancement of technology, the scientists and researchers of both the disciplines (namely Biology and Physics) started exploring a different level of life to understand how actually biological system works.

- The biophysicists largely research on the following types of questions:

  - **How do the cells of nervous system communicate?**

  - **How and why do viruses invade cells?**

  - **What is the functionality of protein synthesis?**

  - **How do plants harness sunlight to make their food?**

Advantages of Biophysics

- The study of life at molecular level helps to understand many phenomena of a human body including various diseases and their treatment.

- Biophysics helped to understand the structure and function of DNA.

DNA Structure

- The study of biophysics helps to understand the various elements of bio-chemistry.

- Biophysics also help to understand the structure and various functionality of protein.

Sub-Branches of Biophysics

- Following are the major sub-branches of biophysics:
  - Biochemistry
  - Physical chemistry
  - Nanotechnology
  - Bioengineering
  - Computational biology
  - Biomechanics
  - Bioinformatics
  - Medicine
  - Neuroscience
  - Physiology
  - Quantum biology
  - Structural biology

Technology of Biophysics

- Following are the major technologies used in Biophysics:
  - Electron microscope
  - X-ray crystallography
  - NMR spectroscopy

NMR spectroscopy

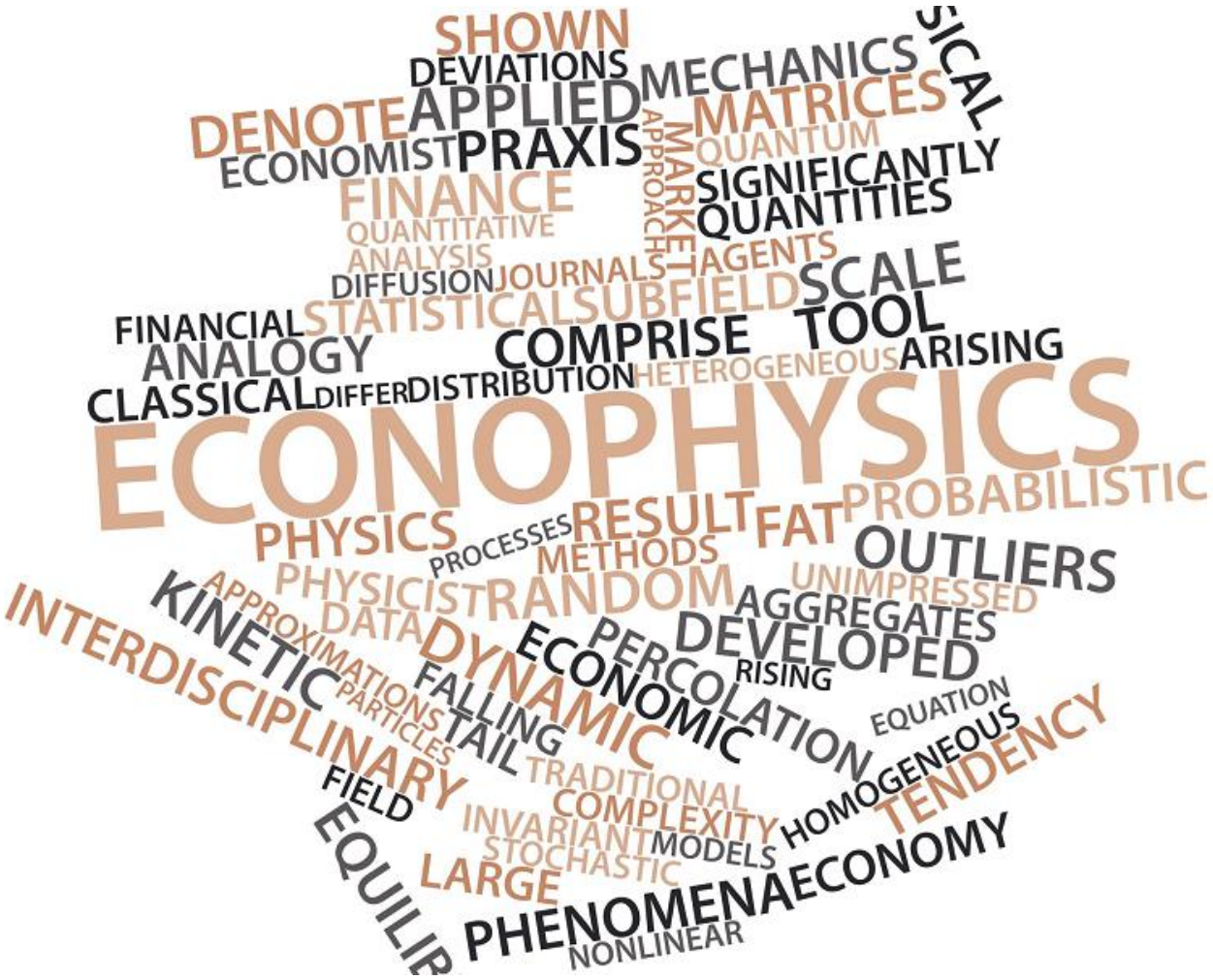
- Atomic force microscope (AFM)
- Small-angle scattering (SAS) technology

5. ECONOPHYSICS

Introduction

- Econophysics is an interdisciplinary science that studies the dynamic behavior of finance and economic markets.

- In order to solve the problems of economics and also to understand the dynamic behavior of the market, the econo-physicists develop applied theories.



- Econophysics, sometime, is also known as the physics of finance.

- It applies statistical mechanics for the economic analysis.

Econophysics Questions

- The econophysics questions include:
  - How to accurately measure and explain the significant properties of market dynamics?
  - How to stabilize the markets?
  - What are the different behaviors in different markets?

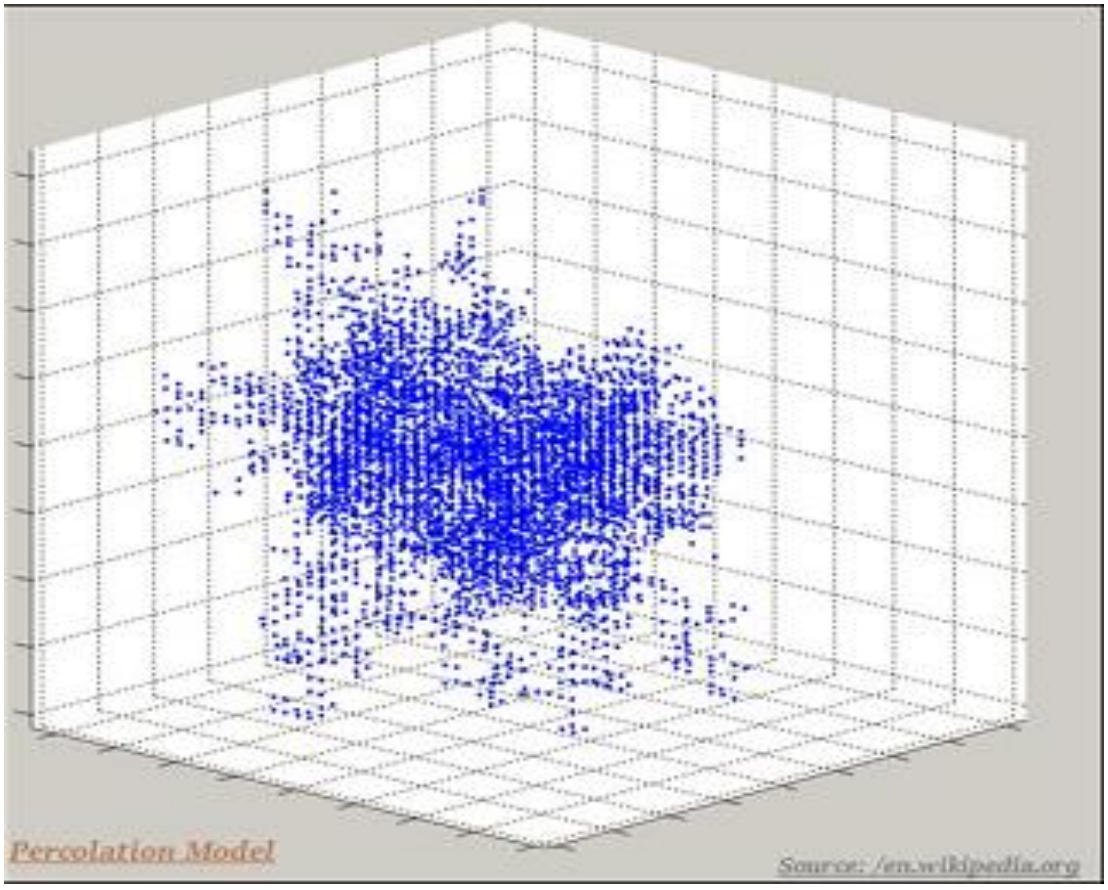
Tools of Econophysics

- The fundamental tools of econophysics are:
  - Probabilistic method
  - Statistical method
  - These two methods are borrowed from statistical physics.

- **Other tools taken from Physics**
  - Fluid dynamics
  - Classical mechanics
  - Quantum mechanics

Models of Econophysics

- Following are the major models those are used in Econophysics:
  - Percolation Model



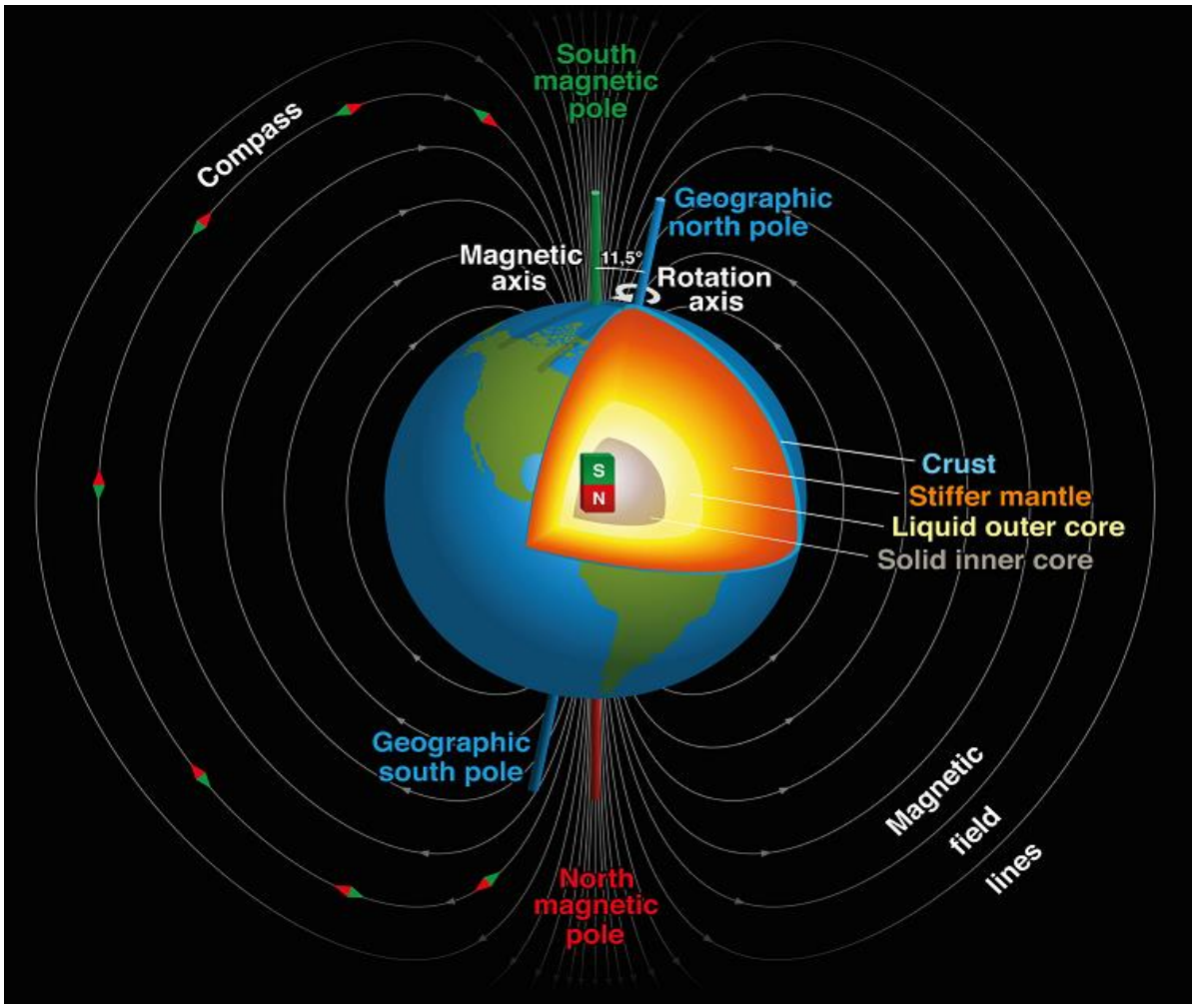
- Kinetic exchange models of markets
- Chaotic models
- Information theory
- Random matrix theory
- Diffusion theory

6. GEOPHYSICS

Introduction

- Geo-physics is a specialized branch of Earth science that studies the physical properties and physical process of the Earth.

- Geophysicists use some quantitative methods and advance technology to analyze the Earth's properties and process.



- Technology of geophysics is used to locate mineral resources, mitigate natural hazards, and protection of the environment.

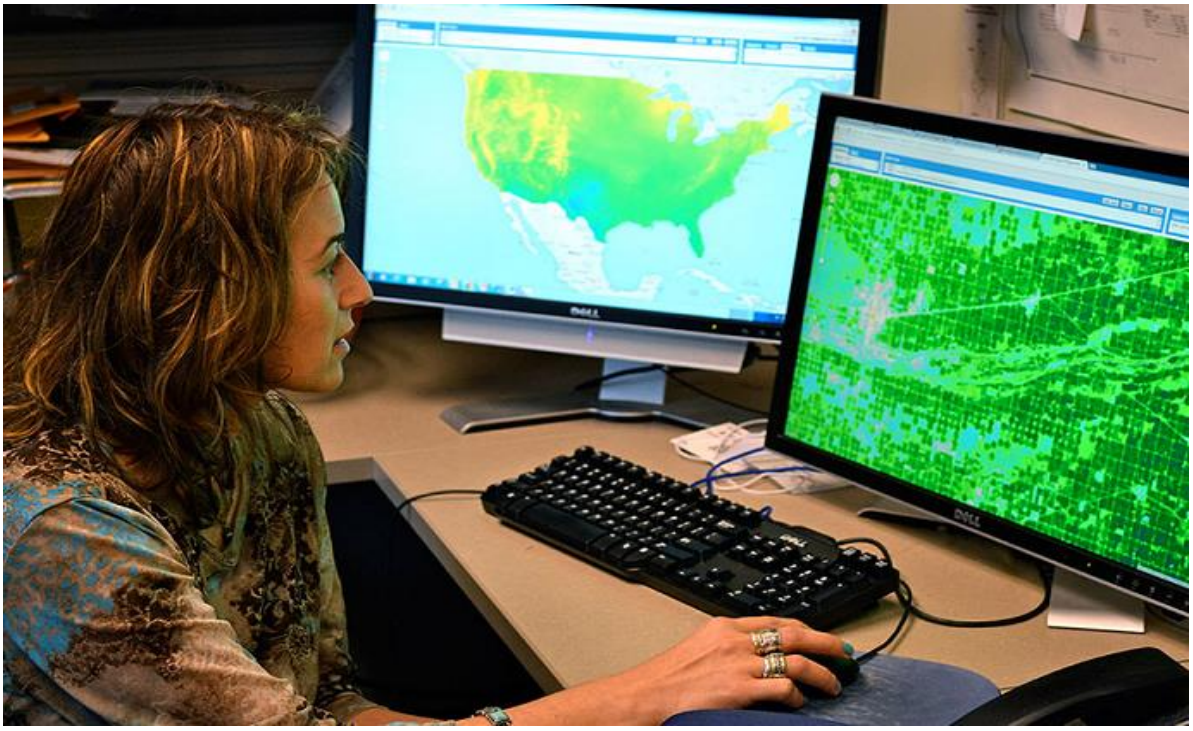
- Geophysics has been carved out as an independent discipline from different subjects, such as, geology, physical geography, astronomy, meteorology, and physics.

Elements of Geophysics

- Major elements those are studied under the geophysics are:
  - Shape of the Earth
  - Gravitational force of the Earth
  - Magnetic Fields of the Earth
  - Internal structure of the Earth
  - Composition of the Earth
  - Movement of the Earth's plate (plate tectonics)
  - Volcanic activity
  - Rock formation
  - Water cycle
  - Fluid dynamics, etc.

Problems that Geophysicists Address

- Following are the problem areas that geophysicists address:
  - Building highways and bridges
  - Mapping and exploration of mineral resources
  - Mapping and exploration of water
  - Mapping the earthquake and volcanic regions
  - Geological mapping



- Archeology discovery
- Construction of dam and its safety
- Forensic discovery (finding the buried dead bodies)

Techniques and Technology of Geophysics

- Following are the major techniques and technology of geophysics:
  - Geo-magnetism
  - Electromagnetics
  - Polarization
  - Seismic technology
  - Ground penetrating radar (GPR), etc.

Benefits of Geophysics

- Following are the major benefits of geophysics:
  - Researching and studying archeological sites without destroying them
  - Designing environmental friendly urban architecture

- Locating and judiciously exploiting natural resources
- Helping in mitigation of natural hazards such as landslide, earthquake, etc.

7. NANOTECHNOLOGY

Introduction

- Nanotechnology is the science of management and manipulation of atoms and molecules to design a new technology.
- Nanotechnology is the supramolecular technology, which means, it is the engineering of functional systems at the molecular or supramolecular scale.
- Interestingly, one nanometer (nm) is equal to one billionth, or 10^{-9}, of a meter.

- The concept and idea of nanotechnology original discussed first time in 1959 by Richard Feynman, the renowned physicist.
- Richard Feynman in his talk "There's Plenty of Room at the Bottom," described the feasibility of synthesis via direct manipulation of atoms.
- However, in 1974, the term "Nano-technology" was first used by Norio Taniguchi.

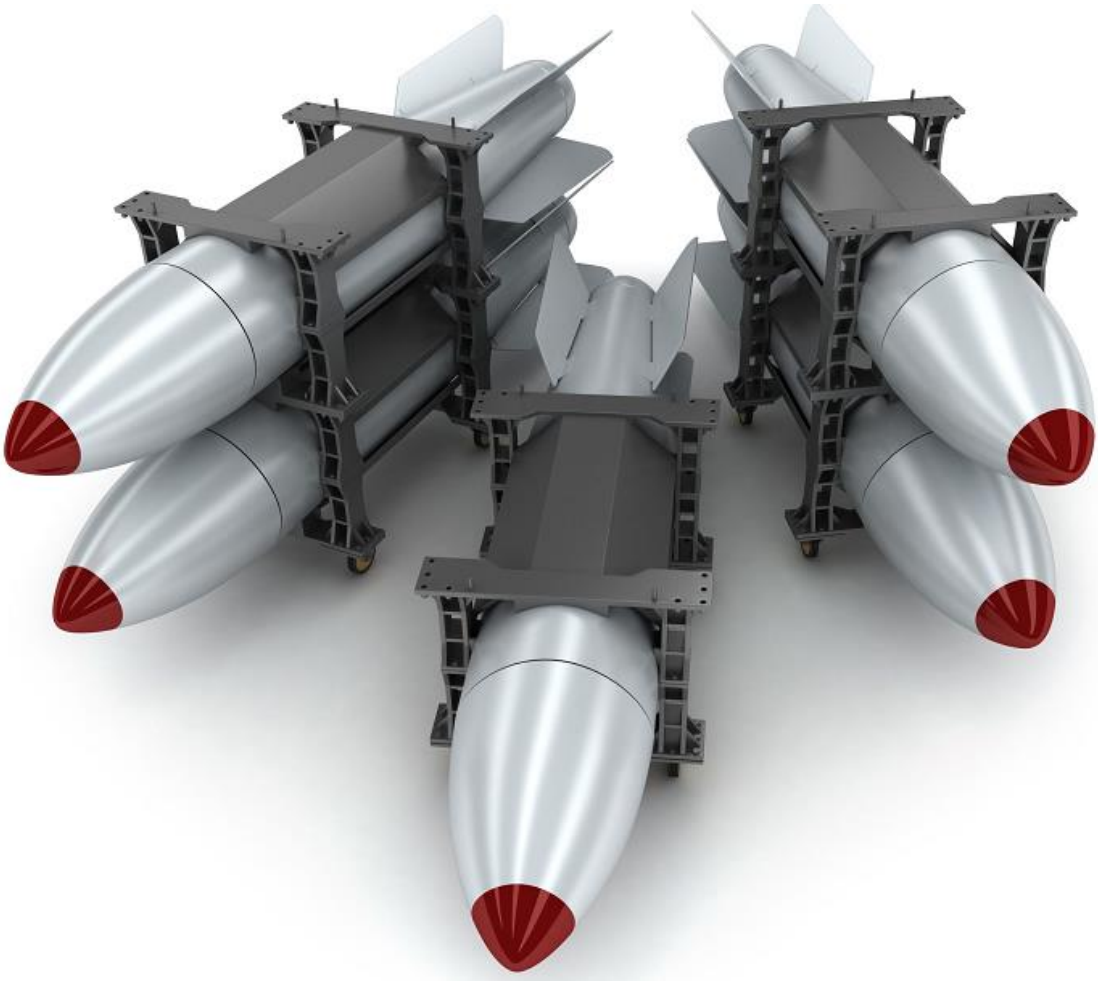
Major fields of Research

- Following are the major fields in which nanotechnology is being researched:
  - Advance computing: Developing super computer
  - Electronics: developing conductors and semi-conductors

- Medicines: Developing technology to treat cancer (especially breast cancer)
- Textile Engineering: Nanofabrication, etc.

Application of Nanotechnology

- Following are the major application of nanotechnology:
  - Manufacturing of lifesaving medical robots
  - Making available the networked computers for everyone in the world
  - Plant networked cameras to watch everyone's movement (very helpful for the administrative service and maintaining the law and order.
  - Manufacturing untraceable weapons of mass destruction.
  - Swift inventions of many wonderful products useful in everyday life.



- Likewise, the molecular technology has range of potentials that benefit to humankind; however, at the same time, it also brings severe dangers. Untraceable weapon of mass destruction is an ideal example of its deadliness.

Major Branches of Nanotechnology

- Following are the major branches of nanotechnology:
  - Nanoelectronics
  - Nanomechanics
  - Nanophotonics
  - Nanoionics

Contributory Disciplines of Nanotechnology

- Following are the major disciplines that integrated into the development of science of nanotechnology:
  - Surface science
  - Organic chemistry
  - Molecular biology
  - Semiconductor physics
  - Microfabrication
  - Molecular engineering

Implication of Nanotechnology

- Every coin has two faces, similarly, the application of nanotechnology at industrial scale i.e. manufacturing nanomaterials might have negative implications on human health as well as on the environment.

- The workers who especially work in such industry where non materials are used, are more vulnerable, as they inhale airborne nanoparticles and nanofibers. These Nano materials may lead to a number of pulmonary diseases, including fibrosis, etc.

8. NEUROPHYSICS

Introduction

- The branch of medical physics that studies the nervous system, such as brain, spinal cords, and nerves, is known as neurophysics.

- The researchers of neurophysics research the basic physical basis of the brain to understand its different functionality.

- Neurophysicists also study the cognitive process of a human being.

- The term 'neurophysics' was originally taken from Greek term namely 'neuron' meaning "**nerve**" and 'physis' meaning '**nature,**' or '**origin**.' So, neurophysics is basically concerned with the study of the workings of the nervous system.

- Furthermore, the integrity of neural physics also postulates that the whole universe is in living, but in a way that is beyond the conception of biological organisms.

Neurophysics Therapy

- Neurophysics therapy is highly sophisticated exercise-based method of treatment. Such technique treats a wide range of diseases and its successful rate is also high.

- Some of the significant diseases that can be treated through neurophysics therapy are listed below:
  - Arthritis
  - Athletic performance
  - Metabolic disorders
  - Rehabilitation
  - Bipolar disorder
  - Migraine
  - Chronic pain

- Motor neuron disease
- Degenerative disorders
- Depression (clinical; reactive)
- Muscular dystrophy
- Drug addiction
- Epilepsy
- Osteoarthritis
- Parkinson's disease
- Vestibular disorders
- Hereditary spastic paraplegia, etc.

- Furthermore, the practice of neurophysics facilitates us to remain healthy and function better in everyday life, as it provides the technique i.e. how to disperse stress evenly in your body and not allowing it to become isolated.

9. PSYCHOPHYSICS

Introduction

- Psychophysics is basically an interdisciplinary branch of psychology and physics; it studies the relationship between physical stimuli and the sensations along with the perceptions they produce.

- The psychophysicists analyze the perceptual processes by studying the effect on a behavior; further, they also study the systematically varying properties of a stimulus along one or more physical dimensions.

- The concept of psychophysics was first time used in 1860 by Gustav Theodor Fechner in Leipzig, Germany.

- Fechner published his research namely '***Elemente der Psychophysik***' (i.e. Elements of Psychophysics).

Terms of Psychophysics

- Following are the commonly used terms in psychophysics:

- **Signal detection theory**: It explains the interaction of the sensory capabilities and the decision making elements in detecting the stimulus.
- **'Ideal observer analysis**: It is a technique for investigating i.e. how information has processed in a perceptual system.
- **Difference thresholds**: It helps to differentiate two stimuli. This point is termed just-noticeable difference.
- **Absolute threshold**: The point at which the person first detects the stimulus strength i.e. presence of stimulus.
- **Scaling**: It uses rating scales to allocate relative values.

Modern Approaches of Psychophysicists

- Modern Psychophysicists research on:
  - Vision
  - Hearing
  - Touch (or sense)
- Based on these, psychophysicists measure what the perceiver's decision extracts from the stimulus.

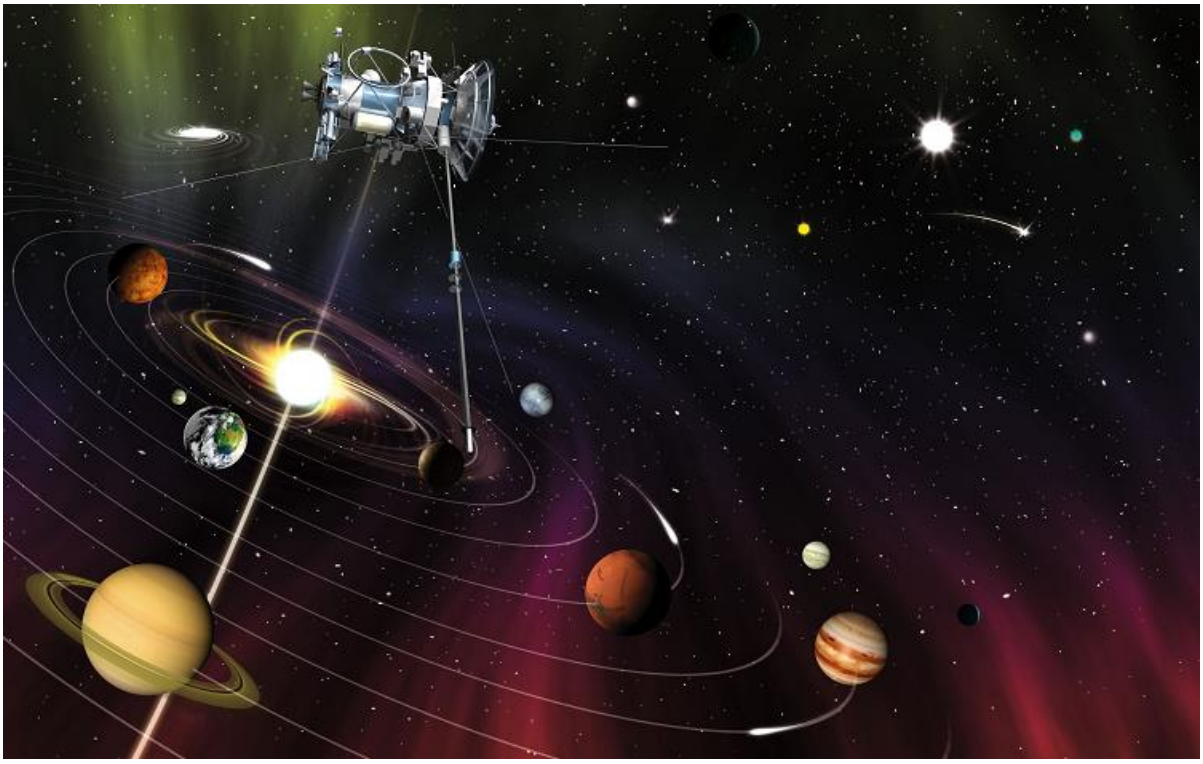
Application of Psychophysicists

- In the present world, psychophysics is commonly applied to treat many of psychological problems.

10. ASTROPHYSICS

Introduction

- Astrophysics is one of the oldest branches of natural science or astronomy.
- Astrophysics is being used as the basis for making calendars and navigation.
- Astrophysics is also being used as an important input for religions because since the beginning, astrologers taking help of this science to in their astrological works.



- The modern branch of astrophysics namely 'Theoretical astrophysics,' describes the functions and behaviors of celestial bodies.
- Theoretical astrophysics uses a wide variety of tools such as analytical models (e.g., polytropes to approximate the behaviors of a star) and the computational numerical simulations.

Topics of Astrophysics

- Following are the major topics of astrophysics (modern):

- Solar System (formation and evolution);
- Stellar dynamics and evolution;
- Galaxy formation and evolution;
- Magneto-hydrodynamics;
- Origin of cosmic rays;
- General relativity and physical cosmology.

Major Works in Astrophysics

- Following are the major developments in Astrophysics:
  - By using telescope, Galileo had performed the first astronomical studies in 1609. Galileo discovered sun spots and four satellites of Saturn.
  - Based on observations of Tycho Brahe, Kepler had developed three laws of planetary motions.
  - In 1687, Newton had introduced the laws of motion and gravitation.
  - By giving the theory of relativity in 1916, Einstein provided the first consistent basis to study cosmology.
  - In 1926, Hubble discovered that the galaxies are recessing and their velocity is increasing with the distance. It means, the universe is expanding and extrapolating this expansion back in time led to the concept of 'Big Bang.'
  - In 1974, Hulse and Taylor discovered a binary system of two pulsars that proved the existence of gravitational waves.

Astronomy

- Astronomy the oldest branch of is a natural science that studies celestial objects their functional phenomena.
- In order to explain the origin of the celestial bodies, their evolution, and phenomena, the different disciplines of science such as physics, chemistry, mathematics are applied.
- The objects of study are:

- Planets
- Satellites or moons
- Stars
- Galaxies
- Comets, etc.

- Some of the important phenomena those are studied are:
  - Supernova explosions
  - Gamma ray bursts, and
  - Cosmic microwave background radiation, etc.

- During the 20th century, based on approach of study, the astronomy is categorized as:
  - **Observational astronomy**: Based on the approach and methods, observational astronomy scientists observe, collect, and analyze the celestial data. To analyze the data, they use basic principles of physics.

- **Theoretical astronomy**: The scientists of theoretical astronomy attempt to develop computer or analytical models in order to describe the celestial bodies and their functionalities.

- Likewise, astronomy incorporates the diverse disciplines such as celestial navigation, astrometry, observational astronomy, etc.; this is how astrophysics is profoundly related to astronomy.

11. MEASUREMENT UNITS

The following table illustrates the major measuring units in physics:

Mass And Related Quantities		
Quantity	Symbol	Unit
Density	ρ	$kg.m^{-3}$
Volume	V	m^{-3}
Force	F	Newton (N)
Torque	M	N.m
Pressure	P	Pascal (Pa)
Dynamic viscosity	η	Pa.s
Acoustic pressure	p	Pascal (pa)
Dynamic volume	v	m^3
Electricity and Magnetism		
Quantity	Symbol	Unit
Power	P	watt (W = J/s)
Energy	W	joule (J = N.m)
Magnetic field strength	H	ampère per metre (A/m)
Electric field	E	volt per metre (V/m)
quantity of electricity	Q	coulomb (C = A.s)
Electrical resistance	R	ohm (Ω = V/A)
electrical capacitance	C	farad (F = C/V)

Potential difference	U	volt (V = W/A)
International System of Units		
meter	m	Length
kilogram	kg	Mass
second	s	Time
ampere	A	Electric Current
kelvin	K	Thermodynamic temperature
mole	mol	Amount of substance
candela	cd	Luminous intensity
radian	rad	Angle
steradian	sr	Solid Angle
hertz	Hz	Frequency
newton	N	Force, weight
pascal	Pa	pressure, stress
joule	J	energy, work, heat
watt	W	Power, radiant, flux
coulomb	C	Electric charge
volt	V	Voltage, electromotive force
farad	F	Electric capacitance
ohm	Ω	Electric resistance
tesla	T	Magnetic flux density
degree Celsius	^{0}C	Temperature
becquerel	Bq	radioactivity

henry	H	Magnetic induction
Angstrom	Å	Wave length

Conversion of Units

Unit I	Value in another unit
1 Inch	2.54 centimeter
1 Foot	0.3048 meter
1 Foot	30.48 centimeter
1 Yard	0.9144 meter
1 Mile	1609.34 meter
1 Chain	20.1168 meter
1 Nautical mile	1.852 kilometer
1 Angstrom	10^{-10} meter
1 Square inch	6.4516 square centimeter
1 Acre	4046.86 square meter
1 grain	64.8 milligram
1 dram	1.77 gm
1 ounce	28.35 gm
1 pound	453.592 gram
1 horse power	735.499 Watt

12. MAJOR INSTRUMENTS & THEIR USES

The following table illustrates the major scientific instruments and their uses:

Instrument	Use
Accelerometer	Measures acceleration
Altimeter	Measures altitude of an aircraft
Ammeter	Measures electric current in ampere
Anemometer	Measures wind speed
Barometer	Measures atmospheric pressure
Bolometer	Measures radiant energy
Caliper	Measures distance
Calorimeter	Measures heat (in chemical reaction)
Crescograph	Measures growth in plant
Dynamometer	Measures torque
Electrometer	Measures electric charge
Ellipsometer	Measures optical refractive indices
Fathometer	Measures depth (in sea)
Gravimeter	Measures the local gravitational field of the Earth
Galvanometer	Measures electric current

Hydrometer	Measures specific gravity of liquid
Hydrophones	Measures sound wave under water
Hygrometer	Measures atmospheric humidity
Inclinometer	Measures angel of slope
Interferometer	Infrared light spectra
Lactometer	Measures purity of milk
Magnetograph	Measures magnetic field
Manometer	Measures pressure of gas
Ohmmeter	Measures electric resistance
Odometer	Measures distance travelled by a wheeled vehicle
Photometer	Measures intensity of light
Pyrometer	Measures temperature of a surface
Radiometer	Measures intensity or force radiation
Radar	Detects distance object, e.g. aircraft, etc.
Sextant	Measures angle between two visible objects
Seismometer	Measures motion of the ground (earthquake/seismic waves)
Spectrometer	Measures spectra (light spectrum)
Theodolite	Measures horizontal and vertical angles

Thermopile	Measures small quantities of radiant heat
Thermometer	Measures temperature
Udometer	Measures amount of rainfall
Viscometer	Measures the viscosity of fluid
Voltmeter	Measures volt
Venturi meter	Measures flow of liquid

13. INVENTIONS & INVENTORS IN PHYSICS

The following table illustrates the major inventions and their inventors in physics uses:

Invention	Inventor
Centigrade scale	Anders Celsius
Watch	Peter Henlein
Radio	Guglielmo Marconi
Telephone	Alexander Graham Bell
Electricity	Benjamin Franklin
Electric Light Bulb	Thomas Edison
Thermometer	Galileo Galilei
Telescope	Hans Lippershey and Zacharias Janssen; later Galileo
Telegraph	Samuel Morse
Cosmic Rays	Victor Hess (but the term 'cosmic rays' first used by Robert Millikan
Automobile	Karl Benz
Magnetic Tape	Fritz Pfleumer
Transformer	Michael Faraday (later Ottó Titusz Bláthy)
Electromagnetic Induction	Michael Faraday
Quantum mechanics	Werner Heisenberg, Max Born, and Pascual Jordan
Wave mechanics	Erwin Schrödinger
Nuclear Reactor	Enrico Fermi
Fuel Cell	William Grove

Airplane	Wright Brothers
Barometer	Evangelista Torricelli
Camera	Nicéphore Niépce
Diesel Engine	Rudolf Diesel
Helicopter	Igor Sikorsky
Dynamite	Alfred Nobel
Lift	Elisha Otis
Laser Printer	Gary Starkweather
Mobile Phone	Martin Cooper
Printing Press	Johannes Gutenberg
Video Games	Ralph Baer
Steam engine	Thomas Newcomen
Railway Engine	George Stephenson
Jet Engine	Frank Whittle
Seismograph	John Milne
Electric Generator	Michael Faraday
Television	John Logie Baird
Refrigerator	William Cullen (later Oliver Evans)
Carburetor	Luigi De Cristoforis & Enrico Bernardi
Air Brake	George Westinghouse
Atomic bomb	Robert Oppenheimer, Edward Teller et al
Air conditioner	Willis Carrier
Machine Gun	Sir Hiram Maxim

Radar	Sir Robert Alexander Watson-Watt
Submarine	Cornelius Drebbel (later) David Bushnell
First military submarine	Yefim Nikonov
Transistor	John Bardeen, Walter Brattain, and William Shockley
Galvanometer	Johann Schweigger
Laser	Theodore H. Maiman (first demonstrated)
Neon lamp	Georges Claude
Rocket Engine	Robert Goddard
Typewriter	Christopher Latham Sholes

14. TIMELINE IN PHYSICS

The following table illustrates the major events (along with probably time period) that occurred in physics:

Event	Time Period
Babylonians collected information of planets and stars	2000 BC to 1600 BC
Ancient Indians explained the evolution of universe and also explained about sun, moon, earth, and other planets	1500 BC to 1000 BC
Greek philosopher Anaxagoras explained the physical universe	During 5th Century BC
Two Greek philosophers namely Leucippus and Democritus established the school of Atomism	During 5th Century BC
Aristotle, the Greek philosopher, described a geocentric universe	During 4th Century BC
The Greek philosopher Heraclides explained the motions of planets and stars	During 4th Century BC
Eratosthenes, the Greek mathematical geographer proposed the round shape of the Earth	During 3rd Century BC
Hipparchus was the first who measured the precession of the equinoxes	During 2nd Century BC
Based on Aristotelian ideas, the Roman-Egyptian mathematician and astronomer Ptolemy described a geocentric model	During 2nd Century AD
The Indian astronomer and mathematician Aryabhata described the earth's elliptical orbit around the sun and its axis (heliocentric view)	During 5th Century AD

Brahmagupta, the Indian mathematician and astronomer noticed the gravity of earth	During 7th Century AD
Abu al-Rayhan al-Biruni, the Persian astronomer described the Earth's gravitation.	During 11th Century AD
Nicolaus Copernicus, the Polish astronomer and polymath explained the heliocentric principal scientifically	During 16th Century Ad
Johannes Kepler, the German mathematician and astronomer propounded Laws of Planetary Motion	During 17th Century AD
Galileo Galilei, the Italian mathematician and physicist invented an astronomical telescope	During 17th Century AD
Sir Isaac Newton, the English mathematician, astronomer, and physicist propounded Laws of Motions and Universal Law of Gravitation	During 17th Century AD
Emanuel Swedenborg first suggested parts of the nebular hypothesis	1734 AD
Immanuel Kant publishing "*Universal Natural History and Theory of the Heavens*," and explained nebular hypothesis.	1755 AD
Max Planck, the German physicist described the law of black body radiation and led the foundation of quantum physics	During 20th Century AD
Albert Einstein, the German physicist propounded the theory relativity	During the 20th Century AD
Max Planck introduced formula for Black Body radiation	1900 AD
Kamerlingh Onnes experimented and noticed superconductivity	1911 AD
Wolfgang Pauli, the Austrian theoretical physicist proposed an important quantum mechanical principle namely the 'Pauli exclusion principle'	1925 AD

Georges Lemaître proposed Big Bang theory	1927 AD
Edwin Hubble explained the expanding nature of universe (known as Hubble's Law)	1929 AD
Otto Hahn discovered nuclear fission discovered	1938 AD
Black Hole Entropy	1972 AD
Richard Feynman proposes quantum computing	1980 AD
Theory of cosmic inflation	1981 AD
Top quark discovered	1995 AD
Gravitational waves detected	2015 AD

15. UNSOLVED PROBLEMS IN PHYSICS

Introduction

- The meaning of unsolved problems is – the developed theories and models are incapable to explain some ongoing phenomenon or science experiments are not able to rectify the concerned phenomena.

- The following table illustrates the major unsolved problems in physics:

Quantum Physics	Is there a single possible past?
	Is the present time physically distinct from the past and future?
	How is quantum information stored as a state of a quantum system?
Cosmology	Is there any feasibility to reconcile time with general relativity?
	Why is the distant universe so homogeneous when the Big Bang theory appears to predict larger measurable anisotropies of the night sky than the observed one?
	Is the universe heading towards a Big Freeze, a Big Crunch, a Big Rip, or a Big Bounce?
	What is the size of the whole universe?
	What is the identity of dark matter?
	What is the probable cause of the observed accelerated expansion of the universe?
Black holes	Is there any way to probe the internal structure of black holes somehow?

Extra dimensions	Does nature have any fifth space time dimensions?
Particle physics	Is the proton fundamentally stable?
	Did particles that carry "magnetic charge" exist in the past?
	What is the electric charge radius of the proton?
	How does electric charge differ from gluonic charge?
Astrophysics	How does the Sun generate its periodically reversing large-scale magnetic field?
	Why & how is the Sun's corona (i.e. atmosphere layer) much hotter than the Sun's surface?
	What is responsible for the numerous interstellar absorption lines discovered in astronomical spectra?
	What is the origin of the M-sigma relation between the supermassive black hole mass and the galaxy velocity dispersion?
	What is the precise mechanism by which an implosion of a dying star becomes an explosion?
	What is the source of space roar?
	Where did Earth's water come from?
	What is the nature of neutron stars and dense nuclear matter?
	What is the origin of the elements in the cosmos?
Optical physics	What is the momentum of light in optical media?

Biophysics	How do genes govern human body, withstanding different external pressures and internal stochasticity?
	What are the quantitative properties of immune responses?
	What are the basic building blocks of immune system networks?
Condensed matter physics	Is topological order stable at non-zero temperature?
	Is it feasible to develop a theoretical model to describe the statistics of a turbulent flow?
	What causes the emission of short bursts of light from imploding bubbles in a liquid when excited by sound?
	What is the nature of the glass transition between a fluid or regular solid and a glassy phase?
	What is the mechanism that causes certain materials to exhibit superconductivity at temperatures much higher than around 25 kelvin?
	Is it possible to make a material that is a superconductor at room temperature?

16. TERMINOLOGIES IN PHYSICS

The following table illustrates the major 'Terms' in physics:

Terms	Meaning
Absolute Zero	It means the theoretical lowest possible temperature
Acoustics	The branch of physics that studies sound
Adhesion	The propensity of dissimilar particles or surfaces to adhere or cling to one another
Alpha particles	It consists of two protons and two neutrons bound together into a particle (i.e. identical to a helium nucleus)
Amorphous solid	It is non-crystalline solid, which has no definite shape
Amplitude	It is height of a wave, which is measured from its center position
Angstrom (Å)	It is an unit of linear measurement that measures micro-particles
Atomic mass unit	It is one-twelfth the mass of an atom of the isotope 12/6C
Beta Particles	It is high-energy, high-speed electrons or positrons emitted by the particular types of radioactive nuclei
Big Bang	The cosmological model that explains the early development of the Universe
Binding energy	The mechanical energy that is required to disassemble a whole into separate parts

Black hole	A region of space-time, which gravity is very powerful and prevents anything, including light, from escaping
Boson	It is one of two classes of elementary particles; second one is fermions
Cathode	An electrode through which electric current flows out of a polarized electrical device
Centrifugal force	Center fleeing
Centripetal force	Center seeking
Condensed matter physics	A branch of physics that studies the physical properties of condensed phases of matter
Convection	The process of transfer of heat by the actual transfer of matter
Crest	The point on a wave with the maximum value
Doppler effect	The change in frequency of a wave for an observer moving relative to its source
Ductility	It is the property of solid material that deform under tensile stress
Elasticity	It is physical property of materials which return to their original shape once they are deformed.
Electromagnet	A typical magnet in which the magnetic field is produced by passing the electric current
Entropy	A quantity that describes the randomness of a substance or a system
Escape velocity	The speed at which the kinetic energy and the gravitational potential energy of an object is zero. Likewise, the escape velocity is the speed required to "break free" from a gravitational field without further propulsion

Free fall	Any motion of a body where its weight is the only force acting upon it
Ice point	A transitional phase of a substance from a liquid to a solid.
Inertia	It is the tendency of an object to resist any change in its motion
Kinematics	Geometry of motion
Neutrino	An electrically neutral subatomic particle
Photon	It is an elementary particle
Quark	It is an elementary particle and a fundamental constituent of matter
Redshift	Shifting towards the red end of the spectrum
Screw	It is a mechanism that converts rotational motion to linear motion
Siphon	An inverted U tube that causes a liquid to flow uphill without support of any pump. It is basically powered by the fall of the liquid as it flows down the tube under the force of gravity
Sublimation	It is a process of transformation in which solid directly changed to gas without passing through an intermediate liquid phase
Supernova	A stellar explosion, which is more energetic than a nova
Vector	Vector is a quantity, which has both magnitude and direction
White dwarf	It is a stellar remnant, which is composed largely of electron-degenerate matter. These are very dense

Wind shear	It is the difference between wind speed and direction over a relatively short distance in the atmosphere

17. MAJOR THEORIES & LAWS IN PHYSICS

The following table illustrates the major theories in Physics along with their respective fields:

Theory	Filed
Standard Model	Nuclear Particle Physics
Quantum field theory	
Quantum electrodynamics	
Quantum chromodynamics	
Electroweak theory	
Effective field theory	
Lattice field theory	
Lattice gauge theory	
Gauge theory	
Supersymmetry	
Grand unification theory	
Superstring theory	
M-theory	
Quantum optics	Optical physics

Quantum chemistry	Atomic and molecular physics
Quantum information science	
BCS theory	Condensed matter physics
Bloch wave	
Density functional theory	
Fermi gas	
Fermi liquid	
Many-body theory	
Statistical Mechanics	
Big Bang	Astrophysics
Cosmic inflation	
General relativity	
Newton's law of universal gravitation	
Lambda-CDM model	
Magneto-hydrodynamics	
Newton's Law of universal gravitation	Mechanics
Newton's Laws of motion	
Ampère's circuital law	Current Electricity

Birch's law	Geophysics
Bell's theorem	Quantum mechanics
Beer–Lambert law	Optics
Avogadro's law	Thermodynamics
Boltzmann equation	
Boyle's law	
Coulomb's law	Electrostatics and Electrodynamics
Doppler effect	Sound
Theory of relativity (Einstein)	Modern Physics
Faraday's law of induction	Electromagnetism
Gauss's law	Mathematical Physics
Pascal's law	Fluid statics and dynamics
Planck's law	Electromagnetism
Raman scattering	Optics
Vlasov equation	Plasma physics

18. NOBEL PRIZE IN PHYSICS

Introduction

- The Nobel Prize in Physics is the most prestigious award given yearly by the Royal Swedish Academy of Sciences.
- The Noble prize is given to those physicists who conferred the most outstanding contributions for mankind (in physics).
- Wilhelm Röntgen, a German/Dutch physicist, was the first person who had received the first Nobel Prize in 1901.
- Wilhelm Röntgen had received the Nobel Prize for discovery of the remarkable x-rays).
- In the field of physics (by the time), only two women have won the Nobel Prize, namely Marie Curie (in 1903) and Maria Goeppert Mayer (in 1963).
- The following table illustrates some of the significant physicists who have received the Nobel Prize along with their remarkable works:

<table>
<tr><th>Name</th><th>Year: Country</th><th>Work</th></tr>
<tr><td>Wilhelm Conrad Röntgen</td><td>1901: Germany</td><td>Discovery of the remarkable rays</td></tr>
<tr><td>Hendrik Lorentz</td><td rowspan="2">1902: Netherlands</td><td rowspan="2">Worked on the influence of magnetism upon radiation phenomena</td></tr>
<tr><td>Pieter Zeeman</td></tr>
<tr><td>Antoine Henri Becquerel</td><td rowspan="3">1903: France</td><td>Spontaneous radioactivity</td></tr>
<tr><td>Pierre Curie</td><td rowspan="2">Radiation phenomena</td></tr>
<tr><td>Maria Skłodowska-Curie</td><td>1903: Poland/France</td></tr>
<tr><td>Philipp Eduard Anton von Lenard</td><td>1905: Austria-Hungary</td><td>Worked on cathode rays</td></tr>
</table>

Guglielmo Marconi	1909: Italy	Development of wireless telegraphy
Karl Ferdinand Braun	1909: Germany	
Max Planck	1918: Germany	Discovered energy quanta
Johannes Stark	1919: Germany	Discovered Doppler effect in canal rays
Albert Einstein	1921: Germany-Switzerland	For the discovery of the law of the photoelectric effect
Niels Bohr	1922: Denmark	Investigated the structure of atoms
Chandrasekhara Venkata Raman	1930: India	Worked on scattering of light
Werner Heisenberg	1932: Germany	Created quantum mechanics
Erwin Schrödinger	1933: Austria	Discovered productive forms of atomic theory
Paul Dirac	1933: United Kingdom	
James Chadwick	1935: UK	Discovered Neutron
Victor Francis Hess	1936: Austria	Discovered cosmic radiation
Willis Eugene Lamb	1955: US	Discovered the fine structure of the hydrogen spectrum
Emilio Gino Segrè	1959: Italy	Discovered the antiproton
Owen Chamberlain	1959: US	
Lev Davidovich Landau	1962: Soviet Union	Theories for condensed matter
Maria Goeppert-Mayer	1963: US	Discovered nuclear shell structure
J. Hans D. Jensen	1963: Germany	

Hans Albrecht Bethe	1967: US	Worked on the theory of nuclear reactions
Murray Gell-Mann	1969: US	Classification of elementary particles and their interactions
Hannes Olof Gösta Alfvén	1970: Sweden	Worked on plasma physics
Louis Néel	1970: France	Worked solid state physics (antiferromagnetism and ferrimagnetism)
Dennis Gabor	1971: Hungary-UK	Developed the holographic method
John Bardeen	1972: US	Developed the theory of superconductivity
Leon Neil Cooper		
John Robert Schrieffer		
Arno Allan Penzias	1978: US	Discovered cosmic microwave background radiation
Robert Woodrow Wilson		
Nicolaas Bloembergen	1981: Netherlands-US	Developed laser spectroscopy
Arthur Leonard Schawlow	1981: US	
Ernst Ruska	1986: Germany	Designed the first electron microscope
Johannes Georg Bednorz	1987: Germany	Discovered the superconductivity in ceramic materials
Karl Alexander Müller	1987: Switzerland	
Robert B. Laughlin	1998: US	Discovered a new form of quantum fluid
Horst Ludwig Störmer	1998: Germany	
Daniel Chee Tsui	1998: China-US	

Jack St. Clair Kilby	2000: US	Developed integrated circuit
Riccardo Giacconi	2002: Italy-US	Discovered cosmic X-ray sources
Roy J. Glauber	2005: US	Worked on the quantum theory of optical coherence
Willard S. Boyle	2009: Canada-US	Invented an imaging semiconductor circuit – the CCD sensor
George E. Smith	2009: US	
Takaaki Kajita	2015: Japan	Discovered neutrino oscillations, which illustrations that the neutrinos have mass
Arthur B. McDonald	2015: Canada	

19. AWARDS GIVEN IN PHYSICS

Following are the exclusive category of awards given in the field of Physics:

David Adler Lectureship Award in the Field of Materials Physics
Alexander Hollaender Award in Biophysics
Hannes Alfvén Prize
Andrew Gemant Award
Appleton Medal and Prize
ASA Gold Medal
ASA Silver Medal
Hans Bethe Prize
Blaise Pascal Chair
Bogolyubov Prize
Bogolyubov Prize (NASU)
Bogolyubov Prize for young scientists
Boltzmann Medal
Ludwig Boltzmann Prize
Tom W. Bonner Prize in Nuclear Physics
Max Born Prize
Breakthrough Prize in Fundamental Physics
Oliver E. Buckley Condensed Matter Prize
CAP-CRM Prize in Theoretical and Mathematical Physics

Charles Hard Townes Award
Comstock Prize in Physics
Elliott Cresson Medal
Davisson–Germer Prize in Atomic or Surface Physics
Demidov Prize
Duddell Medal and Prize
Eddington Medal
Edison Volta Prize
Einstein Prize for Laser Science
Albert Einstein Award
Albert Einstein Medal
Einstein Prize (APS)
Albert Einstein World Award of Science
EPS Europhysics Prize
Faraday Medal and Prize
Nobel Prize in Physics
Fluid Dynamics Prize (APS)
Foresight Institute Feynman Prize in Nanotechnology
List of Fritz London Memorial Prizes
Hector Memorial Medal
Dannie Heineman Prize for Astrophysics
Dannie Heineman Prize for Mathematical Physics
Henri Poincaré Prize

Hoyle Medal and Prize
Infosys Prize
Isaac Newton Medal
Frank Isakson Prize for Optical Effects in Solids
James Clerk Maxwell Prize in Plasma Physics
James C. McGroddy Prize for New Materials
Niels Bohr Institute
Om Prakash Bhasin Award
Otto Hahn Prize
Abraham Pais Prize for History of Physics
George E. Pake Prize
Max Planck Medal
Earle K. Plyler Prize for Molecular Spectroscopy
Pomeranchuk Prize
Prize Ampère
Aneesur Rahman Prize for Computational Physics
Rayleigh Medal
Rayleigh Medal and Prize
David Richardson Medal
Richtmyer Memorial Award
Robert A. Millikan award
Rumford Prize
Rutherford Medal and Prize

Sakurai Prize
Abdus Salam Award
Arthur L. Schawlow Prize in Laser Science
Walter Schottky Prize
Simon Memorial Prize
Sloan Fellowship
R W B Stephens Medal
Swan Medal and Prize
Thomson Medal and Prize
Three Physicists Prize
VASVIK Industrial Research Award
Wolf Prize in Physics

20.SCIENTIFIC UNITS NAMED AFTER INVENTORS

The following table illustrates the list of scientific units, which are exclusively named after their inventors/discovers:

Scientist/Inventor	Unit	Measures
André-Marie Ampère	ampere (A)	Electric current
Lord Kelvin	kelvin (K)	Thermodynamic temperature
Antoine Henri Becquerel	becquerel (Bq)	Radioactivity
Anders Celsius	degree Celsius (°C)	Temperature
Charles-Augustin de Coulomb	coulomb (C)	Electric charge
Alexander Graham Bell	decibel (dB)	Ratio
Michael Faraday	farad (F)	Capacitance
Joseph Henry	henry (H)	Inductance
Heinrich Rudolf Hertz	hertz (Hz)	Frequency
James Prescott Joule	joule (J)	Energy, work, heat
Sir Isaac Newton	newton (N)	Force
Georg Simon Ohm	ohm (Ω)	Electrical resistance
Blaise Pascal	pascal (Pa)	Pressure
Werner von Siemens	siemens (S)	Electrical conductance
Nikola Tesla	tesla (T)	Magnetic flux density
Alessandro Volta	volt (V)	Electric potential & electromotive force
James Watt	watt (W)	Power & radiant flux
Wilhelm Eduard Weber	weber (Wb)	magnetic flux

Jean-Baptiste Biot	biot (Bi)	Electric current
Peter Debye	debye (D)	Electric dipole moment
Loránd Eötvös	eotvos (E)	Gravitational gradient
Galileo Galilei	galileo (Gal)	Acceleration
Carl Friedrich Gauss	gauss (G or Gs)	Magnetic flux density
William Gilbert	gilbert (Gb)	Magnetomotive force
James Clerk Maxwell	maxwell (Mx)	Magnetic flux
Hans Christian Ørsted	oersted (Oe)	Magnetic field strength
Jean Léonard Marie Poiseuille	poise (P)	Dynamic viscosity
George Gabriel Stokes	stokes (S or St)	Kinematic viscosity
Anders Jonas Ångström	ångström (Å)	Distance
Heinrich Barkhausen	Bark scale	Psychoacoustical scale
Thomas Hunt Morgan	centimorgan (cM)	Recombination frequency
Marie Curie and Pierre Curie	curie (Ci)	Radioactivity
John Dalton	dalton (Da)	Atomic mass
Henry Darcy	darcy (D)	Permeability
Gordon Dobson	Dobson unit (DU)	Atmospheric ozone
Daniel Gabriel Fahrenheit	degree Fahrenheit (°F)	Temperature
Enrico Fermi	fermi (fm)	Distance
Godfrey Newbold Hounsfield	Hounsfield scale	Radio density
Karl Jansky	jansky (Jy)	Electromagnetic flux
Samuel Pierpont Langley	langley (ly)	Solar radiation
Irving Langmuir	langmuir (L)	Gas exposure dose

Wilhelm Röntgen	röntgen (R)	X-rays or gamma radiation
Charles Francis Richter	Richter magnitude	Earthquake
Theodor Svedberg	svedberg (S or Sv)	Sedimentation rate
Evangelista Torricelli	torr (Torr)	Pressure

21. TOP INSTITUTES IN PHYSICS

Following are the worldly recognized top institutions in the field of Physics:

Institute	Country
Massachusetts Institute of Technology (MIT)	USA
Harvard University	USA
University of Cambridge	UK
Stanford University	USA
Yale University	USA
University of California, Berkeley (UCB)	USA
University of Oxford	UK
Columbia University	USA
Princeton University	USA
California Institute of Technology (Caltech)	USA
University of Chicago	USA
University of Michigan	USA
ETH Zurich - Swiss Federal Institute of Technology	Switzerland
Ludwig-Maximilians-Universität München	Germany
Technical University of Munich	Germany
University of Toronto	Canada
New York University (NYU)	USA
Imperial College London	UK

University of Pennsylvania	USA
Boston University	USA
The University of Edinburgh	UK
The University of Tokyo	Japan
Cornell University	USA
University of Maryland, College Park	USA
Sapienza University of Rome	Italy
University of Texas at Austin	USA
National University of Singapore (NUS)	Singapore
RWTH Aachen University	Germany
Seoul National University	South Korea
University College London	UK
Georgia Institute of Technology	USA
Peking University	China
Osaka University	Japan
Pennsylvania State University	USA
The University of Melbourne	Australia
University of California, San Diego (UCSD)	USA
University of British Columbia	Canada
McGill University	Canada
National Taiwan University (NTU)	Taiwan
The Australian National University	Australia

Brown University	USA
Duke University	USA
Delft University of Technology	Netherlands
Durham University	UK
Humboldt-Universität zu Berlin	Germany
Johns Hopkins University	USA
Lund University	Sweden
Nagoya University	Japan
Northwestern University	USA
The Ohio State University	USA
Purdue University	USA
Rice University	USA
Rutgers University - New Brunswick	USA
Stockholm University	Sweden
Technische Universität Dresden	Germany
University of Bristol	UK
University of Washington	USA