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ENGLISH IN PHYSICS I

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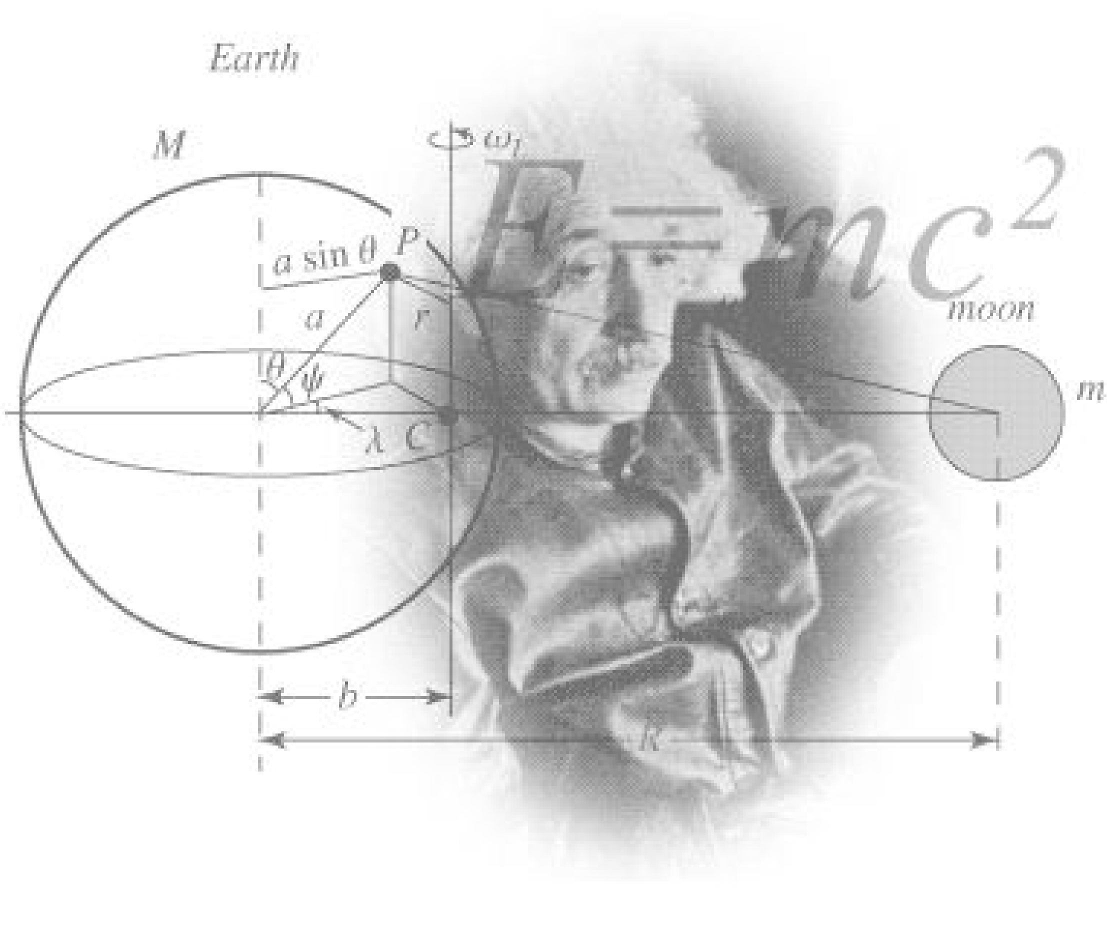

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INTRODUCTION
PHYSICS IN EVERYDAY LIFE

The most basic of the sciences, physics, is all around us every day. If you have ever wondered what makes lightning, why a boomerang returns, how ice skaters can spin so fast, how Michael Jordan can "fly," why waves crash on the beach, how that tiny computer can do complicated problems, or how long it takes light from a star to reach us, you have been thinking about some of the same things physicists study every day.

Physicists like to ask questions. They try to find answers for almost everything from when the universe began to why soda fizzes. If you like to explore and figure out why things are the way they are, you might like physics.

Fig. 1 Alf Rawls performs the "Ollie," the aerial maneuver on which all new skateboard tricks are based. The "Ollie" depends on a rapid compression and decompression of the skater's legs.

If you have had a back-row seat at a rock concert, and could still hear, you experienced physics at work! Physicists studying sound contribute to the design of concert halls and the amplification equipment. Lasers and radioactive elements are tools in the war on cancer and other diseases. Geophysicists are developing methods to give advance warning of earthquakes. The work of physicists made possible the computer chips that are in your digital watch, CD player, electronic games, and hand-held calculator.

The laboratory of the physicist extends from the edge of the universe to inside the nucleus of an atom. A physicist may work in a laboratory designing materials for the computer chips of tomorrow, or smashing atomic particles a in a quest to understand a laboratory designing materials for the computer chips of tomorrow, or smashing atomic particles against one another in a quest to understand how our universe began. Physicists have orbited the Earth as astronauts, and plumbed the oceans' depths. Individuals who have studied physics seek to make instruments that diagnose and cure disease; to develop safer and cleaner fuels for our cars and homes; to harness the power of the sea; to calculate the movement of arctic glaciers; and to create smaller, faster electronic components and integrated circuits. Research physicists work in industry and government, in laboratories and hospitals, and on university campuses. Some physicists serve in the military, teach in high schools and colleges, teach in high schools and colleges, design science museum exhibits, write books and news articles about science, give advice to federal, state, local, and foreign governments, run businesses, even become artists. Students not interested in pursuing a science career can still benefit from courses in physics. The study of physics helps you acquire very special problem-solving skills and teaches you to better observe and understand theworld.

Lesson 1

PHYSICS IN GENERAL

Physics (Greek: physics, meaning "nature") is a natural science that involves the study of matter and its motion through space-time, as well as all applicable concepts, such as energy and force. More broadly, it is the general analysis of nature, conducted in order to understand how the world and universe behave.

Physics is one of the oldest academic disciplines, perhaps the oldest through its inclusion of astronomy. Over the last two millennia, physics had been considered synonymous with philosophy, chemistry, and certain branches of mathematics and biology, but during the Scientific Revolution in the 16th century, it emerged to become a unique modern science in its own right. However, in some subject areas such as in mathematical physics and quantum chemistry, the boundaries of physics remain difficult to distinguish.

CLASSICAL PHYSICS

Classical physics includes the traditional branches and topics that were recognized and fairly well developed before the beginning of the 20th century— mechanics, sound, light, heat, electricity and magnetism. Mechanics is concerned with bodies acted on by forces and bodies in motion and may be divided into statistics (study of the forces on a body at rest), kinematics (study of motion without regard to its causes), and dynamics (study of motion and the forces that affect it); mechanics may also be divided into solid mechanics and fluid mechanics. Acoustics, the study of sound, is often considered a branch of mechanics because sound results from the motion of air particles or other medium through which sound waves can travel. Optics, the study of light, is concerned not only with visible light but also with infrared and ultraviolet radiation. Heat is a form of energy, the internal energy contained in the particles of which a substance is composed; thermodynamics deals with the relationships between heat and other forms of energy. Electricity and magnetism have been studied as a single branch of physics since the intimate connection between them was discovered in the early 19th century.

MODERN PHYSICS

Most of classical physics is concerned with matter and energy on the normal scale of observation; by contrast, much of modern physics deals with the behaviour of matter and energy under extreme conditions or on the very large or very small scale. For example, atomic and nuclear physics studies matter on the smallest scale at which chemical elements can be identified. The physics of elementary particles is concerned with the most basic units of matter; this branch of physics is also known as high-energy physics because of the extremely high energies necessary to produce many types of particles in large particle accelerators. On this scale, ordinary, common sense notions of space, time, matter, and energy are no longer valid.

The two chief theories of modern physics present a different picture of the concepts of space, time, and matter from that presented by classical physics. The quantum theory is concerned with the discrete, rather than continuous, nature of many phenomena at the atomic and subatomic level, and with the complementary aspects of particles and waves in the description of such phenomena. The theory of relativity deals with the description of phenomena that take place in motion with respect to an observer; the special theory of relativity is concerned with relative uniform motion in a straight line and the general theory of relativity with accelerated motion and its connection with gravitation.

KEY WORDS:

space, matter, energy, motion,
physics,
classical physics, modern physics,
mechanics, acoustics, optics, thermodynamics, electrostatics, electrodynamics,
atomic and nuclear physics, physics of elementary particles, high-energy physics,
quantum physics, theory of relativity

EXERCISES:

I Answer the questions:

How can we define physics?
What does classical physics deal with?
What are some branches of classical physics?
How does classical physics differ from modern physics?
What do you know about the quantum theory and theory of relativity?

II Give synonyms for the following words:

basic-_________________, important -____________________________, to be concerned with-
____________________, affect- ________________________, to give rise to- ________________

III. Make sentences of your own using the words from the exercise II

____
____
____
____
____
____

IV. Translate the part of the text dealing with modern physics

SCOPE AND AIMS

Physics covers a wide range of phenomena, from the smallest sub-atomic particles (such as quarks, neutrinos and electrons), to the largest galaxies. Included in these phenomena are the most basic objects from which all other things are composed, and therefore physics is sometimes called the "fundamental science".

Physics aims to describe the various phenomena that occur in nature in terms of simpler phenomena. Thus, physics aims to both connect the things we see around us to root causes, and then to try to connect these causes together in the hope of finding an ultimate reason for why nature is as it is. For example, the ancient Chinese observed that certain rocks were attracted to one another by some invisible force. This effect was later called magnetism, and was first rigorously studied in the 17th century.

A little earlier than the Chinese, the ancient Greeks knew of other objects such as amber, that when rubbed with fur would cause a similar invisible attraction between the two. This was also first studied rigorously in the 17th century, and came to be called electricity. Thus, physics had come to understand two observations of nature in terms of some root cause (electricity and magnetism). However, further work in the 19th century revealed that these two forces were just two different aspects of one force – electromagnetism. This process of "unifying" forces continues today

The scientific method

Physics uses the scientific method to test the validity of a physical theory, using a methodical approach to compare the implications of the theory in question with the associated conclusions drawn from experiments and observations conducted to test it. Experiments and observations are to be collected and matched with the predictions and hypotheses made by a theory, thus aiding in the determination of the validity/invalidity of the theory.

Theories which are very well supported by data and have never failed any competent empirical test are often called scientific laws, or natural laws. Of course, all theories, including those called scientific laws, can always be replaced by more accurate, generalized statements if a disagreement of theory with observed data is ever found.

Theory and experiment

The culture of physics has a higher degree of separation between theory and experiment than many other sciences. Since the twentieth century, most individual physicists have specialized in either theoretical physics or experimental physics. In contrast, almost all the successful theorists in biology and chemistry (e.g. American quantum chemist and biochemist Linus Pauling) have also been experimentalists, although this is changing as of late.

Theorists seek to develop mathematical models that both agree with existing experiments and successfully predict future results, while experimentalists devise and perform experiments to test theoretical predictions and explore new phenomena. Although theory and experiment are developed separately, they are strongly dependent upon each other. Progress in physics frequently comes about when experimentalists make a discovery that existing theories cannot explain, or when new theories generate experimentally testable predictions, which inspire new experiments.

FUN WITH PHYSICS

What is the difference between a physicist, an engineer, and a mathematician?

If an engineer walks into a room and sees a fire in the middle and a bucket of water in the corner, he takes the bucket of water and pours it on the fire and puts it out.
If a physicist walks into a room and sees a fire in the middle and a bucket of water in the corner, he takes the bucket of water and pours it eloquently around the fire and lets the fire put itself out.
If a mathematician walks into a room and sees a fire in the middle and a bucket of water in the corner, he convinces himself there is a solution and leaves.

FUN QUIZ

1. As early as 3500 B.C., a gnomen (a stick in the ground) was used to measure
   Temperature
   Time
   Water levels
   Wind velocity
   Gravity

2. The distance an object travels in a given time frame (regardless of direction) is referred to as its:
   Velocity
   Inertia
   Kinetic energy
   Speed
   Acceleration

3. What causes tides?
   The tilt of the earth on its axis
   Mostly the gravitational pull of the moon
   Mostly the gravitational pull of the sun.

4. To hit a target on land, at what point would you drop a bomb from an airplane?
   Before the target
   Directly over the target
   After passing the target

5. If one cannonball is dropped from a given height and another is fired horizontally from the same height, which one will hit the ground first?
   The one that is dropped
   The one that is fired
   They will both hit the ground at the same time

6. What is the sound barrier?
   The speed that an object must travel to surpass the speed of sound
   A unit for measuring the intensity of sound
   The point at which a sound exceeds the human pain threshold
   The distance between two people that cannot hear one another talking

Answers: 1. Time, 2. Speed, 3. Mostly the gravitational pull of the moon, 4. Before the target, 5. They will both hit the ground at the same time, 6. The speed that an object must travel to surpass the speed of sound,

Lesson 3

BRIEF HISTORY OF PHYSICS

GREEK CONTRIBUTIONS

The earliest history of physics is interrelated with that of the other sciences. A number of contributions were made during the period of Greek civilization, dating from Thales and the early Ionian natural philosophers in the Greek colonies of Asia Minor (6th and 5th cent. BC). Democritus (c.460-370 BC) proposed an atomic theory of matter and extended it to other phenomena as well, but the dominant theories of matter held that it was formed of a few basic elements, usually earth, air, fire, and water.

The most important philosophy of the Greek period was produced by two men at Athens, Plato (427-347 BC) and his student Aristotle (384-322 BC); Aristotle in particular had a critical influence on the development of science in general and physics in particular. The Greek approach to physics was largely geometrical and reached its peak with Archimedes (287-212 BC), who studied a wide range of problems and anticipated the methods of the calculus. Another important scientist of the early Hellenistic period, centered in Alexandria, Egypt, was the astronomer Aristarchus (c.310-220 BC), who proposed a heliocentric, or sun-centered, system of the universe. However, the astronomical system that eventually prevailed was the geocentric system developed in detail by Ptolemy (AD 85-AD 165).

THE SCIENTIFIC REVOLUTION

The first areas of physics to receive close attention were mechanics and the study of planetary motions. Modern mechanics dates from the work of Galileo and Simon Stevin in the late 16th and early 17th century. The great breakthrough in astronomy was made by Nicolaus Copernicus, who proposed (1543) the heliocentric model of the solar system that was later modified by Johannes Kepler (using observations by Tycho Brahe) into the description of planetary motions that is still accepted today. Galileo gave his support to this new system and applied his discoveries in mechanics to its explanation.

The full explanation of both celestial and terrestrial motions was not given until 1687, when Isaac Newton published his Principia [Mathematical Principles of Natural Philosophy]. This work, the most important document of the Scientific Revolution of the 16th and 17th century, contained Newton's famous three laws of motion and showed how the principle of universal gravitation could be used to explain the behaviour of falling bodies on the earth, as well as of the planets and other celestial bodies. To arrive at his results, Newton invented an entirely new branch of mathematics, namely, the calculus (also invented independently by G. W. Leibniz), which was to become an essential tool in much of the later development in most branches of physics.

Other branches of physics also received attention during this period. William Gilbert, court physician to Queen Elizabeth I, published (1600) an important work on magnetism, describing how the earth itself behaves like a giant magnet. Robert Boyle (1627-91) studied the behaviour of gases enclosed in a chamber and formulated the gas law which was later named after him.

Newton himself discovered the separation of white light into a spectrum of colours and published an important work on optics, in which he proposed the theory that light is composed of tiny particles, or corpuscles. This corpuscular theory was related to the mechanistic philosophy presented early in the 17th century by René Descartes, according to which the universe functioned like a mechanical system describable in terms of mathematics.

DEVELOPMENT OF MECHANICS AND THERMODYNAMICS

During the 18th century the mechanics founded by Newton was further developed by several other scientists.
In 1798 Benjamin Thompson found a direct relationship between heat and mechanical energy.

In the 19th century this connection was established quantitatively by J. R. Mayer and J. P. Joule. Their experimental work provided a basis for the formulation of the first two laws of thermodynamics in the 1850s by William Thomson (later Lord Kelvin) and R. J. E. Clausius. The first law is the law of conservation of energy and the second law describes the tendency of energy to be converted from more useful to less useful forms.

ADVANCES IN ELECTRICITY, MAGNETISM, AND THERMODYNAMICS

The study of electricity and magnetism also came into its own during the 18th and 19th centuries. Alessandro Volta had invented the electric battery, so that electric current could also be studied. In 1820, H. C. Oersted found that a current-carrying conductor gives rise to a magnetic force surrounding it, and in 1831 Michael Faraday (and independently Joseph Henry) discovered the reverse effect, the production of an electric potential or current through magnetism.

Faraday invented the concept of the field of force to explain these phenomena and Maxwell developed these ideas mathematically in his theory of electromagnetic radiation and showed that electric and magnetic fields are propagated outward from their source at a speed equal to that of light and that light is one of several kinds of electromagnetic radiation, differing only in frequency and wavelength from the others. Experimental confirmation of Maxwell's theory was provided by Heinrich Hertz, who generated and detected electric waves in 1886 and verified their properties, at the same time foreshadowing their application in radio, television, and other devices. The wave theory of light had been revived in 1801 by Thomas Young and received strong experimental support from the work of A. J. Fresnel and others; the theory was widely accepted by the time of Maxwell's work on the electromagnetic field, and afterward the study of light and that of electricity and magnetism were closely related.

KEY WORDS:
Thales, Democritus, Ptolemy, Plato, Aristotle, Archimedes
Galileo, Nicholas Copernicus, Johannes Kepler, Isaac Newton, Robert Boyle, Alessandro Volta, Michael Faraday, Maxwell, Heinrich Hertz
geometrical approach, heliocentric system, geocentric system, Principia (Mathematical Principles of Natural Philosophy), laws of motion, gas law, spectrum, corpuscular theory, mechanistic philosophy, law of conservation of energy, to convert energy, conductor, theory of light

EXERCISES:
I. Read the text silently
II Underline all new words
III Translate the paragraph *The science revolution*
IV Explain in English the meaning of the words:

describable:____,
court physician: ____,
revive:____,
phenomenon:____.

Lesson 4

GALILEO GALILEI

Galileo Galilei was an Italian physicist, mathematician, astronomer, and philosopher who played a major role in the scientific revolution. His achievements include the first systematic studies of uniformly accelerated motion, improvements to telescope and consequent astronomical observations, and support for Copernicanism. Galileo's empirical work was a significant break from the abstract Aristotelian approach of his time. Galileo has been called the "father of modern observational astronomy", the father of modern physics", and the "father of modern science."

Fig. 1 Galileo Galilei (1564-1642)

One of the most common examples of uniformly accelerated motion is that of an object allowed to fall freely near the Earth's surface. It was widely believed until the time of Galileo that heavier objects fall faster than lighter objects and that the speed of fall is proportional to how heavy the object is.

Aristotle believed heavier objects fall to the ground faster than lighter objects. As legend has it, Galileo dropped two objects from the Leaning Tower of Pisa to disprove Aristotle theory. These objects were the same size, but different weights. They fell to the ground at the same speed. This disproved Aristotle's theory and led Galileo to discover the Law of Falling Bodies.

To support his claim that falling objects increase in speed as they fall, Galileo made use of a clever argument: a heavy stone dropped from a height of 2 m will drive a stake into the ground much further than will the same stone dropped from a height of only 0.2m. Clearly, the stone must be moving faster in the former case.

As we saw, Galileo also claimed that all objects, light or heavy, fall with the same acceleration, at least in the absence of air. If you hold a piece of paper horizontally in one hand and a heavier object in the other, and release them at the same time, the heavier object will reach the ground first. But if you repeat the experiment, this time crumpling the paper into a small wad, you will find that the two objects reach the floor at nearly the same time.

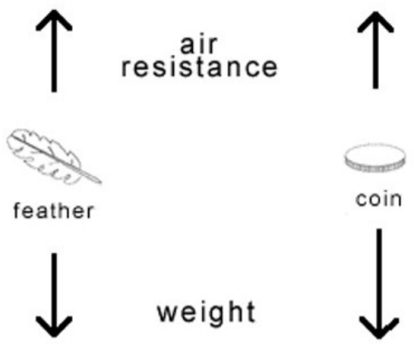

Fig. 2

EXERCISES

I. Read the text silently.
II. Rewrite the text using only the most important pieces of information.

III. Complete the following text with the words in the brackets:

STATES OF MATTER

The three common states of matter are solid, liquid, and gas. A solid maintains a _____ shape and a fixed size; even if a large force is _________ to a solid, it does not readily change in shape or _______.
A liquid does not maintain a fixed shape, it takes on the shape of its container, but like a solid, it is not readily_________, and its volume can be changed significantly only by a very large______.
A gas has neither a fixed shape nor a fixed volume, it will expand to fill its container. For example, when air is pumped into an automobile tire, the air does not run to the ________ as a liquid would; it _________ out to fill the whole volume of the tire.
Since liquids and gases do not_________ a fixed shape, they both have the ability to_______: they are thus often referred to collectively as fluids.
The __________ of matter into three states is not always simple. How, for example, should butter be classified? Furthermore, a fourth state of matter can be distinguished, the________ state, which occurs only at very high temperatures and consists of__________ atoms. Some scientists believe that the so-called colloids should also be considered a separate state of matter.

(ionised, fixed, maintain, plasma, compressible, flow, force, spread, applied, volume, division, bottom)

Lesson 5

ISAAC NEWTON

Fig. 3 Sir Isaac Newton (1642-1727)

Sir Isaac Newton did change the world. He was not a good farmer and was sent to Cambridge to study to become a preacher. One summer Newton was forced to leave his university when it was closed because of plaque. During this period he made some of his most significant discoveries and two years later he came back with a revolutionary understanding of mathematics, gravitation, and optics. A professor of his, upon understanding what Newton had done, resigned his position at Cambridge so Newton could have it. Newton's calculus provided a new mathematical framework for the rapid solution of whole classes of physical problems. Newton was the first scientist ever knighted.

His Philosopia Naturalis Principia Mathematica, published in 1687, is considered to be the most influential book in the history of science. In this work, Newton described universal gravitation and the three laws of motion, laying the groundwork for classical mechanics, which dominated the scientific view of the physical universe for the next three centuries and is the basis for modern engineering. Newton showed that the motions of objects on Earth and of celestial bodies are governed by the same set of natural laws by demonstrating the consistency between Kepler's laws of planetary motion and his theory of gravitation, thus removing the last doubts about heliocentrisism and advancing the scientific revolution.

In mechanics, Newton formulated the principles of conservation of momentum and angular momentum. In optics, he invented the reflecting telescope and developed a theory of colour based on the observation that a prism decomposes white light into a visible spectrum. He also formulated an empirical law of cooling and studied the speed of sound.

In mathematics, Newton shares the credit with Gottfried Leibnitz for the development of the differential and integral calculus.

In a 2005 poll of the Royal Society asking who had the greater effect on the history of science, Newton was deemed much more influential than Albert Einstein.

EXERCISES:

I. Answer the questions!

1. Why did Newton's professor resign his position?
2. What makes Philosopia Naturalis Principia Mathematica one of the most influential scientific works?
3. How was Newton inspired to formulate his theory of universal gravitation?

II. Translate the following text:

Newton's Laws of Motion

Newton's first law of motion is often stated as:

An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
There are two parts to this statement - one which predicts the behaviour of stationary objects and the other which predicts the behaviour of moving objects. The two parts are summarized in the following diagram.

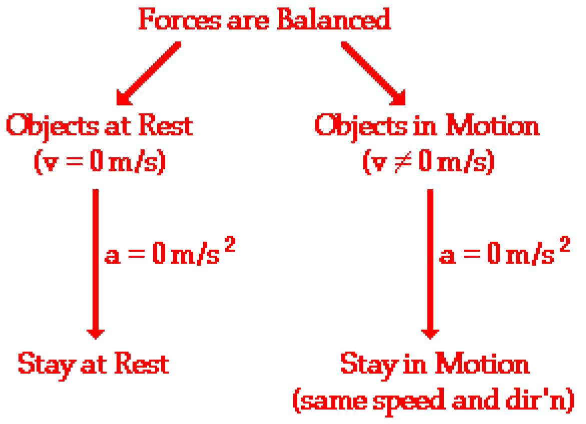

Fig 4 Forces are Balanced

The behaviour of all objects can be described by saying that objects tend to "keep on doing what they're doing". All objects resist changes in their state of motion - they tend to "keep on doing what they're doing."

Second Law of motion:
Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object)
Everyone unconsciously knows the Second Law. Everyone knows that heavier objects require more force to move the same distance as lighter objects.

Third Law of motion:
For every action there is an equal and opposite reaction.
This means that for every force there is a reaction force that is equal in size, but opposite in direction. That is to say that whenever an object pushes another object it gets pushed back in the opposite direction equally hard.

Lesson 6

THE BIRTH OF MODERN PHYSICS

By the late 19th century most of classical physics was complete. Several problems, however, provided the cracks that eventually led to the birth of modern physics. On the experimental side, the discoveries of X rays by Wilhelm Roentgen (1895), radioactivity by A. H. Becquerel (1896), the electron by J. J. Thomson (1897), and new radioactive elements by Marie and Pierre Curie raised questions about the supposedly indestructible atom and the nature of matter. In 1911 Ernest Rutherford interpreted experimental evidence showing that the atom consists of a dense, positively charged nucleus surrounded by negatively charged electrons. Classical theory, however, predicted that this structure should be unstable.

RELATIVITY AND QUANTUM MECHANICS

In 1905, Albert Einstein's special theory of relativity implied, among other things, that mass and energy are equivalent and that the speed of light is the limiting speed for all bodies having mass. Einstein extended his theory to accelerated frames of reference in his general theory (1916), showing the connection between acceleration and gravitation. Newton's mechanics was valid only as an approximation for small speeds compared to that of light.

In 1900 Max Planck's formulated his important quantum theory. Einstein used this theory to explain the photoelectric effect, and in 1913 Niels Bohr again used it to explain the stability of Rutherford's nuclear atom. In the 1920s the theory was extensively developed by Louis de Broglie, Werner Heisenberg, Wolfgang Pauli, Erwin Schrödinger, P. A. M. Dirac, and others; the new quantum mechanics became an indispensable tool in the investigation and explanation of phenomena at the atomic level.

PARTICLES, ENERGY AND CONTEMPORARY PHYSICS

Dirac's theory, which combined quantum mechanics with the theory of relativity, also predicted the existence of antiparticles. During the 1930s the first antiparticles were discovered, as well as other particles.

The discovery of nuclear fission by Otto Hahn and Fritz Strassmann (1938) and its explanation by Lise Meitner and Otto Frisch provided a means for the large-scale conversion of mass into energy, in accordance with the theory of relativity. The growth of physics since the 1930s has been so great that it is impossible in a survey article to name even its most important individual contributors.

Among the areas where fundamental discoveries have been made more recently are solid-state physics, plasma physics, and cryogenics, or low temperature physics. Out of solid-state physics, for example, have come many of the developments in electronics (e.g., the transistor) that have revolutionized much of modern technology. Another development is the laser, with applications ranging from communication and controlled nuclear fusion experiments to atomic clocks and other measurement standards.

KEY WORDS

Wilhelm Roentgen, Marie and Pierre Curie, Albert Einstein, Max Planck, Niels Bohr, Werner Heisenberg, Wolfgang Pauli, Erwin Schrödinger, P. A. M. Dirac

X rays, quantum theory, photoelectric effect, quantum mechanics, antiparticles, nuclear fission, solid-state physics, laser

EXERCISES:

I. Give the opposite of:

modern - __________________, dense- ________________, incomplete - __________________
solid - ____________________, light -_________________, equivalent - __________________

II. Explain the meaning of the following:

fundamental discoveries,
indispensable tool,
indestructible atom

III. Word formation:

NOUN ADJECTIVE

revolution
mass
control
development
fundament

IV. Complete the line:

to predict
to explain
to limit
to complete
to surround

V Complete the extract from Einstein's essay text «The world as I see it » with the words in the brackets and then translate.

«The world as I see it »

"The most beautiful experience we can have is the mysterious. It is the fundamental emotion that stands at the _________ of true art and true science. Whoever does not know it and can no longer wonder, no longer marvel, is as good as dead, and his eyes are dimmed. It was the experience of mystery - even if mixed with______ - that engendered religion. A knowledge of the existence of something we cannot _______________, our perceptions of the profoundest reason and the most ___________beauty, which only in their most primitive forms are___________ to our minds: it is this knowledge and this emotion that ___________ true religiosity. In this sense, and only this sense, I am a deeply religious man... I am satisfied with the mystery of life's eternity and with a knowledge, a sense, of the marvelous structure of existence -- as well as the humble attempt to understand even a tiny ______________of the Reason that manifests itself in nature."

(portion, cradle, fear, penetrate, radiant, accessible, constitute)

NIKOLA TESLA - THE GENIUS WHO LIT THE WORLD

Born in Smiljan, Croatia, Tesla was educated at Graz and Prague, worked for the Continental Edison Company in Paris, and emigrated to the United States in 1884. There he worked briefly for Thomas Edison until the poetic Tesla and the pragmatic Edison fell out. Tesla then went on to sell his patents for a series of alternating current devices to the Westinghouse Electric Company, making Tesla a relatively wealthy man able to set himself up in his own laboratory.

Tesla was a pioneer in many fields. His alternating current induction motor is considered one of the ten greatest discoveries of all time. He designed the first hydroelectric power plant in Niagara Falls in 1895, which was the final victory of alternating current.
The Tesla coil, which he invented in 1891, is widely used today in radio and television sets and other electronic equipment.

Among his discoveries are the fluorescent light, laser beam, wireless communications, wireless transmission of electrical energy, remote control, robotics, Tesla's turbines and vertical takeoff aircraft. Tesla is the father of the radio and the modern electrical transmissions systems. He registered over 700 patents worldwide. His vision included exploration of solar energy and the power of the sea. He foresaw interplanetary communications and satellites. He appears to have discovered x-rays a year before W. K. Roentgen did in Germany, he built a vacuum tube amplifier several years before Lee de Forest did, he was using fluorescent lights in his laboratory 40 years before the industry "invented" them, and he demonstrated the principles used in microwave ovens and radar decades before they became an integral part of our society. Yet we associate his name with none of them.

In Colorado Springs, where he stayed from May 1899 until 1900, Tesla made what he regarded as his most important discovery-- terrestrial stationary waves. By this discovery he proved that the Earth could be used as a conductor and would be as responsive as a tuning fork to electrical vibrations of a certain frequency. He also lighted 200 lamps without wires from a distance of 25 miles(40 kilometers) and created man-made lightning. At one time he was certain he had received signals from another planet in his Colorado laboratory, a claim that was met with disbelief in some scientific journals.

Tesla's concept of wireless electricity was used to power ocean liners, destroy warships, run industry and transportation and send communications instantaneously all over the globe. To stimulate the public's imagination, Tesla suggested that this wireless power could even be used for interplanetary communication. If Tesla were confident to reach Mars, how much less difficult to reach Paris. Many newspapers and periodicals interviewed Tesla and described his new system for supplying wireless power to run all of the earth's industry.

In 1915, a New York Times article announced that Tesla and Edison were to share the Nobel Prize for physics. Oddly, neither man received the prize, the reason being unclear. It was rumoured that Tesla refused the prize because he would not share with Edison, and because Marconi had already received his.
In spite of that, Nikola Tesla was one of the most celebrated personalities in the American press, in this century. According to Life Magazine's special issue of September, 1997, Tesla is among the 100 most famous people of the last 1,000 years. He is one of the great men who divert the stream of human history.

Tesla's celebrity was in its height at the turn of the century. His discoveries, inventions and vision had widespread acceptance by the public, the scientific community and American press. Tesla's discoveries had extensive coverage in the scientific journals, the daily and weekly press as well as in the literary and intellectual publications of the day. He was the Super Star.

EXERCISES:

1. Why did Tesla and Edison fall out?
2. Make a list of some of his most important inventions?
3. Which of (some of) his inventions are associated with other scientists?
4. What do you think is the reason for this?
5. Why was he considered eccentric? What, if anything, do you know about Tesla's private life?

VOCABULARY PRACTICE:

1. Find words in the text which mean:

   mental rejection of something as untrue ....
   having wide or considerable extent ....
   relating to the earth or its inhabitants ....
   an electric utility generating station ....
   an electronic device for amplifying voltage, current, or power....................................

2. Fill in the correct word derived from the word in brackets.

   1. Before the .... (invent) of the telephone, communicating over great distances was slow and difficult.
   2. I see this as .... (recognise) of my role in supporting learning and as .... (acknowledge) of the teaching role that I have.
   3. .... (subscribe) to magazines and periodicals rise.
   4. This leaves me with a number of difficult .... (decision) to make.

TRANSLATE THE PARAGRAPH:

Tesla's generosity eventually left him without adequate funds to pursue and realize his inventions. His idealism and humanism left him with little stomach for the world of industrial and financial intrigue. His New York laboratory was destroyed by a mysterious fire. References to his work and accomplishments were systematically purged from the scientific literature and textbooks. Driven into a Hermetic exile in a New York hotel during the period between the two wars, 20 years of his potentially rich and productive contribution were taken from us. The only occasions of public appearance were the yearly press interviews on his birthday when he would describe amazing and far reaching inventions and technological possibilities. These were distorted and sensationalized in the popular press, particularly when he described advanced weapons systems on the eve of World war II. He died in obscurity in 1943. Only the FBI took note: they searched his papers (in vain) for the design of the "death-ray machine". It is interesting to note that the motivation for our "Star Wars" defense system was based upon fears that the Soviets had begun deployment of weapons based upon Tesla high energy principles. Public reports of mysterious "blindings" of U.S. surveillance satellites, anomalous high altitude flashes and fireballs, elf wave radio interference, and other cases lend credence to this interpretation.

Lesson 8

ALBERT EINSTEIN

"There are only two ways to live your life.
One is as though nothing is a miracle.
The other is as if everything is." *Albert Einstein*

Albert Einstein was born on March 14, 1879 in Ulm, Wurttemberg, Germany. Einstein contributed more than any other scientist since Sir Isaac Newton to our understanding of physical reality.

Einstein was slow to learn to talk, not beginning to speak until sometime after his second birthday. His slow verbal development combined with a native rebelliousness toward authority, led one schoolmaster to say that young Albert would never amount to much.

When Einstein was 10, a poor student named Max Talmud began dining with the Einstein family once a week. Max would bring illustrated science for Albert to study, and they would discuss what Albert learned. Max gave him a geometry textbook two years before Albert was to study the subject at school. Max later recalled, "Soon the flight of his mathematical genius was so high that I could no longer follow."

In 1896, Einstein entered the Swiss Federal Polytechnic School in Zurich to be trained as a physics and mathematics instructor. He graduated in 1901, and unable to find a teaching position, accepted a job as technical assistant in the Swiss Patent Office in Bern. At that time he completed an astonishing range of theoretical physics publications, written in his spare time, without the benefit of scientific literature or close contact with colleagues.

The most well known of these works is Einstein's 1905 paper proposing "the special theory of relativity." He based his new theory on the principle that the laws of physics are in the same form in any frame of reference. As a second fundamental hypothesis, Einstein assumed that the speed of light remained constant in all frames of reference.

Later in 1905 Einstein showed how mass and energy were equivalent expressing it in the famous equation: E=mc2 (energy equals mass times the velocity of light squared). This equation became a cornerstone in the development of nuclear energy.

Einstein received the Nobel prise in 1921 but not for relativity, rather for his 1905 work on the photoelectric effect. He worked on at Princeton until the end of his life on an attempt to unify the laws of physics.

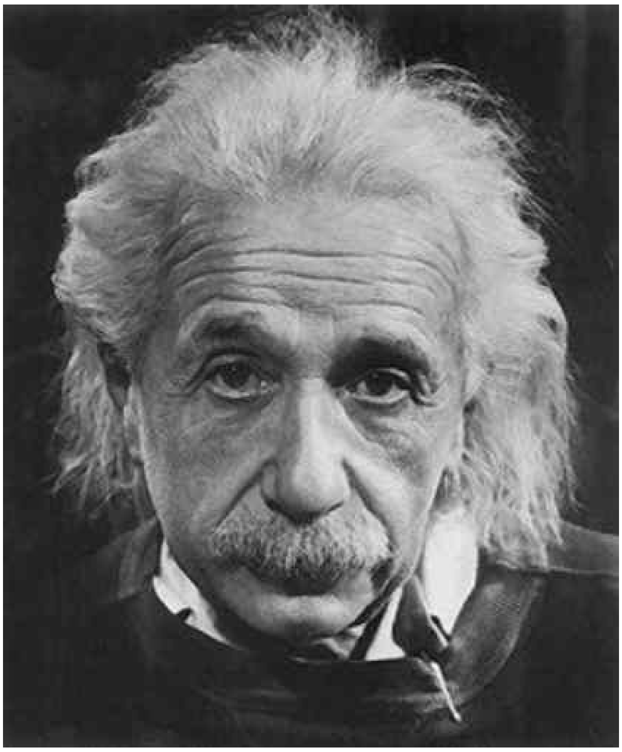

Fig. 5 Albert Einstein (1879-1955)

EXERCISES:

I. Write short notes about the text on Einstein!
II. Translate the following text

Albert Einstein was not only one of the greatest and most influential physicists and scientists in the history of mankind but also a great philosopher. Morality, clarity and wisdom of his ideas are still very relevant and useful in our modern and very disturbed times.

"A human being is part of the whole called by us universe, a part limited in time and space. We experience ourselves, our thoughts and feelings as something separate from the rest. A kind of optical delusion of consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from the prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty. The true value of a human being is determined by the measure and the sense in which they have obtained liberation from the self. We shall require a substantially new manner of thinking if humanity is to survive. " (Albert Einstein, 1954)

III. Write a short comment on the extract of Einstein's essay.

Lesson 9

I. Complete the text about Stephen Hawking with the missing words given in brackets:

STEPHEN HAWKING

The British theoretical physicist Stephen Hawking (1942-), _____________ fame in 1988 with the publication of "A Brief History of Time." The book later was made into a movie of the same name. He holds the professorship at Cambridge University once held by Sir Isaac Newton and did _____________ research on the theory of black holes.

Stephen Hawking has worked on the basic laws which __________ the universe. With Roger Penrose he showed that Einstein's General Theory of Relativity implied space and time would have a beginning in the Big Bang and an end in black holes. These results indicated it was necessary to ____________ General Relativity with Quantum Theory, the other great Scientific development of the first half of the 20th Century. One consequence of such a unification that he discovered was that black holes should not be completely black, but should emit ________________ and eventually evaporate and disappear. Another conjecture is that the universe has no edge or boundary in _____________ time. This would imply that the way the universe began was completely ______________ by the laws of science.

His many ______________ include The Large Scale Structure of Spacetime with G. F. R. Ellis, General Relativity: An Einstein Centenary Survey, with W. Israel, and 300 Years of Gravity, with W. Israel. Stephen Hawking has two popular books published; his ______________ A Brief History of Time, and his later book, Black Holes and Baby Universes and Other Essays.

Most of his work he has done while confined to a wheelchair brought on by amyotrophic lateral sclerosis, or Lou Gehrig's Disease.

(ground-breaking, radiation, imaginary, publications, bestseller, govern, unify, determined, gained)

II. Translate the following text

The expansion of the universe seems to suggest that typical objects in the universe were once much closer together than they are now. This is the basis for the idea that the universe began about 23.7 billion years ago as an expansion from a state of very high density and temperature known affectionately as Big Bang. The Big Bang was not an explosion, because an explosion blows pieces out into the surrounding space. Instead, the Big Bang was the start of an expansion of space itself. The volume of the observable universe was very small at the start and has been expanding ever since. The initial tiny volume of extremely dense matter is not to be thought of as a concentrated mass in the midst of a much larger space around it. The initial tiny but dense volume was the universe – the entire universe. There wouldn't have been anything else. When we say that the universe was once smaller than it is now, we mean that the average separation between galaxies (or other objects) was less. Thus, it is the size of the universe itself that has increased since the Big Bang. A major piece of evidence supporting the Big Bang is the cosmic microwave background radiation (or CMB).

Lesson 10

TERMS YOU SHOULD KNOW

acceleration
The rate of change of velocity with respect to time.
acoustics
The science of the production, transmission, and effect of sound waves.
Ampère's law
It relates a circulating magnetic field to an electric current passing through a loop
anode
The positive terminal of an electrical current flow. In a vacuum tube, electrons flow from a cathode toward the anode.
atom
The smallest unit of a chemical element, the limit of classical physics on the small length scales
Bohr theory
A commonly accepted concept of the atom introduced by Niels Bohr in 1913. It holds that each atom consists of a small, dense, positively charged nucleus surrounded by negatively charged electrons that move in fixed, defined orbits about the nucleus, the total number of electrons normally balancing the total positive charge of particles in the nucleus.
Boyle's law
The principle that the volume of a gas times its pressure is constant at a fixed temperature.
Cathode
The negative terminal of an electric current system. In a vacuum tube, the filament serves as the cathode or source of electrons that are emitted.
Centripetal force
The centrally-directed force exerted on a body moving in a curved direction. The root of this force is the body's impulse to travel in a straight line but that tendency being impeded by the force causing it to curve. e.g. a string exerts centripetal force on a spinning pail to keep it going in a complete circle
Chaos theory
The study of processes in nonlinear dynamical systems, such as the Butterfly effect
Classical mechanics
A set of laws describing the motion of bodies and their aggregations
Conduction
The transfer of heat by molecular motion from a source of high temperature to a region of lower temperature, tending toward a result of equalized temperatures.
Convection
The mechanical transfer of heated molecules of a gas or liquid from a source to another area, as when a room is warmed by the movement of air molecules heated by a radiator.
Coulomb's law
The principle that an electrostatic force of attraction or repulsion between electrical charges is directly proportional to the product of the electrical charges and inversely proportional to the square of the distance between them.
Doppler Effect
The distortion of the reception of a point source due to either a moving source, moving receiver, or both.
Density
A material's mass divided by its volume.
Displacement
The staight-line distance from a moving object's original position to its final position.
Dynamics
The branch of mechanics dealing with the motions of material bodies under the action of given forces

Electric current
The flow of electric charge through an object
Electromotive force
The force that causes the movement of electrons through an electrical circuit.
Energy
The ability to perform work. Energy may be changed from one form to another, as from heat into light, but it normally cannot be created or destroyed.
Fluid
That can flow; not solid; able to move and change shape without separating when under pressure
Force
The influence on a body that causes it to accelerate, as expressed by the formula F = ma.
Frequency
The number of oscillations or waves of an active repetitive motion in one second
Friction
The force of resistance between two surfaces when the two surfaces are in contact with each other.
Gravity
The force in the universe that attracts matter.
Heat
A form of energy that results from the disordered motion of molecules. As the motion becomes more rapid and disordered, the amount of heat is increased.
Heisenberg's Uncertainty Principle
First stated by German physicist Werner Heisenberg, the idea that the exact position and momentum of a particle cannot be precisely detirmined at the same time. Only the probability of its location at a certain time can be predicted.
Inertia
A historical concept used for describing massive, moving objects
Intensity
The property of a form of energy associated with its amplitude. With sound, intensity is usually referred to as loudness.
Joule's law
Equation for the heat generated by a current flowing in a conductor
Kinetic energy
Energy that is associated with the motion of an object as expressed by the formula KE - 1/2mv{2}.
Light
Electromagnetic radiation with a wavelength visible to the human eye
Magnetic field
The space around a magnet or a current within which its magnetic influence can be detected or experienced.
Mass
Simply, the amount of matter in an object. Mass has two primary manifestations: gravitationally and inertially
Mechanics
A branch of physics that deals with the motion of objects.
Molecule
Aa group of atoms joined by chemical bonds
Momentum
The mathematical product of the mass of a moving object and its velocity, as expressed by the formula p = mv.
Newtonian mechanics
The first formulation of classical mechanics
Ohm's law
Relationship between the current flowing in a conductor and the voltage difference between its ends

Orbit
The path taken by a heavenly body during its periodic revolution around another body
Phenomenon
Any fact, circumstance, or experience that is apparent to the senses and that can be scientifically appraised or defined
Potential energy
Energy that is stored because of position or configuration, such as the gravitational energy of a weight that is positioned on the roof of a building.
Power
The rate at which work is performed, as expressed by the formula $P = W/t$.
Pressure
Force exerted against an opposing body; thrust distributed over a surface; expressed in units of force per units of area
Quantum mechanics
The theory that separates classical and modern physics
Relativity
Einstein's observation that the pull of gravity and forces of acceleration cannot be distinguished from one another. One consequence is that the laws of physics must be studied in isolated frames of reference.
Resonance
The tendency of a system to absorb more energy at its resonance frequency in a given process
Satellite
Basically, a small object revolving around a much larger one. The moon is a satellite of the Earth, and the Earth is on of the sun's satellites.
Sound
Longitudinal wave vibrations produced by variations in pressure carried by air or other media which can be perceived by the auditory senses as stimulation.
Temperature
The average kinetic energy of molecules
Thermodynamics
The study of thermal processes in physical systems
Velocity
The speed with which an object travels over a specified distance during a measured amount of time. It may be expressed by the formula $v = d/t$.
Venturi Effect
The observable phenomenon of higher velocity fluids producing lower pressure than lower velocity fluids.
Volume
The amount of space occupied in three dimensions, expressed in cubic units
Wave length
The distance between corresponding parts of a sinusoidal wave.
Weight
The force on a body produced by the downward pull of gravity on it. It may be expressed by the formula $W = mg$, where m represents the mass of the object and g represents the acceleration of gravity.
Work
The force applied to an object times the distance over which it is applied, as expressed by the formula $W = Fd$. Work may be independent of the energy expended.

Lesson 11

THE FIVE MOST IMPORTANT CONCEPTS IN PHYSICS

I. Energy will dissipate from an area of higher energy to one of lower energy without the input of additional energy.

This law governs all energy flow, especially observable in the cases of thermal and electrical energy flow. Heat moves from the hot tea to the relatively cold mug and surrounding air. Electrons tend to spread until an even charge is obtained throughout the entire system. This can also be directly observed with a drop of dye added to a glass of water. The colour will dissipate until the entire solution is a uniform colour.

II. Newton's Three Laws of Motion

1. A body in rest tends to stay at rest, and a body in motion tends to stay in motion, unless the body is compelled to change its state. The evidence supporting the first part of this statement is easily seen. We know that a wheel will not begin rolling by itself. However, we do not see the proof of the second half in our world. That is because there is an ever present inhibiting force known as friction that acts as the external force resisting perpetual motion.

2. The second law is a formula: A=F/m. The acceleration of a body is dependent upon both the mass of the object (not its weight) and the net force perpetuating the motion (total force in the direction of the motion minus the force resisting motion). In the formula, a resisting force would be written as negative to produce a negative acceleration, which means the object would be slowing down.

3. For every action there is an equal and opposite reaction. This means that if I push you, I myself will be slightly pushed back in the process. This is the principle at work behind how jet planes and rockets propel themselves. They expell gases in the opposite direction, are pushed themselves in the process, and thus move forward.

III. The Laws of the Conservation of Energy and of Mass

These laws are intimately intertwined and state that, under normal conditions, the total energy of a contained system and the total mass of that contained system will remain constant. It also postulates that neither mass nor energy can be created or destroyed, that they merely change form (e.g. energy- electrical changes to thermal, or mass- liquid changes to gas). Fairly recently, though under laboratory conditions, scientists have actually observed a minute loss of total mass in a closed system, and this has been attributed to the fact that the mass had actually changed into energy. This led to a modification of the laws, which made the provision that mass and energy can actually change into each other.

IV. Wave-Particle Duality

The principle of quantum mechanics which implies that light (and, indeed, all other subatomic particles) sometimes act like a wave, and sometimes act like a particle, depending on the experiment you are performing. For instance, low frequency electromagnetic radiation tends to act more like a wave than a particle; high frequency electromagnetic radiation tends to act more like a particle than a wave.

V. The Four Fundamental Forces of Nature

Strong- This force is a nuclear force. Its purpose is to hold the nucleus of an atom together, but it decays rapidly with distance; it doesn't even extend beyond an atom's nucleus!!

Weak- The weak nuclear force is associated with beta decay. It is responsible for the nuclear breakdown of neutrons into protons and electrons.

Gravitational- The weakest of the four forces, but still holds us to the Earth, keeps our planet in orbit around the sun, and causes the tides to rise and fall.

Electromagnetic-This force is used on the atomic level to hold the atom together. It is caused by the opposing charges of electrons and protons.

KEY WORDS

dissipate, at rest, in motion, friction, perpetual motion, wave particle duality, beta decay,

EXERCISES:

I. Change the underlined word with the one given in brackets.

HEAT TRANSFER CONVECTION

Heat energy can be transferred from one point to another by different methods and at different rates. Heat energy <u>resides</u> (refuses, stays, replies) in kinetic energy of molecules and in the case of fluids, <u>portions</u> (forces, change, parts) of the fluid may move from point to point carrying the fast moving molecules with their energy to points where the energy per molecule is less so that the energy is transferred by the molecules moving to the new point. This is known as convection. It can be <u>readily</u> (slowly, easily, really) shown with water in a glass tube. Some ink added at the top <u>allows</u> (permits, avoids, ensures) us to follow the motion of convection. In order to get circulation we note that the heating produces a density change and <u>hence</u> (even, although, therefore) a pressure gradient and the density gradient cannot be parallel so that acceleration in different directions are different.

II. Translate the text HEAT TRANSFER CONVECTION

Give the opposite of:

rapidly - __________, rest - ______________, heat- _____________, light- ____________,
liquid - ___________, external - _____________, low- ____________, tide - ____________

III. Write a verb in front of a noun

__________________ a problem
__________________ an experiment
__________________ research
__________________ a phenomenon
__________________ heat

Lesson 12

THE HISTORY OF ANTIMATTER

The history of antimatter begins with a young physicist named Paul Dirac and the strange implications of a mathematical equation.

It was the beginning of the 20th century, an exciting time when the very foundations of physics were shaken by the appearance of two important new theories: relativity and quantum mechanics.

In 1905 Albert Einstein unveiled his theory of Special Relativity, explaining the relationship between space and time, and between energy and mass in his famous equation E=mc2. Meanwhile experiments had revealed that light sometimes behaved as a wave, but other times behaved as if it were a stream of tiny particles. Max Planck proposed that each light wave must come in a little packet, which he called a "quantum": this way light was not just a wave or just a particle, but a bit of both.

By the 1920s, physicists were trying to apply the same concept to the atom and its constituents, and by the end of the decade Erwin Schrodinger and Werner Heisenberg had invented the new quantum theory of physics. The only problem now was that quantum theory was not relativistic - meaning the quantum description worked only for particles moving slowly, and not for those at high (or "relativistic") velocity, close to the speed of light.

In 1928, Paul Dirac solved the problem: he wrote down an equation, which combined quantum theory and special relativity to describe the behaviour of the electron. Dirac's equation won him a Nobel Prize in 1933, but also posed another problem: just as the equation x2=4 can have two possible solutions (x=2 OR x=-2), so Dirac's equation could have two solutions, one for an electron with positive energy, and one for an electron with negative energy. But in classical physics (and common sense!), the energy of a particle must always be a positive number!

Dirac interpreted this to mean that for every particle that exists there is a corresponding antiparticle, exactly matching the particle but with opposite charge. For the electron, for instance, there should be an "antielectron" identical in every way but with a positive electric charge. In his Nobel Lecture, Dirac speculated on the existence of a completely new Universe made out of antimatter!

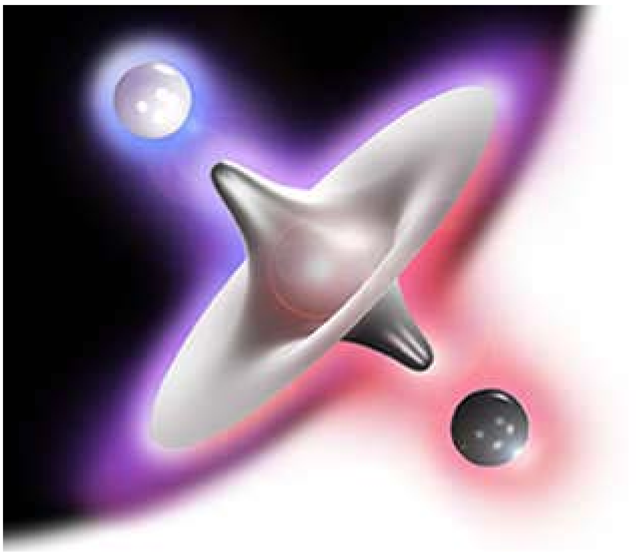

Fig. 7 Antimatter

Lesson 13

THE HISTORY OF ANTIMATTER

FROM 1928 to 1959

From 1930, the hunt for the mysterious antiparticles began.
Earlier in the century, Victor Hess (Nobel Prize winner in 1936) had discovered a natural source of high energy particles: cosmic rays. Cosmic rays are very high energy particles that come from outer space and as they hit the Earth's atmosphere they produce huge showers of lower energy particles that have proved very useful to physicists.

In 1932 Carl Anderson, a young professor at the California Institute of Technology, was studying showers of cosmic particles in a cloud chamber and saw a track left by "something positively charged, and with the same mass as an electron". After nearly one year of effort and observation, he decided the tracks were actually antielectrons, each produced alongside an electron from the impact of cosmic rays in the cloud chamber. He called the antielectron a "positron", for its positive charge. Confirmed soon after by Occhialini and Blackett, the discovery gave Anderson the Nobel Prize in 1936 and proved the existence of antiparticles as predicted by Dirac.

For many years to come, cosmic rays remained the only source of high energy particles. A steady stream of discoveries was made but for the next sought-after antiparticle, the antiproton (antipartner of the proton and much heavier than the positron), physicists had to wait another 22 years.

1954: power tools
The search for antiprotons heated up in the 1940s and 1950s, as laboratory experiments reached ever higher energies...

In 1930, Ernest Lawrence (Nobel Prizewinner in 1939) had invented the cyclotron, a machine that eventually could accelerate a particle like a proton up to an energy of a few tens of MeV. Initially driven by the effort to discover the antiproton, the accelerator era had begun, and with it the new science of "High Energy Physics" was born.

It was Lawrence that, in 1954, built the Bevatron at Berkeley, California (BeV, at the time, was what we now call GeV). The Bevatron could collide two protons together at an energy of 6.2 GeV, expected to be the optimum for producing antiprotons. Meanwhile a team of physicists, headed by Emilio Segre', designed and built a special detector to see the antiprotons.

In October 1955 the big news hit the front page of the New York Times: "New Atom Particle Found; Termed a Negative Proton". With the discovery of the antiproton, Segre' and his group of collaborators had succeeded in a further proof of the essential symmetry of nature, between matter and antimatter.

Segre' and Chamberlain were awarded the Nobel Prize in 1959. Only a year later, a second team working at the Bevatron (B. Cork, O. Piccione, W. Wenzel and G. Lambertson) announced the discovery of the antineutron.

Lesson 14

THE HISTORY OF ANTIMATTER

FROM 1965 TO 1995

By now, all three particles that make up atoms (electrons, protons and neutrons) were known to each have an antiparticle. So if particles, bound together in atoms, are the basic units of matter, it is natural to think that antiparticles, bound together in antiatoms, are the basic units of antimatter.

But are matter and antimatter exactly equal and opposite, or symmetric, as Dirac had implied? The next important step was to test this symmetry . Physicists wanted to know: how do subatomic antiparticles behave when they come together? Would an antiproton and an antineutron stick together to form an antinucleus, just as protons and neutrons stick together to form an atom's nucleus?

The answer to the antinuclei question was found in 1965 with the observation of the antideuteron, a nucleus of antimatter made out of an antiproton plus an antineutron (while a deuteron, the nucleus of the deuterium atom, is made of a proton plus a neutron). The goal was simultaneously achieved by two teams of physicists, one led by Antonino Zichichi, using the Proton Synchrotron at CERN, and the other led by Leon Lederman, using the Alternating Gradient Synchrotron (AGS) accelerator at the Brookhaven National Laboratory, New York.

1995: From antiparticles to antimatter

After making antinuclei, naturally the next question was: can antielectrons stick to antinuclei to make antiatoms?

In fact the answer was only revealed quite recently, thanks to a very special machine, unique to CERN, the Low Energy Antiproton Ring (LEAR). Contrary to an accelerator, LEAR actually "slowed down" antiprotons. Physicists could then try to force a positron (or antielectron) to stick to an antiproton, making an antihydrogen atom, a real antimatter atom.

Towards the end of 1995, the first such antiatoms were produced at CERN by a team of German and Italian physicists. Although only 9 antiatoms were made, the news was so thrilling that it made the front page of many of the world's newspapers.

The achievement suggested that the antihydrogen atom could play a role in the study of the antiworld similar to that played by the hydrogen atom in over more than a century of scientific history. Hydrogen makes up three quarters of our universe, and much of what we know about the cosmos has been discovered by studying ordinary hydrogen.

But does antihydrogen behave exactly like ordinary hydrogen ? To answer this question CERN decided to build a new experimental facility: the Antiproton Decelerator (AD).

Lesson 15

10 MOST INTERESTING PHYSICAL THEORIES

Wave Particle Duality

Matter and light have properties of both waves and particles simultaneously. The results of quantum mechanics make it clear that waves exhibit particle-like properties and particles exhibit wave-like properties, depending on the specific experiment. Quantum physics is therefore able to make descriptions of matter and energy based on wave equations that relate to the probability of a particle existing in a certain spot at a certain time.

Quantum Probability & the Measurement Problem

Quantum physics is defined mathematically by the Schroedinger equation, which depicts the probability of a particle being found at a certain point. This probability is fundamental to the system, not merely a result of ignorance. Once a measurement is made, however, you have a definite result.

The measurement problem is that the theory doesn't completely explain how the act of measurement actually causes this change. Attempts to solve the problem have lead to some intriguing theories.

Heisenberg Uncertainty Principle

The physicist Werner Heisenberg developed the Heisenberg Uncertainty Principle, which says that when measuring the physical state of a quantum system there's a fundamental limit to the amount of precision that can be achieved.

For example, the more precisely you measure the momentum of a particle the less precise your measurement of its position. Again, in Heisenberg's interpretation this wasn't just a measurement error or technological limitation, but an actual physical limit.

Quantum Entanglement & Nonlocality

In quantum theory, certain physical systems can become "entangled," meaning that their states are directly related to the state of another object somewhere else. When one object is measured, and the Schroedinger wavefunction collapses into a single state, the other object collapses into its corresponding state ... no matter how far away the objects are (i.e. nonlocality).

Einstein, who called these influences "spooky action at a distance," illuminated this concept with his EPR Paradox.

Unified Field Theory

Unified field theory is a type of theory that goes about trying to reconcile quantum physics with Einstein's theory of general relativity. The following are examples of specific theories that fall under the heading of unified field theory:

Quantum Gravity
String Theory / Superstring Theory / M-Theory
Grand Unified Theory
Loop Quantum Gravity
Theory of Everything
Supersymmetry

The Big Bang

When Albert Einstein developed the Theory of General Relativity, it predicted a possible expansion of the universe. Georges Lemaitre thought that this indicated the universe began in a

single point. The name "Big Bang" was given by Fred Hoyle while mocking the theory during a radio broadcast.
In 1929, Edwin Hubble discovered a redshift in distant galaxies, indicating that they were receding from Earth. Cosmic background microwave radiation, discovered in 1965, supported Lemaitre's theory.

Dark Matter & Dark Energy
Across astronomical distances, the only significant fundamental force of physics is gravity. Astronomers find that their calculations and observations don't quite match up, though.
An undetected form of matter, called dark matter, was theorized to fix this. Recent evidence supports dark matter.
Other work indicates that there might exist a dark energy, as well.
Current estimates are that the universe is 70% dark energy, 25% dark matter, and only 5% of the universe is visible matter or energy!

Quantum Consciousness
In attempts to solve the measurement problem in quantum physics, physicists frequently run into the problem of consciousness. Though most physicists try to sidestep the issue, it seems that there is a link between the conscious choice of experiment and the outcome of the experiment.
Some physicists, most notably Roger Penrose, believe that current physics cannot explain consciousness, and that consciousness itself has a link to the strange quantum realm.

FUN WITH PHYSICS

COMPLETE THE TEXT WITH THE MISSING WORDS

THIRD MIRACLE

A priest, a drunkard and a physicist were .... to die by the guillotine. The priest is led up to the guillotine and is asked if he.......................... to be facing up or down. He replies "I would like my last earthly sight to be of heaven". The executioner than fastens him in face up and......................... the guillotine blade. It falls, but stops just within an inch of his throat. "A miracle!" the crowd of spectators shout in unison, and the priest is released unharmed.

Next, the drunkard is led up the steps and he is asked if he prefers to face up or down. "Upward", he replied, "so that I can drink, one last time, some good wine you .... down my throat!" After the drunkard is given a drink, the huge blade is released but again stops within an inch of his throat. "Mon dieu! A second miracle!" the crowd......................, and he is released unharmed.

Finally, the physicist is led up to be executed. He also chooses to be shackled to the guillotine faceup. The crowd is placing bets left and right about whether a third miracle will take place. As he lies faceup, he .... the death apparatus above him. Raising his hand, moments before the executioner releases the blade, the physicist shouts:"Wait, wait! ... I see what your problem is!”

Ponders, releases, cheers, condemned, prefers, pour

APPENDIX

Basic physics equations and formulas

TABLE OF INFORMATION FOR 2002

CONSTANTS AND CONVERSION FACTORS

1 unified atomic mass unit,	$1\ \text{u} = 1.66 \times 10^{-27}\ \text{kg}$
	$= 931\ \text{MeV}/c^2$
Proton mass,	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
Neutron mass,	$m_n = 1.67 \times 10^{-27}\ \text{kg}$
Electron mass,	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
Magnitude of the electron charge,	$e = 1.60 \times 10^{-19}\ \text{C}$
Avogadro's number,	$N_0 = 6.02 \times 10^{23}\ \text{mol}^{-1}$
Universal gas constant,	$R = 8.31\ \text{J}/(\text{mol} \cdot \text{K})$
Boltzmann's constant,	$k_B = 1.38 \times 10^{-23}\ \text{J/K}$
Speed of light,	$c = 3.00 \times 10^8\ \text{m/s}$
Planck's constant,	$h = 6.63 \times 10^{-34}\ \text{J} \cdot \text{s}$
	$= 4.14 \times 10^{-15}\ \text{eV} \cdot \text{s}$
	$hc = 1.99 \times 10^{-25}\ \text{J} \cdot \text{m}$
	$= 1.24 \times 10^3\ \text{eV} \cdot \text{nm}$
Vacuum permittivity,	$\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/\text{N} \cdot \text{m}^2$
Coulomb's law constant,	$k = 1/4\pi\epsilon_0 = 9.0 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2$
Vacuum permeability,	$\mu_0 = 4\pi \times 10^{-7} (\text{T} \cdot \text{m})/\text{A}$
Magnetic constant,	$k' = \mu_0/4\pi = 10^{-7} (\text{T} \cdot \text{m})/\text{A}$
Universal gravitational constant,	$G = 6.67 \times 10^{-11}\ \text{m}^3/\text{kg} \cdot \text{s}^2$
Acceleration due to gravity at the Earth's surface,	$g = 9.8\ \text{m/s}^2$
1 atmosphere pressure,	$1\ \text{atm} = 1.0 \times 10^5\ \text{N/m}^2$
	$= 1.0 \times 10^5\ \text{Pa}$
1 electron volt,	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$

UNITS

Name	Symbol
meter	m
kilogram	kg
second	s
ampere	A
kelvin	K
mole	mol
hertz	Hz
newton	N
pascal	Pa
joule	J
watt	W
coulomb	C
volt	V
ohm	Ω
henry	H
farad	F
tesla	T
degree Celsius	°C
electron-volt	eV

PREFIXES

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

θ	sin θ	cos θ	tan θ
0°	0	1	0
30°	1/2	$\sqrt{3}/2$	$\sqrt{3}/3$
37°	3/5	4/5	3/4
45°	$\sqrt{2}/2$	$\sqrt{2}/2$	1
53°	4/5	3/5	4/3
60°	$\sqrt{3}/2$	1/2	$\sqrt{3}$
90°	1	0	∞

TABLE OF ENGLISH TENSES

tense	Affirmative/Negative/Question	Use	Signal Words
[Simple Present]	**A:** He speaks. **N:** He does not speak. **Q:** Does he speak?	action in the present taking place **once, never or several times** facts actions taking place one after another action set by a timetable or schedule	always, every …, never, normally, often, seldom, sometimes, usually if sentences type I (*If I **talk**, …*)
[Present Progressive]	**A:** He is speaking. **N:** He is not speaking. **Q:** Is he speaking?	action taking place in the moment of speaking action taking place only for a limited period of time action arranged for the future	at the moment, just, just now, Listen!, Look!, now, right now
[Simple Past]	**A:** He spoke. **N:** He did not speak. **Q:** Did he speak?	action in the past taking place **once, never or several times** actions taking place one after another action taking place in the middle of another action	yesterday, 2 minutes ago, in 1990, the other day, last Friday if sentence type II (*If I **talked**, …*)
[Past Progressive]	**A:** He was speaking. **N:** He was not speaking. **Q:** Was he speaking?	action **going on** at a certain time in the past actions taking place at the same time action in the past that is interrupted by another action	when, while, as long as
[Present Perfect Simple]	**A:** He has spoken. **N:** He has not spoken. **Q:** Has he spoken?	putting emphasis on the **result** action that is still going on action that stopped recently finished action that has an influence on the present action that has taken place once, never or several times before the moment of speaking	already, ever, just, never, not yet, so far, till now, up to now
[Present Perfect Progressive]	**A:** He has been speaking. **N:** He has not been speaking. **Q:** Has he been speaking?	putting emphasis on the **course or duration** (not the result) action that recently stopped or is still going on finished action that influenced the present	all day, for 4 years, since 1993, how long?, the whole week
[Past Perfect Simple]	**A:** He had spoken. **N:** He had not spoken. **Q:** Had he spoken?	action taking place before a certain time in the past sometimes interchangeable with past perfect progressive	already, just, never, not yet, once, until that day if sentence type

		putting emphasis only on the **fact** (not the duration)	III (*If I **had talked**, …*)
Past Perfect Progressive	**A:** He had been speaking. **N:** He had not been speaking. **Q:** Had he been speaking?	action taking place before a certain time in the past sometimes interchangeable with past perfect simple putting emphasis on the **duration or course** of an action	for, since, the whole day, all day
Future I Simple	**A:** He will speak. **N:** He will not speak. **Q:** Will he speak?	action in the future that cannot be influenced **spontaneous** decision assumption with regard to the future	in a year, next …, tomorrow If-Satz Typ I (*If you ask her, she **will help** you.*) *assumption*: I think, probably, we might …, perhaps
Future I Simple (going to)	**A:** He is going to speak. **N:** He is not going to speak. **Q:** Is he going to speak?	**decision** made for the future conclusion with regard to the future	in one year, next week, tomorrow
Future I Progressive	**A:** He will be speaking. **N:** He will not be speaking. **Q:** Will he be speaking?	action that is **going on** at a certain time in the future action that is sure to happen in the near future	in one year, next week, tomorrow
Future II Simple	**A:** He will have spoken. **N:** He will not have spoken. **Q:** Will he have spoken?	action that will be **finished** at a certain time in the future	by Monday, in a week
Future II Progressive	**A:** He will have been speaking. **N:** He will not have been speaking. **Q:** Will he have been speaking?	action taking place before a certain time in the future putting emphasis on the **course** of an action	for …, the last couple of hours, all day long
Conditional I Simple	**A:** He would speak. **N:** He would not speak. **Q:** Would he speak?	action that **might** take place	if sentences type II (*If I were you, I **would go** home.*)
Conditional I Progressive	**A:** He would be speaking. **N:** He would not be speaking. **Q:** Would he be speaking?	action that might take place putting emphasis on the **course** / **duration** of the action	
Conditional II Simple	**A:** He would have spoken. **N:** He would not have spoken. **Q:** Would he have spoken?	action that **might** have taken place in the past	if sentences type III (*If I had seen that, I **would have helped**.*)
Conditional II Progressive	**A:** He would have been speaking. **N:** He would not have been speaking. **Q:** Would he have been speaking?	action that might have taken place in the past puts emphasis on the **course** / **duration** of the action	

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