

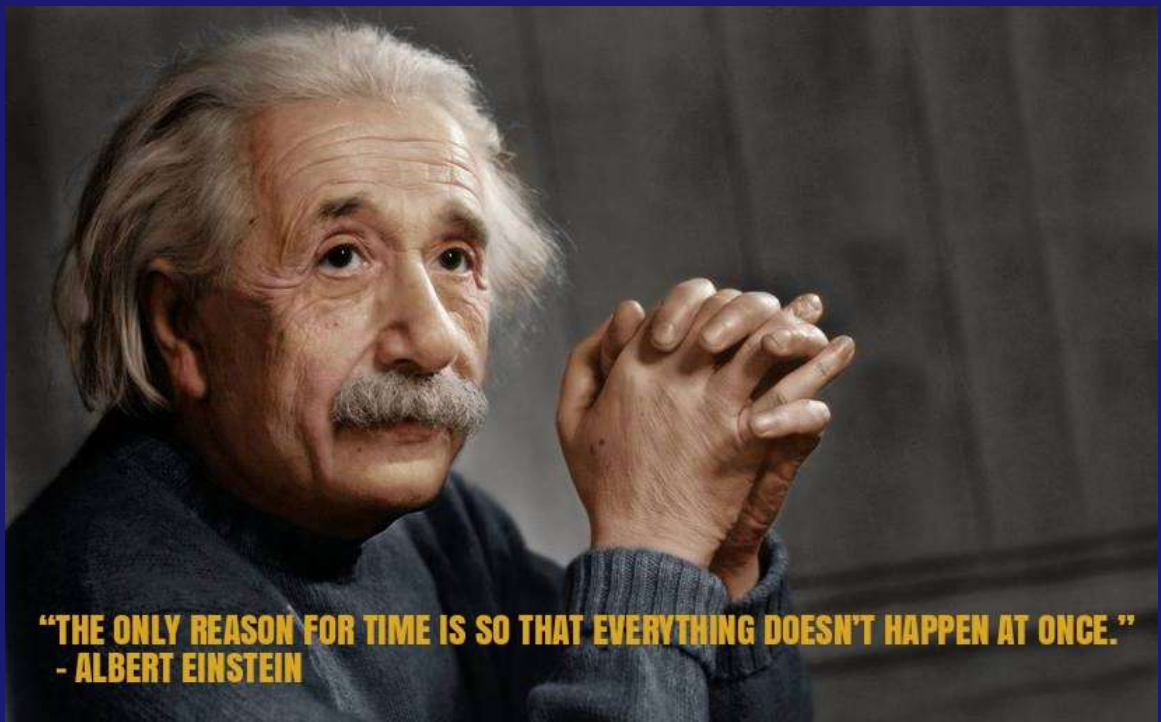
SIR P. T. SARVAJANIK COLLEGE OF SCIENCE
DEPARTMENT OF PHYSICS



Special Issue, March-2019

ALBERT EINSTEIN

Father of Modern Science



**"THE ONLY REASON FOR TIME IS SO THAT EVERYTHING DOESN'T HAPPEN AT ONCE."
- ALBERT EINSTEIN**

Editorial

We are delighted to dedicate special issue of Spectrum magazine to Albert Einstein. It is our great honor that on the occasion of 140th Birth anniversary of Albert Einstein, we were chosen to introduce you, all to the inspiring life and notable work of Einstein. From the childhood Einstein's fascination towards mother nature was remarkable, his keen observational power kept him busy in performing so many thought experiments. His fascination towards science and especially Mathematics and Physics, lead him to develop many important theories such as Special and General theory of relativity, explanation for Photoelectric effect, idea of stimulated emission and many more theories. His contribution towards modern science is still helping physicists to understand bizarre world of physics ranging from atoms to galaxies. To compile just an overview of his life and contributions to field of science is an unending endeavor. Hence it is our humble attempt to give reader an overview of Einstein's impact on science and society. We hope that reader will get same thrill in reading the magazine, that we experienced during its compilation. Also, we are thankful to Prin. Dr. Pruthul Desai and our departmental colleagues for their guidance throughout the journey of compilation of this magazine.

SPECTRUM

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Contents

1. Biographical sketch of Albert Einstein	2
1.1 Childhood and early life	2
1.2 Formative years	4
1.3 Personal life and legacy	4
1.4 Excellence at academics	5
1.5 Awards and achievements	6
1.6 Voyages undertaken	6
1.7 Trivia	8
1.8 Facts about Albert Einstein	8
2. Major works	10
2.1 Annus Mirabilis (1905)	10
2.2 On a heuristic point of view about the creation and conversion of light . .	11
2.3 Investigation of the theory of the Brownian Movement	13
2.4 On the electromagnetics of moving bodies	14
2.5 Does the inertia of a body depend upon its energy content?	16
2.6 General Theory of Relativity	17
2.7 Bending of light	19
2.8 Pound - Rebka experiment	20
2.9 Einstein's quest for a Unified Theory	21
3. How Einstein got the Nobel Prize	24
4. Quotes by Einstein	25
5. A brief history of Albert Einstein	28
6. Event of the month	32



Figure 1: (a) The house where Einstein was born, (b) Childhood photo of Einstein

1. Biographical sketch of Albert Einstein

One story Einstein liked to tell about his childhood was of a “wonder” he saw when he was four or five years old: a magnetic compass. The needle’s invariable northward swing, guided by an invisible force, profoundly impressed him as a child. The compass convinced him that there had to be “something behind things, something deeply hidden.” Even as a small boy Einstein was self-sufficient and thoughtful. According to family legend he was a slow talker at first, pausing to consider what he would say. His sister remembered the concentration and perseverance with which he would build up houses of cards to many stories. Einstein’s thought was stimulated by his uncle, an engineer, and by a medical student who ate dinner once a week at the Einstein’s.

“Look deep into nature, and then you will understand everything better.”

1.1 Childhood and early life

- Born on 14th March 1879, to Hermann Einstein and Pauline Einstein, in Ulm, in the Kingdom of Wurttemberg, Albert Einstein was one of the two children of the couple. He had a younger sister named Maja Einstein.
- The family shifted base to Munich, where his father, along with his uncle, founded the Elektrotechnische Fabrik J. Einstein and Cie Company, manufacturing electrical equipment based on direct current.
- Albert’s first taste of education was at the Catholic Elementary School, when he was five.

After acquiring three years of education, he was transferred to the Luitpold Gymnasium. Post completing advanced primary and secondary school education, he left Germany.

- Right from the early childhood, Einstein showed signs of having an in-depth talent and skill for mathematics. During this time, he used to build models and mechanical devices, but those were for mere entertainment.
- It was at the age of ten that Einstein's fantasy for the mathematics grew, when he was handed over popular books on science, mathematical texts and philosophical writings by Max Talmund. These included Immanuel Kant's Critique of Pure Reason, and Euclid's Elements.
- In 1894, with the introduction of alternating current to the world, Einstein's father went out of business. As such, in search of trade, the family moved to Milan initially and a few months later to Pavia.
- Einstein, however, stayed back at Munich to complete his studies at Luitpold Gymnasium. Though he did try to adhere to the wishes of his father who wanted Einstein to pursue electrical engineering, it wasn't long before Einstein withdrew his name from the school roll list as his views clashed with the study regimen of the education center. While Einstein craved for creative learning, the institution focused on rote learning.
- Joining his family in Pavia in 1894, he started working on what was his first paper titled, **'On the Investigation of the State of the Ether in a Magnetic Field'**.
- The following year, Einstein appeared for the examinations for the Swiss Federal Polytechnic in Zurich. Though he did not clear the test, his grades in physics and mathematics were exceptional.
- Adhering to the advice of the Principal of Polytechnic, Einstein enrolled himself in the Aargau Cantonal School in Aarau, Switzerland, for the academic year 1895-96, to complete his secondary schooling.
- Fearing the call for military service, Einstein renounced his citizenship in the German Kingdom of Wurttemberg in 1896. His decision was duly supported by his father. In the month of September, he passed the exam with overall good grades, once again gaining top grades in papers of mathematics and physics.
- Einstein was only seventeen years of age when he enrolled in the four-year mathematics and physics teaching diploma program at the ETH Zurich. He was awarded the Zurich Polytechnic teaching diploma degree in 1900.

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- The following year, i.e. in 1901, Einstein gained Swiss citizenship.

1.2 Formative years

- Post graduating, Einstein spent two years in search of a job in the teaching sector, but could not secure even one. Finally, with the help of his former classmate's father, he bagged the chair of an assistant examiner at the Federal Office for Intellectual Property, the patent office.
- It was in 1903 that Einstein became a permanent officer therein. His job involved evaluating patent applications for electromagnetic devices.
- His work was mostly related to questions about transmission of electric signals and electrical-mechanical synchronization of time. It was through this that Einstein made his conclusion about the nature of light and the fundamental connection between time and space.
- Four years thence, in 1905, he completed his thesis by presenting a dissertation which was entitled "**A New Determination of Molecular Dimensions**". For the same, he was awarded a PhD by the University of Zurich. However, the degree was just the beginning of the many more things that were waiting to come up.

1.3 Personal life and legacy

- Year 1896 was an important one for Einstein as far as his personal life was concerned, for it was then that he met Mileva Maric. The two became great friends and very soon, this friendship culminated into marriage. However, before the nuptial knots were tied, Einstein and Maric became parents to their first born, a daughter whom they named Lieserl.
- Einstein and Maric married in the January of 1903. Later next year, Maric gave birth to their first son, Hans Albert Einstein. Six years later, the couple was blessed with another son, Eduard. In 1914, Einstein moved to Berlin, while his wife and two sons remained in Zurich.
- Five years later, the two divorced on February 14, 1919. The same year, Einstein remarried with his then lady love, Elsa Lowenthal, after having had a relationship with her since 1912.

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- In 1933, the couple immigrated to the United States. After having being diagnosed with heart and kidney problems in 1935, Elsa didn't live long and passed away the December of 1936.
 - Albert Einstein experienced internal bleeding, which was caused by the rupture of an abdominal aortic aneurysm on April 17, 1955. Although Dr. Rudolph Nissen had reinforced the same surgically in 1948, the problem reappeared. He was admitted to the Princeton Hospital.
 - Though the doctors were preparing for the surgery, Einstein refused the same saying he did not want to prolong life using artificial measures. As a result, Einstein breathed his last on April 18, 1955. He was cremated and his ashes were scattered at an undisclosed location.

1.4 Excellence at academics

- Year 1905, fondly called the Annus Mirabilis or the miracle year in the life of Einstein, saw the birth of Einstein as innovator and creator, for it was during this year that he published his four ground-breaking papers.
- The papers provided information on the photoelectric effect, Brownian motion, special relativity, and the equivalence of matter and energy. They not only changed the way the world looked at time, space and matter, but also contributed and laid foundation for the growth of modern physics. Additionally, the papers brought Einstein to the limelight.
- As expected, post the publication of the papers, Einstein became instantly famous and was recognized as the leading scientist. In 1908, he was appointed as a lecturer at the University of Bern. However, Einstein quit this position as well as the one he was holding at the patent office to take up the profile of physics docent at the University of Zurich.
- In 1911, he became a full-time professor at the Karl-Ferdinand University in Prague.
- Three years later, in 1914, he returned to Germany as he was appointed director of the Kaiser Wilhelm Institute for Physics and a professor at the Humboldt University of Berlin, with a special clause in his contract that freed him from most teaching obligations.
- Two years thence in 1916, Einstein was appointed as the president of the German Physical Society, a position he held for two years. During this time, Einstein also attained membership of the Prussian Academy of Sciences.

1.5 Awards and achievements

- In 1921, he received Nobel Prize in Physics for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect.
- In 1929, Einstein was presented with the Max Planck Medal of the German Physical Society in Berlin.
- In 1936, he was awarded the Franklin Institute's Franklin Medal for his extensive work on relativity and the photo-electric effect.
- United Nations named 2005 as the “**World Year of Physics**” commemorating the 100th anniversary of the publication of the ‘**ANNUS MIRABILIS**’ papers.
- Albert Einstein has to his name a science park, located on the hill, Telegrafenberg in Potsdam, Germany. The park has a tower by the name, Einstein Tower which is an astrophysical, built to perform checks of Einstein's theory of General Relativity.
- Washington DC houses the Albert Einstein Memorial. In it is a monumental bronze statue depicting Einstein seated with manuscript papers in hand.
- In 1955, four months after his death, the chemical element 99 (Einsteinium) was named for him.
- The Time magazine, in 1999, named Einstein as the Person of the Century.
- The United States Postal Service honored Einstein with a Prominent Americans series 8 cent postage stamp.
- In 2008, Einstein was inducted into the New Jersey Hall of Fame.

1.6 Voyages undertaken

- Einstein's growing reputation resulted in his being invited officially by the Mayor of New York, who personally welcomed the great scientist on April 2, 1921. During his stay at New York, Einstein delivered several lectures at the Columbia and Princeton University.
- Post New York, Einstein moved to Washington D.C, where he accompanied several representatives of the National Academy of Science to the White House.
- During his journey back to Europe, Einstein made a short stay as the guest of the British statesman and philosopher Viscount Haldane in London. During his visit, Einstein met

several scientific, intellectual and political figures and delivered a lecture at Kings College.

- The following year, in 1922, Einstein journeyed to Asia and later to Palestine, as a part of the six-month excursion and speaking tour. His travels included Singapore, Ceylon, and Japan, where he gave a series of lecture to more than thousands of Japanese.
- His first lecture at Japan lasted for four hours after which he met the emperor and the empress at the Imperial Palace. Einstein visit to Palestine lasted for 12 days. It also became his only visit to the region.
- Einstein's next visit to America was in 1933. He visited several universities during the tour. He even undertook his third two-month visiting professorship at the California Institute of Technology.
- While returning to Belgium by the end of March, Einstein heard the news that his cottage and recreational boat had been confiscated by the Nazi's, who had risen to power under the authority of Germany's new chancellor.
- Upon returning, Einstein almost immediately went to the German consulate where he turned down his passport and renounced his German citizenship. (He had earlier renounced citizenship in the German Kingdom of Wurttemberg.)
- A new law had been set in Germany according to which Jews could not hold any official positions, including teaching at the universities. Not only were Einstein's work targeted, he himself was on the list of assassination targets of the Nazi's with a dollar \$5,000 bounty on his head.
- Einstein found his temporary shelter in England, before returning to US in the October of 1933. Therein, he took up a position at the Institute for Advanced Study at Princeton, New Jersey, that required his presence for six months each year. His association with the institute lasted until his death.
- Einstein was uncertain of his future, as he had offers from the European Universities as well. He, however, made the decision to permanently stay in the United States and thus, applied for citizenship.
- In the year 1939, a group of Hungarian scientists attempted to alert Washington of the ongoing atomic bomb research undertaken by the Nazi's. However, not much heed was paid to their warning. As such, they resorted to Einstein, who wrote a letter to President Franklin D. Roosevelt alerting him of the possibility.

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- The letter immediately drew the attention of the US government, which became directly involved in uranium research and associated chain reaction research. US utilized its immense financial and scientific resource to initiate the Manhattan Project and surfaced as the only country to successfully develop an atomic bomb during World War II.
 - Einstein gained a permanent citizenship in US in the year 1940. What was most appealing to him about this country and its culture was the existence of meritocracy unlike Europe. In US, people were rewarded for their works and they had the right to say and think what pleased them.
 - Einstein, in his later years, was even offered the position of President of Israel, but he declined the same stating that he had neither the aptitude nor the experience.

1.7 Trivia

- He is known as the Father of Modern Physics. Interestingly, his surname has been adjudged with the meaning 'genius', and is used by the world all over.
- A mastermind and impeccable theoretical physicist, he is responsible for creating new waves in the field of modern physics. However, as a child, he faced speech difficulty and had a slow cadence in speaking.
- Post death, the pathologist of Princeton Hospital, Thomas Stoltz Harvey, removed this proficient scientist's brain for preservation without the permission of his family, in the hope that the neuroscience of the future would be able to discover what made the man who developed the theory of relativity so intelligent.

1.8 Facts about Albert Einstein

1. Albert Einstein considered himself an agnostic, not an atheist as some people believe.
2. He was a ladies' man and had numerous extramarital affairs.
3. His mother was a piano player and she instilled in him a lifelong love for music. Einstein himself was a talented violin player.
4. He was a slow learner as a child and had speech problems.
5. It is said that he expected a lot from his first wife and set some weird rules for her to follow.

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6. Einstein was well-known for his unkempt appearance, especially his unruly hair. A fact that not many people know is that he hated wearing socks.
 7. Einstein was once offered the presidency of Israel which he politely declined.
 8. His Nobel Prize money went to his ex-wife as a divorce settlement.
 9. He was famous for being absent minded-he could not remember names, dates, and phone numbers.
 10. He loved sailing and was given a boat as a gift on his 50th birthday. But he was not a good sailor and had to be constantly rescued.

Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid.



Figure 2: LIFE is like riding a bicycle to keep your balance YOU MUST KEEP MOVING.

2. Major works

- In 1905, Einstein came up with his revolutionary works, which were focused on photoelectric effect, Brownian motion, the special theory of relativity, thermodynamic fluctuations, statistical physics and the equivalence of matter and energy.
- In 1917, at the height of his work on relativity, Einstein published an article in “*Physikalische Zeitschrift*” that proposed the possibility of stimulated emission, the physical process that makes the maser and the laser possible. He even worked on general relativity and applied the same to explain cosmology.

2.1 Annus Mirabilis (1905)

The Annus mirabilis papers (from Latin *annus mirabilis*, “extraordinary year”) are the papers of Albert Einstein published in the *Annalen der Physik* scientific journal in 1905. These four articles contributed substantially to the foundation of modern physics and changed views on space, time, mass, and energy. The annus mirabilis is often called the “miracle year” in English or Wunderjahr in German.

The year of 1905, turned out to be a corner stone for physicist all around the world. A young man of age 26, published four scientific papers in *Annalen der Physik*, all of them discussing the different puzzles of physics. These papers proved to be four strong pillars in development of modern physics. Even though Albert Einstein did publish some of his work prior to 1905, but as per Thomas S. Kuhn’s terminology those papers which he published before 1905 were, “normal science”. However, he did attempt to address some of the fundamental questions on the molecular-kinetic approach to thermal physics, which provided him the basic foundation. With the help of which, he carried out the “scientific revolution”. In those times, peer-review was not yet standard, Einstein just sent his manuscripts to Planck who then subsequently published them. The titles of his famous papers of 1905, are listed below.

1. Einstein, Albert (1905). “Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt” (On a Heuristic Point of View about the Creation and Conversion of Light).
2. Einstein, Albert (1905). “Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen” (Investigations on the theory of Brownian Movement)
3. Einstein, Albert (1905-06-30). “Zur Elektrodynamik bewegter Körper” (On the Electrodynamics of Moving Bodies)

4. Einstein, Albert (1905). “*Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?*” (Does the Inertia of a Body Depend Upon Its Energy Content?)

As it is clear from the titles of the papers which were published in span of only few months, the take away from these papers are not only extraordinary in themselves but they are the master pieces which gave insights to his extraordinary thinking ability. Here what follows is the brief discussion of these papers.

2.2 On a heuristic point of view about the creation and conversion of light

The mentioned paper was received on 18th March, 1905 and was published in 9th June, 1905 which proposed the idea of energy quanta.

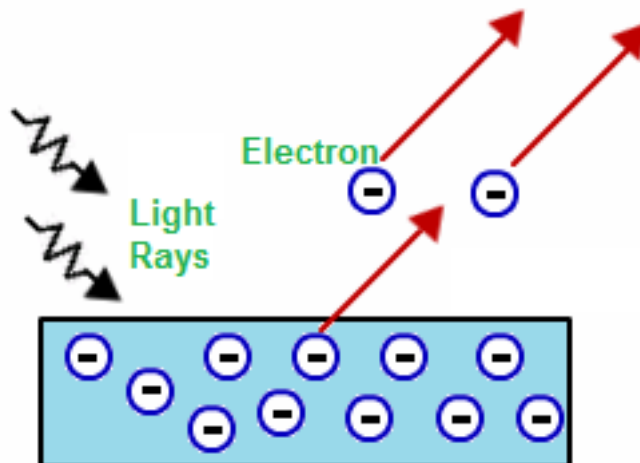


Figure 3: Schematic of Photoelectric effect

When a surface is exposed to electromagnetic radiation above a certain threshold frequency (typically visible light for alkali metals, near ultraviolet for other metals, and extreme ultraviolet for non-metals), the radiation is absorbed and electrons are emitted as shown in fig. 3. Light, and especially ultra-violet light, discharges negatively electrified bodies with the production of rays of the same nature as cathode rays. Under certain circumstances it can directly ionize gases. The first of these phenomena was discovered by Hertz and Hallwachs in 1887. The second was announced first by Philip Lenard in 1900. In 1839, Alexandre Edmond Becquerel discovered the photovoltaic effect while studying the effect of light on electrolytic cells, even though the effect observed was not exactly similar to the so called “photo-electric effect” where incoming electromagnetic radiation of certain frequencies, knock outs electrons from

the surface of the incident material, these electrons are ejected out from the surface of the material whereas in the case of photo-voltaic phenomena the electrons do not get ejected out of the material surface rather they continue their drifting journey inside the material or from one material to another via a junction potential. From the earlier experimental evidences, it was known that the output current in the case of photo-electric effect is independent of intensity of incident radiation, which contradicts Maxwell's equations which states that "the electron energy would be proportional to the intensity of the radiation." The paper solved this evident paradox, by assuming energy can be absorbed or emitted only in discrete amounts, called **quanta**.

Einstein states, "**Energy, during the propagation of a ray of light, is not continuously distributed over steadily increasing spaces, but it consists of a finite number of energy quanta localized at points in space, moving without dividing and capable of being absorbed or generated only as entities.**"

Evidently the above assumption was greatly in-line with the Max Planck's earlier derivation of the law of black-body radiation. He carried forward Planck's idea that energy can be absorbed or emitted in quanta. Einstein noted that the photoelectric effect depended on the wavelength, and hence the frequency of the light. At too low a frequency, even intense light produced no electrons. However, once a certain frequency was reached, even low intensity light produced electrons. He compared this to Planck's hypothesis that light could be emitted only in packets of energy given by hf , where h is Planck's constant and f is the frequency. He then postulated that light travels in packets whose energy depends on the frequency, and therefore only light above a certain frequency would bring sufficient energy to liberate an electron. Einstein also concluded that energy of photoelectrons was dependent only on the **frequency** of the incident light and not on its **intensity**. The mathematical equation which describes the photo-electric effect is

$$h\nu = \phi + E_k \quad (1)$$

where, ϕ is the **work function** of the material and E_k is the **maximum kinetic energy** of the emitted electrons in joules (J). which also explains the linear nature of the observed relation between frequency of incoming radiation and the energy of the electron ejected out from the surface. In 1926, the quanta of energy was coined as "**photon**" by American chemist Gilbert N. Lewis.

Explanation of the photo-electric effect, which fetched him the Nobel prize not only solved the paradox but also provided back-bone to the corpuscles theory of light which then also received verification by Arthur Compton's X-ray scattering experiment, and also provides enough support to the dual-nature of light waves.

2.3 Investigation of the theory of the Brownian Movement

Brownian motion was first observed by Antony van Leeuwenhoek under simple microscope. Robert Brown, being a botanist critically reviewed the work of several of his predecessors, on Brownian motion and noticed the pollen grains moving randomly in water. He described the motion in 1827 but was unable to explain it.

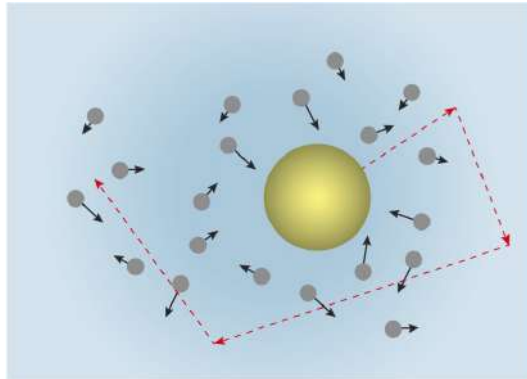


Figure 4: Schematic of a Brownian motion process

The Brownian motion is defined as the random motion of particles suspended in fluid as shown in fig. 4 or Brownian motion is the stochastic motion of particles induced by random collisions with molecules (Chandrasekhar, 1943), reason behind this jittery motion was not satisfactorily known. For example, Brown himself assumed that the motion of pollen particles that he observed in suspension is a signature of life or is associated with living cells only, but by the time he ended his investigation he came to conclusion that for particles to go under a random motion has nothing to do with the life or living cells. Giovanni, Joseph, and Carbonelle independently speculated that collisions with the molecules of the liquid make the suspension particles to go in random motion. However, Carl von Nageli and Ramsey argued against this assumption that the particle suffered no collision along a linear segment of its trajectory except those with two fluid particles at the two ends of the segment. If this scenario is true, then it lead to two puzzles (1) how can molecules of water, which are so small compared to the pollen grain ,cause movements of the latter that are large enough to be visible under ordinary microscope (2) given the large number of possible collisions, the mean free path of the pollen particles is very short ($10^{-12}sec$) which results in frequent collisions ($10^{12}persec$) then how our eyes resolve these events and see them as distinct random displacement of the pollen grains? This paradox was later resolved by Simoluchowski. He pointed out the error in Nageli-Ramsey

objection against the Cantoni-delsaulx-Carbonelle argument. He noticed that each straight segments of the Brownian trajectory are caused not by a single collision with a fluid particle but by an enormously large number of successive collisions from different fluid particles which by rare coincidence, gave rise to a net displacement in the same direction. Simoluchowski didn't published his work until he saw Einstein's published paper on the movement of small particles suspended in a stationary liquid demanded by the molecular kinetic theory of heat" discussing the same effect with the similar arguments that of Simoluchowski. He then decided to publish his work in 1906. Einstein's original paper did not even mentioned the Brownian motion as he was aware of the possible relevance of his theory of molecular kinetic theory of heat, in Brownian motion but he was cautious, he did mentioned in his paper that "it is possible that the movements to be discussed here are identical with the so-called Brownian molecular motion however the information available to me regarding the latter is so lacking in precision that I can form no judgment in the matter" he formulated the problem by assuming that the suspended particles perform an irregular movement even if a very slow one in the liquid on account of the molecular movement of the liquid this is indeed a clearly stated assumption regarding the mechanism of the irregular movement.

The crux of the Einstein's paper can be summarized as follows the mean-square displacement $\langle X^2 \rangle$ suffered by a spherical Brownian particle of radius a, in time t is given by

$$\langle X^2 \rangle = \frac{RT}{(3\pi N_{av} a \eta)} t \quad (2)$$

Where T is the temp. η is the viscosity of the fluid, N_{av} is the Avogadro number. This equation helped Einstein to estimate the molecular size.

Einstein's PhD thesis is perhaps a more important contribution to the theory of Brownian motion than his 1905 paper. Experimental proof of the above equation came from Perrin. Perrin not only confirmed that the root mean square displacement of the dispersed particles grows with time t as per eq stated above but also estimated Avogadro number with good estimate. Perrin won the 1926 *Nobel Prize in Physics*, largely for his work in determining the Avogadro constant by several different methods.

2.4 On the electromagnetics of moving bodies

This paper, which introduced his most famous theory "**The Theory of Special Relativity**". When a body/object travels with respect to an observer, their relative motion comes into picture, like for a person seating still inside a moving train, for him, trees outside the train appears to be moving in the opposite direction where as for the observer standing still outside the moving train, for him the person seating inside the train is in motion. Keeping this in mind Einstein

used to perform a thought experiment, of him traveling alongside a beam of light. He used to wonder does the laws of Physics holds good irrespective of the reference frame chosen? He started his theory by assuming a frame of reference which we now call it as inertial frame of reference in which the Newtonian laws are followed. Special relativity originally proposed by Albert Einstein in a paper published 26 September 1905 titled “**On the Electrodynamics of Moving Bodies**”. It is known that Maxwell’s electrodynamics—as usually understood at the present time—when applied to moving bodies, leads to asymmetries which do not appear to be inherent in the phenomena. Take, for example, the reciprocal electrodynamic action of a magnet and a conductor. The observable phenomenon, here depends only on the relative motion of the conductor and the magnet. The inconsistency of Newtonian mechanics with Maxwell’s equations of electromagnetism and the lack of experimental confirmation for a hypothesized luminiferous aether led to the development of special relativity, which corrects mechanics to handle situations involving motions at a significant fraction of the speed of light (known as relativistic velocities). As of today, special relativity is the most accurate model of motion at any speed when gravitational effects are negligible. Even so, the Newtonian mechanics model is still useful as an approximation at small velocities relative to the speed of light, due to its simplicity and high accuracy within its scope. Albert Einstein’s based his theory of special relativity on two postulates:

1. The laws of physics are invariant (i.e., identical) in all inertial systems (i.e., non-accelerating frames of reference).
2. The speed of light in a vacuum is the same for all observers, regardless of the motion of the light source.

In his paper which had two parts, one dealing with kinematic portion and another one is on Electrodynamical portion. The theory is “special” in that it only applies in the special case where the space- time is flat, i.e., the curvature of space-time, described by the energy-momentum tensor and causing gravity, is negligible. In order to include gravity, Einstein formulated general relativity in 1915. Special relativity, contrary to some outdated descriptions, is capable of handling accelerations as well as reference. The essential observation of Einstein which played important role in the development of Special theory of relativity is his thought experiment of “traveling alongside beam of light”, he observed that the Galilean transformations are no longer valid when object is traveling at speed near to speed of light in vacuum. Instead Galilean transformations are replaced by Lorentz transformation. Infact the Lorentz invariance is the essential ingredient of the special theory of relativity due to which at the speed near to speed of light some bizarre phenomena occur such as length contraction, time dilation, Thomas rotation. This theory also explains that why an object can never travel faster than speed of light

in vacuum. It is to be noted that the mathematical framework for relativity theory was provided by Henri Poincare, French mathematician, by proving that the Lorentz transformations are a subset of his Poincare group of symmetry transformations. Einstein derived these transformations from his Axioms, he indeed extrapolated the already postulated principle of relativity given by Galileo by keeping account for the constant speed of light, the phenomenon that had been observed in the Michelson-Morley experiment. Global Positioning System owes its proper functioning to a large extent, on the Theory of Relativity.

2.5 Does the inertia of a body depend upon its energy content?

His earlier investigation on the electrodynamics of moving bodies, lead him to a very interesting conclusion, which is here to be deduced. he based his investigation on the Maxwell-Hertz equations for empty space, together with the Maxwellian expression for the electromagnetic energy of space and in addition the principle that

“The laws by which the states of physical systems alter are independent of the alternative, to which of two systems of coordinates, in uniform motion of parallel translation relatively to each other, these alterations of state are referred (principle of relativity)”.

He assumed a system of plane waves of light referred to the system of co- ordinates (x, y, z) possess the energy L . moving in a direction which makes an angle of θ with x axis, then he introduce a new system of coordinates (ξ, η, ζ) , moving in uniform parallel translation with respect to the (x, y, z) system and measured the energy possessed by light in system (ξ, η, ζ) which famously turned out to be

$$K_0 - K_1 = \frac{1}{2} \frac{L}{C^2} v^2 \quad (3)$$

where K_0 and K_1 are the kinetic energies of body in question.

From this equation it directly follows that:- If a body gives off the energy L in the form of radiation, its mass diminishes by $\frac{L}{C^2}$. The fact that the energy withdrawn from the body becomes energy of radiation evidently makes no difference, so that we are led to the more general conclusion that "The mass of a body is a measure of its energy-content; if the energy changes by L , the mass changes in the same sense by $\frac{L}{9} \times 10^{20}$, the energy being measured in ergs, and the mass in gram."

It is not impossible that with bodies whose energy-content is variable to a high degree (e.g. with radium salts) the theory may be successfully put to the test.

If the theory corresponds to the facts, radiation conveys inertia between the emitting and absorbing bodies. The paper was submitted in September 1905 as a follow up paper of his “Special Theory of Relativity” submitted earlier in June 1905.

This conclusion resulted into the ever so famous equation $E = mc^2$ The mass-energy relation

can be used to predict how much energy will be released or consumed by nuclear reactions; one simply measures the mass of all constituents and the mass of all the products and multiplies the difference between the two by c^2 . The result shows how much energy will be released or consumed, usually in the form of light or heat. When applied to certain nuclear reactions, the equation shows that an extraordinarily large amount of energy will be released, millions of times as much as in the combustion of chemical explosives, where mass is conserved. This explains why nuclear weapons and nuclear reactors produce such phenomenal amounts of energy, as they release binding energy during nuclear fission and nuclear fusion, and convert a portion of subatomic mass to energy. We all knew that It has been more than 100 years ago Albert Einstein had introduced an immortal equation i.e., $E = mc^2$. There is nothing wrong to say that modern physics started with his contributions, which will stay with us for a long time to come. This equation legacy is as same as Einstein himself. Indeed, this equation has been immortalized because it is simple to speak and contains a huge meaning in it and thus it's influenced to whole world. Here if we uncover this equation, the energy 'E' (in joule) of a body (at rest) is equal to its mass 'm' (in Kg) multiplied by ' c^2 ', where 'c' equals the speed of light (in vacuum i.e., 3×10^8 m/s). It means that the mass and energy of a body are convertible, and the mass of a body can measures its energy content. Let's make it clearer by taking an example, taking 'm' as 1 kg, we can calculate the energy content of 1 kg of matter (any matter) as $E = mc^2 = 1 \times c^2 = 1 \times (3 \times 10^8)^2 = 9 \times 10^{16}$ Joules (divide it by $3 \times 10^8 = 25 \times 10^9$ kWh, that is 25.0 billion kWh. How much energy is that? If we consider 10,000 kWh to be the average annual power consumption (833 kWh per month) of a modern household, so compare the above result, this one kg equivalent energy will give enough energy for 2,500,000 years that is 2.5 million years. To shine this concept more, take unit of 'c' in light year, so here in above equation place $c = 1$ which will give us just $E = m$ meaning energy and mass are equal and the same. This is the most simple, fundamental and most profound equation ever evolved by humanity.

2.6 General Theory of Relativity

General Theory of Relativity, a generalization of Einstein's Special theory of Relativity is according to many Physicists is the Golden egg of Theoretical Physics. Einstein himself commented that during the time of writing the Papers of Special Theory of Relativity A thought came into his mind (which he termed it as happiest Thought of his life):-

“The gravitational field has only a relative existence... Because for an observer freely falling from the roof of a house- at least in his immediate surroundings- there exists no gravitational field.”

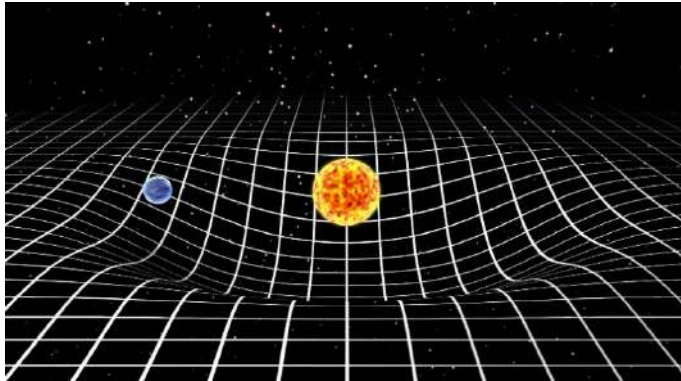


Figure 5: Fabric of space distorted by mass of sun

Initiated by the philosophical questions such as importance of inertial frame of reference and why should absolute velocities be forbidden but absolute accelerations be accepted? Unlike Newton, Einstein believed that Space is indeed affected by the mass present. In Newton's Theory of Gravitation, space is considered as three dimensional but according to Einstein's theory space and time forms Continuum known as four dimensional space-time as shown in fig. 5. Einstein's theory predicted that space-time will get affected by mass or curvature of space-time represents presence of mass. As John Wheeler aptly said space-time tells matter how to move and matter tells the space-time how to curve.

Consequently, in 1907 he wrote an article (published 1908) on acceleration under special relativity. He argued that free fall is really inertial motion, and that for a free falling observer the rules of Special Theory of Relativity must apply. This argument is called the Equivalence principle. In the same article, Einstein also predicted the phenomenon of gravitational time dilation.

In 1911, Einstein published another article expanding on the 1907 article. There, he thought about the case of a uniformly accelerated box not in a gravitational field, and noted that it would be indistinguishable from a box sitting still in an unchanging gravitational field. He used special relativity to see that the rate of clocks at the top of a box accelerating upward would be faster than the rate of clocks at the bottom. He concludes that the rates of clocks depend on their position in a gravitational field, and that the difference in rate is proportional to the gravitational potential to first approximation in 1915, after eight years of sorting his thoughts, Einstein had dreamed up (literally—he had no experimental precursors) an agent that caused gravity. And it wasn't simply a force. According to his theory of General Relativity, gravity is much weirder: a natural consequence of a mass's influence on space.

However, experiments and observations show that Einstein's description accounts for several effects that are unexplained by Newton's law, such as minute anomalies in the orbits of Mercury and other planets. General relativity also predicts novel effects of gravity, such as gravitational waves, gravitational lensing and an effect of gravity on time known as gravitational time dilation. Many of these predictions have been confirmed by experiment or observation, while others are the subject of ongoing research.

2.7 Bending of light

In 1915, Einstein predicted that light will undergo bending in presence of strong gravitational field and challenged the experimentalist to verify the same.

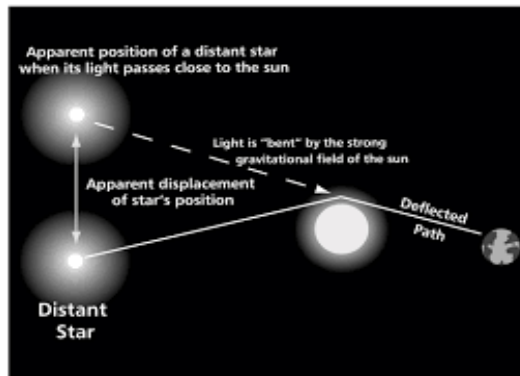


Figure 6: Bending of light by the Sun

The first observation of light deflection was performed by noting the change in position of stars as they passed near the Sun on the celestial sphere. The observations were performed in 1919 by Arthur Eddington, Frank Watson Dyson, and their collaborators during the total solar eclipse on May 29. The solar eclipse allowed the stars near the Sun to be observed as shown in fig. 6. Observations were made simultaneously in the cities of Sobral, Ceará, Brazil and in São Tomé and Príncipe on the west coast of Africa. The observations demonstrated that the light from stars passing close to the Sun was slightly bent, so that stars appeared slightly out of position.

Another of Einstein's notable thought experiments about the nature of the gravitational field is that of the rotating disk (a variant of the Ehrenfest paradox). He imagined an observer performing experiments on a rotating turntable. He noted that such an observer would find a different value for the mathematical constant π than the one predicted by Euclidean geometry.

The reason is that the radius of a circle would be measured with an uncontracted ruler, but, according to special relativity, the circumference would seem to be longer because the ruler would be contracted. Since Einstein believed that the laws of physics were local, described by local fields, he concluded from this that space-time could be locally curved. This led him to study Riemannian geometry, and to formulate general relativity in this language.

You can visualize Einstein's gravity warp by stepping on a trampoline. Your mass causes a depression in the stretchy fabric of space. Roll a ball past the warp at your feet and it'll curve toward your mass. The heavier you are, the more you bend space. Look at the edges of the trampoline—the warp lessens farther away from your mass. Thus, the same Newtonian relationships are explained (and predicted mathematically with better precision), yet through a different lens of warped space. Einstein's theory also triumphantly punched a hole in Newton's logic. If, as Newton claimed, gravity was an, instantaneous force, the information about a sudden change of mass would have to be somehow communicated across the entire universe at once. This made little sense to Einstein. By his reasoning, if the Sun disappeared suddenly, the signal for the planets to stop orbiting would logically have to take some travel time. And it would definitely take longer to arrive at Pluto than it would Mars. Nothing universally instant about that at all.

What did Einstein propose as the missing agent of communication? Enter, again, his very useful space warp. Much like a stone thrown into a pond, a change in mass will cause a ripple in space that travels out from its source in all directions at light speed. As it moves along, the ripple squeezes and stretches space. We call such a disturbance a gravitational wave.

Einstein may have predicted gravitational waves, but he had little faith scientists would ever detect them. Gravitational waves squeeze and stretch space only a small amount. In fact, it's ridiculously, horribly, almost impossibly small: distance hundreds of millions of times smaller than that of an atom. The **first direct observation of gravitational waves** was made on 14th September 2015. This wave (named GW150914) resembling to Chirp of a bird came from 4 ± 0.6 billion light years, the Nobel prize for Physics 2017 was awarded for detecting these Gravitational waves.

2.8 Pound - Rebka experiment

Experimental verification of General theory of Relativity came in the form of Pound- Rebka experiment. In this experiment Robert Pound and his graduate student Rebka in 1959 demonstrated effect of Gravitational field on light. Experiment setup is a variation of Mossbauer spectroscopy. With the help of scintillation detector, two identical gamma emitters placed at sufficient large distance in isolation and in minimalistic scattering environment, the system

works on the basic principle of resonance and Doppler shifting the experiment successfully verifies the Effect of Earth's gravity on beam of gamma ray emitted by the emitter and hence proving the General theory of relativity.

Hence to sum it up Einstein's Theory of Relativity - Special or General proved to be pinnacle in the history of Mankind. Nevertheless, all the published and unpublished work of Einstein are not only masterpiece by themselves but are the source of inspiration for scientific community as well. His vision and the approach to problems in Physics, mathematics and other fields of sciences still inspires young Physicists.

2.9 Einstein's quest for a Unified Theory

After having become famous for several brilliant breakthroughs in physics, including Brownian motion, the photoelectric effect, and the special and general theories of relativity, he spent the last thirty years of his life on a fruitless quest for a way to combine gravity and electromagnetism into a single elegant theory. Einstein was motivated by an intellectual need to unify the forces of nature. He felt very strongly that all of nature must be described by a single theory. "The intellect seeking after an integrated theory cannot rest content with the assumption that there exist two distinct fields totally independent of each other by their nature," Einstein said in his Nobel lecture in 1923.

In addition, he believed there was a link between the need to resolve apparent paradoxes of quantum mechanics and the need to unify electromagnetism and gravity. Einstein always insisted that quantum mechanics could be derived from some more complete theory. For Einstein, who was never satisfied with the weirdness and randomness inherent in quantum theory, any acceptable unified field theory had to have quantum mechanics as a consequence.

In the 1920s, when Einstein began his work on a unified field theory, electromagnetism and gravity were the only known forces, and the electron and the proton were the only known subatomic particles. Most physicists at the time were excited about the newly discovered quantum theory, and spent their time absorbed with exploring its bizarre and interesting consequences. They didn't see any great need for a theory uniting electromagnetism and gravity. But Einstein, and several other scientists, did work on the problem of unification. In 1918, Hermann Weyl proposed a unification scheme based on a generalization of Riemannian geometry. Inspired by Weyl's work, Theodor Kaluza showed that by extending space-time to five dimensions, one could produce the Einstein equations in four dimensions, plus an extra set of equations that is equivalent to Maxwell's equations for electromagnetism. The fifth dimension would be compact, curled up so small that we can't detect it. Oskar Klein later refined this idea.

Einstein liked the five-dimensional approach. In 1919, he wrote to Kaluza, "The idea of achiev-

ing unification by means of a five-dimensional cylinder world would never have dawned on me... At first glance I like your idea enormously." Kaluza published his paper in 1921, and Einstein published his first paper on unified field theory, with Jacob Grommer, following a similar approach, in 1922. Another approach Einstein tried involved extending general relativity to include the equations of electromagnetism by generalizing the metric tensor while keeping the 4-dimensional geometry.

Einstein worked on these two basic approaches persistently for the last thirty years of his life, but neither method ever produced the complete unified theory he was looking for.

He pursued and then soon rejected idea after idea. "Most of my intellectual offspring end up very young in the graveyard of disappointed hopes," Einstein wrote in a letter in 1938.

But he never gave up on his quest for a unified theory. Even while lying on his deathbed, he continued his work. The day before he died, he asked to have his latest notes brought to him.

One reason for Einstein's failure to discover a unified theory may be his rejection of quantum mechanics, which caused him to ignore new developments in physics and distance himself from the rest of the physics community. Einstein was aware of his position, and commented in 1954 that "I must seem like an ostrich who forever buries its head in the relativistic sand in order not to face the evil quanta." But the more he worked on unification, the farther away Einstein drifted from the rest of the physics community.

He also became more and more absorbed in formal mathematical arguments, rather than following the physical intuition that had guided him in his youth to his great discoveries. Many people say that Einstein failed because he was simply ahead of his time. The knowledge and tools needed to complete a unified theory simply hadn't been developed before Einstein died in 1955.

Today, many physicists are taking up his quest. The most promising approach appears to be string theory, which requires 10 or more dimensions and describes all elementary particles as vibrating strings, with different modes of vibration producing different particles.

String theory has not yet made any testable predictions, and some scientists worry that string theorists have, like Einstein in his later years, strayed too far from physical reality in their obsession with beautiful mathematics. But many others believe string theory does indeed hold the key to completing Einstein's quest, and researchers are hoping to find ways to test some of the predictions of string theory.

Though his own work never produced a useful physical theory, Einstein established unification as an important goal of physics. Indeed, a theory of everything is commonly called the "holy grail" of modern physics. Einstein would probably be pleased that so many physicists are

enthusiastically devoting their careers to pursuing his dream.



Figure 7: Einstein's blackboard in his office at The Institute for Advanced Study after his death in 1955.

If a cluttered desk is a sign of a cluttered mind, of what then, is an empty desk?

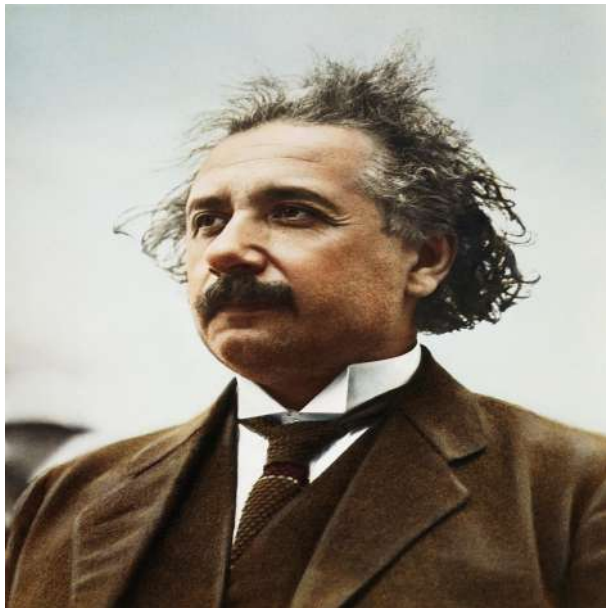


Figure 8: Einstein in pensive mood

3. How Einstein got the Nobel Prize

Einstein received nominations for the Nobel prize in physics for each of the years from 1910 to 1922 except for 1911 and 1915.



Figure 9: Einstein's Nobel prize

On 10th November 1922, a telegram was delivered to the Einstein residence in Berlin. It read: “Nobelpreis fur Physik ihnen zuerkannt naheres schriftlich Aurivilliu s” (Nobel Prize for Physics awarded to you; more by letter). On the same day, a telegram with the identical text must have been received by Niels Bohr in Copenhagen. Also on that day, Professor Christopher Aurivillius, secretary of the Royal Swedish Academy of Sciences, wrote to Einstein: “As I have already informed you by telegram, in its meeting hold yesterday, the Royal Academy of Sciences decided to award you last year's Nobel Prize for Physics, in consideration of your work in theoretical physics, and in particular your discovery of the law of the photoelectric effect, but without taking into account the value which will be accorded your theories of relativity and gravitation, once they are confirmed in the future.” On the day that Einstein the 1921 Prize, the 1922 Prize went to Bohr “for his services in the investigation of the structure of atoms and of the radiation emanating from them.”

4. Quotes by Einstein

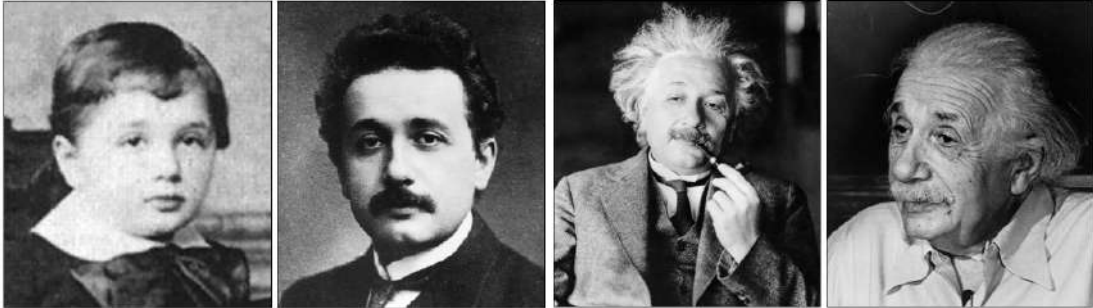
- Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius – and a lot of courage – to move in the opposite direction.
- Gravitation is not responsible for people falling in love.
- The hardest thing in the world to understand is the income tax.
- I never think of the future. It comes soon enough.
- Science without religion is lame. Religion without science is blind.
- Great spirits have often encountered violent opposition from weak minds.
- Everything should be made as simple as possible, but not simpler.
- The secret to creativity is knowing how to hide your sources.
- We can't solve problems by using the same kind of thinking we used when we created them.
- Education is what remains after one has forgotten everything he learned in school.
- Do not worry about your difficulties in Mathematics. I can assure you, mine are still greater.
- Two things are infinite: the universe and human stupidity; and I'm not sure about the universe.
- I know not with what weapons World War III will be fought, but World War IV will be fought with sticks and stones.
- In order to form an immaculate member of a flock of sheep one must, above all, be a sheep.
- The fear of death is the most unjustified of all fears, for there's no risk of accident for someone who's dead.
- The release of atom power has changed everything except our way of thinking... the solution to this problem lies in the heart of mankind. If only I had known, I should have become a watchmaker.
- Not everything that counts can be counted, and not everything that can be counted counts.

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- Insanity is doing the same thing, over and over again, but expecting different results.
 - I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.
 - If you can't explain it to a six-year-old, you don't understand it yourself.
 - Logic will get you from A to Z; imagination will get you everywhere.
 - The most incomprehensible thing about the world is that it is comprehensible.
 - Common sense is the collection of prejudices acquired by age eighteen.
 - Try not to become just a man of success, but rather try to become a man of value.
 - It's not that I'm so smart; it's just that I stay with problems longer.
 - Learn from yesterday, live for today, hope for tomorrow. The important thing is to not stop questioning.
 - I have no special talents. I am only passionately curious.
 - The person who never made a mistake never tried anything new.
 - Example isn't another way to teach, it is the only way to teach.
 - The world is a dangerous place, not because of those who do evil, but because of those who look on and do nothing.
 - When the solution is simple, God is answering.
 - Money only appeals to selfishness and always tempts its owners irresistibly to abuse it. Can anyone imagine Moses, Jesus, or Gandhi armed with the money-bags of Carnegie?
 - An empty stomach is not a good political adviser.
 - The difference between genius and stupidity is; genius has its limits.
 - When you are courting a nice girl, an hour seems like a second. When you sit on a red-hot cinder a second seems like an hour. That's relativity.
 - A clever person solves a problem. A wise person avoids it.
 - If A is a success in life, then A equal' x plus y plus z. Work is x; y is play; and z is keeping your mouth shut.

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- Men marry women with the hope they will never change. Women marry men with the hope they will change. Invariably they are both disappointed.
 - It would be possible to describe everything scientifically, but it would make no sense; it would be without meaning, as if you described a Beethoven symphony as a variation of wave pressure.
 - A ship is always safe at the shore - but that is NOT what it is built for.
 - If people are good only because they fear punishment, and hope for reward, then we are a sorry lot indeed.
 - Even on the most solemn occasions I got away without wearing socks and hid that lack of civilization in high boots.
 - A person starts to live when he can live outside himself.
 - Technological change is like an axe in the hands of a pathological criminal.
 - The only justifiable purpose of political institutions is to ensure the unhindered development of the individual.
 - Work is the only thing that gives substance to life.
 - Never lose a holy curiosity.
 - When you look at yourself from a universal standpoint, something inside always reminds or informs you that there are bigger and better things to worry about.
 - Paper is to write things down that we need to remember. Our brains are used to Think.

5. A brief history of Albert Einstein

Born in Germany in 1879, Einstein became the most famous physicist the world has ever seen



The early years

1879 Born 14 March at Bahnhofstraße 135, Ulm, Germany

1880 Einstein's family moves to Munich, where his father founds a firm manufacturing electrical equipment

1888 Enters Luitpold Gymnasium in Munich

1894 Family moves to Italy; Albert stays in Munich, but gets depressed without his family and does not complete his schooling

1895 Albert joins family in Italy; fails entrance exam for the ETH Zurich; moves to Aarau, Switzerland

1896 Obtains diploma from cantonal school in Aarau, which allows him to enroll for the ETH Zurich; relinquishes German citizenship

1900 Receives diploma from Zurich, scoring 5 (out of a possible 6) for theoretical physics, experimental physics and astronomy, and 5.5 for theory of functions

Life after college

1901 Becomes a Swiss citizen, but declared unfit for military service due to flat feet and varicose veins; gets a few temporary school-teaching jobs

1902 Appointed technical expert (third class) at the patent office in Bern with a salary of SwFr 3500; fiancée Mileva Marić - a fellow student from Zurich - gives birth to illegitimate daughter Lieserl

1903 Marries Mileva on 6 January

1904 First son, Hans Albert, born 14 May

1905 Einstein's *annus mirabilis*: submits PhD thesis on molecular dimensions to University of Zurich, as well as two papers on special relativity, one on quantum theory and another on Brownian motion to *Annalen der Physik*

1906 Promoted to technical expert (second class), salary raised to SwFr 4500

1907 Einstein has "the happiest thought of my life" - that a gravitational field is equivalent to acceleration

Turning professional

1909 Resigns from patent office and starts work as associate professor at University of Zurich on 15 October

1910 Second son, Eduard, born 28 July

1911 Appointed full professor at the German University of Prague, where he works out that the bending of light should be detectable during a solar eclipse; attends first Solvay Congress in Brussels

1912 Returns to Switzerland as professor at the ETH Zurich

1914 Becomes professor at the University of Berlin; moves into a bachelor apartment after

separating from Mileva, who returns with sons to Zurich

1915 Completes theory of general relativity; co-signs an anti-war manifesto urging people to join a “League of Europeans”

1916 Writes 10 papers, including first paper on gravitational waves, and one on the spontaneous and stimulated emission of light; publishes *The Origins of the General Theory of Relativity*; succeeds Max Planck as president of the German Physical Society

1917 Becomes founding director of Kaiser-Wilhelm Institute, Berlin; writes paper on the twin paradox; introduces the cosmological constant; overwork triggers liver problem, stomach ulcer and jaundice that together confine him to bed for several months - looked after by his cousin Elsa Einstein Löwenthal

Public fame

1919 Marries Elsa on 2 June; divorce settlement with Mileva stipulates that she would receive any Nobel-prize money from Einstein; eclipse watchers confirm his prediction that the Sun bends distant starlight, leading to headlines around the world

1920 Toys with leaving Germany after attacks on relativity by anti-Semites

1921 Visits the US for first time

1922 Awarded 1921 Nobel Prize for Physics for his “services to theoretical physics and in particular for his discovery of the law of the photoelectric effect” - prize money of about \$ 32 000 given to Mileva; completes first paper on unified field theory

1924 Einstein Institute founded in Potsdam; predicts Bose - Einstein condensation

1927 Attends fifth Solvay Congress in Brussels and starts debate on quantum theory with Niels Bohr

Life in the US

1933 Leaves Germany after Nazis take power and joins the Institute for Advanced Study in Princeton - a “quaint and ceremonious village of demigods on stilts”; rejects cosmological constant

1935 Publishes strident attack on quantum theory with Boris Podolsky and Nathan Rosen

1936 Elsa dies

1939 Signs letter to President Roosevelt warning of dangers of atomic bomb

1940 Becomes US citizen, while retaining Swiss citizenship

1944 Retires from Princeton, aged 65; writes out by hand his original 1905 paper on special relativity for auction, raising \$ 6m for US war effort

1946 Becomes chairman of the Emergency Committee of Atomic Scientists; calls for world government to be formed

1952 Turns down an offer to be President of Israel

1955 Signs “Russell–Einstein manifesto” on 11 April urging nations to renounce nuclear weapons; dies in Princeton at 1:10 a.m. on 18 April from ruptured abdominal aorta; brain removed by pathologist Thomas Harvey; body cremated at the Ewing Crematorium

6. Event of the month



Greetings and welcome to the **Einstein's Corner** !!!!

14th March, 2019 was 140th birth anniversary of Prof. Albert Einstein “The Man of the Millennium”. To commemorate this special day, our college library had organized inauguration ceremony of Einstein’s corner. Einstein’s corner- a rack devoted to the books specifically written by Einstein or written on Einstein and his work. It was inaugurated by our Principal Dr. Pruthul R. Desai. Inauguration ceremony was followed by brief overview on Einstein by Prof. Viresh Thakkar and Dr. Desai. The ceremony was attended by all staff members and the students of our college. Since then, students and staff members have started visiting the corner on a regular basis.

Our Contributors



Mr. Mukesh Sharma



Mr. Abhay Padsala



Mr. Yash Ghoda



Ms. Charmi Desai



Ms. Vibhuti Vashi



Einstein had around ten different violins throughout his life, each receiving the nickname of Lina. It was whilst Einstein was playing one of these violins that his second wife Elsa was supposed to have fallen in love with him. She was reported to have said she'd fallen for Einstein as he played the violin "so beautifully".

Einstein once said, "Life without playing music is inconceivable for me."

"I love my daydreams in music. I see my life in terms of music....I get most joy in life out of music."