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NASA's Hubble Space Telescope and NASA's Chandra X-ray Observatory have teamed up to identify a new possible example of a rare class of black holes. Called NGC 6099 HLX-1, this bright X-ray source seems to reside in a compact star cluster in a giant elliptical galaxy.

Just a few years after its 1990 launch, Hubble discovered that galaxies throughout the universe can contain supermassive black holes at their centers weighing millions or billions of times the mass of our Sun. In addition, galaxies also contain as many as millions of small black holes weighing less than 100 times the mass of the Sun. These form when massive stars reach the end of their lives.

Far more elusive are intermediate-mass black holes (IMBHs), weighing between a few hundred to a few 100,000 times the mass of our Sun. This not-too-big, not-too-small category of black holes is often invisible to us because IMBHs don't gobble as much gas and stars as the supermassive ones, which would emit powerful radiation. They have to be caught in the act of foraging in order to be found. When they occasionally devour a hapless bypassing star — in what astronomers call a tidal disruption event— they pour out a gusher of radiation.

Link: https://science.nasa.gov/missions/hubble/nasas-hubble-chandra-spot-rare-type-of-black-hole-eating-a-star/

Bulletin of The Indian Association of Physics Teachers

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Editorial

Quantum Mechanics follows Hierarchy

The evolution of Quantum Mechanics has been a journey of very deep and intensive scrutiny both from the points of view of physics and mathematics. The ball was set rolling with the advent of Quantum Theory in early twentieth century at the hands of stalwarts like Planck, Einstein, Bohr and others. Following on its heels Quantum Mechanics stormed into the scene with the formulations made by Schrödinger, Heisenberg, Dirac, Jordan, Born and others. The most striking feature of the formalism arrived at by these iconic physicists was the unity among the approaches brought about by them, which got established by way of invoking abstract mathematics, primarily in the garb *inter alia* of linear algebra, non-commutative algebra, group theory and above all infinite-dimensional complex (Hilbert) space, based on which von Newmann had provided the axiomatic foundation of Quantum Mechanics.

Coming to the issue of applying the formulations, it transpires that in the realm of quantum mechanics atoms and similar entities are a set of energies and wave functions, which in the non-relativistic case satisfy Schrödinger equation. But exact solution of the equation is possible for simple systems such as a hydrogen atom or a linear harmonic oscillator or an infinite square well. Otherwise, one has to resort to approximate solutions which are obtained by separating the potential into two parts, where one part is simple which can be solved with exactitude using the Schrödinger equation; for the other part, we use the assumption that the wave function for the overall potential can be expanded in terms of the already known solution of the simpler part. As a matter of fact, in case of additional energy terms, one can generate a sequence of approximations, which if found to converge will produce accurate results. In all such analyses, one gets the sense of a hierarchical edifice proceeding from simpler to the complex part of the potential function.

The real taste of the hierarchical structure of the physical world can be savored by handling the intricacies of condensed matter in terms of its building blocks – the atoms and molecules. Again, the behaviour of atoms and molecules can be explained in terms of the electrons and nucleons and then the farther minute sub-atomic particles. The hierarchy of the operations involved suggests a kind of an assembly of a string of models in which each of the constituent part of one model happens to be the element of study of a more minuscular model. Depending on the nature and the complications of the phenomenon being studied, the models can be constructed with logically well-defined mathematically consistent scaffolds so as to enable explanation of the properties of a model getting inferred from the fundamental assumptions, that is the axioms, as was conceived by von Newmann.

An illustrative example of the hierarchical model can be visualized in the method of LCAO (Linear Combination of Atomic Orbitals) which was introduced by Sir John Lennard-Jones. As the name suggests, LCAO is essentially an approximate method for obtaining the molecular orbitals by taking into consideration linear combination of atomic orbitals. It helps in describing the nature of distribution of electrons in molecules and *inter alia* their role in bonding.

Thus, hierarchy inbuilt in the systems through judicious application of mathematics plays an important role in the thrift of quantum mechanical calculations.

Chinmoy Kumar Ghosh

Physics News

MARATHON experiment offers most precise measurement of nucleon structure yet

Nucleons, which include protons and neutrons, are the composite particles that make up atomic nuclei. While these particles have been widely studied in the past, their internal structure has not yet been fully elucidated. Inside nucleons, however, one can also find many quark-antiquark pairs that continuously appear and disappear. The distribution of momentum and spin across all the different building blocks of nucleons has not yet been uncovered. Recently, the researchers involved in this experiment published the most precise measurement yet of the ratio of the neutron and proton structure functions, which essentially describes the share of momentum among quarks inside nucleons. Notably, the Jefferson Lab Hall A Tritium Collaboration's measurement of the EMC effect of tritium is the first of its kind and will most likely not be collected again in the future. This measurement, along with the others they collected, could have significant implications for the study of nuclear and particle physics, as it could help to improve existing models of nucleon structure and validate theoretical predictions.

Read more at: https://phys.org/news/2025-08-marathon-precise-nucleon.html

Original Paper: Physical Review Letters (2025). DOI: 10.1103/31xz-s84d

Bon voyage: General Atomics set to ship final piece of giant battery to nuclear fusion project in France

The final section of what scientists and engineers say will be the largest and most powerful pulsed, superconducting magnet in the world has been completed at the Poway campus of San Diego-based General Atomics. The 270,000-pound module is poised for shipment to France, where it will join six other identical sections at the ITER project. Six pieces will be stacked together to make up what's called the Central Solenoid at the center of the ITER facility. The seventh piece on display Thursday will be used as a spare. The Central Solenoid at ITER is designed to generate a powerful magnetic field that steers and shapes an intensely hot, energy-producing plasma that looks like a cloud. When the hydrogen plasma reaches 150 million degrees Celsius (more than 300 million degrees Fahrenheit), fusion occurs. The U.S. contribution makes up about 9% of ITER's costs, but the U.S. will receive access to 100% of the project's data and intellectual property, which would prove valuable in the development of future fusion programs and potential power plants.

Read more at: https://phys.org/news/2025-08-bon-voyage-general-atomics-ship.html

Statistical mechanics method helps machines better understand complex systems

A study by University of Hawai‘i researchers is advancing how we learn the laws that govern complex systems—from predator-prey relationships to traffic patterns in cities to how populations grow and shift—using artificial intelligence (AI) and physics. This matters because many scientific fields rely on understanding how systems. The study shows when collecting more data won't help, an insight that can save time and resources. By borrowing tools such as "free energy" and the "partition function" from physics, the method identifies when a model is likely to fail due to complexity or lack of data. Change over time, whether tracking disease spread, analyzing climate change or predicting the stock market. It also estimates how much uncertainty is in the result, a key factor when making real-world decisions based on data. This UH-led innovation could impact everything from engineering and ecology to economics and medicine, where understanding the rules behind data can lead to better predictions, smarter decisions and deeper insights into how our world works.

Read more at: https://phys.org/news/2025-08-statistical-mechanics-method-machines-complex.html

Original paper: Physical Review Research (2025). DOI: 10.1103/4d98-tdlp

Soumya Sarkar
IISER PUNE

September: This Month in the History of Physics

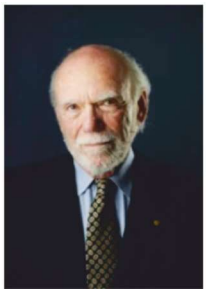
2015 Gravitational Waves

Though guessed by some scientists earlier, especially after Maxwell's electromagnetic theory of light was established, it was the ten nonlinear equations of the famous Einstein's matrix equations of general relativity in 1915 that predicted the existence of gravitational waves (GW) on solid scientific ground. Since then, gravity is identified as the warping of space- time fabric under heavy mass (or energy). If a system of two enormous masses approach each other with velocities comparable to that of light this warping will move with the velocity of light, like the ripples on the surface of a pond produced by a pebble thrown in it. But the detection of the resulting GW is badly problematic. Such collisions of huge celestial bodies occur at millions to billions of light years distances and only a feeble amount of the disturbance reaches the earth. Hence detection of those is extremely difficult. Though Karl Schwarzschild laid the foundation of black hole immediately after Einstein's theory was published still the latter was sceptical about their detection.

In 1936, Einstein, through a manuscript sent for publication in Physical Review, pleaded against the possibility of GW at all. However, just months later, he retracted it. Meanwhile, from 1930s, increased information poured in regarding pulsars and black holes until their experimental existences were proved around 1970. The knowledge of their huge masses concentrated in astoundingly small space and their light-comparable spinning velocities led experimental scientists and engineers to believe that GW might be detected. US National Science Foundation started construction of dual LIGO (Laser Interferometer Gravitational-wave Observatory) detection centres, one in Hanford and the other in Livingstone at a mutual separation distance of 3000 km to eliminate noise due to any possible earthly disturbances and to localise the source of GW, once detected. Actually, each of the two detectors are Michelson Interferometer with Fabry Perot cavities and special mirrors to enhance the effective paths of propagation of GW inside the instruments and the power of laser source. This arrangement can detect a change of path difference of 10^{-19} m only (ten thousandth of a proton diameter).

On September 14, 2015 at 3.30 pm IST, scientists and engineers of MIT and Caltech verified GW through changes in the interference pattern obtained in LIGO. They identified the source of these waves as at 1.4 billion light years from earth and formed due to the collision of two black holes of masses 36 M_s and 29M_s which merged into a single black hole of mass 62 M_s, where M_s is the mass of the sun.

Rainer Weiss



Barry C Barish

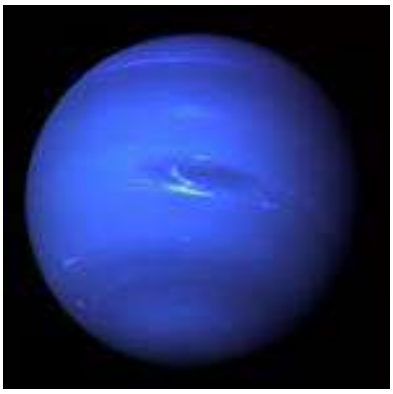
Kip S Thorne

In the final moment the total energy released in the event (GW150914) was calculated to be fifty times the total energy of the visible universe. Rainer Weiss, Barry C Barish and Kip S Thorne were awarded the Nobel prize in physics in 2017 “for decisive contributions to the LIGO detector and the observation of gravitational waves".

1846 Discovery of Neptune

After discovery and proper identification of six planets closer to sun Uranus was discovered by British astronomer William Herschel (1738-1822) in 1781. Inspired by this discovery, the astronomers, and the sky watchers with telescopes of higher resolutions started search for more planets beyond Uranus. The expectation was based on some reasons. First, an empirical law proposed by Titius (J D Titius; 1729-96) and Bode (J E Bode; 1747-1826) were indicating the existence of a planet beyond the Uranus. Second, the orbit of Uranus from its calculated path seen at different times deviated from

its theoretical positions calculated using the Newton's law of gravitation. Titius-Bode law, had a reliability since it had predicted average distances of the planets and was found to be approximately valid. This law had suggested that a planet beyond the Uranus should be at about 39.2 AU from the sun. But no such planet was detected.



The Planet Neptune

British mathematician J C Adams (1819-92) tried to account for the irregular motion of Uranus with possible existence of some distant planet. But at that time his studies were not taken seriously. Unaware of Adam's works, French astronomer, and mathematician U Le Verrier; (1811-1877) began a detailed study on this and predicted the actual position profile of a new planet beyond Uranus. He sent his results to German astronomer J G Galle (1812-1910) at the Berlin Observatory on *September 23, 1846*. Galle and his student H L d'Arrest; (1822-75) identified the planet at the same position predicted by Verrier on the same night and confirmed the planet as a new one in the next night. It turned out to be the eighth planet of the solar system. Incidentally Titius Bode's Law also broke down at this point and it became a part of history.

1845 Discovery of Magneto-optic phenomena

In 1840s several physicists in France and in England were studying the influence of different transparent materials, both solid and liquid, on the rotation of the plane of polarization of a light beam when a polarized light passed through the material. By that time Michael Faraday (1791-1867) also began to believe that light has some connection with the electromagnetic phenomena. He began trying to influence the plane of polarization of light beam by applying a magnetic field in a direction parallel to the light beam on a medium that were showing the property of rotating the plane of polarization.

Michael Faraday

This led to the discovery of what is now called as magneto-optic phenomena, in general, and the observations have come to be known as Faraday Effect. Michael Faraday, like many of his period, had the habit of maintaining a personal notebook where he used to keep a track of his scientific work. In the daily entry of September 13, 1845, he wrote "…..**BUT**, *when the contrary magnetic poles were on the same side, there was an effect produced on the polarized ray*, and thus magnetic force and light were proved to have relation to each other. …" .

It was a clear indication in favour of his belief that light and electromagnetism have some connection. We need to remember that light was not known as an electromagnetic wave till then. And his entry dated September 30, 1845 to the same notebook contains a confirmatory note in the form "…… *Still, I have at last succeeded in illuminating a magnetic curve or line of force, and in magnetizing a ray of light. …".*

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Asit Chakrabarti

Article

An insight into how we learn, memorize and perform other cognitive functions

Vipin Srivastava
Former Professor of Physics
at the University of Hyderabad

As a discipline, neuroscience is over four centuries old and by now, we know precisely which part of the brain does which cognitive task. However, not a great deal is known about the physiological mechanisms underlying even the basic cognitive learning and memory. The reason, in my view, is that until a few decades back, neuroscience was studied solely in wet- labs. There was less emphasis on a theoretical approach in which natural phenomena are modelled formally, e.g., mathematically, and their results are compared with experiments. This has been practiced in Physics, since Galileo's time.[(1)]

[(1)]**Experiments and theory should go hand in hand**: When a new phenomenon is observed, physicists try to understand it by building a simple mathematical model for it using the available information and evince some numerical results out of it. These are then compared with the experimental numbers. The theoretical numbers are brought as close to the

experimental results as possible by systematically improving the mathematical model. When the two sets of numbers agree with each other within an acceptable limit, insights into the mechanism of the observed new phenomenon are deduced from the theoretical model.

It is quite common that a mathematical model developed as a tool to analyse a particular phenomenon comes in handy while deciphering another phenomenon in an entirely different setting provided certain analogies between the two can be identified. Something akin to this was attempted to grasp the physiology of learning and memory and it turned out to be a remarkable success. This was achieved through the spin-glass model due to Sam Edwards and Phil Anderson. I will explain it in simple terms taking cues from my previous article.

The brain has over 100 billion neurons, which frantically exchange electrical impulses (called 'action potentials') through synapses. Following psychologist Donald Hebb, we understand that when the brain assimilates new information, the tenor or efficacy of the synaptic connections changes plastically (i.e., irreversibly). The nature of synaptic connections can be excitatory or inhibitory so that the electrical impulse going from a pre-synaptic neuron can raise or lower the potential – the post-synaptic potential (PSP) – at the recipient neuron. A neuron simultaneously receives impulses from thousands of neurons. If the net PSP at a neuron exceeds its built-in natural threshold, it will fire and emit an impulse, otherwise it will remain quiescent.

Thus, like the up/down spins of magnetic atoms in a spin-glass, the neurons are binary entities – they either fire or they do not. Besides, they interact over all ranges, both short and long, and prompt the next neuron to either fire or remain quiescent just as a spin in the spin-glass influences other spins to be oriented parallel to it or antiparallel depending on their separation from it. So, like a spin in a spin-glass, a neuron, faced with two simultaneous but conflicting demands to fire or remain quiescent, is notionally 'frustrated' (see below). This is central to our understanding of how we learn and memorise!

Inscription in the brain: Neuroscientists tell us that when an information comes to be lodged in the brain it triggers neural activity of firing/not-firing extensively over large parts of the brain. This in turn causes the synaptic connections between the neurons to change plastically as hypothesised by Donald Hebb. John Hopfield's adaptation of spin-glass model to the network of neurons consolidated this by showing that information is indeed stored in the brain as the changes of synaptic efficacies.Thus, an information is first converted into a pattern of

firing/non-firing neurons like an array of ↑/↓ spins or +/-1s, and then it is stored as the resulting changes in synaptic connections.

When the brain encounters another piece of information, the same set of neurons is triggered again to exchange action potentials. They soon settle with a new pattern of PSPs, i.e. firing/non-firing neurons. Again, the synaptic connections get modified over and above their values attained when the previous pattern was learned/stored. Thus, the two patterns are stacked on the same set of synapses, like one on top of the other.

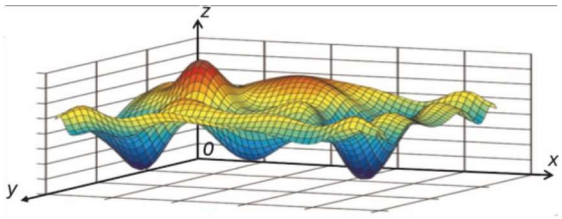
In this manner a very large number[(2)] of patterns is learned and stacked across a network of neurons as cumulative changes in the efficacies of the synapses that interlink them. In contrast, in a computer, the memories are localised in isolated pockets distributed in a magnetic device.

[(2)]**Total number of possible patterns**: To be exact, there will be 2^N distinct patterns if there are N spins/neurons and each one is assumed (for simplicity) to take only two orientations, up/down or firing/not-firing or +/-1. Imagine how big this number will be for N on the order of a billion!

In a spin-glass, the spins, 'frustrated' by the conflicting commands from other spins, produce a huge number of patterns of randomly oriented spins,[(2)] each one of which, in principle, minimises the total energy of the system and therefore, can act as a stable state[(3)] of the system. Analogously, a neuronal network involves interacting neurons, which make conflicting demands on each other to fire, or not fire, and produce a huge number of possible patterns of firing/non-firing neurons. By adapting the spin-glass formulation to the neural system, we can deduce that each pattern of firing/non-firing neurons can be taken to represent a memory stored as 'changes' in synaptic efficacies.

Those who were initiated into 'modern physics' (post 1900) will appreciate that we can write a spin-glass like Hamiltonian, the total energy function, for a neural network with the interaction between the spins replaced by a mathematical representation of Hebb's learning rule as proposed by physicist Leon Cooper, and show that an exceptionally large number of patterns of firing/non-firing neurons can minimise the total energy of the system.

We can imagine an energy landscape with valleys and hills as shown schematically in the figure.[(3)] It will be spanned by 2^N points, each point representing a pattern of firing/non-firing neurons. A small subset of 2^N points can represent all the information we come across in our life and store in memory! This subset of points sits at the bottoms of the valleys or the energy minima and represents the stable states[(3)], or the memories.



[(3)]**Multi-dimensional hyperspace and vectors**: The above figure shows an energy landscape, drawn, for ease of visualisation, in the 3-dimensional space that we are familiar with. In fact, the landscape should be imagined in an (N+1)-dimensional hyperspace – the vertical *z*-axis in the figure would give the value of the energy while the *x*-*y* plane would correspond to an N-dimensional hyperspace – the 2^N points would spread out in this *N*-dim hyperspace. Each point can be represented by a **vector**, which stretches from the origin to the point, and has N components – its projections on the N axes. Thus, a pattern of N firing/not-firing neurons is represented by a vector in this hyperspace; its N components, +/-1 (+1 for a firing neuron and

-1 for a quiescent one), represent N different features of an entity and the values +/-1 designate their presence/absence, like yes/no.

The point at the bottom of a valley represents a memory, which is a 'stable' state because whichever point in the valley is chosen to start the retrieval process it will slide or converge to the bottom. The valley is also therefore termed as 'basin of attraction'.

Recovery from memory: It may seem like a tall order to pull out a particular memory from the humongous jumble of stacked information[4], but in reality, it is not! The prescription for retrieval from the memory stock in the present model achieves it by association – the brain encounters a known pattern of firing/not-firing neurons, or +/-1's; the neurons start communicating frantically with each other via the synapses that are now drastically modified (while storing a large number of memories) and generate on each neuron a 'local field' of PSP. This set of PSPs will represent a pattern of firing/non-firing neurons, which in most cases coincides with the presented pattern. This signals the association of the presented pattern with the one in the memory store. Thus, a memory is recalled or retrieved. The underlying mathematics is simple, but it requires writing down some equations, which is intentionally avoided here.

What if the above association fails and the recall doesn't happen? This problem is highlighted below. Also, it often happens that while assimilating new information/patterns certain patterns turn up that have already been stored. Our model should be cognitively sound to detect this and avoid reloading the brain. These two problems happen to have a common solution, which will be addressed in the next article. Here we will underline a remarkable cognitive feature that this model possesses in its present form.

[4]**Stacking of information**: To gauge the complexity of the storage mechanism in the brain, suppose, for simplicity, each of the *N* neurons 'synoptically' connects with all the rest of N-1 neurons. So, there will be N(N-1) pairs of connections that will undergo changes as a pattern of N firing/non-firing neurons is inscribed. The same array of N(N-1) connections will record the next round of changes while storing the next pattern. The changes pile up cumulatively as patterns continue to be added.

It might seem impossible to pull out from this highly modified set of N(N-1) synaptic connections one particular set of N(N-1) changes that happened when a specific pattern was inscribed! But the brain does it all the time while recalling old or recent memories, and the present mathematical prescription is expected to mimic that physiological process.

If this model brain comes across something that is different from a stored pattern but is similar to it then with some effort, it can associate the unknown entity with the one in the memory. For example, we recognise familiar objects even if they are presented partially or as deformed.

The N-dimensional energy landscape explains it. The point at the bottom of a valley corresponds to an entity (represented by a pattern/vector) that is stored in the memory. But all other points around it that lie inside the well-like "basin of attraction"[3] correspond to the entities that are 'similar' to one in the memory. When we subject any of these points to the retrieval prescription, they converge/slide to the point at the bottom of the basin. That is, the presented entity associates with the one in the memory.

Despite these favourable features, the present model is quite far removed from the real cognitive memory. In fact, it may at best be a toy model of the brain! By and by we can work on the shortcomings like the ones pointed out above and make it more realistic. A particularly embarrassing problem is that this brain with N neurons can retain only 0.14N (14% of N) memories. If it learns more patterns than 0.14N then the memory breaks down resulting in what is called 'memory-catastrophe', and none of the learned patterns is retrieved.

For N on the order of a 100 billion, 0.14N is a huge number. A memory of this size can easily accommodate all the information we gather in our lifetime. However, what is unacceptable in a model for the brain is that it should breakdown if overloaded! A normal brain can make room for new information almost endlessly. A lot of effort was made to fix this snag. In the next article we will discuss one that brought novel insights into the mechanism of learning.

Article

Quaternions for Physicists

From Real Numbers to Complex Numbers and to Quaternions

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Abstract: Quaternions, a four-dimensional extension of complex numbers, have emerged as a powerful and indispensable tool for physicists across various sub-disciplines. While initially conceived by Sir William Rowan Hamilton in the 19th century as a means to describe rotations in three-dimensional space, their profound algebraic structure and non-commutative properties make them uniquely suited for tackling complex problems in modern physics. Beyond their elegance in representing rotations without the singularities of Euler angles, quaternions provide a natural language for describing spacetime transformations in relativity and for formulating quantum mechanics. Their ability to unify scalar and vector quantities into a single mathematical entity allows for a more compact and geometrically intuitive description of physical phenomena, solidifying their role as a fundamental element in the physicist's mathematical toolkit.

Introduction

In mathematics, the quaternion number system extends the complex numbers. Quaternions were first described by the Irish mathematician William Rowan Hamilton in 1843[1-4] and applied to mechanics in three-dimensional space. The set of all quaternions is conventionally denoted by H for Hamilton. Quaternions are not quite a field, because in general, multiplication of quaternions is not commutative. Quaternion q in 4D space may be expressed as;

$$q = \mathbf{1}q_0 + \boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3$$

q_0, q_1, q_2, q_3 are real numbers and $\mathbf{1}, \boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k}$ are the *basis vectors* or *basis elements*

Quaternions are used in pure mathematics, but also have practical uses in applied mathematics, particularly for calculations involving three-dimensional rotations, such as in three-dimensional computer graphics, computer vision, robotics, magnetic resonance imaging and crystallographic texture analysis.[5-6] They can be used alongside other methods of rotation, such as Euler angles and rotation matrices, or as an alternative to them, depending on the application.

A quaternion q is a number expressed as

$$q = \mathbf{1}q_0 + \boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3 = q_0 + \boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3$$

Where $q_0, q_1, q_2, q_3 \in \boldsymbol{R}$, while orthogonal basis vectors $\mathbf{1}, \boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k} \in \boldsymbol{R^4}$, **4D vector space**

$$\mathbf{1} = (1,0,0,0), \boldsymbol{i} = (0,1,0,0), \boldsymbol{j} = (0,0,1,0), \boldsymbol{k} = (1,0,0,1),$$

The representation fits well in regard to a quaternion q as a vector in 4D vector space $\boldsymbol{R^4}$ with orthogonal normal basis vectors $\mathbf{1}, \boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k}$.

The real numbers q_0, q_1, q_2, q_3 are known as scalars/components of quaternion q that can be expressed in two parts (i) real part or scalar part q_0, (ii) vector part $\boldsymbol{q} = \boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3$ so that a stylish representation of a quaternion is possible as following.

$$q = q_0 + \boldsymbol{q} = (q_0, \boldsymbol{q})$$

Where $\boldsymbol{q}$ is a usually represented vector in 3D space $\boldsymbol{R^3}$, while its magnitude $q = |\boldsymbol{q}|$.

From the so far discussion, one may hold an opinion that quaternions are 4D vectors in $\boldsymbol{R^4}$ space. Though it is partially true but it is not the whole story. As the product of the quaternions are non-commutative it raises its unique structure algebra.

Zero Quaternion: $q = (0, \mathbf{0}) = 0 + \boldsymbol{i}0 + \boldsymbol{j}0 + \boldsymbol{k}0$

Unit scalar Quaternion: $q = (1, \mathbf{0}) = 1 + \boldsymbol{i}0 + \boldsymbol{j}0 + \boldsymbol{k}0$

Unit Quaternion: $q = (q_0, \boldsymbol{q})$ for

$$\sqrt{q_0^2 + q_1^2 + q_2^2 + q_3^2} = 1$$

Pure quaternion: $q = (0, \boldsymbol{q}) = 1 + \boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3$

Negative Quaternion: $-q = (-q_0, -\boldsymbol{q}) = -q_0 - (\boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3)$

Equality of Quaternions: $p = q \Leftrightarrow p_0 = q_0, p_1 = q_1, p_2 = q_2, p_3 = q_3$

Complex conjugate of a Quaternion : $q^* = q_0 - \boldsymbol{q}$ and $(q^*)^* = q$

The Norm of Quaternion: $N(q) = \sqrt{qq^*} = \sqrt{q^*q} = |q| = \sqrt{q_0^2 + q_1^2 + q_2^2 + q_3^2}$

$$N(pq) = N(p)N(q)$$

The inverse of the quaternion: $qq^{-1} = q^{-1}q = 1 = unit\ quaternion$

$$q^{-1} = \frac{q^*}{N^2(q)}, q \neq 0$$

Algebra of Quaternions

For $p = (p_0, \boldsymbol{p}) = p_0 + (\boldsymbol{i}p_1 + \boldsymbol{j}p_2 + \boldsymbol{k}p_3), q = (q_0, \boldsymbol{q}) = q_0 + (\boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3)$

Addition and subtraction of Quaternions:

$$p \pm q = [p_0 + (\boldsymbol{i}p_1 + \boldsymbol{j}p_2 + \boldsymbol{k}p_3)] \pm [q_0 + (\boldsymbol{i}q_1 + \boldsymbol{j}q_2 + \boldsymbol{k}q_3)]$$

$$p \pm q = p_0 \pm q_0 + (\boldsymbol{p} \pm \boldsymbol{q})$$

Addition is commutative, $p + q = p_0 + q_0 + (\boldsymbol{p} + \boldsymbol{q}) = q_0 + p_0 + (\boldsymbol{q} + \boldsymbol{p}) = q + p$

Scalar Multiplication: $sq = sq_0 + s\boldsymbol{q} = q_0 s + \boldsymbol{q}s = qs$

The inner Product of two quaternions

For two quaternions $p = p_0 + \boldsymbol{p}, q = q_0 + \boldsymbol{q}$

$$p.q = (p_0 + \boldsymbol{p}).(q_0 + \boldsymbol{q}) = p_0q_0 + \boldsymbol{p}.\boldsymbol{q} = p_0q_0 + p_1q_1 + p_2q_2 + p_3q_3$$

Before mentioning the product rule for quaternions, we shall discuss **fundamental product formulae** for quaternions multiplication in case of its basis vectors $\boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k}$ as defined by Hamiltonian in 1843.

$$\boldsymbol{i}^2 = \boldsymbol{j}^2 = \boldsymbol{k}^2 = \boldsymbol{ijk} = -1$$

$$\boldsymbol{ij} = \boldsymbol{k} = -\boldsymbol{ji}, \boldsymbol{jk} = \boldsymbol{i} = -\boldsymbol{kj}, \boldsymbol{ki} = \boldsymbol{j} = -\boldsymbol{ik}$$

Just as complex numbers extend real numbers by adding an imaginary unit '$\boldsymbol{i}$' where $\boldsymbol{i}^2 = -1$, quaternions extend complex numbers by adding two more imaginary units, '$\boldsymbol{j}$' and '$\boldsymbol{k}$'.

The Product of any two quaternions

For two quaternions $p = p_0 + \boldsymbol{p}, q = q_0 + \boldsymbol{q}$

$$p.q = (p_0 + \boldsymbol{p}).(q_0 + \boldsymbol{q}) = p_0q_0 - \boldsymbol{p}.\boldsymbol{q} + p_0\boldsymbol{q} + q_0\boldsymbol{p} + \boldsymbol{p} \times \boldsymbol{q}$$

Square of quaternion

$$p.p = p_0p_0 - \boldsymbol{p}.\boldsymbol{p} + p_0\boldsymbol{p} + p_0\boldsymbol{p} + \boldsymbol{p} \times \boldsymbol{p}$$

$$p.p = p_0p_0 - (p_1q_1 + p_2q_2 + p_3q_3) + 2p_0\boldsymbol{p}$$

$$p^2 = (p_0p_0 - p_1q_1 - p_2q_2 - p_3q_3, 2p_0\boldsymbol{p})$$

The quaternions product in Matrix form

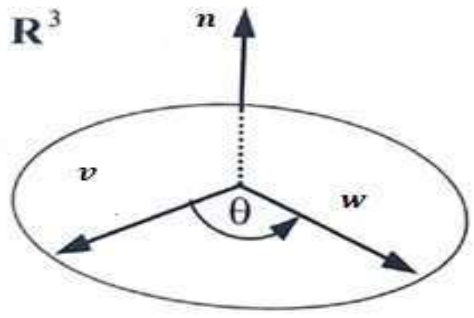
$$pq = \begin{bmatrix} p_0 & -p_1 & -p_2 & -p_3 \\ p_1 & p_0 & -p_3 & p_2 \\ p_2 & p_3 & p_0 & -p_1 \\ p_3 & -p_2 & p_1 & p_0 \end{bmatrix} \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ q_3 \end{bmatrix}$$

Rotation in 3D Space

We specify a fixed point as origin O and three mutually orthogonal axis OX, OY, OZ as co-ordinate axis such that, they form a right-handed co-ordinate frame as shown in the figure. In 3D representation of a point $P(x, y, z)$ as the vector $\boldsymbol{v} = \boldsymbol{OP}$. In three dimensional space we have two types of rotations fixed frame & fixed vector. Note that one has to consider rotation about an axis and not about a point. The rotation in 3D is represented by a 3×3 orthogonal matrix that has determinant unity. Under frame rotation in 3D, $X' = A.X$, where A is the rotation operator. Similarly in 3D, a vector $\boldsymbol{v} \in R^3$ is mapped to some vector $\boldsymbol{w} \in R^3$.

$$\boldsymbol{w} = A\boldsymbol{v}$$

The geometric representation of the facts are shown in the following figures.



$\boldsymbol{n}$: axis of rotation, $\boldsymbol{w} = R(\boldsymbol{v})$ where the vector $\boldsymbol{v}$ is rotated to new position $\boldsymbol{w}$.

With this background we are ready to discuss the role of a quaternion as a rotation operator in 3D rotations. It means that the action of rotation results in taking a vector to some other vector, leaving the magnitude or the length of the rotating vector unchanged. To summarise rotation in 3D, the following facts be noted.

- Rotation is an act or an operation and mathematically it is represented by an operator, say R. In 2D and 3D, these operators are orthogonal matrices with determinant +1.
- Rotation is specified by two things: axis of rotation about which rotation takes place and angle through which rotation is performed. The axis of rotation is fixed and its direction is given by some vector.
- Rotation acts on the points of the space and carries them to new positions. It means that rotation acts on the vectors. Mathematically we say that a rotation operator R acts on a vector $\boldsymbol{v}$ and takes

it to another vector, say $\boldsymbol{w}$. Thus we have $R(\boldsymbol{v}) = \boldsymbol{w}$. The most important thing is that rotation takes three dimensional vectors to three dimensional vectors i.e. $\boldsymbol{v} \in R^3$, then $R(\boldsymbol{v}) \in R^3$such that length of $\boldsymbol{v} = length\ of\ R(\boldsymbol{v})$. Thus $R(\boldsymbol{v})$ is a length preserving operator; $|R(\boldsymbol{v})| = |\boldsymbol{v}|$.

- The operator R is linear.

Quaternion rotation operator

We define the quaternion rotation operator L_q and L_{q*} as follows: and

$$L_q = q\boldsymbol{v}q^*, L_{q*} = q^*\boldsymbol{v}q$$

The operator L_q is associated with the unit quaternion q acting on a vector $\boldsymbol{v}$ in R^3 and L_{q*} is associated with the unit quaternion q acting on a vector $\boldsymbol{v}$ in R^3. Though these two operators are designated as rotation operators, it is necessary to confirm this fact i.e. they must satisfy the conditions to qualify rotation operators, already narrated in the previous section. We first consider the operator L_q. To play the role of rotation, it must satisfy the following properties:

(i) $L_q(\boldsymbol{v}) \in R^3$

(ii) L_q preserves length i.e. $|L_q(\boldsymbol{v})| = |\boldsymbol{v}|$

(ii) L_q is linear.

Angle associated with a unit quaternion operator q

We have noted that in R^2 the rotation matrix operator A is associated with an angle of rotation. Same holds in R^3 i.e. every rotation matrix operator in R^3 associated with an angle of rotation about an axis of rotation. We show that this is also possible for a quaternion operator. Consider a rotation quaternion operator

$$q = (q_0, \boldsymbol{q})$$

such that its norm is 1 i.e. unit quaternion.

$$N(q) = 1\ i.e.\ q_0^2 + |\boldsymbol{q}|^2 = 1$$

For any real angle θ

$$q_0^2 = cos^2\theta, |\boldsymbol{q}|^2 = sin^2\theta$$

To make θ unique, we consider $-\pi < \theta \leq \pi$. Thus an unique angle θ is associated with a quaternion q. To rewrite q in terms of θ, we define a unit vector $\hat{\boldsymbol{u}}$ in the direction of $\boldsymbol{q}$ by

$$\hat{\boldsymbol{u}} = \frac{\boldsymbol{q}}{|\boldsymbol{q}|} = \frac{\boldsymbol{q}}{sin\theta} \Rightarrow \boldsymbol{q} = \hat{\boldsymbol{u}}\, sin\theta$$

$$q = (q_0, \boldsymbol{q}) = (cos\theta, \hat{\boldsymbol{u}} sin\theta)$$

Vectors using Quaternions

Quaternions can lead to scalars, vectors, product of scalar & vector and a cross product of vector. Following quaternionic operations can facilitate such commutes.

$$p = (a, \boldsymbol{B}), q = (c, \boldsymbol{D})$$

$$pq = (a, \boldsymbol{B})(c, \boldsymbol{D})$$

$$pq = ac - \boldsymbol{B}\cdot\boldsymbol{D} + a\boldsymbol{D} + \boldsymbol{B}c + \boldsymbol{B}\times\boldsymbol{D}$$

$$a = \frac{p + p^*}{2}, c = \frac{q + q^*}{2}$$

$$ac - \boldsymbol{B}\cdot\boldsymbol{D} = \frac{pq + (pq)^*}{2}$$

$$\boldsymbol{B} = \frac{p - p^*}{2}, \boldsymbol{D} = \frac{q - q^*}{2}$$

$$a\boldsymbol{D} + \boldsymbol{B}c = \frac{(pq + qp) - (pq + qp)^*}{2}$$

$$\boldsymbol{B}\times\boldsymbol{D} = \frac{pq - qp}{\mathbf{2}}$$

Product of Quaternions for Gradient, Divergence and Curl

$$p = (a, \boldsymbol{B}), q = (c, \boldsymbol{D})$$

$$pq = (a, \boldsymbol{B})(c, \boldsymbol{D}) = ac - \boldsymbol{B}\cdot\boldsymbol{D} + a\boldsymbol{D} + \boldsymbol{B}c + \boldsymbol{B}\times\boldsymbol{D}$$

$$\left(\frac{d}{dt}, \boldsymbol{\nabla}\right)(c, \boldsymbol{D}) = \frac{d}{dt}c - \boldsymbol{\nabla}\cdot\boldsymbol{D} + \frac{d}{dt}\boldsymbol{D} + \boldsymbol{\nabla}c + \boldsymbol{\nabla}\times\boldsymbol{D}$$

$$\left(\frac{d}{dt}, \boldsymbol{\nabla}\right)\left(\frac{d}{dt}, \boldsymbol{\nabla}\right) = \frac{d^2}{dt^2} - \boldsymbol{\nabla}\cdot\boldsymbol{\nabla} + \frac{d}{dt}\boldsymbol{\nabla} + \boldsymbol{\nabla}\frac{d}{dt} + \boldsymbol{\nabla}\times\boldsymbol{\nabla}$$

$$\left(\frac{d}{dt}, \boldsymbol{\nabla}\right)^2 = \frac{d^2}{dt^2} - \nabla^2 + 2\frac{d}{dt}\boldsymbol{\nabla} + \boldsymbol{\nabla}\times\boldsymbol{\nabla}$$

$$\left(\frac{d}{dt}, \boldsymbol{\nabla}\right)^2 = \partial_t^2 - \partial_x^2 - \partial_y^2 - \partial_x^2 + \hat{\imath}(2\partial_{tx} + \partial_{yz}) + \hat{\jmath}(2\partial_{ty} - \partial_{xz}) + \hat{k}(2\partial_{tz} + \partial_{xy})$$

Quaternionic Lorentz Transformation

The Lorentz transformations for space and time can be expressed in form of quaternions for transforming space-time coordinate[6-11] from frame S to a frame S' moving with uniform velocity characterized by say $\boldsymbol{v}$ or β and γ with their usual meanings as $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$ with a contention $c = 1$.

$$p' = Lp = pqr,\ pp^* = qq^* = 1$$

$$p = (t, x, y, z) = (t, \boldsymbol{r})$$

$$p' = (t', x', y', z') = (t', \boldsymbol{r}')$$

$$\boldsymbol{r}' = (x', y', z') = (\gamma x - \gamma v t, y, z)$$

$$p' = (t', x', y', z') = (\gamma t - \gamma v x, \gamma x - \gamma v t, y, z)$$

$$p' = Lp \Rightarrow L = \frac{p'}{p} = p' p^{-1}$$

$$L = (\gamma t - \gamma v x, \gamma x - \gamma v t, y, z) \frac{(t, -x, -y, -z)}{(t^2 + x^2 + y^2 + z^2)}$$

$$p = (t, x, y, z) = (t, \boldsymbol{r})$$

$$p^2 = (t^2 - \boldsymbol{r} \cdot \boldsymbol{r}, 2t\boldsymbol{r}) = (t^2 - r^2, 2t\boldsymbol{r})$$

$$p' = (t', x', y', z') = (\gamma t - \gamma v x, \gamma x - \gamma v t, y, z)$$

$$p'^2 = (t', x', y', z')^2 = (\gamma t - \gamma v x, \gamma x - \gamma v t, y, z)^2$$

$$p'^2 = \left(t^2 - r^2, 2[\beta t^2 + \beta x^2 - tx - tx\beta^2], 2\gamma y(t - \beta x), 2\gamma z(t - \beta x)\right)$$

The invariant scalar part in p^2 and p'^2 is $t^2 - r^2$ for $c = 1$.

Conclusion

The exploration of quaternions reveals them not merely as a historical curiosity, but as a robust and essential toolkit for modern physics. Their rich algebraic structure, defined by a non-commutative multiplication and the elegant unification of scalar and vector components, provides a powerful language for describing physical phenomena. This non-commutative nature is particularly profound, as it directly mirrors the non-commutative behavior of successive rotations in three dimensions, offering a singularity-free alternative to Euler angles for describing orientation. In the realm of relativity, this algebraic prowess translates into a more compact and geometrically intuitive framework. Quaternions enable a single, unified expression for Lorentz transformations, moving beyond the cumbersome machinery of tensors. They naturally embed the structure of spacetime, where the scalar part of a quaternion can represent time and the vector part can represent spatial coordinates. This approach not only simplifies the mathematical formulation of relativistic mechanics but also provides deeper insights into the underlying geometric nature of spacetime transformations. In essence, the quaternion acts as a bridge, unifying rotations, translations, and boosts into a single coherent mathematical object, solidifying its place as an invaluable tool for physicists seeking a more fundamental and elegant understanding of the universe.

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Anveshika Physics Bharat Yatra Sessions at Chandigarh (IAPT RC-03)

IAPT RC-03 organised various events as a part of Anveshika Physics Bharat Yatra (APBY) 2025-26. The e-torch of APBY was received by Dr. Sanjay Kr. Sharma, Secretary, IAPT for Chandigarh at NIT, Kurukshetra on 23-08-2025 in a ceremonial function from the team of Janta Vedic Anveshika, Barot, Baghpat. Following activities were organised in three colleges:

DATE: 25th August 2025

VENUE: GGDSD College, Sector 32

THEME: "Learning Physics through Experiments"

IAPT RC-03 in collaboration with The BOSON Club of Department of Physics, GGDSD College, Sector 32, Chandigarh organised a session on Learning Physics with Simple Experiments and Demonstrations as a part of APBY, where the ceremonial e-torch (Mashaal) was received by Prof. Ajay Sharma, Principal of the college along with Dr. Neelu Mahajan, Head of Physics Dept., Dr. Amit Goyal, and the students of UG and PG classes of Physics. Prof. M.S. Marwaha and Prof. Sanjay Kr. Sharma were the resource persons for the program and more than 100 enthusiastic students actively participated in this event. Prof. M.S. Marwaha explained to the students the concepts of free, forced, and resonant vibrations; simple harmonic motion; coupled oscillators through simple experimental setups. Dr. Sanjay Sharma explained to the students the concept of conservation of momentum by demonstrating it with simple plastic bottles. Dr. Neelu Mahajan, delivered the vote of thanks, Dr. Amit Goyal coordinated the program very effectively.

DATE: 26th August 2025

VENUE: SGGS College, Sector 26

THEME: "Physics Experiments with Introduction of 21st Century ICT Skills in Education."

The second program in the series was organized by RC-03 in collaboration with SGGS College, Sector-26, Chandigarh on 26-08-2025 where the ceremonial e-torch was enthusiastically received by the Vice Principal Prof Harbhajan Singh, HoD of Physics Dr. Ranbir Singh, Faculty members and NCC students in presence of RC-03 President Prof. S. K. Tripathi and Secretary Prof. Ranjan Kumar. Prof. Sanjay Kr. Sharma and Mr. Paramjit Singh were the resource persons for the program where Prof Sharma demonstrated various hands-on activities and explained the principles of Physics behind these activities and Mr. Paramjit Singh talked about the 21st century Skills in Physics Education to more than 150 students of UG and PG of the college. The program was coordinated by Dr. Saroj Bala, Assistant Professor of the Physics Department.

DATE: 27th August 2025

VENUE: Govt. College of Education, Sector 20 D

THEME: "Role of Visualization and Hands on Experimental Demonstrations in Effective Learning"

The third program was organized at Government College of Education Sector 20 D Chandigarh on 27-8-2025 where the ceremonial e-torch (Mashaal) of Anveshika Physics Bharat Yatra was handed over to the college Dean Dr A K Srivastava, and faculty members Dr Sanjeev Kumar, Dr Sheojee Singh, Dr Lilu Ram, Dr Vandana Aggarwal, Dr Punam Bansal, Dr Balwinder Kaur and others along with students by Prof Sanjay Kr. Sharma, Secretary IAPT and Prof M S Marwaha, former Principal of SGGS College, Sector 26 Chandigarh. Dr A K Srivastava, formally welcomed the guests and inspired the students to get the maximum benefit from this session. Prof Sanjay Sharma explained the purpose of Anveshika Physics Bharat Yatra and highlighted how this brainchild of Padmashree Prof H C Verma was launched jointly at Srinagar in May 2025 by him and Shri Manoj Sinha, the LG of UT J & K with a purpose to share the joy of learning Physics with an aim of reaching the unreached throughout the country under the aegis of Indian Association of Physics Teachers (IAPT). Prof Sharma explained the role of Visualization in effective

learning through various simple video animations and highlighted how such an approach has changed the way of learning science.

Prof M S Marwaha presented his simple science demonstrations and explained how simple hands-on activities bring liveliness, uniqueness and inspiration in science classrooms. Around 100 students of B Ed first semester and PGDGC attended the session. Students and faculty enjoyed the session very much. At the end of the program, Dr Sanjeev Kumar proposed the vote of thanks. The program was coordinated by Dr Sheojee Singh.

APBY Mashaal received by
Prof. Ajay Sharma,
Principal, GGDSD College,
Sector 32, Chandigarh

APBY Mashaal received by
Prof. Harbhajan Singh,
Vice Principal, SGGS College,
Sector 26, Chandigarh

Dr. Sanjay Kr. Sharma and
Prof. MS Marwaha
demonstrating some
experiments.

Sheojee Singh

Report (RC – 13)

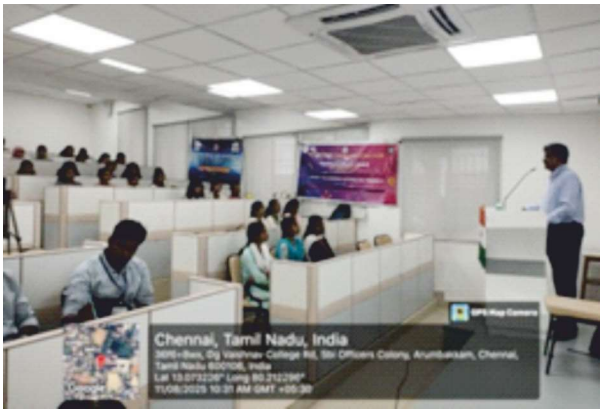
Quizzard 2K25- Intercollegiate quiz contest

Quizzard 2K25, the second edition of intercollegiate quiz contest **RENOWNED INDIAN SCIENTISTS** was organized by the Department of Physics, Dwaraka Doss Goverdhan Doss Vaishnav College in association with RC-13 (TN and Puducherry) on August 11, 2025 in commemoration with Independence Day. The quiz provided a platform for students to learn about Indian scientists and our current S&T advancements. 21 teams of UG and PG Physics students from 15 city colleges participated in the event.

The time has come for us to highlight our contributions to science and technology and reflect on where we stand today. It's time to inspire a passion for learning science, support our teachers and students in discovering these important facts, and introduce remarkable scientists like J.C. Bose, P.C. Ray, J.R.D. Tata, Anna Mani, Kamala Sohoni, P.C. Mahalanobis, Aseema Chatterjee, E K Janaki Ammal, Annapoorani Subramaniam and many more who shaped our scientific legacy. The quiz was conceptualized around the theme *"Renowned Indian Scientists"*, with a strategic focus on the scientific achievements of Indian scientists. It emphasized the role of indigenous technologies in building a *Viksit Bharat*, showcasing how home-grown innovations can address national challenges and contribute to the overall well-being of society.

Mr. Gopalakrishnan Karthikeyan, the quiz master, ensured the session was highly interactive and educational for both participants and the audience. The quiz had preliminary writing test, and the final 6 teams were selected from 21 teams. Each team had 3 students. There were many interesting rounds, viz, Crossword, Bharath Prathiba, Theme party, Kaleidoscope, rapid-fire, audio-visual rounds excited the participants. The special question round sparked great enthusiasm among the audience.

The prize winners were awarded with certificates and trophies. The enthusiastic audience were also given special prizes. Students gained deeper insights into Indian scientists, their contributions, and institutions of national importance. It was a valuable and enriching experience, offering them an engaging platform for experiential learning



V Renganayaki
Organizing Secretary

Corrigendum

In the table published in the August 2025 issue of the Bulletin on page 248, the information at serial number 5 was incorrectly printed. Prof. Vijay Kumar assumed the role of APhO Coordinator on 23rd July 2023. He has completed two years in this position, and is currently serving his third year.
We regret the error and apologize for any confusion caused.

Rekha Ghorpade
General Secretary, IAPT

C. K. Majumdar Memorial Summer Workshop In Physics, 2025
(Venue: S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata)

This year C. K. Majumdar Memorial Summer Workshop 2025, was jointly organized with the S.N. Bose National Centre for Basic Sciences (SNBNCBS), Kolkata, from July 15th - 24th, 2025 in the Institute campus. This workshop was dedicated to the memory of Prof. C. K. Majumdar, the Founder-Director of S.N. Bose National Centre for Basic Sciences (SNBNCBS).

Apart from the students from different districts of West Bengal, students from different states and UTs like Odisha,UP, Uttarakhand, Haryana, Pondicherry and Kerala participated in this workshop providing it a desired all-India character.

On the inaugural session on July 15, Prof. Ranjit Biswas, (Senior Professor and the Dean of Academic Programmes, SNBNCBS delivered the welcome address to the participants and the teachers and IAPT members present there in. He briefly talked about SNBNCBS and its activities. Thereafter Dr. Bhupati Chakrabarti, former General Secretary, IAPT, introduced the students to the nationwide multiple activities of IAPT towards the betterment of physics education. He also highlighted the genesis of the Workshop and acknowledged the resources and support of SNBNCBS over the years as the joint organizer of this Workshop.

The daily workshop schedule broadly had two academic sessions; the morning half consisted of three lectures and afternoon half meant for laboratory-work and visits to the research labs of SNBNCBS. These sessions were designed to reinforce theoretical concepts and enhance the skill in the practical domain. Participating 23 students were divided into two groups for greater exposure to the experiments along with the functioning of high precision analytical instruments (TEM, AFM, XRD, PPMSetc.) at the host institute. This year two indigenous experiments developed by IAPT- members: Dr. Surajit Chakrabarti and Prof. Minaz Hossain were included in the experimental session in the C.K. Majumdar Laboratory of SNBNCBS. The host institute paved the path smoother with the on-spot demonstration by Ph.D. scholars and the supporting staff of the laboratories of SNBNCBS. Two faculty members of SNBNCB, Dr. Avijit Chaudhuri and Dr. Saqib Samim provided very able guidance to the participants.

On the inaugural day, the first academic lecture was delivered by Prof. Krishnendu Sengupta from the Indian Association for the Cultivation of Science (IACS), Kolkata, on magnetization and introduced a concept of order parameter, which quantifies the degree of order in a Ferromagnetic system. The second lecture session was a bit different, a bridge between Biology and Physics. Dr. Shubhasis Haldar of SNBNCB introduced his indigenous developed protein chain measurement microscope and clear biological insight with the hint of chemistry. Thereafter, Dr. Surajit Chakrabarti, a senior member of IAPT RC-15, like previous years, referred 30 international educational journal papers to the participants to study and present their understandings and observations and analysis in a couple of the students' sessions marked in the schedule in last couple of days.

On day 2, Dr. Parijat Dey of SNBNCBS illustrated and derived thoroughly how the Ising model unfolded ferromagnetic behaviour. The next two lectures were taken by Prof. Bhupendra Nath Dev, Centre for Quantum Engineering, Research and Education, TCG CREST, Kolkata. Prof. Dev laid emphasis on the growth of physics without mathematical jungle. His enigmatic presentation drove the audience to the deepest insight of current thriving areas of the Quantum Bit system from the very beginning of Quantum theory. In the post lunch sessions students enriched themselves with the laboratory work.

The third day (17th July '25), began with Dr. Manik Banik of SNBNCBS. He eloquently illustrated the change of worldview from Newtonian's world to Bell's inequality. The next lecture entitled “A Twist in

the Tale of Light" was delivered by Prof. Nirmalya Ghosh of IISER Kolkata, enlightened us with the action of Oscillatory Dipole Moment to Spin Angular Moment of photon.

Fourth day (18th July '25), Dr. Saquib Shamim of the host institute shared a detailed topological insulator fabrication technique and its wide applications. Thereafter, President Prof. P.K. Ahluwalia (Himachal

Pradesh University), delivered a thought-provoking lecture, titled "Pope of Physics: Enrico Fermi's Legacy as a Quantum Physicist and a Teacher." The lecture sounded like a documentary film on "Enrico Fermi." The assemblage was amazed at the story-telling and the handwritten note books of the legendary physicist and teacher apart from the contribution to the profound enrichment in physics. The third talk was delivered by Dr. Bhupati Chakrabarti, Formerly Associate Professor, City College, Kolkata. He unfolded the indigenous effort in quantifying and connecting the natural constants in SI units by Bureau International des Poids et Mesures (BIPM).

On the fifth day (19th July '25), the morning session was hosted by Dr. Barun Ghosh, SNBNCBS. He elaborated the bandgap geometry towards topological insulators and inferred Berry Curvature and axion in a simple and lucid way. Middle session was an open one, where Prof. Ahluwalia interacted with the participants. He explained the spectrum of activities of IAPT with the help of IAPT webpage: https://www.indapt.org.in. After that Prof. Swagatam Das, Indian Statistical Institute, Kolkata discussed Algorithms for Intersection of Science and Machine Learning. He showed that the young science of AI (Artificial Intelligence) is more a specialized tool to analyze data than a silver bullet to solve any problem. The after-lunch session was taken over by Prof. Syed Minhaz Hossain, IIEST Shibpur. He delivered two fascinating lectures with a

live demonstration on "Colors Around Us: The Physics of Light Scattering." which held the audience awe-struck. It was a magical show with physical insight. Prof. Hossain exhibited all colors around us, the insight of Physics of light scattering. With several excellent demonstrations that supplemented his talk, he took the audience to a different world. His students had a great role in arranging these demonstrations.

On the sixth day (20th July '25), the first session was taken over by Prof Abhirup Dutta of IIT Indore. Prof. Dutta discussed the advances and opportunities in Radio astronomy utilizing different types of astronomical telescopes specially, the Square KilometerArray (SKA) and thereby indicated a future of advancing technique of imaging in radio astronomy. Thereafter, in the next session Prof. Sunandan Gangopadhyay of SNBNCBS, explained Schwinger's source theory, a theoretical model of quantum electrodynamics (QED) to investigate real time dynamics of perturbed vacuum.

Day seventh (21th July '25), the first session conducted by Dr P. S. Pachfule, SNBNCBS Dr. Pachfule discussed the process of developing novel 2D and 3D covalent organic framework (COFs) for applications in photo-catalysis, electro-catalysis, energy storage and CO_2 reduction. In the next session Prof. Anjan Barman, SNBNCBS, delivered a talk on the principles and mechanisms behind lasers-devices and its advancement towards the diverse fields of applications. The after-lunch session was significantly different as the participants in a small group presented a topic from the papers assigned to them at the beginning. They performed very well despite the scarcity of time in their maiden venture.

Day eight (22nd July '25), the first lecture was delivered by one of our conveners of the hosting institute Dr. Urna Basu, SNBNCBS, on "From Passive to Active: Exploring Nonequilibrium Dynamics".The next talk was a paradigm shift from physics to a wider horizon of knowledge. Dr. Achintya Pal, a retired Exploration Geophysicist, ONGC reopened the book

of Pyramid Era in ancient Egypt from the 21st century. In his lecture, he introduced us to the work of polymath Thomas Young as an Egyptologist and underlined that he is the same person whom the physics students know through his double slit experiment and a modulus of elasticity. The next lecture was delivered by Prof. Satyaki Bhattacharya, Saha Institute of Nuclear Physics, Kolkata on Higgs discovery. His detailed discussion clarified how AI helped to speculate the path length of Higgs Boson appropriately. The day ended with a laboratory session.

On the ninth day (23rd July '25), Prof. Ranjit Biswas gave us the physical insight of Physical Chemistry in phase transition of any material with a beautiful example of Borax on Gold brings down melting temperature (melting temp of Gold: 1337 K) enormously thus a goldsmith demoulds into intricate designs at home station. Prof. Suman Chakrabarty, SNBNCBS took over the next session. He endorsed Computational Methods in Physics: From Molecular Simulation to Machine Learning. Thereafter, Dr. Arijit Haldar, SNBNCBS discussed Variational principle in Quantum Mechanics and some of its applications with on-the-spot Python verification. After lunch, the students' session started. Their performances were remarkable. Then Dr. Ramkrishna Das (SNBNCBS) delivered a lecture on “The Explosive Universe" and led everyone to the roof top of the institute for observing celestial objects with the installed telescope but participants were disappointed due to urban smog.

Last day (24th July '25), came in a wink, students presented well in some of the thriving areas of physics. Then the valedictory session began with the certificate and prize distribution. Former GS of IAPT, Dr. Bhupati Chakrabarti, acknowledged every resource person in making the workshop fruitful and delightful. He conveyed his special thanks to the joint conveners, IAPT (Dr. Swati Das & Dr. Lipika Santra) and SNBNCBS (Dr. Urna Basu and Dr. Subhashis Haldar). He also mentioned a special thanks to the technical assistant at Fermion Hall all along. Overall Dr. Chakrabarti expressed his heartfelt regards to the wonderful team effort of IAPT RC-15 and specially the present current Secretary of IAPT RC 15, Dr. Shinjinee Dasgupta. Next, the participating students expressed their rare experiences. Most of them felt most of the sessions were engaging, stimulating and of informative experiences. They also added that this workshop would guide them in shaping their future. The valedictory session ended with a decent bend through a brief cultural program where the participants were the performers.

Finally, we must acknowledge the SNBNCBS, the joint organizer of the programme along with IAPT RC 15 for providing infrastructural and other support. We are also grateful to the IAPT President for visiting SNBNCBS during the programme and providing an opportunity to the IAPT RC-15 members to have an informal interaction session with him to discuss the activities and future course of journey of our organization.

Swati Das
Lipika Santra

Report (North Zone)

Prof R M Dharkar Memorial Workshop

on

Designing and Analyzing Cognitively Aligned Question Items for Quality Driven Assessment in Physics

Prof R M Dharkar Memorial workshop on Designing and Analyzing Cognitively Aligned Question Items for Quality Driven Assessment in Physics was organized from June 23-July 07, 2025, daily 5 pm to 7 pm on zoom platform. 48 teachers from Universities/ Colleges/ Schools from all over India enthusiastically participated in this workshop.

Workshop was inaugurated on 23rd June by Chief Guest Prof B P Tyagi, Guest of Honour Prof Vijay Singh, Prof P K Ahluwalia, President IAPT & Chief Patron. Dr Neetu Verma, Convenor welcomed the guests, resource persons and the participants. Prof Meenakshi Sayal, Coordinator, shared an overview of the workshop from its conceptualization to its inauguration. Ice-breaking session, led by Dr Sapna Sharma in which participants introduced themselves. The inaugural session was followed by a series of insightful talks.

Prof Kailash Juglan, Dean Physical Sciences, LPU highlighted various cognitive domains with practical examples of how to frame questions using appropriate action verbs. Dr B S Achutha, HOD Physics, VVS Sardar Patel College, Bangalore demonstrated how effective questions include the necessary information, precise action verbs and a clear intent regarding what is being assessed. He offered a lucid explanation of the distinction between evaluation and assessment, and the difference between High order thinking & low order thinking questions. Prof M L Ogalapurkar, Ex Chief Coordinator, Exams explained meticulous points about what care needs to be taken while setting multiple choice questions and what are good distractors.

Prof Vijay Singh, Former President IAPT & Guest of Honour shared his fond memories with Prof R M Dharkar, in context of International Physics Olympiad. Prof Singh shared a heartfelt narrative of his journey in developing Olympiads, pioneering new experiments and evolving methodologies in Physics education. Prof B P Tyagi, Chief Coordinator, Exams & Chief Guest explained that how by making small modifications in question at each step, different difficulty levels can be achieved. Prof PK Ahluwalia, President IAPT gave his concluding remarks with ever encouraging words for the organizing team and the participants. Dr Neha Munjal, Co- Convenor proposed a vote of thanks.

On 24th June, Dr K K Mashood, Associate Professor at Homi Bhabha Centre for Science Education, TIFR Mumbai delivered his talk on Development and Evolution of a concept inventory in rotational kinematics. He outlined the session by brainstorming all the participants with the question on common misconception/ alternate conception present in science education. Second talk was delivered by Dr Garima Sharma, Delhi Institute of Rural Development on Advance Bloom Taxonomy and she discussed that Bloom Taxonomy encourages higher order thinking, critical thinking, innovation and interdisciplinary integration.

25th June witnessed Prof Meenakshi Sayal, Vice President (North Zone) where she introduced LUSI project and elaborated on designing various types of problems- understanding, analyzing, critical thinking and real world etc. In the second session, Dr Sapna Sharma, Associate Prof St Bede's College Shimla expressed her views on the topic: Writing Measurable learning objectives and discussed the nuanced distinction between learning objectives and learning outcomes.

On fourth day, 26th June, Prof Meenakshi, delivered a talk on the topic: Elaboration on Cognitive Levels with case studies from Physics. She effectively covered both classical and modern physics topics, providing a logical flow from basic laws to advanced quantum concepts. Prof Seema Vats, Motilal Nehru

College, University of Delhi delivered a highly engaging and application-oriented lecture aiming at deepening the conceptual understanding of physics while emphasizing creativity, innovation and real-world relevance.

On 27th June, fifth day of the workshop, Prof M K Raghvendra, IISC Bangalore gave presentation on exploring cognitive levels through Physics case studies which was engaging and thought provoking. He demonstrated how to integrate concepts like application, analysis and evaluation into teaching, using real life examples. In the second session, Dr Neetu Verma, Dean Sciences, KMV Jalandhar delivered a talk on the topic, Exploring Physics through Questions: A critical thinking approach focused on fostering inquiry and innovation in Physics education.

On the first day of the second week on 30th June, Dr Devesh Tyagi shared his views on the topic, Exploring Ideas for creating question items for Quality- Driven Assessment in Physics. Dr Tyagi analyzed the limitations of traditional assessments and advocated for a more scientific approach, categorizing assessments into Pre-assessment, Formative assessment and Summative assessment. Second session was conducted by Dr M K Raghvendra, IIS Bangalore in which he highlighted the designing of questions based on experimental contexts.

Second day of the second week, 1st July was very interesting & informative in which Prof C K Ghosh, Ex- Director, National center for innovation in distance education, IGNOU and Dr Seema Vats, Prof Moti Lal Nehru College threw light on designing of Assertion- Reasoning questions based on cognitive levels- Application & analysis. Mrs. Pragya Nopany, Retired faculty, Birla Vidya Mandir School, New Delhi & Coordinator BVN-IAPT Aneshka conducted a session on 2nd July on Designing of new questions to facilitate critical thinking. She shared valuable insights on how to make classroom teaching more engaging by incorporating critical thinking-based questions. Mrs. Nopany explained how to design effective and thought-provoking questions that promote deeper understanding.

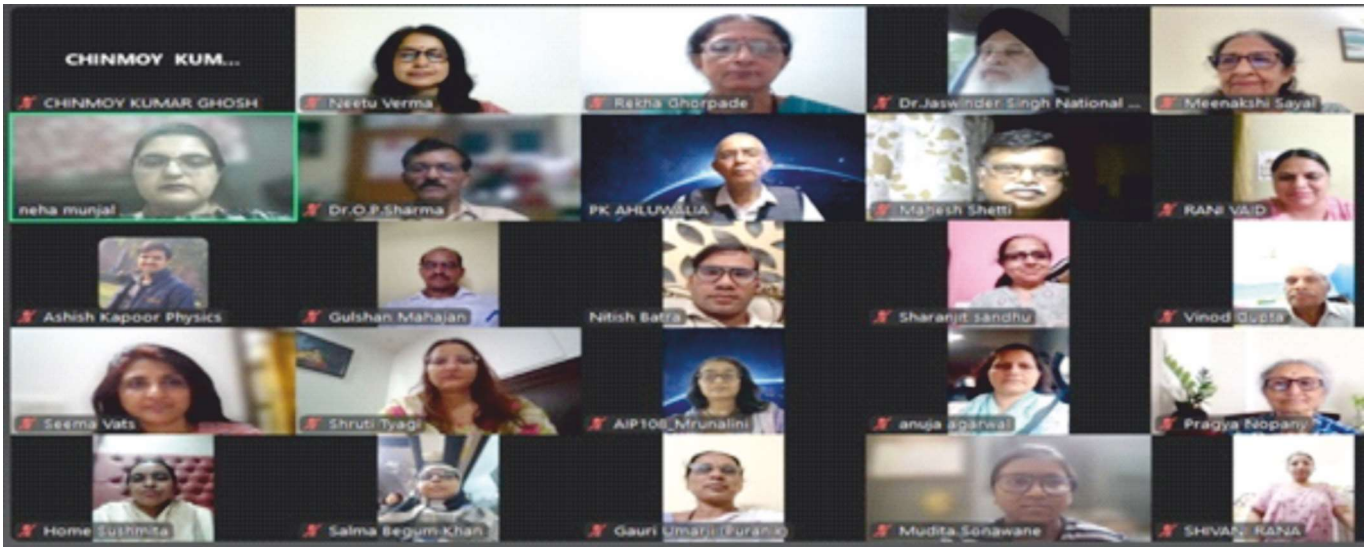
3rd and 4th July 2025 were very interesting in which participants gave their presentation of designing of new multiple-choice question along with solution explaining the cognitive levels of Bloom Taxonomy involved and distractors used in the options. Sessions were conducted by Dr Sharanjit, DAV College, Jalandhar and Dr Mahesh Shetti, Wilson College Mumbai. Panelists of the sessions were Prof B P Tyagi, Prof M K Raghvendra and Prof Devesh Tyagi. Session of 5th July was very fascinating in which participants discussed the cognitive levels of the problems of previous NSEP examination in zoom break out rooms and afterwards presented their solutions to the panelists Prof P K Ahluwalia, Prof Meenakshi Sayal, Dr Neetu Verma & Dr Neha Munjal.

Finally, 7th July 2025 was concluding day of the workshop. In this Valedictory session, Dr Neetu Verma welcomed guests, resource persons and participants. Prof Meenakshi Sayal briefed the happenings of two-week workshop and discussed the outcomes of the workshop. Dr Jaswinder Singh, President IAPT-RC 2 provided the feedback of the workshop and said that this workshop is a milestone for IAPT. Participants-Dr Mahesh Shetti, Wilson College Mumbai; Mrs. Priti Bhardwaj, Research Scholar, Amity University Mohali; Dr C. Joseph Prabagar, lecturer, Central Polytechnic College, Chennai, Dr Gulshan Mahajan, Assistant Prof , Govt College Karsog, Himachal Pradesh; Mr. Nitish Batra, Hanumat International School, Goraya; Mr. Ashish, DAV School Ludhiana and Ms. Rani Vaid , Lotus Valley International School, Noida extension spoke very high about the workshop in their feedback. This was very valuable feedback for the conduct of future workshops.

Guests of Honors, Prof C K Ghosh and Prof Rekha Ghorpade, General Secretary, IAPT highlighted the importance of the workshop and expressed their contentment about the program. Chief guest Prof O P Sharma, Director-National Centre for innovation in distance education, IGNOU expressed his views highlighting the need of the workshop. Presidential remarks of Prof P K Ahluwalia were very encouraging. He shared the example of a question on using a barometer to find the height of a school

building, posed by a teacher in a class test with a preconceived answer, and the student frustrating him by using barometer to measure height by not giving the answer which the teacher was expecting and giving his answers in multiple ways- underlining how crucial is the design of a question to seek correct response like an expert in the context of the question. His input emphasized the importance of the conduct of this workshop as a capacity building effort. Prof Ahluwalia appreciated the organizers and resource persons for their insightful presentations and interactive engagement, which will significantly contribute to professional development in Physics education. He said that these workshops can be conducted in different zones in collaboration with different Regional Councils throughout the country. Resource material generated in this workshop can serve as a very valuable resource for future workshops and help create valuable assessment tools on identified content areas at different levels.

Highlight of the workshop was meaningful involvement of the enthusiastic participants with assignments provided by the resource persons of different sessions in google classroom. Full paper of NSEP, session 2023-24 was provided for analysis by the participants seeking identification of each question designed in the light of problem-solving cognitive levels available in literature of Physics Education research to the form of a comprehensive Google form with humble efforts of Prof P K Ahluwalia & Prof M K Raghvendra. It is also expected that this workshop will generate a team of question item designers for the engaging classroom and for IAPT activities. E-certificates have been provided to the participants after submission of all assignments & presentation.



Meenakshi Sayal, Neetu Verma, Neha Munjal

Report (RC-21)

Pre- convention workshop on Empowering Physics Educators

A two-day workshop on Empowering Physics Educators was successfully conducted by RC-21, in association with the Goa Science Centre, Miramar, Goa. The sessions were conducted by the eminent physicist, **Padma Shri Prof. H. C. Verma**, renowned experimentalist, author of the celebrated Concepts of Physics books, and Emeritus Professor at IIT Kanpur.

The workshop was held on **8th and 9th August 2025** with distinct focus groups on each day.

In the inaugural function, the Project coordinator of the Science Centre, Ms. Manjula Yadav welcomed Prof. . Verma and the participants of the workshop. The function began with the lighting of the traditional lamp by Prof. H. C. Verma and other dignitaries.

President, Prof. Keluskar then addressed the gathering and shared details about the programme:

Day 1 (8th August 2025)

Dedicated to **Higher Secondary School (HSS) Physics teachers**, the session focused on innovative teaching methodologies, simple and effective classroom experiments, and ways to kindle curiosity in students. Prof. Verma demonstrated low-cost yet impactful experiments that can be easily replicated in school laboratories, emphasizing the importance of conceptual clarity over rote learning. This session was attended by 98 HSS teachers.

Day 2 (9th August 2025)

In the felicitation programme held on 9th August, Prof. Verma was felicitated by RC 21 at the hands of Shri Bushan Savoikar, Director, Directorate of Science and Technology, Government of Goa. Designed for **college teachers and students**, this session explored deeper concepts in Physics, experimental techniques, and problem-solving strategies. Prof. Verma presented interactive demonstrations, linking fundamental principles to real-world applications. Students were encouraged to ask questions and think beyond textbooks. This session was attended by 120 Participants.

During his talk, he also reflected on the rich heritage of India in the field of mathematics, reminding the audience that our country has been home to great mathematicians such as Aryabhata, Brahmagupta, Bhaskara, and Srinivasa Ramanujan, whose contributions have shaped the world's understanding of the subject. However, he expressed his disappointment that, in such a nation with a profound mathematical legacy, many students today perceive mathematics as a difficult and intimidating subject. He emphasized the need to change this mindset through better teaching methods, real-life applications, and by nurturing curiosity, so that students can appreciate the beauty and logic of mathematics rather than fear it. Prof. Verma stressed the significance of nurturing scientific temperament, critical thinking, and hands-on learning in Physics education. His interactive and inspiring approach kept the participants engaged and motivated.

The workshop witnessed enthusiastic participation, with over 200 teachers and students attending on both days.

In the concluding session, Dr. Reshma Raut Dessai, Secretary, Goa Regional Council, expressed heartfelt gratitude to Prof. Verma for his valuable time, guidance, and dedication to Physics education. She also extended thanks to the Director of Higher Education, the Director of SCERT, and the Goa Science Centre for their support and collaboration in hosting the event. She urged the participants to attend the convention, to be held from 5th to 7th October, in large numbers.

Reshma Raut Dessai

Report (SRC-08B)

Science Exhibition, Teaching aids and Career Counselling

Venue: Patuck Technical High School and Junior College, Santacruz, Mumbai
Organized by: SRC-08B and Patuck Technical High School and Junior College Mumbai.
No. of Participants: 100 students of 9th to 12thclass, Lab assistants and teachers (17).
Date: 26thJuly. 2025. **Schedule**:11 am to 4.30 pm
Resource person: Prof. K G Bhole, Prof. Shyamala Bodhane, Prof Susmita Meta.
Coordinator: Mrs. Susmita Meta

The science exhibition and career counselling' was successfully held at Patuck Technical High School and Jr college on 26th July 2025 in the college auditorium. The function commenced with lightning of lamp by the Chief Guest. Dr. Sooryansh Asthana from IIT Bombay, accompanied by Chairman Mr. Adil J. Patuck, Mrs. Bakul Anklesaria, Secretary, Mr. Dr. Krishna Bhole, President, Prof. Shyamala Bodhane, Treasurer, Sub RC 08, followed by Saraswati Vandana, sung by students of the institute.Mrs. Sushmita Meta welcomed the chief guest and other dignitaries. The Administrator of the college highlighted the history of Patuck Institution in brief. Mr. Adil J. Patuck motivated the students for new exploration and innovation.

The exhibition part was inaugurated with cutting of a ribbon conducted by Mr. Adil. J. Patuck. The exhibition featured over 18 projects across various disciplines viz. Physics, Chemistry, Biology, Math and Environmental Science. Students and Teachers from different schools and colleges enthusiastically presented state-of-the-art models and experiments. Some quite noteworthy projects included Quantum, Tunneling Effect, Density of Population, and Structure of atomic models, Matrix, Function and Biogas.

Mr. Patuck along with the Mrs. Suman Singh, and Madam Bakul Anklesaria, IAPT members inspected the different models designed and presented by participants.

Dr. Soorryansh Asthana delivered a lecture on 'Quantum Science'. Students were thrilled to hear him. A panel of external judges, evaluated the projects and assessed the descriptions given by the participants based on innovation, presentation and scientific relevance.

In second session Dr. Krishna Bhole delivered a lecture on 'Career Counseling.' In his lecture he guided the students about careers in Physics. He urged the students to focus on hard work, innovation, collaboration, smart work as well as how to select a suitable career in Physics and described all steps necessary to plan career smartly.

After that Mrs. Sunita Lambole staff of 'Support NGO' told the students about Support and appealed the students to take advantages of free training and placement courses on General Duty Assistant and Home Health Aid offered by Support NGO.

The event concluded with a prize distribution ceremony where participants with the best projects were awarded certificates and trophies, facilitated by Mrs. Angela Thomson, followed by Vote of thanks by Mrs. Sushmit Meta.

Sushmit Meta
Secretary

NATIONAL GRADUATE PHYSICS EXAMINATION (NGPE-2026)

Conducted by

INDIAN ASSOCIATION OF PHYSICS TEACHERS

Registered Office : 206, Adarsh Complex, OPR 4, Awas Vikas-1, Keshavpuram, Kalyanpur, Kanpur - 208017
Web: www.indapt.org (Regd. No. K 1448)

Day, Date & Time of Examination SUNDAY, January 25, 2026
TIME : 10.00 AM to 1.00 PM

Last Date for Enrolment : 17th November 2025

Eligibility for Appearing in NGPE-2026 : Students of B.Sc. I, II and III (Pass, Hons. or Integrated) are eligible. (Any one who has already passed B.Sc. is NOT eligible)

Exam Information :

Enrolment Fee : ₹ 300 (Rupees Three Hundred Only)
Language for NGPE : English, Hindi, Gujarati, Tamil, Telugu or any other language if 100 or more Students opt for it.

Format for NGPE :

Part A : 25 MCQs with any number of options (1,2,3 or all 4) may be correct. Credit is given only if all the correct options are marked (6 marks each; Total 150 marks)
Part B1 : 10 Short Answer (5 to 6 Lines) Questions (5 marks each ; Total 50 marks)
Part B2 : Ten Problems (10 marks each ; Total 100 marks)

Unique Features of this Examination :

- Fully voluntary examination in a stress free environment.
- Carry away the question paper both part A and part B.
- It provides Individual's own assessment at all India level.
- Same paper for all BSc I, II and III Year Students with separate national merit.
- Solutions in printed form are provided to Centre In-Charge for each participant.
- The only national level examination testing students in both theory & experiment.
- Previous Year (2025) Question Paper & Solution for every centre registered for NGPE - 2026.

CERTIFICATES AND AWARDS IN NGPE - 2026

(Cash Award will be released only if the candidate continues higher studies in Physics)

NGPE-2026 Awards

TOP 10% at Each Centre	:	Centre Topper Certificate
TOP 1% at State Level	:	State Topper Merit Certificate
TOP 1% at National Level	:	National Topper Merit Certificate + Book Prize
Top 5 Students in India	:	Merit Certificate + GOLD MEDAL + ₹ 20,000/- Cash Award

- Top 25 will be eligible for appearing in NGPE Part-C Examination - 2026 (an examination in experimental skill) for final selection for GOLD MEDAL and one time Scholarship (Max. 5 in Number) worth ₹ 20,000/- for pursuing higher studies in Physics. TA is paid and free lodging arranged.
- Top 25 will have eligiblity for an interview for Admission in Post - B.Sc. Integrated Ph.D. Programme in Physical Sciences 2026 of S N BOSE NATIONAL CENTRE FOR BASIC SCIENCES. KOLKATA, (Only BSc III year students with more than 60% Marks)
  For more details must see website: http://bose.res.in/admission.htm or write email to admission@bose.res.in
- May get opportunity to attend one week EXPERIMENTAL PHYSICS WORKSHOP organized by IAPT AT KOLKATA (Regional Council - 15). TA is paid.
- Top 5 to 10 students of B.Sc. First year (of University 3Yr System) shall be eligible to participate in prestigious NATIONAL INITIATIVE FOR UNDERGRADUATE SCIENCE [NIUS] program of Homi Bhabha Center for Science Education, TIFR, Mumbai. [This is A Govt. of India, DAE Program organized at Mumbai].
- Top 20 students of B.Sc. I appearing in NGPE-2026 may get an opportunity for two weeks Academic Workshop on Basic Physics at IIT Guwahati (Preferably for those from University 3-yr B.Sc. System)
- Some more programmes for toppers may be declared later.

To obtain previous Ten Year Question Papers with complete solution deposit / transfer Rs. 150/- (One hundred fifty only) per set in IAPT account as per Bank details: Name of the account: Indian Association of Physics Teachers, Name of the bank : Indian Bank, Branch : Dalanwala, Dehradun Pin 248 001, Account Number : 50492247138, IFSC Code : IDIB000D515. Then write a mail to iaptddn@gmail.com

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Obituary

In loving memory of our IAPT Stalwart - Professor V. SRINIVASAN (15.02.1936 - 22.06.2025)

With deep sorrow, we announce the passing away of our IAPT stalwart Prof. V, Srinivasan on 22nd June 2025.

Prof V. Srinivasan was born in 1936 and passed away at the age of 89. He is survived by his wife and son and was residing with his family in Thane, Mumbai.

He completed his schooling in Chennai and earned his SSLC from Model High School, Teachers College, Saidapet, Chennai. He pursued his B.Sc. Physics at the American College, Madurai from 1951 to 1955 securing top rank in his class. He went on to complete his M.A. in Physics, specializing in Electronics at Annamalai University, Chidambaram during 1955-1957. In July 1959 he joined the Department of Physics at The American College, Madurai as a Tutor in Physics. Later he pursued his M.S. in Physics at the University of Oregon, USA, during 1970-1971, as a Fullbright Scholar.

Upon returning to India, he resumed his role as Lecturer in Physics at The American College, Madurai. He was an exceptional teacher, academically strong and taught subjects Electronics, Electromagnetic Theory and Optics. During this period, he developed a strong professional association with the then Head of the Department of Physics, Dr. Richard P. Riez. One of the most memorable and proud moment in the history of Department of Physics was Prof Srinivasan's interaction with Nobel Laurette Sir C. V. Raman which took place in the Department premises. After the retirement of Dr. R.P. Reiz, Prof Srinivasan assumed the position of Head of the Department.

Contribution to IAPT:

Prof. V. Srinivasan contributed his valuable services to IAPT in various positions as Life Member, Editor of Bulletin of IAPT, Joint Secretary, General Secretary, NSEP Coordinator and NGPE Coordinator. He joined as Life Member of IAPT(LM0023) along with his Madura College friends Prof Raman (LM0024) and Prof M.R. Ganapathy (LM0025) in the year 1984 in the inaugural year of IAPT. With Dr Babulal Saraf as President, Dr. D. P. Khandelwal as General Secretary of IAPT. he worked as Joint Secretary in the year 1984. He published his paper “An improved way to conduct Physics Practical Examinations” in the Bulletin of IAPT Vol.1 No.8 October 1984. He became Editor of Bulletin of IAPT and Joint Secretary in 1985. He and Prof. R. Narayanasami of Alagappa College Karaikudi then Vice President of IAPT worked together to enrol about 60 Life Members of IAPT and organised Second Annual Convention of IAPT at Alagappa College, Karaikudi. Prof. Srinivasan served as Controller of Examinations Bharathiar University in 1986 and in IAPT worked as member of Committee for Funding Agencies along with Prof Hans and Dr D.P. Khandelwal in 1988. He organized Sixth Annual Convention of IAPT at The American College, Madurai in Nov 1991.Prof. Srinivasan took position of General Secretary of IAPT and Dr Khandelwal becoming President in the same year. He also took charge of NSEP Coordinator in 1991and then NGPE Coordinator. Dr V.S. Murti succeeded Prof. Srinivasan as General Secretary in 1993 but the latter continued his services in IAPT in Editorial Board of the Bulletin of IAPT.

K. Subramanian
Bangalore

Socio - Cultural Studies of Science and Education: Glimpses of What They Say?

Building on our previous explorations of philosophy of science and cognitive science, we now turn to another interesting area of study relevant to science education: sociocultural perspectives. This cohort of studies offers valuable insights into the complex interplay between science, society, and culture, shedding light on the ways in which social, economical and cultural factors shape construction of scientific knowledge and practices. This perspective also unravel factors that contribute to the production and perpetuation of inequities and social injustices. In this column, we provide examples of insights from these studies relevant to science education.

As an illustration, let us discuss the conceptualization of `merit'. Consider a hypothetical classroom scenario and two students therein - one whom a teacher describes as very `smart', `diligent' and `hardworking' while the other one as `uninterested', `lazy', `inattentive' and so on. Such a characterization is not unusual; in fact, it is quite prevalent. A socio-cultural account will problematize this characterization as naive, lacking in depth and inconsistent with the commonly held ideals of the goals of education and democracy. Instead of naively labeling one student as "good" and the other as "bad"—a characterization that lacks productive value—they offer a perspective that enhances our understanding of the situation.

Merit and excellence are conceptualized as products or outcomes of privilege and exceptional conditions of acquisition (material, social, and cultural). This is, in many cases, obvious and self-evident to common sense. The "good" students are often from households that are economically well-off, have educated family members, and multiple support structures. In contrast, the "bad" students in many cases come from poor families with uneducated parents, living in resource-constrained environments. The logic can be extended to communities and even countries that have been historically privileged, as well as those that have been deprived or oppressed in various ways. For a full fledged discussion along these lines and familiarity with some of the constructs used in such analyses, refer to: Nash, R. (1990). Bourdieu on education and social and cultural reproduction. *British journal of sociology of education*, *11*(4), 431-447. https://www.jstor.org/stable/pdf/1392877.pdf

To illustrate the nature of concepts and constructs used in studies like the one above, let us briefly discuss the notion of `Cultural capital'. This concept, developed by French sociologist Pierre Bourdieu, refers to resources that individuals or groups possess other than financial, which can contribute to their social mobility. Examples of these resources or assets can include: a) educational background of the family b) cultural knowledge c) language proficiency d) social connections e) familiarity with dominant cultural norms, among others.

It may be noted that one limitation of discussions problematizing merit and excellence as discussed above is that they are silent or often overlook exceptional cases. For example, how despite lacking "social and cultural capital," individuals like APJ Abdul Kalam, Abraham Lincoln, or Maryam Mirzakhani managed to beat the odds is not accounted for.

The discussion so far was not subject specific. For a study that focus on aspects pertaining to physics education, see the below paper as an example. The paper throws light on how students, often from underrepresented groups, come to see physics as being not for them.

Archer, L., Moote, J., & MacLeod, E. (2020). Learning that physics is 'not for me': Pedagogic work and the cultivation of habitus among advanced level physics students. *Journal of the Learning Sciences*, *29*(3), 347-384. https://www.tandfonline.com/doi/pdf/10.1080/10508406.2019.1707679

K K Mashood
HBCSE - TIFR, Mumbai

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