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# THE INDIAN ASSOCIATION OF PHYSICS TEACHERS

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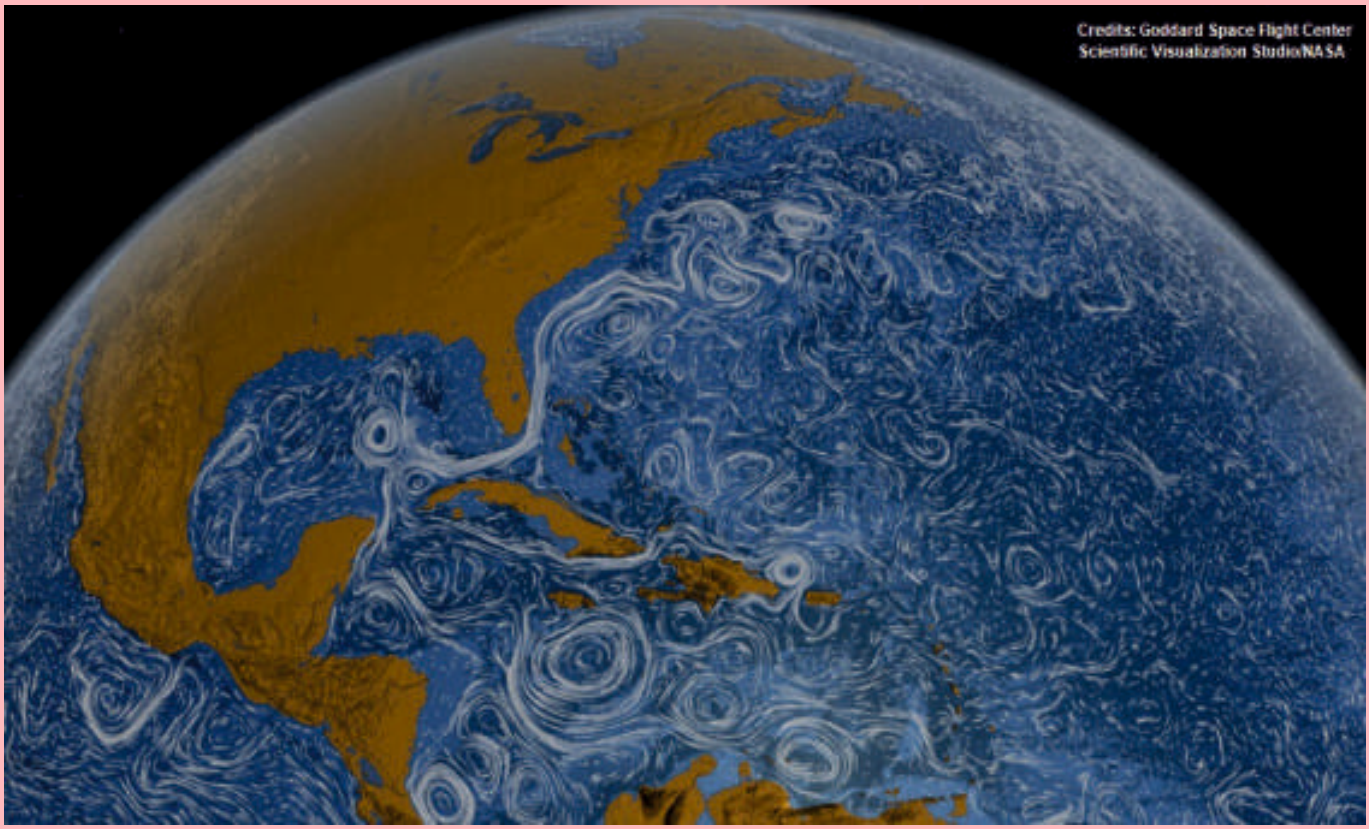


Earth's climate is a vastly complex system on a grand scale. On a microscopic level, so is the complicated physics of atoms and molecules found within materials. The 2021 Nobel Prize in physics knits together the work of Syukuro Manabe, Klaus Hasselmann and Giorgio Parisi, who illuminated such intricate physical systems by harnessing basic tools of physics. All three researchers used a similar strategy of isolating a specific piece of a complex system in a model, a mathematical representation of something found in nature. By studying that model, and then integrating that understanding into more complicated descriptions, the researchers made progress on understanding otherwise perplexing systems. Their work laid the foundation for simulations that capture the immense complexity of climate and other Earth systems such as ocean surface currents, shown in the visualization (above). The prize, normally an apolitical affair, sends a message to world leaders. Human emissions of greenhouse gases, including carbon dioxide, have increased Earth's average temperature by more than 1 degree Celsius since preindustrial times. That warming is affecting every region on Earth, exacerbating extreme weather events such as heat waves, wildfires and drought.(https://www.sciencenews.org/article/nobel-prize-physics-2021-complex-systems-climate)

# The Story of Cosmology through Postal Stamps- 06

**THE ANCIENT ASTRONOMY**

***INDIAN ASTRONOMY***

Observational Indian astronomy developed from the 4th century AD under the Gupta Dynasty (Chandragupta Murya), Aryabhatt (476-550 AD), Brahmgupta, Bhaskara, Panini were some prominent scholars of that period. Indian always took great care to measure time, length of the day, and year. Calendar reform was known after King Vikramaditya (102 BC). Stone tools for astronomical measurements were constructed by King Jai Singh of Jaipur. Samantha Chandrasekhara (1835- 1904) known as Tycho of Indian astronomy.


**Jantar mantar** -Stone observatory in jaipur , Cancellation shows the world largest sun dial of the observatory

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# Editorial

Dear Members

This issue carries two important announcements – the election notice for the new Executive Council and the notice for the Annual General Body Meeting (AGBM ).

1) IAPT is a democratic organization whose top echelon is replaced with a new body of elected members every three years. The election gives the members an opportunity to choose a team which they hope will take along the organization in forward direction to achieve new and higher goals. If the members of an organization are active, vigilant and take interest in its activities, the new team will work harder to achieve the goals. It is the collective will of the members that is reflected in the composition of the team. For that to happen the members must vote. If out of, say, 10,000 members of an organization, only 1000 vote, can it be termed 'collective will' ?

   So, members please, do vote.

2) An important item in the agenda for AGBM is about the amendments to the constitution.

An organization runs according to its Constitution which gives a broad layout of the manner in which it should be run to cater to its objectives. With time, the scenario changes and appropriate changes in it become desirable and necessary. A constitution is thus a dynamic document, needing amendment from time to time to keep pace with the changing times.

The Constitution of IAPT was last amended and submitted to the Registrar of Societies, Kanpur in 2007 under the president ship of Prof. Patki. 14 years is a long time. It needed a relook. The task was undertaken, as our President has pointed out, nearly 2 years back, before the advent of pandemic. The pandemic took its toll of time.

The amendments to be considered have already been published in October issue (p 378). In all, 19 amendments have been proposed which are given in a table which gives the original statement ( in the Constitution of 2007 ) of a clause, the amended version of the clause and the reason for amendment. It is a meticulously prepared document by Prof. Gadre for which we are thankful to him.

These amendments have been approved by the Executive Council and will now be put before the General Body for its approval in the AGBM to be held on November 29 2021. Please go through them carefully and if you have a different opinion about any of them, do speak up and share your opinion with others.

Also, AGBM is the occasion when the report card of the whole year is put before the members. Feel free to ask questions and give suggestions.

**U S Kushwaha**

*Matter regarding elections in RCs will appear in the next issue.*

## PHYSICS NEWS

**New photonic chip for isolating light may be key to miniaturizing quantum devices**

Researchers have designed a simple, compact photonic circuit that uses sound waves to rein in light. The new study demonstrates a powerful way to isolate or control the directionality of light. The team's measurements show that their approach to isolation currently outperforms all previous on-chip alternatives and is optimized for compatibility with atom-based sensors. The measurements revealed that nearly every photon moves through the waveguide in the forward direction, while having only one-in-ten-thousand chance of making it through backwards. This means that the design reduced losses, or undesirable light absorption, to nearly zero, which has been a long-standing problem with previous on-chip isolators. The data show that the new devices exhibit record-breaking performance for on-chip isolation and operate as well as the larger magnet-based devices. In addition, the approach is flexible and can be used for multiple wavelengths without changing the starting material. This could make the new design useful for other applications, like quantum computing, where stray, uncontrolled magnetic fields as well as unwanted light can erode overall device performance.

**Read more at :** https://phys.org/news/2021-10-photonic-chip-isolating-key-miniaturizing.html

**Original paper :** Nature Photonics (2021). DOI: 10.1038/s41566-021-00884-x.

**Physicists announce the world's most precise measurement of neutron lifetime**

Physicists have spent decades trying to measure the precise lifetime of a neutron using two techniques, one involving bottles and the other beams. But the results from the two methods have not matched: they differ by about 9 seconds, which is significant for a particle that only lives about 15 minutes.

Now, a team of scientists has made the most precise measurement yet of a neutron's lifetime using the bottle technique. The experiment, known as UCNtau (for Ultra Cold Neutrons tau, where tau refers to the neutron lifetime), has revealed that the neutron lives 14.629 minutes with an uncertainty of 0.005 minutes. This is a factor of two more precise than previous measurements made using either of the methods. While the results do not solve the mystery of why the bottle and beam methods disagree, they bring scientists closer to an answer. The results can also help to solve other long-standing mysteries, such as how matter in our infant universe first congealed out of a hot soup of neutrons and other particles.

**Read more at :** https://phys.org/news/2021-10-physicists-world-precise-neutron-lifetime.html

**Original paper :** Physical Review Letters (2021). DOI: 10.1103/PhysRevLett.127.162501

**Amount of information in visible universe quantified**

Researchers have long suspected a connection between information and the physical universe, with various paradoxes and thought experiments used to explore how or why information could be encoded in physical matter. A researcher attempts to shed light on exactly how much of this information is out there and presents a numerical estimate for the amount of encoded information in all the visible matter in the universe—approximately 6 times 10 to the power of 80 bits of information.

To produce the estimate, the author used Shannon's information theory to quantify the amount of information encoded in each elementary particle in the observable universe as 1.509 bits of information. While the approach in this study ignored antiparticles and neutrinos and made certain assumptions about information transfer and storage, it offers a unique tool for estimating the information content per elementary particle. Practical experiments can now be used to test and refine these predictions, including research to prove or disprove the hypothesis that information is the fifth state of matter in the universe.

**Read more at :** https://phys.org/news/2021-10-amount-visible-universe-quantified.html

**Original paper :** AIP Advances (2021). DOI: doi.org/10.1063/5.0064475

**Pankaj Bhardwaj**

Friedrich Alexander University, Erlangen & Nuremberg, Germany

# Election Notification
## Indian Association of Physics Teachers
## Formation of the Executive Council 2022-24

**(A)** I, the undersigned, am pleased to declare the following candidates elected unopposed to the posts mentioned before their names.

| Sr No | Name of the Post | Name of the Candidate (Life Membership No) |
|---|---|---|
| 1 | General Secretary | Rekha Ghorpade, Thane (L 0283) |
| 2 | Vice President – North | Ravi S. Bhattacharjee, Delhi (L 3291) |
| 3 | Vice President – East | Dr. Ranjita Deka, Guwahati (L 4345) |
| 4 | Vice President – Central | Ashok Kumar Jain, Roorkee (L 6190) |
| 5 | Vice President – South | P. Nagaraju, Bangalore (L 2694) |
| 6 | Vice President – General | Prof. H.C. Verma, Kanpur L 0081) |
| 7 | EC Member RC 02 | Meenakshi Sayal, Jalandhar (L 3915) |
| 8 | EC Member RC 03 | Pawan Kumar, Shimla (L 6218) |
| 9 | EC Member RC 04 | Dr. Sunder Singh, Baralie (L 5287) |
| 10 | EC Member RC 05 | L. P. Purohit, Haridwar (L4471) |
| 11 | EC Member RC 07 | Chetan G Limbachiya, Vadodara (L 4069) |
| 12 | EC Member RC 08 | S B Mane, Islampur (L 4075) |
| 13 | EC Member RC 9 | Pradip Kumar Deubey, Indore (L 5073) |
| 14 | EC Member RC 12 | Dr. M S Jogad, Kalburgi (L 1581) |
| 15 | EC Member RC 13 | Prof. Anandvadivel, Sriperumpudar (L1812) |
| 16 | EC Member RC 15 | Makhanlal Nanda Goswami, Midnapur (L 2510) |
| 17 | EC Member RC 18 | Kalipada Adhikari, Agartala (L 5203) |
| 18 | EC Member RC 20 | Shyam Ranjan Kumar, Ranchi (L 7222) |
| 19 | EC Member RC 22 | DR. V Rajeshwar Rao, Karimnagar (L 3871) |

**(B)** The following posts remain vacant as no nominations were received. The next elected Executive Council will do the needful to fill up these posts.

| Sr No | Name of the Post |
|---|---|
| 1 | EC Member RC 01 |
| 2 | EC Member RC 06 |
| 3 | EC Member RC 10 |
| 4 | EC Member RC 11 |
| 5 | EC Member RC 14 |
| 6 | EC Member RC 16 |
| 7 | EC Member RC 17 |
| 8 | EC Member RC 19 |
| 9 | EC Member RC 21 |

© There are 2 posts for which there are more than one contestant. Therefore election is declared for the following

1) President IAPT
2) Vice President West Zone

All the concerned should note that ---

1. All the members, whose names appear in the Register of Membership as on 1st of October, 2021 are eligible to vote.
2. One voter shall cast only one vote per relevant post.
3. All the voters (IAPT members throughout India) should vote for the post of President IAPT using one ballot paper.
4. Additionally, all the voters from West Zone only (Rajasthan, Gujarat, Maharashtra and Goa) should vote in a separate ballot paper, for the post of Vice President West Zone. Members from West Zone alone are eligible to vote for the Vice President of West Zone.
5. The voter shall use **only the Ballot Paper format given below** and send it to the undersigned (Returning Officer) **by speed post or by courier service,** so as to reach **on or before 8th December 2021**. No other method of sending the ballot paper is acceptable.
6. The ballot paper format has 2 parts. The Part-A which is above the dotted line, is for casting the vote. The voter shall copy / scan / print the Ballot Paper and mark (X) against the candidate's name he / she wishes to vote for in the Part-A. The Part-B which is below the dotted line is for identification of the voter. The voter shall fill and complete both the parts of the Ballot Paper.
7. The voter shall separate the 2 parts (Part-A and Part-B) of the Ballot Paper. Part-A that has the vote marked on it, should be enclosed in an inner envelope and that envelope should be sealed. Do not write anything on the inner envelope (including name of the voter, or his address etc) which may disclose the voter's identity.
8. Enclose the Part-B of the Ballot Paper which has the identification of the voter, and the sealed inner

envelope containing Part-A which has the vote marked, in an outer envelope. Only the outer envelope should indicate the sender's name, address etc.

9. Members from West Zone should use 2 separate ballot papers - one for President IAPT and another for Vice President West Zone. Part-A of both the ballot papers (President IAPT and Vice President West Zone) may be enclosed in a single inner envelope and sealed. Part-B of both the ballot papers and the inner envelope may be enclosed in a single outer envelope.
10. Envelope received by Returning Officer (RO) will be opened and Part-B bearing voter's identity will be separated from the inner sealed envelope.
11. The RO and his team shall verify the voter's identity. The counting of votes will be done subsequently by opening the inner envelope.
12. Incompletely filled ballot papers, and those disclosing voter's identity in any form on the inner sealed envelope or on Part-A, will NOT be entertained and will be treated as invalid.
13. The RO in consultation with the IAPT President and the GS may form a small committee from the members of IAPT to assist him in the process of counting.
14. The last date for the completely filled Ballot Paper (**hard copy only**) to reach the Returning Officer is **8th December, 2021.**
15. Results of voting for these positions will be announced in January 2022 Bulletin.
16. This announcement is available on IAPT website (indapt.org)

17. The ballot paper format is as given on below —

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# Indian Association of Physics Teachers
# Elections to the Executive Council
## For The Term January 01, 2022 to December 31, 2024

## Proforma of Ballot Paper For Election To

## Post: President IAPT

**Part-A**

| Name of the Post | Name of the Candidate | Details | Vote Mark |
|---|---|---|---|
| **President IAPT** | Prof. P. K. Ahuluwalia | Shimla<br>Life Membership No. L 0326 | |
| | Prof. G. Venkatesh | Bangalore<br>Life Membership No. L 3995 | |

(Cut along the dotted line shown below, enclose the Part-A (above) in a separate sealed envelope)

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Name of the Voter Member:
Voter's Life Membership No.:
Address (as mentioned for the dispatch of the Bulletin)
Date & Place:

Signature of the Voter Member

Send the outer envelope (containing the Part-B, and the inner sealed envelope with enclosed Part-A) to the Returning Officer IAPT EC Elections 2021, at the following address so as to reach on or before 8-Dec-2021:

**Prof. P. D. Lele**
Bldg. A4, Flat No. 6, Doodhsagar CHS
Aarey Check Naka
Goregaon (East), MUMBAI - 400 065
Contact No.: 9409288348

# Indian Association of Physics Teachers
# Elections to the Executive Council
## For The Term January 01, 2022 to December 31, 2024

## Proforma of Ballot Paper For Election To

## Post: Vice President West Zone

**Part-B**

| Name of the Post | Name of the Candidate | Details | Vote Mark |
|---|---|---|---|
| **Vice President West Zone** | Prof. Arun V. Kulkarni | Goa<br>Life Membership No. L 4513 | |
| | Prof. Sivanand Appanna Masti | Hasarchampu, Maharashtra<br>Life Membership No. L 3681 | |

(Cut along the dotted line shown below, enclose the Part-A (above) in a separate sealed envelope)

---

Name of the Voter Member:
Voter's Life Membership No.:
Address (as mentioned for the dispatch of the Bulletin)
Date & Place:

Signature of the Voter Member

Send the outer envelope (containing the Part-B, and the inner sealed envelope with enclosed Part-A) to the Returning Officer IAPT EC Elections 2021, at the following address so as to reach on or before 8-Dec-2021:

**Prof. P. D. Lele**
Bldg. – A4, Flat No. 6, Doodhsagar CHS
Aarey Check Naka
Goregaon (East), MUMBAI - 400 065
Contact No.: 9409288348

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**ANNOUNCEMENT**

# Grievance Redressal Committee

IAPT President Prof. Vijay Singh has nominated the Grievance Redressal Committee, as follows.

**Grievance Redressal Committee, IAPT elections 2021**

1. Prof. Bhupati Chakrabarti; <chakrabhu@gmail.com>
2. Prof. S. K. Joshi; <joshisantoshk@yahoo.com>
3. Prof. Mrs. Arundhati Mishra; <mishra.arundhati60@gmail.com>

**K.N. Joshipura**
General Secretary

# NOTICE

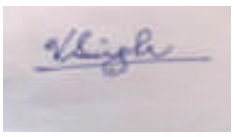
**The General Body Meeting (GBM)** of the Indian Association of Physics Teachers (IAPT) will be held on **Monday November 29, 2021 at 4-00 pm** in the Main Auditorium, Shri Vaishnav VidyapeethVishwavidyalaya, Ujjain Road, Gram Baroli, Indore – 453111 (MP). All members of the IAPT are requested to attend. Please note that no TA/ DA will be admissible for attending the meeting.
The agenda for the meeting is given below.

## AGENDA

1. Welcome address by Prof. Vijay Singh, President,IAPT.
2. (a) Reading and confirmation of the minutes of the last AGB meeting held on October 13, 2019 at the Auditorium hall IIIT Allahabad-Prayagraj UP;

These minutes were published in the IAPT Bulletin, December 2019, p. 362.
(b) Discussion of the matter that may arise from theminutes.

3. Presentation of the Annual Reports of the last two years by the General Secretary.
4. Submission of accounts and audit reports of IAPT for the FY2020-2021, and Presentation of the revised budget for the FY2021-2022.
5. Soft copy of the Bulletin over the next year due to Budgetary constraints – an appeal
6. Report on the IAPT exams, by the CCE Prof. B. P. Tyagi
7. Proposed Amendments in the IAPT Constitution, discussion and approval by the General Body.
8. Any other item from the Chair, or with the permission of theChair.



**Prof. K.N.Joshipura**
GeneralSecretary,IAPT

**Prof. VijaySingh**
President,IAPT

ARTICLE

# Fourier's Legacy in Modern Science

**V Satya Prakash**
Tara Govt College (Autonomous), Sangareddy-502001, India.

**Abstract:***Fourier series and Fourier transform are very important techniques in science with the wide spectrum applicability. Today almost every branch of science is influenced by the Fourier's ideas .The genesis of Fourier series and Fourier transform is discussed in the paper in the historical context. The Fourier related transforms (discrete Fourier transform, fast Fourier transform and wavelet transform)originated by fulfilling the shortcomings of Fourier transform are also discussed in the paper. Finally the daily life applications and the impact of Fourier's work on different branches of science like physics, chemistry, biology and mathematics are also discussed in the paper.*

## Introduction

The present decade witnessed the 250th birth anniversary of Joseph Fourier who made enormous contributions to the field of science .His work had been greatly influencing the modern science and technology. Fourier analysis introduced by him is the most natural way of analysing the data .In fact Fourier analysis is found everywhere in the nature. For example Human eyes and ears decompose light and sound waves respectively before sending them to the brain. These Fourier transformed signals then reach the brain where the construction of actual light or sound waves takes place. Even though Fourier developed his ideas in the context of heat, his theory gradually embraced to many other fields of science with numerous applications. Today Fourier analysis is used in many branches of science like physics, chemistry, biology and computer science. Fourier analysis also greatly influenced the research in pure mathematics as well. Apart from facilitating to evolve the new concepts like Heisenberg uncertainty principle in physics and set theory in mathematics, Fourier's work found many daily life applications from compressing MP3 files and JPEG images to medical image processing of MRI,CT scan and NMR. This legacy of Fourier's work in modern science and technology is discussed in the present paper.

## Fourier series and Fourier Transforms

Jean Baptiste Joseph Fourier was a French mathematician and scientist who studied the propagation of heat through solid substances in 1790s.He tried to apply his mathematical skills to the problem of heat transfer and finally discovered a partial differential equation governing the heat transfer through the solid materials. Fourier also proposed the solution to his partial differential equation. Any solution to this differential equation has to give the temperature distribution of the body at any time from the known temperature distribution at the initial time. Fourier considered the heat transfer as propagation of waves through solid materials. So he proposed the solution to the heat equation which is very similar the solution to wave equation in mechanics .Furthermore, he allowed the arbitrary (continuous or discontinuous) functions to represent the temperature profile of the substance.

## Fourier's heat equation:

After doing a lot of experimentation Fourier finally came up with a partial differential equation governing the heat transfer through the solids:

$$\frac{\partial u(t,x)}{\partial t} = \sum_{k,l=1}^{n} \frac{\partial}{\partial x_k}\left(a_{kl}\frac{\partial u(t,x)}{\partial x_l}\right)$$

where $u(t,x)$ is the temperature at position x and time t

and n=1,2 or 3 are one, two or three dimensions respectively

Initial distribution of heat is assumed by the initial condition u(x,0) = h(x) along with some other initial conditions due to geometrical constraints of the problem

The solution to this equation is assumed to be an arbitrary function with a sequence of arbitrary values. Even though transitions from one value to other value usually occur in continuous manner, there is a chance of occurring discontinuities in the sequence of values. This makes temperature variable 'u' a discontinuous function as well. Thus

contrary to the prevailing idea that the mathematical function should be a smooth function , Fourier gave a new definition of the function by introducing an arbitrary function as the solution to the heat equation[1].Physically this arbitrary solution for the heat equation allows the abrupt jumps in the temperature of the substance.

## Fourier's Series:

Fourier proposed the solution of heat equation u(x,t) as an arbitrary function f(x) which can be written as a trigonometric series:

f(x) =$\sum_{n=0}^{\infty} A_n$cos nx+$\sum_{n=1}^{\infty} B_n$sin nx

where $A_n$ and $B_n$ are the Fourier coefficients

Here coefficients $A_n$ and $B_n$ are determined by the orthogonal properties of the trigonometric functions.

This solution is very much similar to the solution of wave equation in mechanics. Daniel Bernoulli was first introduced the solution to wave equation as a sum of sinusoidal waves with the coefficients being determined by orthogonality of the trigonometric functions. Fourier proposed the similar solution to the heat transfer problem but he considered the solution to be an arbitrary function. Contemporary mathematicians suspected this solution representing an arbitrary function as the sum of smooth functions. But Fourier's work gradually gained the acceptance of his critiques and his work finally started to establish after the publication of his book "The Analytical Theory of Heat" in 1822.

## Fourier Transforms:

Fourier also studied the problem of infinite strip. This allowed him to introduce the concept of Fourier Transform in 1817.This is the straight forward extension of Fourier series to the non-periodic function. This is the Fourier's second stroke of genius after his discovery of heat equation and its solution by the year 1807.

Consider a non-periodic function f(x).A non-periodic function f(x) is now written as the sum of sinusoidal functions in the range - ∞ to + ∞ instead of its range – l to +l.

Fourier series in the finite range – l to +l is given by:

f(x) = $\frac{1}{2l}\sum_{+\infty}^{-\infty} c_{n,l}\, e^{i\Pi nx/l}$

where $c_{n,l}$ =$\int_{-l}^{+l} f(x)\, e^{-i\Pi nx/l}$ dx

.Let $\Pi/l$ =$\Delta\boldsymbol{\xi}$and $\xi_n$ =n$\Delta\boldsymbol{\xi}$= $n\Pi/l$.

This gives:

f(x) = $\frac{1}{2\Pi}\sum_{+\infty}^{-\infty} c_{n,l}\, e^{i\xi_n x}\Delta\boldsymbol{\xi}$

and $c_{n,l}$ =$\int_{-l}^{+l} f(x)\, e^{-i\xi_n x}$ dx

For f(x)→0 at x→ $\pm\infty$,$c_{n,l}$ will not change very much in the new interval.

$\therefore\ c_{n,l} \approx \int_{-\infty}^{+\infty} f(x)\, e^{-i\xi_n x}$ dx

Since this is the function of $\xi_n$ only, we may write:

$\hat{f}(\xi_n) \approx \int_{-\infty}^{+\infty} f(x)\, e^{-i\xi_n x}$ dx

Therefore, for l→ ∞ and $\Delta\boldsymbol{\xi}\rightarrow 0$:

f(x) = $\frac{1}{2\Pi}\int_{-\infty}^{+\infty} \hat{f}(\xi)\, e^{i\xi x} d\boldsymbol{\xi}$ where $\hat{f}(\xi) = \int_{-\infty}^{+\infty} f(x)\, e^{-i}$ dx

Here $\hat{f}$ (x) is called the "Fourier Transform" of function f(x).The formula for f(x) which is expressed in terms of $\hat{f}(\xi)$ is called *Fourier inversion formula*.

There are two types of Fourier transforms based on the function under consideration. If the function f(x) is a continuous function providing values for every real number, then it can be written as series of sinusoidal functions with all frequencies. When the function f(x) is made up of discrete measurements, then it can be written as series of sinusoidal functions with that particular discrete set of frequencies.

## Fourier related transforms:

The discrete Fourier transform, fast Fourier transform and wavelet transform are the modern versions of Fourier transform .These transforms are also called as Fourier related transforms. These transforms are developed by overcoming the shortcomings of original Fourier transform.

## Discrete Fourier Transform:

In discrete Fourier transform, the transform can only be computed at discrete data points in the finite interval of length $\boldsymbol{\Omega}$.The value of $\hat{f}(\xi)$can be completely calculated by its values at the sequence of data points: $\xi=\frac{2\Pi m}{\Omega}$ where m is an integer:

$\hat{f}(\xi) = \hat{f}\left(\frac{2\Pi m}{\Omega}\right) = \int_0^{\Omega} e^{-2\Pi i m x/\Omega} f(x)$dx

Dividing the interval of length $\boldsymbol{\Omega}$ into N equal parts with end points x = $\frac{n\Omega}{N}$, the length of each equal interval becomes dx= $\frac{\Omega}{N}$ for n=0,1,2,3,....,N.Then

$$\hat{f}(\xi) \approx \sum_{n=0}^{N-1} e^{-2\Pi i m n/N} f\left(\frac{n\Omega}{N}\right)\frac{\Omega}{N}$$

If f ($\frac{n\Omega}{N}$) = $a_n$, then:

$$\hat{f}(\xi) \approx \frac{\Omega}{N}\sum_{n=0}^{N-1} e^{-2\Pi i m n/N}\, a_n$$

or $\hat{f}(\xi) = \frac{\boldsymbol{\Omega}}{N}\widehat{a_m}$

where $\widehat{a_m} = \sum_{n=0}^{N-1} e^{-2\Pi i m n/N}\, a_n$

Here$\widehat{a_m}$ transforms$a_0$ ,….,$a_{N-1}$(for n=0,1,2,..,N-1)in to another set of values$\widehat{a_0}$,….,$\widehat{a_{N-1}}$(for m=0,1,2,...,N-1).So $\widehat{a_m}$ is called the *discrete Fourier transform* of $a_n$.

So we have:

$\widehat{a_m} = \sum_{n=0}^{N-1} e^{-2\Pi imn/N}\, a_n$

The *inverse Fourier transform* is now given by:

$a_n = \frac{1}{N}\sum_{n=0}^{N-1} e^{2\Pi imn/N}\, \widehat{a_m}$

So discrete Fourier transform resembles the ordinary Fourier transform .In fact the discrete Fourier transform is only a numerical approximation of the ordinary Fourier transform. It is important to note that the discrete Fourier transform is not only a computational device but also has many applications in pure mathematics branch called *number theory*.

## Fast Fourier Transform:

The discrete Fourier transform reveals that calculation of $a_n$ requires the total $N^2$operations since the calculation of each $\widehat{a_m}$ requiresN primary operations and there are N numbers of such $\widehat{a_m}$s in the expression.

For large N,$N^2$ becomes too high to compute and Fourier transform becomes computationally massive. The computational task can be reduced in the case when N is composite:

N=$N_1 N_2 \ldots\ldots\ldots N_k$

Now the elementary operations can be reduced from $N^2 = N(N_1 N_2 \ldots\ldots\ldots N_k)$ toN$(N_1+N_2+\cdots+N_k)$.This is because N $(N_1+N_2+\cdots+N_k)$ is much smaller than $N^2$ =N$(N_1 N_2 \ldots\ldots\ldots N_k)$ operations in the original method.So the algorithm to compute the discrete Fourier Transform in this manner is called as *Fast Fourier Transform.* This algorithm was put forward by Cooley and Turkey in 1965[2].This algorithm or some of its variants were already in use by the year 1805.But this came in to prominence only after its introduction by Cooley and Turkey. Thisstarted a new revolution in scientific computation because it made possible a very fast and efficient processing of large amounts of data. This enabled the practical use of Fourier transform in different branches of science which was long pending due to massive computations.

## Wavelet Transform:

In 1982, Morlet first introduced the idea of wavelet transform for seismic data analysis[3]. Later on Grossman recognized the importance of wavelet transform proposed by Morlet and developed exact inversion form for wavelet transform. This wavelet theory is very much similar to Fourier theory in which an arbitrary function can be decomposed in to sinusoidal functions.

The wavelet transform fulfils the shortcomings of the Fourier transform where frequency of the spectrum in local time base is neglected. As a solution to this problem Dennis Gabor first introduced the *short time Fourier transform*in 1946.This transform is also called *windowed Fourier transform* or *Gabor transform* or *wavelet transform.* In this transform a *windowed function* is used to localize the Fourier transform at different times.This gives the accurate local information of the function at different times.

The wavelet transform of a function ‘f’ with respect to a windowed function ‘g’ is given by:

$\widetilde{f_g}(\boldsymbol{\nu},t)=\frac{1}{\sqrt{2\Pi}}\int_{-\infty}^{+\infty} f(\tau)\,\bar{g}(\boldsymbol{\tau}\text{-}t)e^{i\nu\tau}d\boldsymbol{\tau}$

where $\bar{g}(\boldsymbol{\tau}\text{-}t)$ is a complex conjugate of a windowed function g($\boldsymbol{\tau}$-t)

and $\boldsymbol{\tau}$ is the translational parameter which facilitates the translation of window

over the entire time domain

Here $\widetilde{f_g}(\boldsymbol{\nu},t)$ gives the frequency distribution of signal at one particular time t.

When g is continuous and the values of f($\boldsymbol{\tau}$) with $\boldsymbol{\tau}$ are small, the localization will be very smooth. This property is very important in signal processing.

When windowed function is discrete, the resulting transformation is called *discrete windowed Fourier transform* or *discrete Gabor transform.* The discrete windowed function is given by:

$g_{m,n}(t)=e^{im\ \ _0t}$g(t-n$t_0$)

where $\boldsymbol{\omega}$=m$\omega_0$ and t=n$t_0$ with m,n being integers and $\omega_0$ and $t_0$ being positive quantities.

Now the discrete wave transform is given by:

F(m,n)=$\int_{-\infty}^{+\infty} f(t)\,\overline{g_{m,n}}(t)\,dt$

where $\overline{g_{m,n}}$(t) is the complex conjugate of windowed function$g_{m,n}(t)$.

Here $\sum_{m,n=-\infty}^{+\infty} F(m,n)\,g_{m,n}$(t) is called Gabor series of function f(t) – which is analogous to Fourier series.However, wavelet series becomes more efficient representation when the function has a small number of discontinuities.

## Applications of Fourier series and Fourier Transform:

The application of Fourier transforms rangefrom compression JPEG images in daily life to detection of gravitational waves in pure physics.

A basic application of Fourier series is decomposing complex waves in to known simple waves called sinusoidal waves. A Fourier transform gives the same information as the Fourier series but it gives the property of a specific sinusoidal wave component of the Fourier series.

So Fourier transform allows one to deal separately with each frequency of the given function. This helps us to remove random noise frequencies from the sound and image files in the form of MP3 and JPEG formats respectively. This allows the compression of data in the sound or image files.

The Fourier transform of a molecule is provided by the X-ray scattering image of that molecule (diffraction pattern of that molecule). The amplitude information can be extracted from the intensity of the diffraction pattern and the phase information can be extracted by comparing the diffraction pattern with the patterns of some other similar molecules. So working back on the amplitude and phase information in Fourier transform will give the original 3-D structure of the molecule. This is in fact used in the discovery of double helix structure of DNA in 1962[4].This discovery revolutionized the branch of science called molecular biology.

In chemistry Fourier transform techniques are used in the Fourier transform spectrometers- which are used for the chemical analysis. In this method light from the sample is collected by the interferometer as the Fourier transform of the spectrum of the molecule. So working back on it by using a computer gives the original spectrum of the molecule. This method is more sensitive and also has much shorter sampling times compared to the other conventional spectroscopic techniques. So this is an indispensable tool for chemical analysis in chemistry.

Fourier transforms can also be used for medical image processing in MRI, CT scan and NMR. Modern NMR methods collect the data of the object in the form of electrical signals varying with time. But the display of the data will be done as a function of frequency. This conversion of data from time domain to frequency domain is essentially a Fourier transform. So Fourier transforms revolutionized the medical diagnostics in a drastic manner.

The Fourier transforms also played an important role in the recent discovery of gravitational waves by LIGO (Laser Interferometer Gravitational-Wave Observatory) scientific collaboration [5]. The identification of gravitational wave frequencies originating from the pulsars was done by LIGO detectors by the elimination of noise in the corresponding LIGO data. For this purpose time domain data is converted in to frequency domain data by using the Fourier transforms. Then the possible source frequencies are extracted from the entire frequency domain data. This confirmed the existence of gravitational waves – a prediction made by Einstein‘s general theory of relativity.

Fourier series and Fourier transform methods can be used to solve both ordinary and partial differential equations with the boundary conditions. This can be found as straight forward application of Fourier methods in almost all standard mathematics and mathematical physics books. Fourier series method can be applied for bounded systems whereas Fourier transform techniques can be applied for unbounded systems as well. Furthermore, Fourier transforms can be used to covert a partial differential equation in to a solvable ordinary differential equation with the same boundary conditions [6].

The application of Fourier transform is inherently present in the derivation of Heisenberg‘s uncertainty principle [7,8,9]. According to the Heisenberg‘s uncertainty principle the simultaneous determination of canonically conjugate variables in quantum mechanics can only be done with the characteristic uncertainty ‘ h’ (Planck‘s constant).Heisenberg argued that the mathematical formalism of quantum mechanics imposes this characteristic uncertainty in the simultaneous measurement of the conjugate parameters.

The Fourier transform is inherently present in the Heisenberg‘s derivation of his uncertainty principle. The brief sketch of his derivation is presented here but the detailed derivation can be found in his historical paper shown in Ref 8. as well as in his book shown in Ref 9.However, the terminology and notation used here are modern and hence are different from those that are used in the original derivation.

Heisenberg defined uncertainty in coordinate ($\Delta q$) and momentum ($\Delta p$) in terms of amplitudes$\boldsymbol{\Psi}$ ($q'$) and $\phi(p')$respectively:

$$\frac{1}{2}(\Delta q)^2 = \int (q' - < q >)^2 \, |\Psi(q')|^2 dq'$$

$$\frac{1}{2}(\Delta p)^2 = \int (p' - < p >)^2 \, |\phi(p')|^2 dp'$$

where <q>and <p> are the expectation vales of coordinate and momentum respectively.

Here the amplitudes $\Psi(q')$ and $\phi(p')$are related to each other by a transformation matrix $<q'|p'>$ which transforms a Hilbert space in which p is diagonal to another Hilbert space in which q is diagonal:

$$\Psi(q') = \int dp' < q'|p' > \phi(p')$$

$\phi(p')=\int dq' <p'|q'> \Psi(q')$

This can be checked by writing wave functions in terms of wave kets:

$\phi(p') = <p'|\phi>$

$\Psi(q') = <q'|\Psi>$

Requiring:

$\int dq' < p'|q' ><q'|p''> = \delta(q' - q'')$

$\int dp' < q'|p' ><p'|q''> = \delta(p' - p'')$

we have:

$<q'|p'> = \frac{1}{\sqrt{2\Pi\hbar}} e^{ip'q'/\hbar}$

where $\frac{1}{\sqrt{2\Pi\hbar}}$is the normalization constant

This gives:

$\phi(p') = \frac{1}{\sqrt{2\Pi\hbar}} \int \Psi(q') \ e^{-ip'q'/\hbar} dq' \Psi(q') = \frac{1}{\sqrt{2\Pi\hbar}} \int \Psi(p') \ e^{ip'q'/\hbar} \ dp'$

This is the *pair of Fourier transform equations* transforming the system from coordinate space to momentum space vice versa. Heisenberg utilized this pair of equations to derive the uncertainty relation:

$\Delta q \Delta p \gg \hbar/2$

where $\Delta q$ is the uncertainty inthe co ordinate

and $\Delta p$is the uncertainty in the momentum

So Fourier transform not only allows for the dual space - coordinate space & momentum space description of a quantum system but also enable the creation of quantum mechanics in the form of Heisenberg's uncertainty principle. In fact, the Nobel Prize was awarded to Heisenberg in 1932: "for the creation of quantum mechanics,….".

Fourier's work had some profound influence on the mathematical analysis research also. So, large number of mathematicians worked on the problem of convergence and uniqueness of Fourier series. In 1829 Dirichlet worked on the problem of convergence of Fourier series, a problem which was completely ignored by the Fourier. Cauchy also worked on the same problem. Fourier's ideas enabled the discussion on the convergence: absolute convergence and uniform convergence of a mathematical function. Riemann worked on the integral named after him as a tool of convergence of Fourier series. Later on Raymond also worked on the convergence of Fourier series and the problem of infinity. In 1870 Cantor studied the uniqueness of trigonometric representation of Fourier series. This enabled him to introduce an important branch of mathematics called set theory [10].

## Conclusion:

Lord Kelvin stated in 1867: "Fourier's theorem is not only one of the most beautiful results of modem analysis, but it may be said to furnish an indispensable instrument in the treatment of nearly every recondite question in modem physics." This is literally true even today as Fourier‘s work is constantly finding new applications not only in physics but also in so many other fields. In the early twentieth century his work paved the way for the derivation of Heisenberg‘s uncertainty principle and hence the creation of quantum mechanics. In the present century it laid the strong foundation of Einstein‘s general theory of relativity by its use in the detection of gravitational waves from the LIGO data. In addition to this, the use of Fourier transforms from the daily life applications like compression of MP3,JPEG files to the analysis of MRI,CT scan and NMR data in medical diagnostics has made the Fourier‘s legacy alive in the modern science and technology.

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ARTICLE

# Historic brachistochrone problem: theory and measurements for the time of descent

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## Abstract

This article describes the measurements and the relevant theory with a Demo version used to exhibit the famous '*Brachistochrone*' problem of classical mechanics. From the Demo performed with the apparatus, we measured the time of fastest descent of an object along the cycloid path, and also calculated the time for descent from the relevant theory. Time measurements were done with the stop watch available in a mobile phone. Agreement between measurements and theory is quite satisfactory. Sources of error are also pointed out.

## Introduction

"Given two points A and B in a vertical plane, what is the curve traced out by a particle acted on only by gravity, which starts at A and reaches B in the shortest time?"

This simple question posed by Johann Bernoulli to challenge the world's best mathematicians is the starting point to this exciting problem way back in 1696. In Greek, '*brachistos*' means '*the shortest*' and '*chronos*' means '*time*', hence the name '*brachistochrone*' of the curve along which the object traverses in the least time. When Johann Bernoulli put forward the challenge, he was thinking of a problem so difficult that he wrote;

"Nothing is more attractive to intelligent people than an honest, challenging problem, whose possible solution will bestow fame and remain as a lasting monument. Following the example set by Pascal, Fermat, etc., I hope to gain the gratitude of the whole scientific community by placing before the finest mathematicians of our time a problem which will test their methods and the strength of their intellect. If someone communicates to me the solution of the proposed problem, I shall publicly declare him worthy of praise [1]."

It is also known that Johann Bernoulli and Gottfried Leibniz deliberately tempted Isaac Newton with this problem. Newton, who was in a rather retirement mood in those days, swung into action, and gave an elegant solution [2] almost overnight…! He published the solution through the Royal Society [2]anonymously. However, the mathematicians across Europe immediately recognized that this could be none other than the great Isaac Newton…!! AndJohann Bernoulli responded saying, "*We know the lion by his claw.* ."The solution to thishistoricproblem lies in the '*calculus of variation*', the formalism developed by Isaac Newton, and explored later by another mathematician Euler.

## Theory

The '*variational principle*' isjust an alternative formulation of Newtonian mechanics. The general mathematical framework for the development and application of this technique is the '*calculus of variation*'. With the help of the Euler–Lagrange formalism of the variational principle one obtains the solution to the brachistochrone.We revisit herethebrachistochrone problem that is now an important topic of classical mechanics [3, 4] whichin turnis an integral part of the teaching and learning of Physics in our UG-PG classes. This is a famous time-minimization problem, and as discussed in our standard

textbooks [3, 4] the curve of the fastest descent is a cycloid. Detailed historical description of the brachistochrone problem [5] and variational principal related calculus with a working model [6] has been already discussed elsewhere.

With this background the focus of the present article is to find a reasonable agreement between the theory and measurement of the shortest travel time for the above said particle (in the brachistochrone problem statement) from point*A* to *B*. In the present context let us concentrate on the time of descent in the actual Demo apparatus.Thus we wishto find the time taken by the object on each of these two paths, viz. the straight lineAB and the curveACB, (figure 1) in theory and in measurements.Our aim is tocompare the theoretical and measured results.

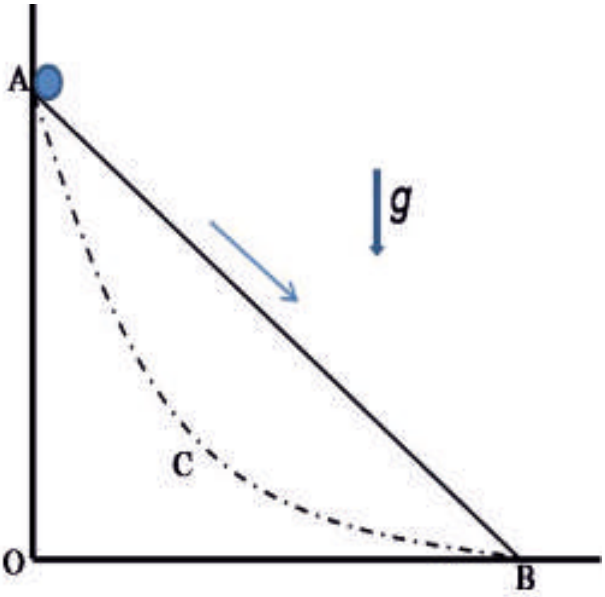


Figure 1: Brachistochrone Problem

Let's explore the brachistochrone problem with the help of figure 1. Consider in this figure a particle of mass *m* initially at point A. Theusual question is: what is the path along which, the particle under the downward gravitational acceleration ***g***(only) reaches point B in the shortest possible time?! One may consider an obvious path viz., the straight line connecting points A and B. The second path is a curve ACB. From figure 1 the shortest *distance* between points A and B isthe straight line and one may simply think of the solution to this problem to be the straight line AB. That however is not true. The basic theoretical analysis of the brachistochrone problem reveals that the travel time between A and B is minimum if the path is a particular curve called cycloid (path ACB).

In this backdrop, we arefocused on the time of descent of the object in question, especially since good sturdy Demo devices are available as small table-top versions and also as large versions for exhibiting the phenomenon described above. One such Demo apparatus, displayed at the Community Science Centre, Sardar Patel University Vallabh Vidyanagar, is shown in figure 2. On a sturdyvertical frame two iron rods are fixed neatly; one of them is slanting representing the straight line AB, and the other is a curved one representing the cycloid ACB of figure 1.

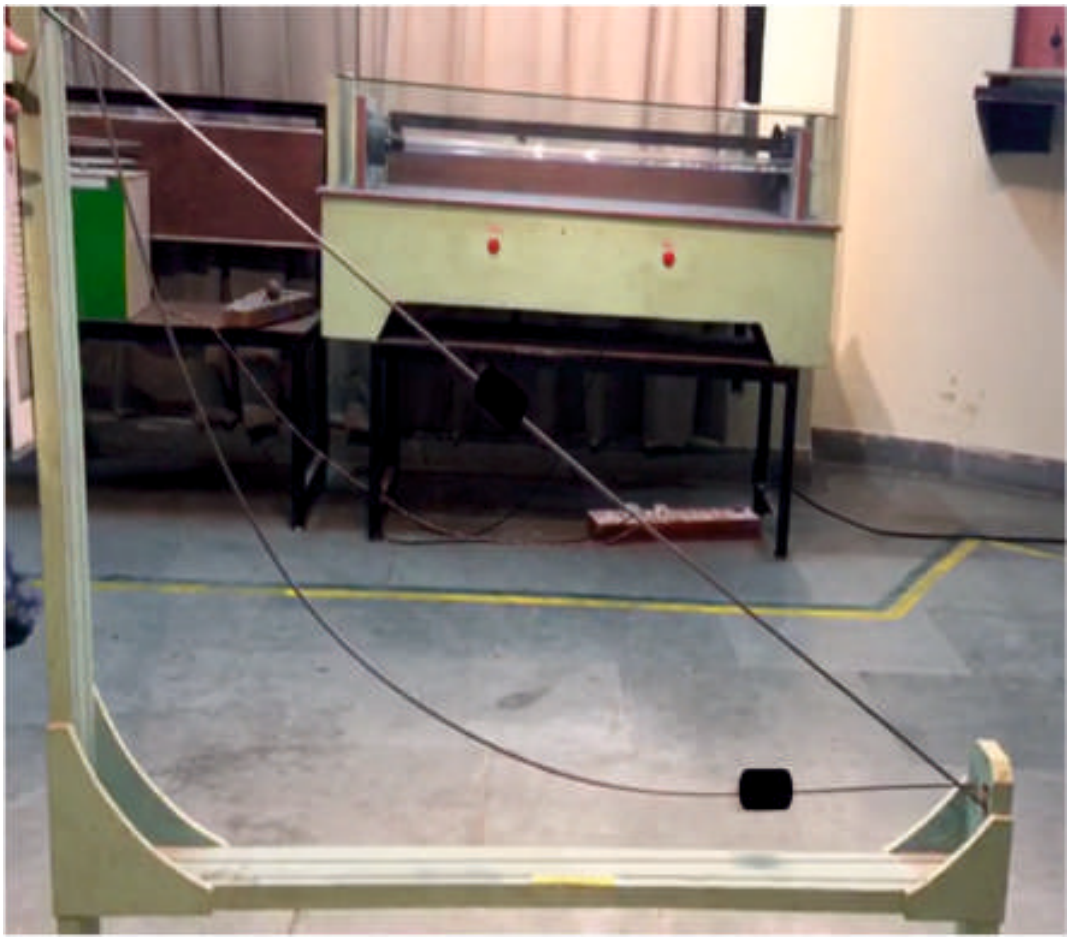

Figure 2: Photograph of the brachistochrone Demo apparatus

With this set-up in mind, our present problem is two-fold, namely (i) to find the actual time taken by the object on each of the straight-line and the cycloid paths (figures 1, 2)through measurements, and (ii) to calculate in theory, the travel times for two paths, under simple assumptions of course. We then compared our measured and theoretical results.

Here we have assumed the object having mass $m$ to go down under gravity along frictionless curves A→B and A→C→B with initial velocity $v_0$=0. The angle ∠AOB = $90^0$ in figure 1 and correspondingly in figure 2. Let us have,

$T_1$= the time interval for descent along the straight line AB, and

$T_2$ = the time interval for descent along the curved or the cycloid path ACB

To get a simple idea of the time intervals involved here, we also considered the case of freefall of the mass $m$ from point A to directly to O, although it was not happening in the Demo experiment. The time for free fall along AO = 80 cm is denoted by $T_0$. Now, the theoretical times $T_0$, $T_1$ and $T_2$ are calculated using standard formalism. The free fall time $T_0$ is obtained simply through,

$$h(= AO) = \frac{1}{2} g T_0^2 \qquad (1)$$

For the straight line along the slanted path, the time $T_1$ is obtained from the same basic equation by employing the appropriate component of the gravitational acceleration $\boldsymbol{g}$. The crucial quantity $T_2$ is determined from the equation for the cycloid,

$$T_2 = \pi\sqrt{\frac{a}{g}} \tag{2}$$

Where, '$a$' is the radius of the generating circle of the cycloid.
Let us outlinea simple derivation of equation (2).
Here bead is moving on a cycloid AB. Let A be located on the origin of the Cartesian coordinate system.

The equations of cycloid are given by

$$x = a(\theta - sin\theta)$$
$$y = a(1 - cos\theta) \tag{3}$$

Here $a$ and $\theta$ are the radius and angular displacement of the generating circle respectively.

Upon differentiating both the equation with respect to $\theta$,

$$\frac{dx}{d\theta} = a\,(1 - cos\theta)$$
$$\frac{dy}{d\theta} = a\,sin\theta \tag{4}$$

If $S$is the distance A to B, we have

$$\left(\frac{ds}{d\theta}\right)^2 = \left(\frac{dx}{d\theta}\right)^2 + \left(\frac{dy}{d\theta}\right)^2$$

$$= a^2(1 - cos\theta)^2 + a^2 sin^2\theta$$

$$= 2a^2(1 - cos\theta)$$

Here we have

$$\frac{ds}{d\theta} = a\sqrt{2(1 - cos\theta)} \tag{5}$$

We also know that

$$v = \frac{ds}{dt}$$

thus,

$$dt = \frac{ds}{v}$$

Integrating on both the sides will give us the desired time of decent.

$$t = \int \frac{ds}{v} \tag{6}$$

From the principal of conservation of energy,

$$mgy = \frac{1}{2}mv^2$$

Here we have

$$v = \sqrt{2gy}; \quad where\ y = a(1 - cos\theta)$$

Thus

$$v = \sqrt{2ga(1 - cos\theta)} \tag{7}$$

Using equation (5) and (7) in eqn (6)

$$t = \int_0^{\pi} \frac{a\sqrt{2(1 - cos\theta)}}{\sqrt{2ga(1 - cos\theta)}} d\theta$$

Because at the top $\theta = 0$ and at bottom $\theta = \pi$ .
This will give usfinally

$$t = T_2 = \pi \sqrt{\frac{a}{g}} \tag{8}$$

Equation (8) providesthe time required for the mass *m*to slide along the brachistochrone from A to B. Here '*a'* is the radius of the generating circle of cycloid.

## Measurements, results and discussion

This was a modest experimental cum theoretical study on the well-known brachistochrone problem.
Measurements were carried out for the travel time of the mass *m* from point A to B on the straight line and also from A to B via C, the cycloid. Further, for the Demo apparatus we have, the lengths AO= 80 cm, OB = 130 cm, and the hypotenuse AB is measured to be 153 cm.At least 10 observations were carried out each for measuring time intervals $T_1$, $T_2$ and the root mean square error (RMSE) was determined.

While $T_0$ is found out exactly from equation (1), $T_1$and $T_2$are measured using the stop watchavailable in a mobile phone now-a-days. For $T_2$ we employed equation (2), in which the parameter '*a*' for this particular cycloid is obtained from the measurement of the curved length ACB which in our case is 167 cm.Table 1 displays $T_0$ as calculated from equation (1), along with the other two time intervals as measured and calculated presently. While, $T_0$ is the smallest of the three time intervals, we have $T_2 < T_1$.

| Time | Measurements (Sec.) | Calculations (Sec.) | RMSE |
|---|---|---|---|
| **$T_0$** | - | 0.40 | - |
| **$T_1$** | 0.78 | 0.77 | 0.007 |
| **$T_2$** | 0.45 | 0.47 | 0.001 |

Table 1: Estimated results Vsmeasurements with RMSE

It is clear from Table1 that the measurements are very much in accord with relevant theory, especially for the time $T_2$ for travel on the cycloid path. The cycloid path ACB is the brachistochrone.

Thus, a good satisfactory agreement can be seen between theory and experiment here. However, a study like this would be incomplete without discussion on the sources of error, not only in experiment but in the theory as well. Therefore we note that,

- Friction has been neglected, although it can beminimized.
- While the theory assumes *m* to be a point mass, the object in the actual Demo apparatus is a small hollow cylinder of about 8 cm length.
- Accuracy in the fabrication of the cycloid path in the Demo apparatus is not known. In order to check whether the curved path of the apparatus in the figure 2 is really a cycloid, it can be digitized from the photograph, to determine the equation of the curve. We have not attempted this presently.
- The time measurementscarriedout by using a mobile phone may involve human error.

In future, one can think of including smooth curves other than cycloid in the Demo apparatus for comparisons.

Thus in conclusion, this is a modest attempt to show how a simple scientific display item (Such as in figure 2) can be employed to carry out measurements using the stop watch of mobile phone, and a theoretical cum experimental study can be carried out.A short video of this Demo is available with the author.

## Acknowledgement

We are thankful to Prof. P. C. Deshmukh (Retd. IIT- Tirupati) for his valuable suggestions and comments on this work. We also appreciate the support extended by the Hon. Director of the Community Science Centre SPU, VV Nagar (Dist. Anand, Gujarat), for the brachistochrone Demo apparatus (figure 2).

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ARTICLE

# New dimensions of Assessing Students Learning in Physics

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## ABSTRACT

*Assessment is an important part of teaching-learning process. A summative assessment in physics using a usual paper pen test does not assess higher order thinking skills such as critical thinking and problem-solving attitude to a large extent which are essential for developing cognitive, affective, and psychomotor domains. Thereby, using different assessment tools such as Canva, Mindmup, Tagcrowd, Wordpress, Mentimeter, Go formative, Audacity, Flipgrid and Powtoon can help in meeting the desired objective of developing creativity and innovative thinking and further help in assessment of learning. Good assessment tools moreover can help in construction of knowledge if these are used as regular tools in assessment for learning*

## INTRODUCTION

Our education system has of late become mere a rote learning model wherein, there is everything old-the old system of teaching and the old system of evaluation. This has made our work force redundant in the global market which lacks the necessary skills required to attain jobs. What follows next is the increasing unemployment and rate of suicides among youth. We should not forget that our country has the highest youth population and if we could tap its potential in a good manner then we can surely create assets for our society and build a generation of leaders who would work in national development.

The National Education Policy 2020 is one such educational movement which focuses on bringing an overhaul into the education regime that could improve the quality of our education system. And, needless to forget that Assessment is an important aspect which guides the foundation of our knowledge. Of late, it has become summative type at all levels of education encouraging today's coaching culture. It is thus the need of the hour, to bring a paradigm shift in assessment techniques which could guide our generation towards creative and critical thinking and that is what exactly our NEP 2020 describes.

NEP also clearly mentions about the pivotal role Technology plays in bringing about the paradigm shift in education. Moreover, technology can provide different sets of assessment techniques which will help in developing critical thinking aspects and by which assessment can be made such that it is holistic, integrated, enjoyable, and engaging [1].

## DIFFERENT ASSESSMENT TECHNIQUES

The basic and the fore most question is how to change the way we are teaching and assessing Physics learning at present. We are generally so used to teaching using boards and assessing using the usual paper pen tests that we have forgotten whether it is leading to development of required skills among our students or not. The need of the present hour therefore

is in exploring technology a bit. There are different assessment tools which are available online such as Mindmup [6], Mentimeter [2], Go formative [3], Flipgrid [4] and Powtoon [5] which help in developing creativity and innovative thinking and are useful in assessment of learning. These tools are discussed one by one;

**Mentimeter:** Mentimeter [2] is basically a presentation tool wherein short assessment can be done. This tool can have a teacher controller as well as a presenter controller option. In real time, all the students can be assessed. It can be used in making multiple choice, word cloud and open-ended questions. It can also be made into quiz type wherein students will get points for answering. In Mentimeter, you can even add time limit for each question. Basically, for using Mentimeter in teacher-controlled mode, all students should join at the same time frame. And in teacher-controlled mode, teacher being the controller and in case the teacher starts and some students have not yet joined then those students will not be able to assess the missed questions again. Also, students must be instructed to join with their own full name only. This at many times creates problem for the evaluator or the teacher to comprehend the result. This tool is fun to use especially for short type of questions. It's more type of a game wherein students can have fun while learning as it is an interactive presentation software. But teacher should be very careful in its use or while assessing as when administering the test to the students as the teacher presses or clicks, the question item gets changed.

**Google forms** is another tool that can be used to make quiz-based assessment. Different types of questions can be framed and point values can be attached to them. It evaluates the tests on its own if it is quiz based. Moreover, Google forms can work out best when the test result is not displayed as the test of a student ends. Rather result should be sent by mail or attached using Google Classroom after the time limit is over for the whole class. Although, MCQ's can be best tested using this tool but other subjective questions can also be asked and later the teacher can check them and display the result using Google Classroom. Using Google classroom, enables the teacher to display the result of any test to individual students on their dashboard. No other student can have access to it.

**Goformative** [3] is another tool which works in real time space. Using this tool, the teacher will come to know in real time which student has started attempting and is writing what. This can work as a good tool in assessing student's knowledge.

**Megaeaxms** is also a tool which can be used. For using this tool, all students who needs to be assessed, should be added into the teacher's login account of Megaexams. This enables the teacher to get comprehensive report of the class for every test which can help in tracking the class progress. Also, each student will have their own login credentials and teacher can change them as per his/her choice. Teacher can send the login credentials by mail to each student automatically. Also, in Megaexams, there exist a question bank. Questions can be taken from the question bank or teacher can build own questions.

Mentimeter, Goformative, Google forms all come under the same category of Quiz based assessments. Microsoft forms [8] can also be used to create quizzes. Testmoz [9] is another application which can help in building graded tests online. Testmoz interface is such that it would feel that teacher is checking individual papers. It is time bound type assessment and incase the student exceeds the time limit, then it will show on teacher's dashboard. Some of the tools of Testmoz are free to use. The teacher can moreover change the settings as per his/ her choice and administer the test just by sending the link of the test at the starting time of the test using e-mail or whatsapp. Also, in this the students cannot go back to the previous question if they wish to and the teacher even can shuffle the order of questions using this online tool. Classkick [10], PaperShala [11] and exam.net [12] are other such tools in the same category of assessment.

But why the assessment should only have to be written type. Why can't that incorporate other tools which can make learning fun to do with. So, next in the category are video /audio based, blog based and visualization-based assessment tools which are equally good and fun to deal with.

**Flipgrid [4] and Powtoons [5]** are video based assessment tools wherein students can make short, animated videos to demonstrate their knowledge and skills learned. In flipgrid, a discussion topic is created and shared with the learning community. Learners record and share short videos while developing their own learning.

**Powtoons [5]** can also be used to make animated videos. Teachers' can judge student's knowledge about any topic by asking them to prepare presentations on that topic.

**Audacity** is an audio-based assessment tool which can help students in developing communication skills. Students can put their views in the form of an audio and all the student's community can communicate with each other through audio messages.

**WordPress** [7] is a blog-based assessment tool wherein student's communication skills, data handling and inference abilities will be judged. Using this tool, students can learn from each other. The teacher or the other students can post some questions in the blog posts. The other students can think about that question and then put forth their ideas on it. This way a discussion can continue on the topic being posted which can help in constructing knowledge about the topic in hand. Moreover, in google classroom also there is an option to put questions. In this way, students can reply to the teacher and they can reply to each other as well. This helps in building a sense of community among students where they can think about queries of others as well as build their own knowledge base.

**Mindmup** [6] on the other hand comes under the category of visualization-based tool wherein students would be assessed upon their knowledge by making mind maps related to a topic in hand. Students would visualize everything related to a topic and then connect all those in a single picture. These mind maps help the students in better understanding of the concept by linking it to other concepts. Mindmup has tools like arrows, square, rectangle which can be used for interlinking concepts. After making a mind map

online, the student can share their creation using link with others.

This was all about various tools. Now considering a practical example, while practically applying these tools to practice, a test was prepared on the topic- "Resolution of vectors, scaler and vector product of vectors" using Testmoz and was administered on a group of 47 students of eleventh standard. The test was scheduled for 10 minutes duration and the same information was provided to the students earlier through WhatsApp. The questions that were tested were of MCQ and open-ended type both. Moreover, open ended questions were chosen such that they do not involve much mathematics as mathematical values makes writing a bit difficult in online mode. The below image shows the dashboard of the Testmoz tool-

Each time the duration of the test was decided, keeping in mind the type and complexity of the questions. At the time when the test was scheduled, the link of that test was sent to the students through WhatsApp. The students just have to open the link in their browser and then they can take the test. Generally, while using Testmoz students just have to enter their name. The proctor can if they want ask for other details instead of name. Also, there is an option to fix a passcode for every test by the proctor. Moreover, the Testmoz interface is such that it tells the timings when a particular student started and ended the test. Thus, for all those students, who completed the test within the given time frame, their test was evaluated and the marks were shown to the student individually using their Google Classroom account. But the objective questions are evaluated on its own in this interface whereas subjective questions are to be evaluated by the teacher and marks are to be attached. The most important question which pertains here is how and from where the questions are to be selected. Ideally, a teacher should make his/her questions on the topic and incase taking questions from already existing source then the language and mathematical values should be changed.

Thus, though technology goes a long way in knowledge construction and evaluation but still there are some loopholes which every teacher must address. Likewise, the questions which teacher give to the students should be framed in a different manner and with mathematical values changed so that the students cannot find the answers online.

## CONCLUSION

For developing critical thinking attitude, it is at most important to assess student's learning on different grounds and parameters and using different tools. In this regard, teacher's need to work a lot on designing different assessments using a variety of tools catering to students' needs. The need of the hour not only lies in providing teacher with the tool but also with the know-how of how that tool works. Also, the teacher needs to change the question type and assess student's knowledge by building different forms of the same question. This way student's knowledge can be assessed in perfect form. And, it is important and imperative for a teacher to understand that not one tool will go hand in hand and work always. Rather, a teacher must work on different sets of tools to assess students' knowledge base.

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**TRIBUTE**

# A Homage to Dr D P Khandelwal

I am delighted to write a few words in sincerest homage to the great visionary, maven of teaching profession, Professor D P Khandelwal, who was ardently interested to bring all physics teachers across the country, north to south & east to west, into one fold - IAPT, a completely voluntary organization. He, thus, imparted a massive momentum for development and betterment of Physics teaching and learning at all levels. He took pains to enhancing performance of both teaching and student community.

I vividly remember those two days when he had academic discussions with our faculty as he came to visit our Department in late nineteen eighties; he immediately struck me as a person concerned and worried, as I capitulate, about diminution of teaching standard, in general, and declining quality of laboratory (experimentation) teaching, in particular. And, while I was Vice President of RC-7, we had conducted, following his advice, a seminar on 'Understanding Physics' at Physical Research Laboratory (PRL), Ahmedabad in presence of late Dr. Sudhir Pandya, late Dr. Babulal Saraf, Dr. Madhuben Shah.

Today is 100 years of his birth and, eventually, 25 years of passing of his death - he passed away rather, unfortunately, too early to inspire more young teachers. On this occasion, I extend a huge bunch of sincere tributes to him.


**S K Arora**
Crystallography scientist,
Formerly Professor of Physics
Sardar Patel University
Vallabh Vidyanagar Gujarat

# Dr. D. P. Khandelwal
**(In USA, 1988)**

**L-R: Mira Bajpai, Mrs Khandelwal, Dr Khandelwal, Shyam Bajpai, son/Vipul. Our older son Vivek is taking photo, August 1988**

Dr D. P. Khandelwal, the founder of IAPT, was a great visionary, who connected people from all over India. The entire community is beneficiary of his hard work and vision. This idea of celebrating his 100$^{th}$ birth anniversary made by IAPT is laudable. On this occasion I would like to share my own experience in association with him.

I took admission in M.Sc. at Agra College, Agra in 1968. I applied for tuition fee waiver. Dr Khandelwal was the head of the department. He called me for an interview in his office. I explained to him that my father just retired and our family cannot afford to pay the tuition fees. He listened to me and approved tuition waiver. This was my first impression about his kindness, leadership and visionary qualities. In 1969, He joined HBTI, Kanpur. After completing my degree, he helped me getting a teaching job at Kanpur, where I spent next few years. This is where, I became close to him and his family. I left Kanpur for Ph.D. at IIT Delhi. I completed Ph.D. in Magnetostatic/Microwave Excitation and Propagation and came to USA in 1981.

Initially, I joined Westinghouse Research and Development Center, Pittsburg. Clarence Zener, inventor of Zener Breakdown/Diode, was once Director of Research at Westinghouse (1951-65). In 1983, I joined the Faculty of Electrical Engineering, at State University of New York at Stony Brook University. Around this time, Dr. Khandelwal, founded the IAPT and asked me to become life member and I did. In 1988, Dr Khandelwal wrote to me that they will be travelling to London, USA and Canada in July/August. I wrote to him that we will be honored to

welcome at our place and take you around. Dr Sahab and Aunti ji arrived from London and stayed with us at Stony Brook, Long Inland, New York, for a week. **On First day**, in evening, I took them to Mall. There were no shopping malls in India those days.

**On Second day,** I took them to New York City, about 90 minutes' drive. We visited Statue of Liberty, World Trade Center, United Nations. He insisted to see Central Park, so we took them to Central Park, a unique identity of Manhattan, NY City. My wife, Mira still remembers that there was short rain while we were visiting Statue of Liberty, we all got wet. At the end of the day, I drove back to Stony Brook. **On the third day**, I invited some Indian families for dinner in evening at our place. Most of us were associated with Brookhaven National Laboratory (BNL) and Stony Brook University. Dr Khandelwal enjoyed the gathering, professionally and personally, Aunti ji also enjoyed, They were able to find common connections; he was very happy with the meeting.

**On Fourth day**, I took him to the University Campus. Prof Ram Srivastav, took us for lunch in cafeteria. Then, sitting in my office, he made few phone calls to some people: Dr Harish Pant, Dr Alok Kumar, one in Rodhe Island. He wanted to meet his relative Mr Rawat in Maryland. On **Fifth day**, we drove them to Washington D.C, 6 hours drive. I was driving and Dr Khandelwal was reading the map and giving me directions, he was always 100% accurate. In evening, we dropped them at the home of Mr Rawat in Maryland, 25 miles before Washington DC. I and Mira, stayed with our IIT/D friend. **On Sixth day** Rawat family took them to DC for tour. On **Seventh day**, I picked them up from the home of Mr Rawat and drove to Scranton, Pennsylvania. This is where, I put them on Greyhound, luxury coach Bus for Syracuse, New York - about 3 hours journey. (Late) Dr Ram Das Choudhry of Oswego University came to pick him. He stayed for few days with them and then was picked by his relative in Canada. Sending them off was emotional to me. I came back home after 3 hours drive. Dr Sahab said that this was his second visit to USA. I have met so many people in my life, but only few have inspired me to the extent that it stays so long and fresh; Dr Khandelwal is one of them. His creation of IAPT, is incredible effort and he did it with dedicated leadership for the good of subject and students. It was a most difficult undertaking. It is almost impossible to re-create. As time moves, Dr. Khandelwal's, creation of IAPT will be more and more admired.

In 1991, I got an opportunity and joined National Oceanic and Atmospheric Administration (NOAA) to Lead the Future Weather Satellite Systems Development. So, we moved to the State of Maryland and retired in 2014. Below is the memory in photo. I feel that I am talking to them.

**Shyam N. Bajpai Ph.D**

Maryland, USA.

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**TRIBUTE**

## My teacher - Dr D.P. Khandelwal

I had the good fortune to be a student of Prof. D.P. Khandelwal when I joined Agra College for my Masters Degree (1969- 1971). He was held in high regard as a professor of Physics by the staff and students. But I could sense something extraordinary in his attitude. His passion for the subject came across vibrantly. Here I want to tell you about his love for books and his concern for those who might not be so privileged as to bear the high cost of books.

A very special feature of his concern for the students was a special scheme. Quality books were costly for the student like us who came from ordinary middle class family. He provided one open shelf in the departmental library for M.Sc. students. Our Physics

departmental library had an independent access in the college campus. He ordered that all teachers have to give the list of books referred to by them in M. Sc. Previous and final classes on that very day to the library clerk. He would put at least one copy of each in the open shelf. Any student of Physics who wanted to stay in the library after the college is over to consult books and make notes was allowed to stay and was supposed to sign on the card attached to the keys of the open shelf and the door of the library. This was given to the student himself. When he wanted to leave he would have to find that student who was going to stay longest and get his signature on the card before handing over the keys to him. If the last student left the library before 11 p.m., he was supposed to go to nearby Raja Mandi crossing to Prof Khandelwal's official residence to return the keys. But in case it was late, he might keep them but had to return the keys before the college reopened next day. The only guarantee taken was that in case of any misbehavior or if any book was found lost, the facility would be discontinued. During my two years stay in the college, I prepared all my notes in the library sitting every day after my dinner from my hostel, Bhargava Hostel or Old boys hostel as now it is called. Such was the concern and trust of my Guru.

After my M.Sc. I joined St. John's College Agra for Ph.D under Dr J.K. Ghose, Agra College was better equipped with research journals, so Dr Ghose wrote a letter requesting Dr Khandelwal to allow me to use his library. When I produced that letter before him, Prof. Khandelwal immediately wrote "permitted" and said ' 00you are my student too' and there was no need for any recommendations.

Dr D.P. Khandelwal was the teacher of teachers. As he mentioned in several seminars and summer institutes, he wanted to improve the quality and dedication of the teachers for their profession. It is mentioned by several other authors in earlier IAPT bulletin.

Post graduate classes in St. John's College started in 1966. Dr J.K.Ghose and Prof G .M. Ram were instrumental in making the post graduate laboratory almost from scratch. Dr Khandelwal along with Dr Ghose designed some innovative experiments for undergraduate classes. Dr Khandelwal redesigned the syllabi of Agra university. In June 1971 a summer institute was organized for this purpose at D.S.B. College Nainital. We carried all the laboratory material from our college to Nainital. Based on the work done there, Dr Khandelwal later wrote a book " A Laboratory Manual of Physics, Vani Educational Books (1985)..

In 1971, I joined the Physics department of St. John's College as a lecturer. I was also one of the founder members of IAPT. After few years I was made the Joint Secretary and given the responsibility of ELCB (Extra Low Cost Books) scheme. He taught me that in order to convince the publishers to agree to supply their books at reduced cost of 40% of the printed price, I should tell them that this programme is to help them to give free sample copies. Here the interested teacher was paying at least 40% and is sure to go through these books. This logic served the purpose of the publishers too.

Prof. Khandelwal was a person of high internal strength, would continue to work untiringly even when he was not well. I bow my head to such a wonderful personality.

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# Dr. D. P. Khandelwal 100th Birthday Celebration

This year, on October1, IAPT members came together for 100th birthday celebration and remembrance of late Dr. D. P. Khandelwal, the founder of IAPT. The programme was hosted on Zoom platform by Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore. The event started at 4:35 p.m. with the welcome address by Dr. P. K. Dubey, EC member of IAPT RC – 9 (Madhya Pradesh) and lighting of lamp followed by Maa Saraswati vandana. Post that ,President of IAPT Prof. Vijay A. Singh and General Secretary Prof. K. N. Joshipura along with Hon'ble Vice Chancellor of SVVV Prof. UpindraDhar paid homage to Dr. D. P. Khandelwal by putting virtual garlands on his portrait.

After that Prof. Upinder Dhar was invited for the inaugural speech. Remembering Dr. D. P. Khandelwal, Prof. Dhar stated that he was a great scientist and a noble soul. He briefly narrated about the academic and social activities of Shri Vaishnav Trust. He was thankful to IAPT for its collaboration with SVVV and also invited everyone for the 35th Annual Convention of IAPT ( 28 – 30November 2021). Prof. Vijay A. Singh also welcomed all the participants and shared the memories of his association with IAPT right from the initial days of its establishment. He emphasized on the most important characteristics of this organization i.e. volunteer work and democratic body. He praised Dr. Khandelwal for his visionary initiative in the establishment of this organization. Prof. K. N. Joshipura, General Secretary of IAPT described the structure of IAPT and the various programme and activities organized for the teachers and students by its members. Then Ms. ShivaniMisra, a Research Scholar in Physics, from MB Govt. PG College, Haldwani, beautifully recited a poem entitled "*SWADESH*" written by Dr. Khandelwal.

Dr. S. C. Samanta presented an overview of Birth Centenary activities organized by various groups and different RC's. The NGPE 2020 Part C was dedicated to Dr. D P Khandelwal. RC 15 observed 99th Birth Anniversary on 1st October 2020. IAPT formed Dr. D P Khandelwal Birth Centenary Celebrations Committee under the convenorship of Dr. S C Samanta. This committee organised National Science Show on Zoom platform with the collaboration of SVVV Indore, on 28th February and 1st March 2021 by showing videos of Science Stage Shows. Dr. Samanta also reported the activities organized by RC 04, NANI, RC 03, RC 15, RC 08 and RC 07. An Innovation Hub was inaugurated at CSC Midnapur on 27th September 2021 and a series of webinars were also conducted from 27th to 30th September 2021.

Prof. P. K. Ahluwalia in his presentation paid tribute to Dr. Khandelwal by designating him as 'Visionary of Reformation in Physics Education at Grassroots Level'. In his power point presentation he showed some old pics and scanned images of first issue of IAPT bulletin and explained all the difficulties and tough times experienced by Dr. Khandelwal and some other devoted persons like Prof. Babu Lal Saraf, Dr. R. N. Kapoor, Prof. Tarnekar, Prof. Kushwaha and many more. Prof. Ahluwalia also showed hand written letters which were communicated between him and Dr. Khandelwal.

After this Prof. T R Anantkrishnan demonstrated and explained Atomic Pressure followed bythe presentation of Dr. Poornima of St. Paul's College who showed the method of measuring Atomic Pressure. The topic of the second video was 'Study on the Refraction of Light through a Medium with Spherical Boundaries' by Ms. Sheba A. PGT in Bhartiya Vidya Bhavan School, Kozhikode, Kerala.

The Chief Editor of IAPT Bulletin, Prof. U. S. Kushwaha shared his memories and experiences while working for IAPT during its early years. He was the student of Dr. Khandelwal during his M.Sc. Physics at Agra College Agra in the year 1952 to 1954. Prof. Kushwaha also narrated the story of beginning of National Standard Examination in Physics (NSEP) as

he was the first coordinator and in a span of just four months he managed this herculean task with the help of his colleagues in Panjab University Chandigarh. The first NSEP was held on 25th January 1987 while the prize distribution ceremony was held on 9th June 1987. The chief guest of the ceremony was Hon'ble President of India, Sardar Gyani Zail Singh.

The programme was concluded with the vote of thanks presented by Dr. Sanjay Kr. Sharma.

The event was also attended by the family members of Dr. Khandelwal. His son Mr. Anil Khandelwal, daughter Ms. Mita and grandson Mr. Akshat also shared their memories and were thankful to IAPT for giving this tribute on the 100th Birthday of Dr. D. P. Khandelwal.

**Sanjay Kr. Sharma**

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# Khandelwal Birth Centenary Celebration Activities – An Overview

**Initiation of the Celebration**

President Prof Vijay Singh at the end of the first virtual meeting of the IAPT Executive Council in June, 2020, announced the celebration of the 99th birth anniversary of Dr D P Khandelwal on 01.10.2020. This time Prof B P Tyagi, was thinking of conducting the NGPE Part C. So a small group, NGPE Part C group, of IAPT members, mostly associated with Midnapore CSC, founded by Dr Khandelwal, was formed. This group resolved to conduct the NGPE Part C -2020 as well as to celebrate the Khandelwal Birth Centenary (KBC).

It was really challenging to set up a question paper based on experiment (s), new to each examinee, particularly in the pandemic period. Ultimately, it became possible and the paper was vetted, as regards its standard and difficulty level in a meeting of an all India group of experts. The examination was successfully conducted on 21.08.2020. The examinees performed the experiments, keeping Smartphone camera on, so that the expert group could proctor their performance. After the examination was over the students uploaded their answer scripts in the Google classroom; the experts evaluated them digitally. PK College, Contai, East Midnapore, WB - the virtual examination centre provided the online platform.

Delighted by the success of the above exercise, the organizers dedicated NGPE Part C 2020 to the memory of Dr Khandewal, who designed this format of evaluating the experimental skill of the toppers of NGPE.

Afterwards, an online competition in physics practical for 100 HS students was conducted successfully by IAPT RC 15 in his memory, following a similar procedure. This showed that if the examination authority decides, it is not difficult to conduct even an online skill tests for aspiring engineers also. In fact, Dr Khandelwal cherished a dream of such tests and this was the reason that led him to devise NSEP Part C and NGPE Part C in the nineties of the last century.

**KBC Celebration on 01.10.2020**

West Bengal Regional Council (RC 15) decided to celebrate the 99th birth anniversary of Dr Khandelwal virtually. The platform was managed by Dr P Panchadhyayee, while Dr B Chakraborti coordinated the event. Prof Vijay A Singh and Prof K N Joshipura respectively President and General Secretary of IAPT; Prof H C Pradhan, past president of IAPT; Prof P N Ghosh and Prof G P Das respectively past and present president of IAPT RC 15 along with Prof S Lokanathan, colleague of Dr Khandelwal in Rajasthan University, Jaipur, were the dignitaries who attended the meeting and remembered Dr Khandelwal.

**Formation of the D P Khandelwal Birth Centenary Celebration Committee (DPKBCCC)**

In November, 2020, the IAPT announced a committee with Dr SC Samanta as its Convener. The first meeting of DPKBCCC was held on 7th and 8th December, 2020. All

the nine members: Prof V A Singh, Prof K N Joshipura, Prof R Ghorpade, Prof R Bhattacharjee, Prof Y K Vijay, Prof S B Welankar, Dr S K Sharma, Dr T R Ananthakrishnan and Dr S C Samanta attended the meeting.

Meeting on the first day was adjourned mid-way after getting the shocking news of the sudden demise of an IAPT stalwart Prof R M Dharkar.

The following activities were proposed as part of the celebration:

I. Science Stage Shows on National Science Day, 2021 to be coordinated by Dr T R Ananthakrishnan, a senior EC member of IAPT and a noted Show Master.

II. Publication of Biography of Dr Khandelwal, his Collected works and Commemorative Works to be initiated by Professor Y K Vijay, who was associated with Dr Khandelwal over 20 years.

III. A national level Survey to understand status of Lab based physics education and online competition on physics practical for HS students at the RCs with Dr S C Samanta, who had the experience of organizing such a competition on behalf of RC 15, as the Coordinator.

IV. Documentaries on CSC, Midnapore and Anweshika to be produced by the respective organizations.

V. Asian Physics Olympiad -2022, dedicated to DPK will be hosted by IAPT and Prof R Bhattacharjee will coordinate this prestigious event.

VI.The RCs would organize webinars with the themes, mostly consistent with the thought of Dr Khandelwal. His long time associate of Prof Vijay would help to suggest the themes, if asked for.

**Outcomes – an Update**

I. *NSD programme*: Dr T R Ananthakrishnan efficiently conducted the event renamed Khandelwal Science Stage Shows (KSSS) on 28.02.2021 & 01.03.2021. Altogether 08 presenters - Dr B N Das, Dr B. Chakradeo, Dr P K Dubey, Prof Sow (of Singapore National University), Prof H C Verma, Dr T R Ananthakrishnan, Prof Y K Vijay and Prof Sarmistha Sahu presented their shows. Prof R Bhattacharjee presented an APhO Experiment; 16 videos had been uploaded in the IAPT YouTube channel.

II. *Publication of Biography, Collected works, Commemorative Volume:* Implementation of this task is a slow process and Corona has made it slower. Till date, around 10 reminiscences have been published and some more will appear in November issue of our Bulletin.

III. *National Level Survey on the Status of Physics Labs & Physics Practical Competition at HS level* : Survey documents have been prepared after intense discussions among Prof R. Ghorpade, Dr K S Mann, Dr M Sayal, Dr P K Dubey, Dr O P Sharma, Dr V Wagh, Dr S K Sharma, Dr P Panchadhyayee, Dr S M Hossain and Dr S C Samanta. Dr K S Mann and Prof R Ghorpade are designated respectively as Editor and Co-editor of this Survey. The questionnaires have been communicated to the target groups. Last date of submission was 30.09.2021. But response is very poor, so it has to be extended.

Physics practical competition at HS level would be organized in the coming months.

IV. *Documentaries on CSC and Anweshikas:* No tangible work has been done. Only a remarkable job has been done by Prof Vijay. He has added to CSC, Midnapore, one of his Innovation Hubs; he personally visited Midnapore to dedicate it on behalf of RC 6 and Centre for Development of Physics Experiments, to Dr D P Khandelwal, the founder of CSC, Midnapore College.

Both CSC and Anveshikas are to be pursued to produce documentaries in the coming months. National Anveshika Network of India has undertaken some activities on photoelectric effect for celebration of the 100 years of the Nobel Award to Einstein as a KBC programmes.

V. *Asian Physics Olympiad 2022 dedicated to Dr Khandelwal*: IAPT is determined to host APhO- 2022 in collaboration with Graphic Era Hill University, Dehradun, UK, as the venue. Right now an intense preparatory activity is going on in Dehradun in this direction in the premises of GEHU.

VI. *Activities at RC Level*: Some RCs and individual

IAPT members have done indeed some wonderful activities dedicated to Dr Khandelwal. Very brief account of them is given below:

A) Dr S Singh, Secretary, UP RC (04) has reported a commendable job they have done in organizing a students' friendly Workshop in this Corona period. Usefulness of this 'Revision' Workshop has been revealed through a long time interaction among the student- participants and the speakers. Other RCs may follow UP in this regard. UP RC has also organised a good number of activities to celebrate the 100$^{th}$ anniversary of Nobel Award to Einstein involving some Anweshikas under the stewardship of Prof H C Verma, Vice President, IAPT.

B) Dr C N Kumar, President, Himachal Pradesh & Chandigarh RC 03 has reported some activities mostly in the computational physics in the domain of theory but with reference to their applicability in experimental physics. It may be noted that in one experiment in the recently conducted NGPE Part C 2021, the examinees used the tracker software for analyzing data; they had captured having used smartphone. DPKBCCC also organized four Webinars on the use of softwares in doing physics experiments (27$^{th}$ to 30$^{th}$ September).

C) Even in the absence of evergreen, enthusiastic and effective IAPT member Dr T. Pandya, (who did a commendable job in organising NGPE Part C 2020 on August 21, 2020), as reported by Prof Joshipura, Gujarat RC 07 conducted a good number of webinars and experiment based activities and published an e-book also, - all for paying homage to Dr Khandelwal in his birth centenary year.

D) Prof R Ghorpade, an EC member of IAPT has reported that Maharashtra SRC (08B) organized a Summer School involving 84 college student- participants from across the country in the last summer for 12 days on computational physics, as a tribute to Dr Khandelwal. Prof P D Lele of Gujarat University (Retd) delivered inaugural lecture on this pan India event which was initiated by him and concluding lecture was delivered by Prof P K Ahluwalia of Himachal Pradesh University (Retd). The Course of the School covered theory including computational physics as well as experiments. A team of renowned physics teachers efficiently managed the activities from a digital platform as Resource Persons.

This SRC also organized a Workshop on "Experiment from Home" for 85 high school teachers. Ms Susmita Meta who was a participant of this Workshop has reported that she designed in this workshop some low cost HS experiments. This testifies that a willing teacher can do a lot of experiment related activities while staying at home.

E) MP RC 09 always extends its helping hand for conducting the DPKBCCC activities from online platform together with SVVV, Indore. It is presumed that MP has done some works in paying tribute to Dr Khandelwal but no report has been received. But the MP RC is going to host the IAPT Annual Convention, dedicated to the memory of Dr Khandelwal, together with SVVV , Indore.

F) Rajasthan RC 06 led by Prof Y K Vijay has taken a vow to do enough activities remembering his association with Dr Khandelwal of more than twenty years; very recently, he went to Midnapore to establish an Innovation Hub at IAPT Midnapore College CSC in his memory as a joint activity of IAPT RC06 and CDPE, Rajasthan University.

G) Most of the activities of RC15 regarding KBC have been detailed elsewhere, but still initiatives of some individuals from this RC are mentioned below:

Dr B N Das, conducted around 30 activities, and Mr Debmalya Sen and Nanigopal Mandal organised some progammes to celebrate the 100 years of Nobel Award to Einstein, on behalf of National Anweshika Network of India, dedicated to Dr Khandelwal. Mr Sen also designed and developed a good working model for electroscope.

H) Karnataka RC is quite active, it is right now busy in hosting the National Students' Symposium dedicated to Dr Khandelwal.

**Recent Activities**

Like 2020, the NGPE PartC 2021, dedicated to Dr Khandelwal, has been conducted successfully on 21.08.2021 with CSC, Midnapore College as the host and Dr M N Goswami as the Incharge.

As a prelude to KBC celebration on 01.10.2021, Prof Y K Vijay established an Innovation Hub at CSC, Midnapore on 27$^{th}$ September, 2021. Webinars have been organized on September 27$^{th}$ & 28$^{th}$ on the use of software and Smartphone for doing physics experiments. The 100$^{th}$ birth anniversary of Dr Khandelwal was celebrated on 1$^{st}$ October, 2021 with active participation of Prof V A Singh, Prof K N Joshipura, Ms Shivani Misra, Dr S C Samanta, Prof P K Ahluwalia, Prof U S Kushwaha and Dr S K Sharma in presence of a galaxy of dignitaries and family members of Dr Khandewal. Dr P K Dubey and Dr U Sharma together managed the13 online platform and abchored the entire event.

*(Separate reports for each event are in the preparatory stage and would be communicated for publication in the Bulletin)

**Activities in the Coming Months**

Due to pandemic reasons, IAPT could not undertake many activities, so it has decided to continue the centenary related activities till the IAPT Annual Convention 2022. Hence in the coming months, apart from completing the unfinished works, the IAPT shall have to

organize some academic programmes as mentioned below:

I) From each RC some dedicated HS school teachers have to be identified, who would motivate some of their students to perform selected low cost experiments while staying at home, even in absence of Covid. For selection of experiments the following manuals may be consulted: a) DPK: UG Lab Manual, b) IAPT Manual: Operation Physics Through Experiments, Authored by D A Desai, R M Dharkar and B A Patki, and c) NCERT Physics Lab Manuals for XI & XII. The experiments developed over the years in CSC, Midnapore and Anveshikas can also be used for this purpose. Such exercises would create conducive environment for doing experiment at the grass route level- a scenario Dr Khandelwal dreamt of.

II) About 8000+ Atal Tinkering Labs (ATLs) have been established in the country by the Govt of India. They have good material resources appropriate for Model To start with DPKBCCC would have to pursue each RC to prepare a list of ATLs in its geographical jurisdiction. Then the ATLs would be requested to demonstrate the experiments in basic sciences they have developed using ATL facilities. These ATLs have rich resources which IAPT can explore for organizing school level activities at no cost. In fact each ATL enriched with enough material resources can be considered as a model HS lab perceived by Dr Khandelwal.

The item I can be executed by any RC using the facilities of its neighborhood ATL (s), also. So fund is not an absolute necessity. Initiative is most important.

III) At the initiative of RC 6, Professor Vijay has established so far 25 Innovation Hubs in the country, some more are in the pipeline. Each hub has 25 experiments and most of them can be used for designing and developing new experiments. IAPT can organize programmes for UG students and teachers, based on these innovative experiments in the Innovation Hubs. The recent book, containing INPhO experiments, published by Homi Bhaba Centre for Science Education (HBCSE, TIFR), Mumbai can also be used for the purpose.

IV) Each RC can be pursued to organize programmes similar to NGPE Part C for a chosen small group of UG students.

V) Each member of the National Anveshika Network, India (NANI) can be requested to organize exhibition of the experiments they have developed so far in basic sciences.

VI) There are large numbers of NSEP Part C and NGPE Part C experiments accumulated over the years. A programme may be organized to exhibit all such experiments at different RCs.

VII) In CSC, Midnapore College, a large number of experiments at different levels have been developed as projects. The CSC may be persuaded to demonstrate those experiments from a national platform.

VIII) HBCSE, Mumbai, may be pursued to exhibit all the International Physics Experiments and Asian Physics Olympiad Experiments from an online platform, in a phased manner.

**Enough Resources at the Ground!**

It is a common saying in the IAPT parlor, that IAPT cannot undertake many academic programmes, particularly experiment based ones in the physical mode, because of limited financial resources. Undoubtedly, finance is a problem, but factually we are short of Human Resources. In the pandemic days, the senior teachers proposed the themes of the experiments needed for preparing the question paper for NGPE Part C. It is the young members who could design and test the experiments; only their dedication to IAPT work led to the preparation of the question paper and conduction of the examination successfully. Similar is the case of conducting 'online competition of physics practical at HS level, which was also successful only due to hard intellectual and physical labour of some dedicated teachers. IAPT have to create conducive environment so that these young members can flourish in their academic pursuit. This is the Khandelwal's approach of grooming the youngsters in the IAPT.

Recently, an ATL incharge approached CSC, Midnapore to help organize a Teachers' Workshop in physical mode using their resources -material and financial ; CSC has to provide Human Resources only. So, as in ATLs, we have the hidden Resources, we have to discover them. Eight activities mentioned above, can be undertaken if we really desire so. Factually, there are enough resources at the ground!

**Concluding Remark**

President Vijay A Singh has suggested to shorten the name of the committee from DPKBCCC to KCC, Khandelwal Centanary Committee. Hereafter, we shall refer to KCC instead of DPKBCCC. Thanks Professor Singh.

**Acknowledgement**

I gratefully acknowledge IAPT, particularly the President and the General Secretary for entrusting me to organize the KBC celebration. I have always got the support and confidence of all the members of DPKBCCC in conducting the activities with much liberty. In executing all the exercises, narrated in the above report, each one involved has done his/her part of the work with utmost sincerity; I convey my sincere gratitude to all of them.

**Subhash Chandra Samanta**
**Convener**

# The Story of Cosmology through Postal Stamps-07

## THE ANCIENT ASTRONOMY

**CHINA AND FAR EAST**

Cnihese astronomers were keen observer to celestial phenomenon and eager to detect even most minute change in their order or orientation, because they believe that it may affect the life of their monarch and his empire

Comet and its chinese symbol

Cheomseong-dae - (7th century)and Kwanchon-dae (17th century) observatory – South Korea

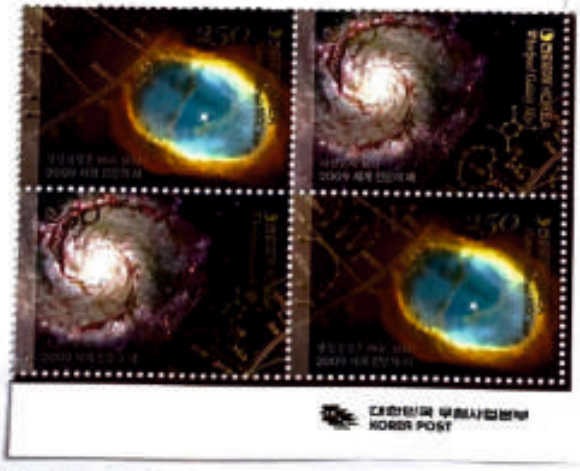
**Chinese Astro- Metrological devices (10th – 11th century)**

***Ancient Armillary Sphere Astrolobe***- At Imperial Astronomical bservatory(Beijing) designed by Guo-Shoujing(1271-1368)

***The dragon-tode Sesimometer*** (Houfeng Didong Yi) - 132AD created by astronomer Zhang Heng

**Odometer**- *Ji Ji Gauche* it is ancient Li recording drum carriage

***Early Compass-(400BC)***-Spoon is made of lodestone, its handle pointing toward South, mounted on brass plate with astrological symbols



***A block of Tete-beche pair on cover*** showing Whirlpool Galaxy M51 and the Planetary Nebula NGC3132 in the background of ancient diagram of constellation

First map of the sky with stars and costellation was prepared by ***Su Song*** in 4th century , which is showen in the background of IYA 2009 issue of South Korea

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