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This is the first high-resolution, colour image to be sent back by the Hazard Cameras (Hazcams) on the underside of NASA's Perseverance Mars rover after its landing on Feb. 18, 2021. A key objective for Perseverance's mission on Mars is astrobiology, including the search for signs of ancient microbial life. The rover will characterize the planet's geology and past climate, pave the way for human exploration of the Red Planet, and be the first mission to collect and cache Martian rock and regolith (broken rock and dust). The Mars 2020 mission is part of a larger program that includes missions to the Moon as a way to prepare for human exploration of the Red Planet.
(https://www.nasa.gov/image-feature/jpl/perseverance-s-first-full-color-look-at-mars)

PHYSICS NEWS

Searching for Dark Matter through the Fifth Dimension

Theoretical physicists of the PRISMA+ Cluster of Excellence are working on a theory that goes beyond the Standard Model of particle physics and can answer questions where the Standard Model has to pass. The central element of the theory is an extra dimension in spacetime. They found that the 5-dimensional field equations predicted the existence of a new, heavy particle with similar properties as the famous Higgs boson but a much heavier mass. It is so heavy that it cannot be produced even at the highest-energy particle collider in the world: the Large Hadron Collider (LHC) at the European Center for Nuclear Research CERN near Geneva (Switzerland). They discovered that their proposed particle would necessarily mediate a new force between the known elementary particles (our visible universe) and the mysterious dark matter (the dark sector). Even the abundance of dark matter in the cosmos, as observed in astrophysical experiments, can be explained by their theory. This offers exciting new ways to search for the constituents of the dark matter and obtain clues about the physics at a very early stage in the history of our universe, when the dark matter was produced.

Read more at: https://scitechdaily.com/searching-for-dark-matter-through-the-fifth-dimension-new-theoretical-physics-discovery-to-help-unravel-the-mysteries-of-dark-matter/

***Original paper* :**The European Physical Journal C (2021). DOI:10.1140/epjc/s10052-021-08851-0

'Magnetic graphene' forms a new kind of magnetism

Researchers have identified a new form of magnetism in so-called magnetic graphene. The researchers were able to control the conductivity and magnetism of Iron Thiophosphate (FePS3), a two-dimensional material which undergoes a transition from an insulator to a metal when compressed. Using new high-pressure techniques, the researchers have shown what happens to magnetic graphene during the transition from insulator to conductor and into its unconventional metallic state, realised only under ultra-high pressure conditions. When the material becomes metallic, it remains magnetic, which is contrary to previous results and provides clues as to how the electrical conduction in the metallic phase works. The newly discovered high-pressure magnetic phase likely forms a precursor to superconductivity so understanding its mechanisms is vital. Their results also suggest a way that new materials could be engineered to have combined conduction and magnetic properties, which could be useful in the development of new technologies such as spintronics, which could transform the way in which computers process information.

Read more at : https://www.sciencedaily.com/releases/2021/02/210208114309.htm

***Original paper* :**Physical Review X (2021). DOI: 10.1103/PhysRevX.11.011024

Researchers observe stationary Hawking radiation in an analog black hole

Theoretical physicist Stephen Hawking predicted that while nothing can escape from within them, black holes spontaneously emit a limited amount of light, which is known as Hawking radiation. According to his predictions, this radiation is spontaneous and stationary. Researchers tested Hawking's theoretical predictions by creating an "artificial black hole" in a laboratory. The artificial black hole created was approximately 0.1 millimeters long and was made of a gas composed of 8000 rubidium atoms. The Hawking radiation emitted by this analog black hole is made of sound waves, rather than light waves. When trying to identify the Hawking radiation emitted by the analog black hole they created, researchers looked for similar pairs of sound waves, one coming out of the black hole and one moving into it. Once they identified these pairs of sound waves, the researchers tried to determine whether there were so-called correlations between them. In one of their previous studies, researchers were able to confirm that the radiation by this analog black hole is spontaneous. In their new study, the findings appear to confirm that the radiation emitted by black holes is stationary. While these findings apply primarily to the analog black hole they created, theoretical studies could help to confirm if they can also be applied to real black holes.

Read more at :https://phys.org/news/2021-02-stationary-hawking-analog-black-hole.html

***Original paper* :**Nature Physics (2021). DOI: 10.1038/s41567-020-01076-0

Pankaj Bhardwaj

Friedrich Alexander University, Erlangen & Nuremberg, Germany

Letter to the Editor

Sir,

I have been a member of IAPT from 1987 (about 32 years). To date, every IAPT bulletin has been sent to me. It shows that PHYSICS is not an excellent subject only but the work of dedicated PHYSICS persons involved in it is also excellent. Salute and Thanks to IAPT.

T L Ramolia
Vadodara (Life Member)

DPK Birth Centenary Celebrations

As planned earlier, the KSSS (Khandelwal Stage Science Show) was successfully organized on National Science Day, Feb 28 and March 1, 2021 from an online platform. The Chief Guest was Dr. Upinder Dhar, Vice Chancellor, SVV Vishwavidyalaya, Indore. Those who presented their stage show (through pre-recorded videos) were, Dr B N Das, Prof B Chakradeo, Dr P K Dubey and Dr R Bhattacharjee on Feb 28 and Prof Sow Chong Haur (Singapore National University), Prof H C Verma, Prof Ananthkrishnan, Prof Y K Vijay and Prof Sarmistha Sahoo on March 1.

Those who participated in the programme included Prof Vijay Singh, Prof K N Joshipura, Dr SC Samanta and Prof S B Welankar.

The entire two-day programme can be viewed through IAPT you tube.

A detailed report will appear in the next issue.

S C Samanta

Understanding of Moon and Scientific Tools - an overview

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1. Introduction

Space is a difficult terrain to conquer, and the lunar surface lays polluted with many remains of unsuccessful attempts. Most of the failures are attributed to the lack of atmosphere on the moon, which renders parachutes useless. The landers on the moon's surface are left solely at the mercy of the thrusters during landing. Despite this difficulty, nearly 20 successful moon landing missions (nearly 50 including all types, lander, rover, impact, fly type, orbiter, *etc.*) have marked success [1]. Luna-9 launched by the Union of Soviet Socialist Republics (USSR) in 1966 became the first spacecraft to achieve a controlled soft landing on the moon. The first successful manned mission (Apollo 11) was launched by the USA in 1969 and the first human walk on moon has celebrated its golden jubilee. Later, the space exploration became an international affair and more countries joined the lunar club. Moon missions were started in Japan in 1990, Europe in 2003, China in 2007, India in 2008, and Israel in 2019. A fair amount of understanding has been developed about the moon and its surface, but many aspects still remain unexplored and unanswered.

2. Our Understanding on the 50th anniversary of the Moon Landing

The Moon is not only the Earth's natural satellite it is the closest cosmic body. Even when the Venus is closest to the Earth, it is more than 100 times farther away compared to the moon. Therefore, understanding Moon via Lunar missions can be considered as the first step towards the understanding of our solar system and the universe. More than a hundred missions to the moon have been conducted in last 50 years by space agencies worldwide [1]. Even Indian Space agency ISRO is not far behind. ISRO has come a long way in specialized low-costing space launches since the early 1960s, when the components assembled by hand were transported via bicycles and bullock carts. The reliability and cost- effectiveness allowed ISRO to launch a record 104 satellites in under 18 minutes, in 2017 [2]. Its Chandrayaan-2 mission lives on in the orbiter and will continue to orbit the Moon. On 30th July 2020, Terrain Mapping Camera – 2 (TMC-2) onboard ISRO's Chandrayaan – 2 captured the crater on the lunar surface in the north east quadrant of the Moon. Paying tributes to the Father of the Indian Space Program, Dr. Vikram Sarabhai on his birth centenary year, ISRO named this crater as Sarabhai Crater (Fig.1- see Appendix).

Data from prior lunar missions have made scientists to conclude that sunlight never shines on the floors of some craters near the moon's poles. These areas, known as permanently shadowed regions, have a much larger area in the south pole compared to the north pole of the moon. There is a possibility of the presence of water in these permanently shadowed areas. Chandrayaan-1 was India's first moon mission that discovered some traces of water on the moon. According to the ISRO, the south pole region of the moon has craters that are cold traps and may contain the fossil record of the early solar system. Due to the darkness on this side of the moon, water ice persists inside the moon's regolith (a top layer of fine-grained unconsolidated surface material) and at the bottom of the craters [3]. While mapping the moon NASA's Lunar Crater Observation and Sensing Satellite with the Lunar Reconnaissance Orbiter has indicated the presence of areas rich in metals like sodium, mercury, silver and titanium ore [4-6]. This makes south pole an untapped source of essential resources. Hence, present scientific investigations aim to study the lunar topography, mineralogy, elemental abundance, the lunar exosphere and signatures of hydroxyl and water ice.

3. Science on the Moon

The payload is a common term associated with every spacecraft or satellite. Payloads in general are the different scientific instruments carried by a satellite for predefined specific purposes. A satellite can carry multiple payloads to carry out different type of operations depending upon their weight. For orbiting type satellites, the payload is fixed to the lower orbiting satellite and for lander type missions it attached to the lander and/or rover arm. In either case the measurements that are conducted on the moon, in the original place of the material, are known as the in-situ measurements.

The kind of instruments those are taken to the moon mission or the payloads can be further classified based on their sensitivity, coverage area or position on the orbiter, lander or rover. An instrument capable of recording data remotely from the lunar orbits can be termed as orbiter payload. For measurements requiring closer proximity to the sample, the instrument can be placed on the lander or rover. Most common payloads in every mission are imaging instruments, which not only help in safe landing but also map the lunar surface. Terrain mapping cameras are used on-board primarily to map the lunar surface. Orbiter high-resolution cameras provide high-resolution images of the landing site and ensure the lander's safe touchdown by detecting any craters or boulders prior to separation. When it comes to the depth profiling, thermo physical experiment using a thermal probe (sensors and a heater) that is inserted into the lunar regolith, measures the vertical temperature gradient and thermal conductivity of the lunar surface with time. The RADAR payloads provide high-resolution lunar mapping in the polar regions and are used for the estimation of the regolith thickness and its distribution within the depth of penetration. Imaging infrared, visible and ultraviolet spectrometers not only provide data related to the mineralogical mapping of the moon, they also measure the solar radiation reflected off the moon's surface. Neutron Measurements at the Lunar Surface is another method to determine the amount of neutron radiation at the surface of the Moon by measuring the thermal and epithermal count rates. The amount of neutron radiation at the lunar surface help in understanding the Moon's near surface composition in terms of elemental abundances and hydrogen content [5]. Polar maps of lunar epithermal neutron counting rates indicating regions of enhanced hydrogen abundances by dark regions are shown in (Fig.2-see Appendix)

In analogy to the term earthquakes, quakes on the moon are called moonquakes. Different kinds of shallow or deep, thermal or vibrational moonquakes are frequent on the moon. Vibrational quakes occur when an object like an asteroid or meteorite crashes into the surface of the moon. Thermal quakes originate from the expansion of the frigid crust when first illuminated by the morning sun after two weeks of deep-freeze lunar night. Lunar seismic activity is monitored using a micro-electromechanical system MEMS-based seismometer that can detect minute ground displacement, velocity, or acceleration caused by lunar quakes. Large area soft X-Ray spectrometer measures the moon's X-Ray Fluorescence (XRF) spectra to examine the presence of major elements such as Magnesium, Aluminum, Silicon, Calcium, Titanium, Iron, Sodium and others. The XRF technique detects these elements by measuring the characteristic X-rays they emit when excited by the Sun rays. Solar X-ray monitors observe the X-rays emitted by the Sun and its corona every second. The lunar ionosphere is a highly dynamic plasma environment. Sensitive Langmuir probes have proven to be an effective diagnostic tool to measure electron density/temperature near the lunar surface as well as its temporal evolution under different solar conditions. Atmospheric compositional explorers use mass spectrometers to carry out in-situ studies on the composition and distribution of the lunar neutral exosphere and its variability. The temporal evolution of electron density in the lunar ionosphere is studied by radio occultation technique. In this technique, coherent signals from a satellite are received at ground based station network receivers. The phase of the radio signal, propagating from a satellite to the ground station, gets perturbed when it crosses through the planetary/lunar atmosphere.

Instrumentation requiring very close proximity to the object is placed on the rover arms, as these arms can be controlled from the base station on earth. More refined apparatus like alpha particle X-ray spectrometer determines the elemental composition of the moon's surface near the landing site. Using this spectroscopy technique, where X-rays or alpha particles are used to excite the surface and all major rock-forming elements such as Sodium, Magnesium, Aluminium, Silica, Calcium, Titanium, Iron, and some trace elements such as Strontium, Yttrium and Zirconium can be detected. Identification of different crystalline or amorphous phase compounds and their proportion in a mixture is carried out by Laser Raman spectrometers. Laser induced breakdown spectroscopy aims to identify and determine the abundance of elements near the landing site. It does this by firing high-powered laser pulses at various locations and analyzing the radiation emitted by the decaying plasma. Many other prototype experiments are underway to be used as future payloads.

4. Science off the Moon

Alternately, in manned missions, astronauts walk and/or drive on the moon with the help of lunar rover. They may collect and bring a lot of lunar samples (lunar soil, rocks, minerals, *etc.*) to the Earth for further studies. Many heavy instruments, which are difficult to carry as payloads are used for the ex-situ measurements on these lunar samples. These measurements on Earth can also be carried out in extreme/ different temperature, pressure or atmospheric conditions. Thousands of samples of lunar soil, basalts (flows of volcanic magma), breccias (welded debris from impact craters), and plutonic rocks (coarsely crystalline rocks of slowly cooled deep- seated) have been studied extensively across the globe. The collection of in-situ and ex-situ data from the lunar surface and lunar samples, and the findings of their combined analyses have led to our understanding of the moon. Thus, one can say that the technology, instrumentation, data collection techniques and analyses are the key ingredients to our understanding of the moon [3-6].

5. The Moon Race

The race to the moon is to grow by leaps and bounds in coming times. Lunar explorations from China, Europe, India, Russia, and USA are lined up with ambitious projects. While NASA (USA) hopes to build the Gateway and land astronauts around the moon's south pole by 2024, the ESA (European) is working on their Moon Village development project. Russia, after a long gap, hopes to build an orbital habitat - the Lunar Orbital Station, which will facilitate long-term missions to the moon surface. The China National Space Administration also intends to conclude the third phase of its lunar exploration program before investigating the South-Pole Aitken Basin, the largest known impact craters in the Solar System in its fourth phase. The new Israeli Beresheet 2 moon mission is planned for the first half of 2024.

Private companies are also contributing to the lunar missions. NASA has shortlisted nine companies to bid on delivering science and technology payload services to the lunar surface through Commercial Lunar Payload Service contracts. SpaceX, Blue Origin, and other private commercial aerospace companies are also hoping to establish their presence on the moon. With the worldwide race to the Moon, it is entirely possible that the travel to the Moon becomes safe, comfortable and affordable with time and a human presence may be established on the moon by the 2040s in the form of rotating research teams. Who knows? Despite so many challenges like lack of water, extreme temperatures, showering rocks (asteroid or meteorite) etc., there may come a time when the Moon could have human settlements [7]. Whichever way this may turn out, with cutting edge technologies and enhanced capabilities of scientific instruments coupled with computing power, finding water-ice reserves and obtaining more and more information (better understanding) about the moon still remains the ultimate goal of forthcoming lunar missions.

6. References

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[7]. Spacefarers - How Humans Will Settle the Moon, Mars, and Beyond, Christopher Wanjek. Harvard University Press, Cambridge UK (2020) ISBN:9780674984486

Latest Information on Lunar missions can also be found on the web sites of;

China National Space administration: http://www.cnsa.gov.cn/english/

Indian Space Research Organisation: https://www.isro.gov.in/

Israeli space organization: https://www.spaceil.com/

The *European Space Agency:* https://www.esa.int/

The Japan Aerospace Exploration Agency: https://global.jaxa.jp/

The National Aeronautics and Space Administration: https://www.nasa.gov

: http://en.roscosmos.ru/

The Roscosmos State Corporation for Space Activities

Appendix:

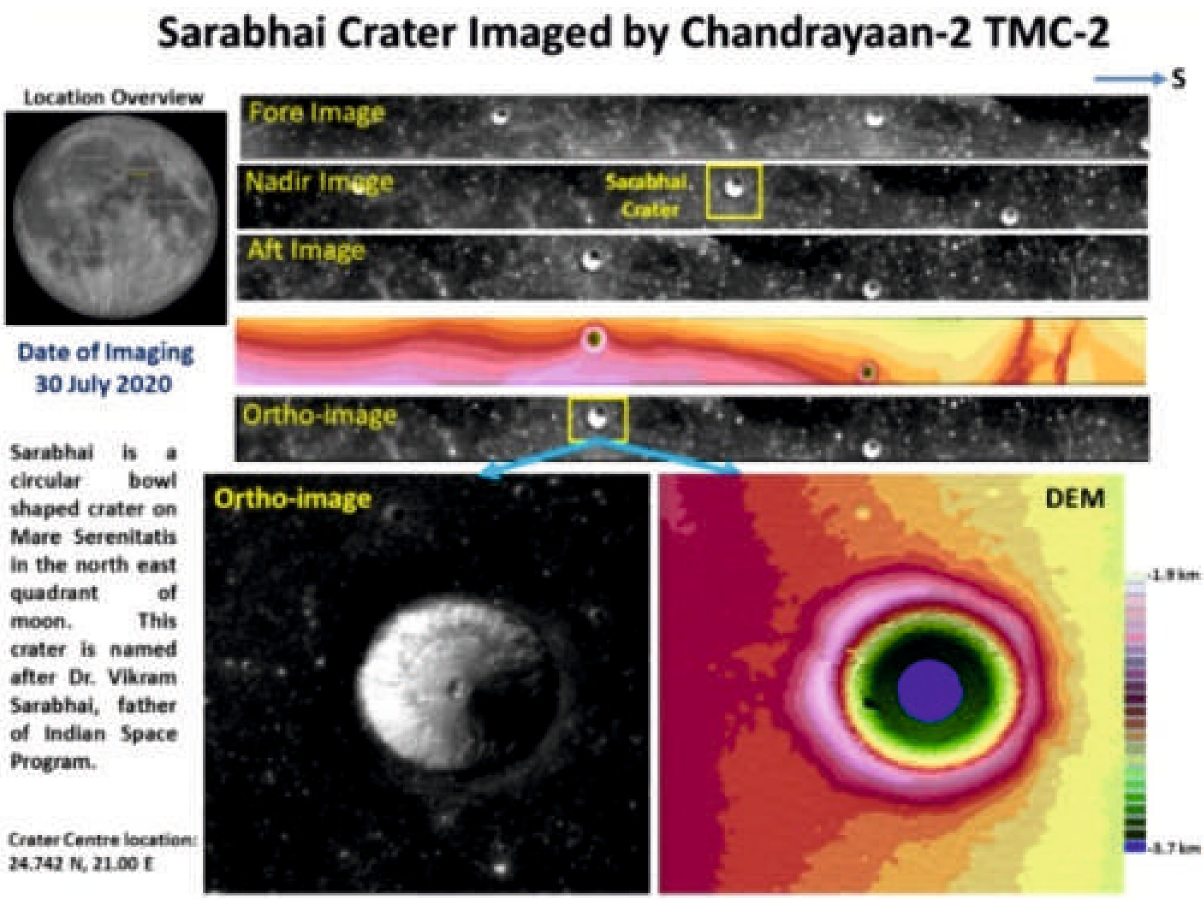

Fig.1. Terrain Mapping Camera – 2 (TMC-2) onboard ISRO's Chandrayaan – 2 captured the Sarabhai Crater on Mare Serenitatis in the north east quadrant of the Moon. SOURCE:https://www.isro.gov.in/chandrayaan-2-imaged-sarabhai-crater-moon

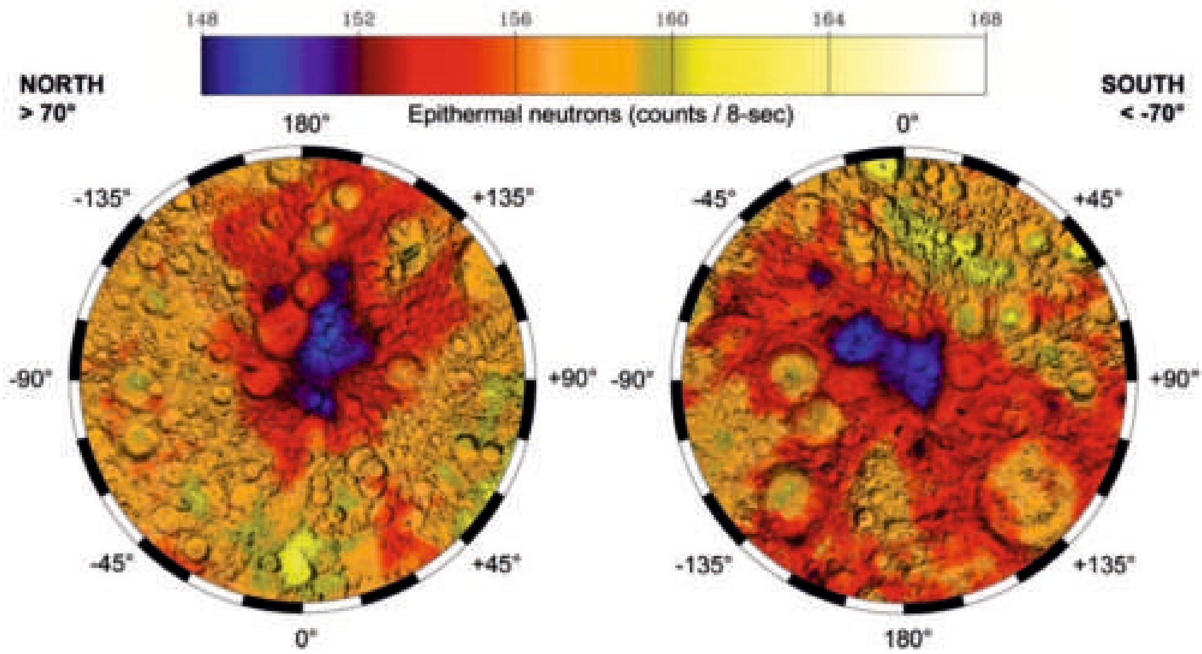

Fig.2. Polar maps of lunar epithermal neutron counting rates. The dark regions indicate locations of enhanced hydrogen abundances [5].

Terrain Mapping Camera (TMC) onboard Chandrayaan-2 comprises of three identical detectors aligned for three views (at –25, 0 and +25 degree) along the track direction for the generation of stereo images. The corresponding three views/images obtained at –25, 0 and +25 degrees are known as Fore, Nadir and aft-views, in that order.

A digital elevation model (DEM) is a 3D representation (via computer graphics) of elevation data to represent terrain, commonly of a planet (in this case Moon). The stereo images data is used for the production of ortho-image and 3D terrain visualization. The ortho-image is geometrically corrected (orthorectified) aerial satellite image such that the scale is uniform and the resulting photo/image follows a given map projection.

Finally, how the north and south are fixed for the moon?

The poles of astronomical bodies are determined based on the invariable plane of the solar system.

The invariable plane of the solar system is defined as the plane perpendicular to its total angular momentum vector and passing through its barycentre (center of mass of the bodies that orbit one another and is the point about which the bodies orbit). Thus, it is a fixed reference plane passing through the centre of mass of the Solar System, and oriented perpendicular to the axis about which the angular momentum of the Solar System is measured. As per the international Astronomical Union (IAU), the north pole of any planet is the pole that points toward somewhere in the north part of the sky relative to the invariable plane. Similarly, a south pole of a planet is said to be pointing towards the south part of the sky relative to the invariable plane.

A Few Practical Optical Devices

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Abstract

This article is about some practically useful optical devices, namely constant deviation prisms, retro-reflectors and the Fresnel prism. The main purpose is to fill up some voids in the textbooks on optics.

Introduction

In this article we shall look into some optical devices which have found use in technical fields. These include (A) special types of prism which are used in constant deviation spectrometers, (B) retro-reflectors, used for accurate measurements of large distances and (C) the Fresnel lens, used in spot lights (in particular, at light houses) for producing a wide parallel beam of light.

A. Constant deviation prisms

We shall begin by analysing the properties of two of the better known types of constant deviation prisms. These are used in constant deviation spectrometers, where the source of light and the detecting device (telescope, photo-multiplier tube etc.) are kept in fixed positions and only the prism (appropriately mounted on the prism table) is rotated to deflect, in turn, lights of different wavelengths into the detector. An accurately calibrated circular scale may directly give the value of the wavelength.

1. The Abbe prism: This prism has a triangular cross-section; one angle of the triangle is 90°, the other two angles being 60° and 30°.

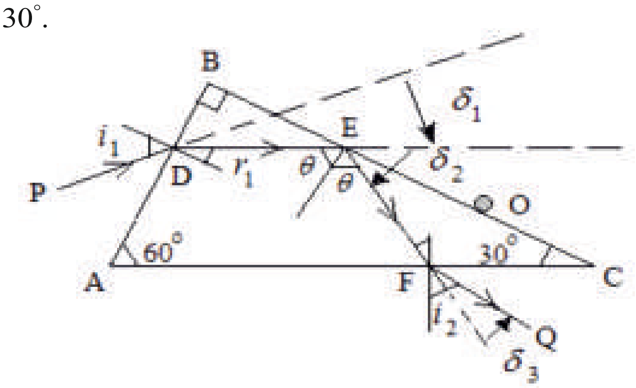

Fig. 1

We wish to find the deviation of an incident ray (PD), as it passes through the prism. Referring to Fig. 1, we have

$\delta_1 = i_1 - r_1 = \sin^{-1}(\mu \sin r_1) - r_1$

$\delta_2 = 2(90^\circ - \theta) = 2r_1$

$r_2 = (180^\circ - 30^\circ - r_1) - 90^\circ = 60^\circ - r_1$

$\delta_3 = i_2 - r_2 = \sin^{-1}(\mu \sin r_2) - r_2 = \sin^{-1}(\mu \sin(60^\circ - r_1)) - (60^\circ - r_1)$

Total deviation:

$\Delta = \delta_1 + \delta_2 - \delta_3 = \sin^{-1}(\mu \sin r_1) - \sin^{-1}(\mu \sin(60^\circ - r_1)) + 60^\circ$

Thus, if $r_1 = 30^\circ$, then irrespective of the refractive index (hence, wavelength) the total deviation is $\Delta = 60^\circ$.

In Fig. 1, the small gray circle beside the letter O represents the point where the axis of rotation cuts the prism table. As the prism table is rotated, lights of different colours (or wavelengths) successively have $r_1 = 30^\circ$ and the emergent ray (FQ) has $\Delta = 60^\circ$.

2. The Pellin – Broca prism: The cross-section of this prism has the shape of a quadrilateral, one of its angles being a right angle. See Fig. 2.

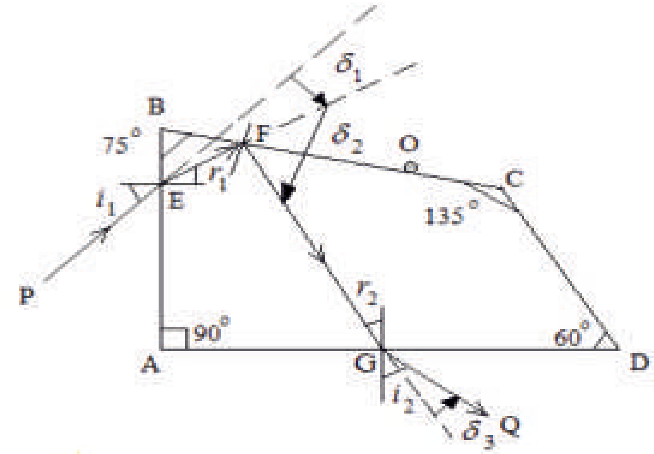

Fig. 2

Here

$$\delta_1 = i_1 - r_1 = \sin^{-1}(\mu \sin r_1) - r_1$$

$$\delta_2 = 2\left(180^\circ - (90^\circ - r_1) - 75^\circ\right) = 2\,(r_1 + 15^\circ)$$

$$r_2 = \left(360^\circ - 135^\circ - 60^\circ - (r_1 + 15^\circ)\right) - 90^\circ = 60^\circ - r_1$$

$$\delta_3 = i_2 - r_2 = \sin^{-1}(\mu \sin r_2) - r_2$$

Finally, total deviation is given by

$$\Delta = \delta_1 + \delta_2 - \delta_3 = \sin^{-1}(\mu \sin r_1) - \sin^{-1}(\mu \sin(60^\circ - r_1)) + 90^\circ$$

So, once again, if $r_1 = 30^\circ$, then

$$\Delta = 90^\circ$$

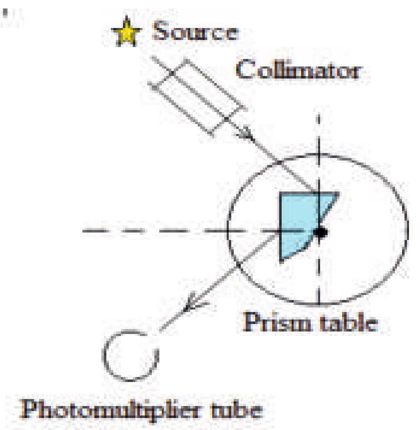

Fig. 3

Fig. 3 is a schematic diagram of the experimental set up.

B. Retro-reflectors

A retro-reflector reflects a ray of light back towards the source. Such a device can be used to measure very accurately the distance between two points by sending a pulse of laser light from one point to the other (where a retro-reflector has been placed) and measuring the time it takes for the 'echo' to return to the sender. Retro-reflectors have been used to measure the distance from the earth to the moon to an accuracy ~ 10 metres in 3, 84, 000 km!

There are several types of retro-reflectors. We shall discuss just two of these.

1. Two Pellin-Broca prisms oriented perpendicularly with respect to each other.

This type of retro-reflector can be used provided the second or target point can be physically accessed and an adjustable prism table can be set up there. Initial adjustments have to be made to ensure that a laser beam hits the first of the two Pellin-Broca prisms at the correct angle of incidence:

$$i_1 = sin^{-1}(\mu_{laser} \sin 30^{\circ}) = sin^{-1}(\frac{\mu_{laser}}{2})$$

where μ_{laser} is the refractive index of the Pellin-Broca prisms for the laser beam.

See Fig. 4. (Actually, the orthogonal arrangement of prisms guarantees that the retro-reflection characteristic of the device is robust against a small variation of the angle of incidence).

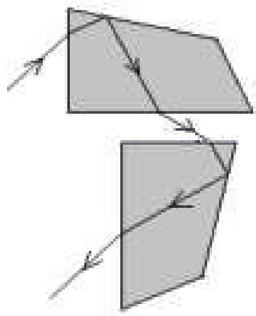

Fig. 4

2. The corner-cube retro-reflector.

This is a much more versatile device. It is also achromatic. The device comprises of three identical mirrors, each having the shape of a right-angled triangle. These are placed together in such a way that the system resembles a corner of a cube. Each mirror is thus perpendicular to both of the other mirrors. See Fig. 5.

Actually, the mirrors need not be identical; the only essential requirement is that all of them should be right-angled triangles. In fact, rectangular mirrors may also be used.

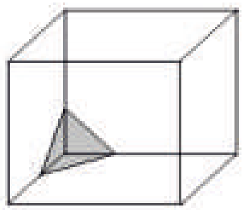

Fig. 5

The corner-cube retro-reflector needs a minimum amount of initial adjustment. Afterwards it can act as a stand-alone device. The principle of its operation is outlined below.

See Fig. 6 in this connection. (The photograph on the left-hand-side shows a corner-cube reflector made by the author. All three triangles are identical; each having a hypotenuse about 5 cm long.)

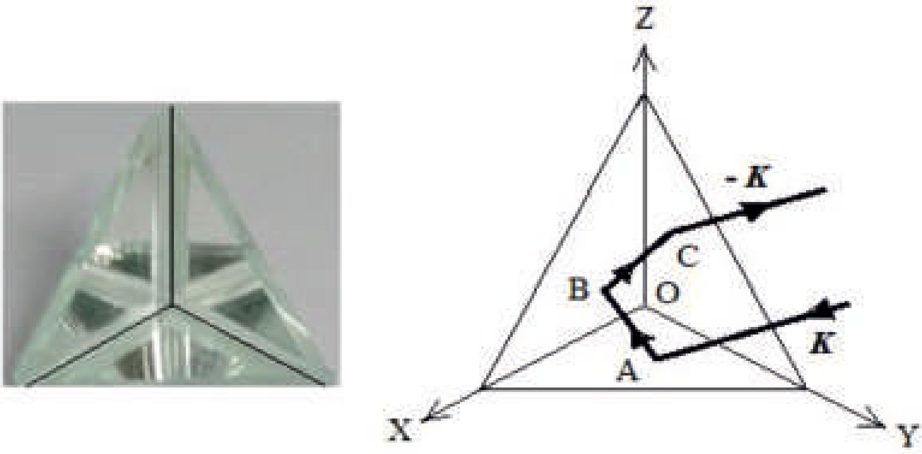

Fig. 6

Suppose the ray, specified by the wave-vector $\boldsymbol{K} = k_x\boldsymbol{i} + k_y\boldsymbol{j} + k_z\boldsymbol{k}$, where $\boldsymbol{i}, \boldsymbol{j}$ and $\boldsymbol{k}$ have their usual significance, strikes the mirror lying on the XY plane at A. The reflected ray has the wave-vector

$\boldsymbol{K}_1 = k_x\boldsymbol{i} + k_y\boldsymbol{j} - k_z\boldsymbol{k}$

This ray strikes the mirror coinciding with the XZ plane at B and gets reflected along BC. The ray that proceeds along BC has the wave-vector

$\boldsymbol{K}_2 = k_x\boldsymbol{i} - k_y\boldsymbol{j} - k_z\boldsymbol{k}$

Upon reflection from C, the ray emerges out of the reflecting system with wave-vector

$\boldsymbol{K}_3 = -k_x\boldsymbol{i} - k_y\boldsymbol{j} - k_z\boldsymbol{k} = -\boldsymbol{K}$

Thus the emergent ray travels back towards the source of light; there is, however, a lateral shift). So this system of mirrors acts as a retro-reflector. (Incidentally, the size of the mirrors determines the range of directions of the incident ray for which the device will act as desired.)

C. Fresnel lens

In the Chambers Science and Technology Dictionary, the Fresnel lens is defined as ‘A lens having a surface of stepped concentric circles, thinner and flatter than a conventional lens of equivalent focal length; used in view-finders and as a condenser in studio spot lights.’

The reason why such a lens can have (nearly) the same focal length as a conventional Plano-convex lens can be understood by referring to Fig. 7. On the left-hand-side of Fig. 7 is shown a meridional cross-section of the conventional lens. Imagine that the lens is cut-up into several concentric rings. Each ring will have a different thickness, the central one (a solid cylinder) being most thick. If the rings are now stacked up so that their leading edges lie on a plane and the trailing sides are trimmed so that they all lie on a plane parallel to the previously mentioned plane, then such a body will have a cross-section as shown on the right-hand-side of Fig. 7. This new object constitutes a Fresnel lens. Each ring of the Fresnel lens refracts an incident ray in the same manner as the corresponding region of the original lens, and, if we can ignore the differences in thickness, the newly designed lens will have the same focal length as the Plano-convex lens. (On the right-hand–side of Fig. 7 we have drawn two vertical lines, one solid and one dashed, to indicate how thickness of the Fresnel lens depends on the extent of trimming). Note that the weight of the Fresnel lens is comparatively small.

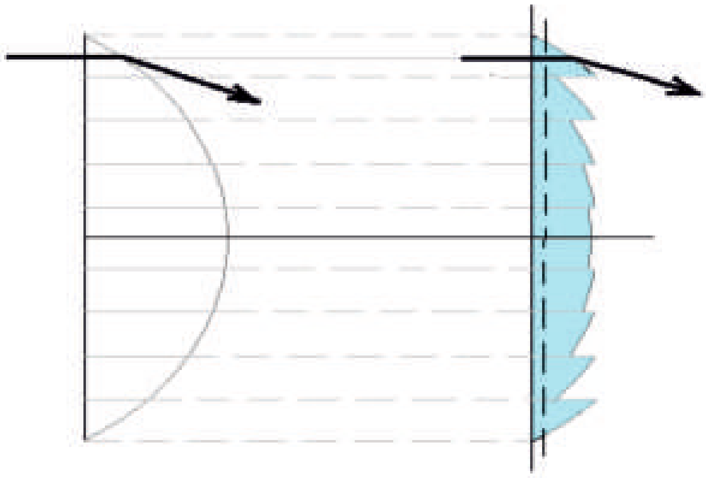

Fig. 7

A spot light (or a light house) has a powerful source of light placed at the focal point of a Fresnel lens, which converts the divergent beam from the source into a wide parallel beam. See Fig. 8. As the size of the Fresnel lens is large, it cannot be obtained by cutting up a big conventional lens. Instead separate transparent rings having appropriate shapes and sizes have to be fabricated and then mounted on a frame. It is not necessary to fabricate all the rings; gaps may be left between rings, as shown in Fig. 9. Such an arrangement is much lighter in weight; however, the beam is also less powerful.

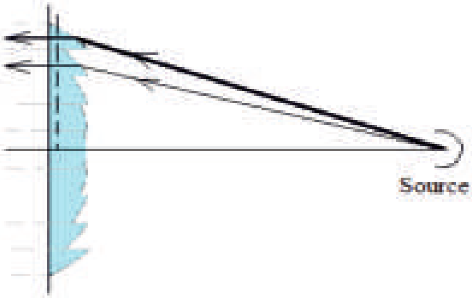

Fig. 8

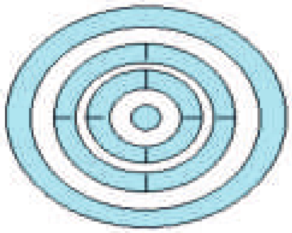

Fig. 9

Conclusion

The optical devices discussed above have been in use for a long time. Yet there is little awareness about them and they rarely find place in textbooks. The corner-cube retro-reflector, in particular, is a fascinating object that can be relatively easily constructed and its reflecting characteristics can readily be tested. Give it a try.

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Teaching Physics Through Emerging Disruptive Technology of Augmented Reality

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Abstract

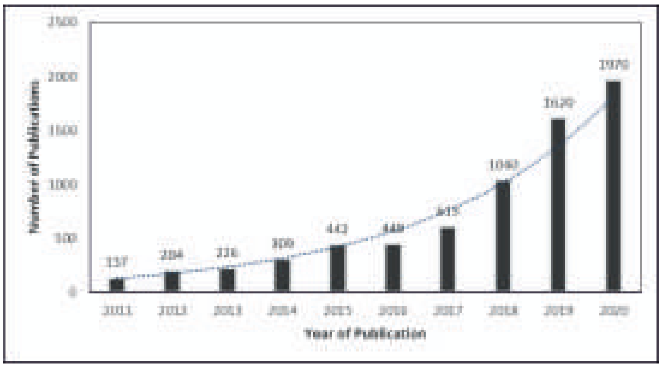
Recent technological advances provide the appropriate mechanism required by the Physics teachers to make the learning process more efficient. The structured activities with innovative products and services can creatively apply knowledge. The challenge that Physics teachers face making the subject interesting, attractive, relevant, etc. may be made so by the use of proper technological driven products. The new National Education Policy (NPE-2020) mentions some of the recent technologies that are going to be embedded in both school and higher learning centers. This paper describes the plausible use of one such emerging technology i.e. augmented reality in Physics education. The pedagogy thus devised, may have the capability to overcome many problems as faced by conventional methods of online teaching-learning. This paper also lists some of the advantages and challenges, the augmented reality faces during its preliminary applications in studying Physics. The conclusions solicit the augmented reality use in science and engineering institutes with the suggestions and future scope of work.

Keywords: Augmented reality, educational technology, emerging teaching technologies, physics learning

Introduction

Due to the COVID-19 pandemic, teaching-learning process has witnessed tremendous changes all over the world. The use of emerging disruptive technologies finds relevance in the recent literature too, however, covid-times added urgency to it. Government of India floated the online courses, that to be offered by top 100 NIRF rank, national universities. At this point in time we need to review the online teaching pedagogy and make necessary adjustment. The science education needs special attention since it require learning through live experimentation to get better understanding of natural phenomenon. Therefore, we need to use latest technologies in order to make science learning easy. Augmented reality is one of the promising solution to this problem. In augmented reality we get computer generated graphics after mixing it with the user's view field and provide extra information or visualized enhancements in the respective surroundings. It provides extra senses of users which could not be achieved ordinarily. Augmented Reality, in simple words is *"three-dimensional virtual objects which get integrated on three dimensional real environments in real time"*. The basic requirement for augmented reality, are (1) there should be a combination of virtual & real objects in real environment, (2) there must be alignment of virtual & real objects with each other, and (3) both virtual & real objects should run interactively.

There has been a tremendous increase in the search for new methodologies adopted for Physics education using Augmented Reality. The last decade witness



many groups trying to teach, otherwise complicated subjects of Physics, using this new emerging technology. The evidence is drawn from graph below, which shows, the monotonic exponential increase in the publications reported by https://scholar.google.com/ filtered through search phrase: *intitle:"Augmented Reality" & "Physics."*

In this paper we discuss the methodology for the use of augmented reality and its use in studying Physics with challenges faced and future scope.

Method and Data Collection

The present study is done to act as a reference for new pedagogies tools that are being used worldwide in studying the complex experimental science subjects like Physics. The new technologies that are being used in studying subjects like Physics and Engineering, are virtual and augmented realities. The data collection is done through a literature survey and a total of ten case studies discussed here. Based on these studies challenges, suggestions, and conclusions are drawn.

Some Methods to Augment Reality

Before we discuss the use of augmented reality, let us first describe few techniques/technologies that is currently used in augmenting the reality.

1) To get the augmented field user have to wear or carry devices like helmet, goggles or gloves. Such devices are smart ones which provides information about the physical objects either on touch or watch in such a way that user can see, or hear and touch virtual object that is immersed into virtual computer environment. Data glove is one of the examples wearing that one can make projections of slides and video in a controlled manner as any user do by making natural gestures. By using this tool user have to just make gesture to get projection running during a talk.

2) Some of the applications are such that the user can see through the physical object by the use of smart goggles. Consider an obstetrician may be able to examine pregnant women with her ultrasound report using live pictures. This is done by video image of women merged with computer generated ultrasound images.

3) Any physical object can be augmented by embedding input, output or computational devices on or within it. The electronic brick is one of the example which is made by sensors, electronic circuitry and motors etc. to perform this task.

4) The surroundings of an object can also be augmented so that neither user nor its surroundings get affected. This can be accomplished by collecting the information onto object and displaying this information from surroundings. For example, digital desk which is made by video camera and used to detect user point of action.

5) US army, making awareness about the use of augmented reality. Tactical augmented reality (TAR) is an eyepiece which help the soldier precisely whereabouts of both friend and foe. TAR will replace the conventional night vision glasses and hand-held GPS systems.

6) Acura is the live-streamed race based on augmented reality. In this case drivers wear a camera mounted helmet and brought views in fount of them.

Learning approaches: Traditional *versus* Augmented Reality

The classical system of teaching-learning that is attending lectures, taking notes, reading facts from books and taking exams become outdated and boring. This may be noted from the positive responses of learners during online teaching mechanism as were adopted in Covid lockdown period. So we need to put efforts to make learning more interesting for post Covid future. That will be done by including the use of technological advances rather than transferring professor's notes to students' notes without striking the mind of learners. The true learning in sciences could be accomplished by live experimentation in classrooms itself. The human psychology is to make learning best by doing rather than reading or listening. The fact is, more the senses involved while learning more powerful the learning experience is.

The augmented reality is an attractive way to engage students while teaching, especially during remote online sessions. It can provide deep understating of the concepts as watching strike mind stronger than listening. The difficulty levels of a complex concept can be made simpler once it is explained through 3D modelling. In todays' world where kids use smartphones, teacher and parents need not to spend much efforts in making them learn about the sophisticated devices used to augment reality.

Learning Physics through Augmented Reality: Research teams and their experiences

The learning procedures for the subjects like Physics where learners needs to understand concepts and principles of physical world that sometimes cannot be seen for example atomic structure, gravitational fields *etc.* The studies shows that augmented reality could be efficiently utilized for Physics learning. Some of these studies are discussed below:

1. Tangible augmented reality was used by Aw Kien Sin to create live solar system (LSS). The use of this augmented reality involves combination of tangible interfaces. In this study it was ensured that learners have an intuitive interface to create a new learning experience for them. During the study traditional devices like keyboards and mice replaced by physical objects like cubes and cards as input devices in LSS. The learners were free to interact with these input devices by rotating, picking up down, placing holding in order to manipulate the astronomical bodies. The test were done to get the feedback from learners and it was found that LSS so developed was able to cast better understanding of complex subject of Astronomy. Siqueira *et al* also reported to have developed online methodology to visualize 3D objects to achieve better learning environment for solar system using NASA data.

2. Motion captured technologies as reported by Enyedy *et al* can be used as a set of augmented reality, called SPASES (Semiotic Pivots and Activity Spaces for Elementary Science). In order to make first and second graders to learn the concepts of Newtonian force and motion. This happens to be a game like experience for 6-8 year old students. They interrogate their own understanding and explore the physics concepts. Pre/Post-test results so obtained shows that these students were able to develop a conceptual understanding of speed, force, friction and two-dimensional motion.

3. Augmented books by Dunser *et al.* are the three dimensional animations in the form of book. Such books creates a medium for the student to interact with the contents hence get engage while reading. They overlaid the virtual contents on real book pages so that certain types of interactions may be supported. Electromagnetism lectures were delivered to two different groups, one through traditional means and other through augmented books. The participants were asked to do pre/post tests and results suggested that augmented books has potential to be an effective teaching tool for complex 3D concepts.

4. Yuki Aoki reported to have developed an augmented reality tool using tablet Nexus 7 of Asus as it is equipped with sensors like camera, speaker, microphone, magnetometer, gyroscope, accelerometer, GPS systems. It is used as teaching aid for middle stage school students for Physics experiments. This enable students to intuitively understand scientific phenomena.

5. Su Cai reported that the experiment like convex lens image-formation that realized through augmented reality render much better understanding than real or virtual experiment. Many shortcomings and limitations of pure virtual experiment also got reduced by using augmented reality.

6. Radu *et al* used augmented reality to designed Hololens systems and participants were asked to learn the physical description of audio speakers. After analyzing the participants focus on time management,

learning structure and knowledge balance, they concluded that the use of augmented reality gave better results than the results without augmented reality.

7. Akcayir *et al* studied the effects of use of augmented reality in Physics laboratories and reported to get positive attitude among students.

8. Unahalekhaka *et al* studied the effect of collaborative learning of Physics qualitatively. This group found that collaborative learning activities while using augmented reality shows better results. The learning attitude changes all together when augmented reality is used and participants in augmented reality environment shows higher tendency to believe that the Physics is easy.

9. Ismail *et al* created an application based on augmented reality that can be used as physics learning media. The virtual visualization immersed on real visualization to create augmented environment. They used android environment to accomplish this, hence reported that the participants found this application easy to be used and result in better understanding.

10. Recently, Kumar *et al*, developed an augmented reality tool that is based scaffold and it improved the learning experience of engineering students for the subject embedded systems. They reported to have overall usability score of 79.5%.

Need and urgency

Many developing countries have reported embedding emerging technologies into education at much faster rates than India. Education is the backbone for the advent of civilization and technological advancement in any society. In India, with diversity and poverty, many children lose interest in science learning due to poor understanding of basic concepts. The decline of enrollments in basic science education has been the main concern for policymakers. Technology like augmented reality, therefore need to get explored for immediate use in science education from the primary to higher education levels. At the current juncture, after the Covid pandemic, where we have experienced online teaching-learning and have the new avenues under National Education Policy 2020, we must move ahead for the incorporation of such educational technologies, especially in Physics education.

Challenges of Augmented Reality During Learning

Technological challenge: The use of bulky gadgets put additional baggage for the learners that may make learning process cumbersome with discomfort. This may lead to poor understanding and make teaching-learning, bad experience. However, advent of technology may provide portable solutions to this problem so that learning may become less obstructive.

Pedagogical challenge: There might be some constraints in initial implementation of such heavy technology from administration. It require initial investments that needs to be made financial viable. Teachers may also put some resistance as was the case with many more innovative ideas in past. On time syllabus completion is always a challenge especially in semester mode of education which may also restrict use of augmented reality in education.18

Learning challenge: The use of high end technology like augmented reality may deliver large amount of information in small duration. The situations like this may make learners being overloaded as they need to handle technology along with learning. Therefore, the multitasking during the use of augmented reality may make some learners confuse and physics instructor has to be cautious about it.

Conclusions and Implications

The above discussions amply prove that the use of augmented reality can enhance the learning for subjects like Physics which require understanding of imaginative concepts. The use of augmented reality for Physics instruction is in its early stages but empirical data indicates positive impact on students while learning. The comprehensive study with large sample size however needed to understand educational value of this technology. It is also suggested that special curriculum may be designed to embed technological driven learning of science. Most of the studies for augmented reality are on technological aspect but its application in learning subject like Physics needs to be explored by creating study material based on augmented reality. The current outbreak of Covid-19 pandemic created an urgent situation for the amalgamation of high end technologies like augmented reality in education. It is suggested that we should work in this direction to achieve efficient environment of learning especially in sciences and engineering. The Govt. of India should also allocate funds for this purpose and put efforts for timely implementation of same.

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ICE CUBE EXPERIMENT
–The Harbinger to Multimessenger Astronomy

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Introduction

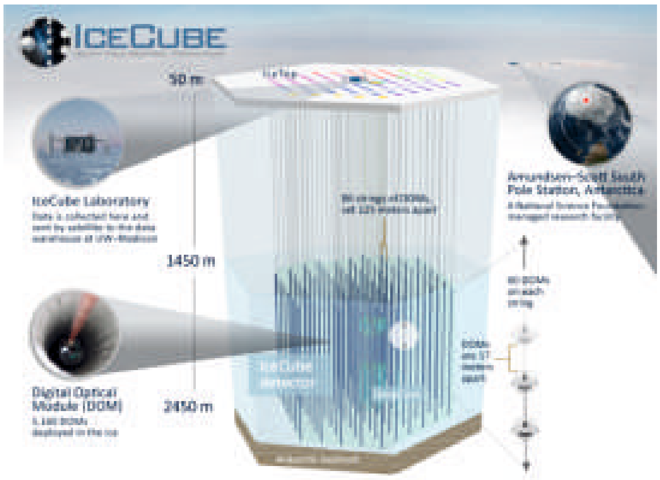
Ice Cube experiment is one of the most ambitious and extreme experiments on earth. It has started operations at the South Pole in 2010. Buried under the Antarctic ice (Fig-1), it was designed primarily to capture high energy neutrinos that are presumably produced by powerful cosmic events. Neutrinos originate in some of the most violent and least understood events in the universe. The cataclysmic events like supernovas, Gamma ray bursts (G R B), objects like active galactic nuclei and black holes are just a few possible sources of high energy neutrinos. The advent of Ice Cube experiment signaled the ushering in of a new era – Multimessenger Astronomy.

Fig.1 The Ice Cube Laboratory at the Amundsen-Scott South Pole Station, in Antarctica. Far below, detectors suffuse a cubic kilometer of pristine ice, forming a potent observatory for studying cosmic neutrinos.
Credit: ErikBeiser, IceCube, NSF

Neutrinos Background

Neutrinos are invisible, nearly massless subatomic particles that are electrically neutral. They can travel at nearly the speed of light from the edge of the universe without being deflected by magnetic fields or absorbed by matter. They travel in straight lines from their sources. This makes them excellent messengers of information about the objects or events in which they originate. About 100 trillion neutrinos pass through our body each second, without ever being felt by us, and they are the atmospheric neutrinos coming from Sun or produced by the cosmic ray interactions with atoms / molecules of the gases in the atmosphere. But Ice Cube is designed to detect and segregate the high energy cosmic neutrinos from solar and atmospheric neutrinos.

Experimental Set up



The Ice Cube Neutrino Observatory was built under a NSF (National Science Foundation, U.S.A.) research program with the University of Wisconsin, Madison as the lead institution with more than 50 other institutions worldwide, involved in this scientific endeavor. The IceCube detector consists of one cubic kilometer of hundred thousand year old Antarctic ice – that would be enough to fill one million big size swimming pools. It comprises 86 cables, each holding 60 digital optical modules (DOM). Each of the 85 cables has a theme, and each DOM has a name that reflects the theme. The 5,160 in-ice DOMs hold extremely sensitive light detectors, or photo multiplier tubes, along with micro computers that relay data to the surface. An additional 324 DOMs make up a surface detector called 'Ice Top'. DOMs are attached to the cables beginning at a depth of 1,450m and ending at a depth of 2,450m. As of October 2019, about 300 physicists, computer scientists and engineers make up the IceCube collaboration team from 52 institutions in 12 countries.

Ice is a perfect natural neutrino detector because when a neutrino does occasionally interact with atoms in the ice, the material lights up by releasing a shower of charged particles that radiates light. This so called 'Cherenkov radiation' travels hundreds of meters through the pure transparent ice. Cherenkov radiation is produced when a particle is moving through a medium, in this case ice, with a speed greater than the speed of light in the medium. IceCube with its 5,160 DOMs spaced symmetrically throughout its volume will spot this light. IceCube detects nearly 275 atmospheric neutrinos daily and about 1,00,000per year. One Tera byte of unfiltered data is collected every day and about hundred Giga bytes are sent over satellites for analysis.

Experimental Results

One day in 2012,IceCube team members observed signals reflected by two neutrinos, carrying more than thousand times the energy of the most energetic neutrinos produced by an accelerator on earth and almost a billion times the energy of the neutrinos regularly sent out by the Sun. It turns out to be a game changing moment! One of the graduate students whimsically nicknamed the two neutrinos as 'Bert' and 'Ernie'- the first pixels of the distant neutrino universe. Over the next one year, the IceCubeteam has found 54 high energy neutrinos in total, including one dubbed “Big Bird” with energy twice that of Ernie and Bert. The energies of Ernie and Bert and the others that have been observed so far are about a Peta – electron volt (PeV) or 10^{15} eV; Ernie and Bert were 1.07PeV and 1.24PeV respectively. For comparison, the particle beams at L.H.C., CERN, are in the TeV or 10^{12}eV range. Most important, the PeV energies of these two neutrinos tell us that they must be part of some cosmic signal. The next big thing for the scientists at IceCube is to identify where in the sky these high-energy neutrinos came from and how they originated? The two significant cosmic occurrences, Supernova and Gamma Ray Bursts(GRB) lead us in this direction and both these cataclysmic events give rise to cosmic rays. If we can definitively trace the high-energy neutrinos to these likely sources of cosmic rays, it will open up a new frontier in our understanding of the universe.

Cosmic Rays

Cosmic rays, which constantly bombard Earth from space, are made of extremely high energy protons and other charged particles. When they arrive at Earth, we cannot deduce where in the universe they came from because their electrical charge allows galactic and intergalactic magnetic fields to alter their course as they cross space. Luckily, however, theory suggests that cosmic rays also interact at their birth places with photons to produce neutrinos. Therefore, although cosmic rays themselves cannot lead us to where they began, the highly energetic neutrinos they presumably produce can do so for them. One probable source of cosmic rays is the death throes of massive stars. About three supernova explosions in the Milkyway every century, converting a reasonable fraction of a star's mass into fuel for particle acceleration, could account for the steady flow of cosmic rays seen in the galaxy. Extra galactic cosmic rays, which originate from beyond our home galaxy, are generally even higher in energy than the cosmic rays coming from nearby, and they require a more energetic source to create them. One contender is Gamma Ray Bursts (GRB). Even brighter than regular supernova, GRB's are somewhat mysterious but probably occur during a special class of star collapse that involves very high mass stars under extreme conditions. Another theoretical source of extragalactic cosmic rays is active galactic nuclei – a class of galaxies suspected to have a super massive black hole at their center that is absorbing large quantities of matter.

On September 22, 2017, IceCube physicists detected a high-energy(PeV) neutrino passing through the Antarctic ice for more than one kilometer. Within 43 seconds, the observatory's computers calculated the particle's track and the general direction in the sky it came from and set out an alert out to telescopes around the world to train their eyes on a particular set of coordinates in the sky. The point on the sky the neutrinos came from was identified as a distant galaxy named TXS0506+056. It's a galaxy about 12 billion light years away with an active, enormous supermassive black hole at the center of it. This worldwide hunt allowed scientists to pinpoint the particle's birth place: an extremely luminous galaxy called a **'Blazar'**.

Blazars are a type of active galaxy with one of its jets pointing toward earth. It emits both neutrinos and gamma rays that could be detected by the Ice Cube Neutrino Observatory as well as by other telescopes on Earth and in space. Courtesy IceCube/NASA.

A blazar is a huge black hole sitting in the center of a distant galaxy, flaring as it eats the galaxy's matter. A blazar acts like a cosmic accelerator, spitting out a constant stream of particles from its core.

But there are other possible, more exotic explanations for these high energy neutrinos. One suggestion is that they may be signatures of 'Dark Matter' – the invisible material that seems to make up more than 80 percent of all matter in the universe, spawning cosmic rays and high energy neutrinos. In such a scenario, dark matter particles could occasionally decay to produce the PeV – energy

neutrinos that are observed in Ice Cube.

Multimessenger Astronomy

Multimessanger Astronomy is an emerging field of astronomy that uses multiple telescopes and different methods to observe the sky to learn as much as possible about an astronomical event. Multimessanger Astronomy combines information from different cosmic messengers – cosmic rays, gamma rays, cosmic neutrinos and gravitational waves – to learn about the distant and extreme universe. "The era of Multimessanger Astronomy is here" said N.S.F. director – FranceCordova. Each messenger gives us a more complete understanding of the universe and important insights into the most powerful objects and events in the sky. Each of these cosmic messengers is produced by distinct processes at its origin, and thus carries information about different mechanisms within its source. The messengers also differ widely in how they carry this information to the astronomer: for example, gravitational waves and neutrinos can pass through matter and intergalactic magnetic fields, providing an unobstructed view of the Universe at all wavelengths. Combining observations of different messengers will therefore let us see more and look farther.

Multimessenger astronomy also allows us to address the question of why we are here in the first place, by shedding light on the origin of heavy elements and the evolution of galaxies and the Universe.Multimessenger observations are an emerging branch of astronomy, poised to disrupt our understanding of the most energetic cosmic events, the evolution of the Universe and possibly some of the fundamental laws of physics. Multimessenger astronomy is a pioneering field in which even some basic questions have not yet been answered. This is mostly uncharted territory, with ample opportunities for newcomers and students.

When our experimental sensitivity catches up to physical reality of relic neutrinos, we will be one step closer to understanding just how exactly our universe came to be.

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Report (RC-07)

III PRL-IAPT Dr. Vikram Sarabhai Lecture

Date: February11, 2021 **Time**: 4pm -6pm

Speaker: - Prof. Mrs. Srubabati Goswami
Senior Professor, theoretical physics division
Physical Research Laboratory Ahmedabad

Topic: -Neutrinos: the invisible messengers

This event was the third in the annual lecture series organized jointly by Physical Research Laboratory (PRL) Ahmedabad and IAPT (RC-7). IAPT has received, in this regard, an excellent support from the Dr. Anil Bhardwaj Director PRL, who gave the first lecture of the series in 2019 that was followed in 2020 by the lecture given by Dr. R D Deshpande, Geosciences division PRL. This year it was held online with a live streaming on YouTube channel, as per a prior announcement. In his opening remarks, Dr. Anil Bhardwaj described it as a memorial lecture in honour of our visionary scientist Dr. Vikram Sarabhai, and also recalled that the programme was being held this year on February 11, the International Day for women and girls in Science.

The invited Speaker Prof. Mrs. S.Goswami is a Fellow of The World Academy of Sciences (TWAS) and also the three Science Academies of India, NASI, INSA and IASc, and has received several awards for her academic excellence. Her research area is high energy Physics phenomenology with special emphasis on neutrino physics.

*"I have done a terrible thing.I have postulated a particle that cannot be detected..!"*said the famous physicist Wolfgang Pauli as he proposed neutrino - the unusual

particle - in 1929 in order to explain the different aspects of the beta decay process. With no charge and 'no' mass, the postulated particle was quite difficult to detect. Neutrinos are all around us, but they remain elusive as they hardly interact with matter. As the online lecture was in process (…and as *you* are reading this article right now...), billions and trillions of neutrinos mostly coming from the Sun must have passed through us, and still nothing happened to us…!

The speaker very nicely described the various sources of neutrinos, touched upon their first detection, and highlighted terrestrial detectors developed thereafter. The detection experiments have established that there exist different kinds of neutrinos, and quite surprisingly they transform among each other on their way from the source to the detector…! This phenomenon, known as neutrino oscillation, requires the neutrino to be massive, and compels us to think beyond the standard ideas of fundamental particles and their interactions. The speaker nicely emphasized how a new window towards a deeper understanding of nature is thrown open in the form of neutrinos. Photons of various radiations are well-known to bring to us the amazing knowledge of the universe. But, as she pointed out, there could also be other messengers of the cosmos. Prof. Mrs. Goswami discussed the importance of neutrinos in a multi-messenger astronomy. The speaker also mentioned about the upcoming India-based Neutrino Observatory, a multi-institute collaborative project, with which she is associated actively.

Prof. D PallamRaju, Dean PRL conducted the lecture session, along with an interesting question-answer session after the lecture.

The other part of this programme was an e-launch of an ebook published by IAPT RC-7. The ebook named '*I do …and I understand…*' is a collection of 21 articles on the theme of experiments & Demo in physics and computational physics. It is dedicated to the loving memory of Dr. Tushar C. Pandya, a very active member and an asset to IAPT RC-7, who succumbed to corona in October last. Many of these articles have been contributed by his students of the St. Xavier's College Ahmedabad. Releasing the ebook on the occasion Dr. Anil Bhardwaj and others remembered the active role played by Dr. Pandya in organizing the previous two annual lectures of the series, as also in several other academic activities over the past few years. The ebook will be shared to all through our main website *indapt.org*.

The online lecture programme was well attended by students, teachers, scientists and others all over India and abroad. Towards the end of the programme, Prof. Arun Pratap (MSU, Vadodara), the president of RC-07 extended a vote of thanks.

Now, as per the annual tradition of RC-7, the lecture will be published as an article in English, in our Gujarati/English magazine *Pragaami Tarang*.

K N Joshipura

To our readers

For change of address and non-receipt of the Bulletin, please write (only) to:

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Online Competition of Physics Practical at +2 Level

A Solution for Future Science Education

IAPT has planned to undertake different types of activities from 01.10.2020 - 01.10.2021 to celebrate the birth centenary of its founder Prof D P Khandelwal. He was a pioneer and a visionary in spreading a developed framework of science education, preferably Physics education, all over the country. Being a freedom fighter in the period of Quit India movement he perceived that the all-round development of India could be attained through proper science education with equal emphasis on theory and practical. With this aim, D P Khandelwal Forum for Science Education (DPKFSE) was established by the members and supporters of RC15. The only motto was to bring all the teachers of science under an umbrella and motivate them in the line of thought of Prof. Khandelwal.

Due to the pandemic crisis online classes were organized by experienced teachers since October 2020 in order to help numerous students. But proper assimilation of scientific concepts and thoughts by the students was quite at stake due to the absence of practical classes. Majority teachers had rooted ideas that practical classes could be taken only under the ambience of conventional laboratory setup. DPKFSE undertook an attempt to modify this idea,on the demand of plus two level students and made an effective programme on practical teaching in Physics. The planning resulted in the form of a competition, which the RC accepted as an activity for the celebration of the birth centenary of D P Khandelwal.

At the outset, expected candidates were asked to perform some experiments at home as per availability of apparatus. The suggested experiments were as simple as-some experiments with simple pendulum, measurement of density of liquid by using U tube, experiments involving measurement of mass using a scale balance, experiments on bending of thin beam, determination of surface tension by using injection syringe with needle and some experiments with a convex lens.

As the students were not able to attend school physically, they were deprived of direct practical learning. Still the students showed high level of interest as they benefitted through our endeavor. In this regard, it was decided that a Google Classroom would be created with the teachers of the willing schools where the students could contact their teachers to clarify their doubts.

Primarily, nearly 500 students of H.S. section enrolled their names as competitors and expressed their desire to do the prescribed, open-ended experiments under the guidance of their teachers. Students were from seven different districts of West Bengal. The teachers managed the digital platform and guided the students in the proper direction. All sorts of activities like mock tests, preparing questions, selection of correct digital platform and evaluation etc were conducted by the teachers. Senior IAPT members functioned as the co-coordinators and the whole programme was completed successfully. Accordingly, two Google Classrooms were created. The First one (DPKFSE Class Room - 1) was for teachers while the second one named DPKFSE - 2020 was for students. A Whatsapp group for teachers named IAPT LM was also initiated to make contact with each other. Through elaborative discussions it was decided the teachers would ask and help their intending students to arrange and perform six items of practical experiments, developed at IAPT Midnapur College Centre for Scientific Culture, with inexpensive materials available from their homes and neighborhood markets.

Later the plan was reviewed and finalized after scrutiny and detailed discussion in several online meetings in the presence of some of the experts from IAPT, namely Dr. Pradipta Panchadhyayee, Dr. Minhaz Hossain, Sri Suchand Kumar Pan, Dr. Debapriyo Syam, Dr. Mita Chowdhury, Dr. Surajit Chakraborty. Dr Saswati Dasgupta and Dr Lipika Santra (all from West Bengal RC) together with Dr Swapan Kumar Majumdar and Dr B Mahato (both from Tripura RC)

Google Classrooms were created by the willing teachers individually before preparing separate assignments for students. Through the links of YouTube and Google Meet they guided students to perform the experiments. Each of the guide-teachers then placed an assignment of practical question within a stipulated period. After completing the experiments, students uploaded their answer scripts on Google Classroom as a PDF (.pdf) file. After evaluation of the content of scripts teachers returned the answer scripts with marks. After such practical exposure two consecutive mock tests were conducted for 189 students and the answer scripts were duly evaluated by teachers. At last, the final test in which 129 students participated was conducted. The test was divided into two parts: 60 marks for online practical examination on Google Classroom and Google Meet and the rest 40 marks for online quiz. The first part (60 marks) was held on Jan. 24, 2021.

The whole test was monitored by 5 different Google Meet live meetings. 1st group was monitored by Sanjoy Kumar Pal, Suchand Pan, Mousumi Ballav, Kakali Khan and Soumen Mandal. 2nd group was monitored by Soumen Sarkar, Kamrul Jaman Khan, Gouranga Ghosh, Chinmoy Bera and Dr. Surajit Chakraborty. Biresh Layek, Dr. Kriti Ranjan Sahoo, Anjan Mishra, Mustak Sir and Mita Chowdhury monitored the group 3. 4th group was monitored by Bidyut Ghosh, Sourav Kanti Dey, Pradyut Sen, Avijit Santra and Dr. Swedesh Ranjan Bera. The 5 th group was monitored by Pintu Mandal, Shreyam Jana, Ajam Ali Khan, SoumyajitSahoo and Anirban Samanta.

Senior IAPT members monitor the whole session of examination. The answer scripts were evaluated by two different groups of teachers separately. Then the marks given by the two groups were averaged out. The second part of the exam of 40 marks (40 MCQ) was taken through SOCRATIVE application via online mode on Feb. 7, 2021. The question paper of this competition was made by seven guide-teachers. The answer scripts were auto-evaluated by the application. At last, the result of this competitive examination of total 100 marks was published on Feb. 8, 2021 and 20 top performers were selected from the final performance report.

Though 500 students enrolled, only 129 candidates participated in the final competition, having sat for two consecutive mock tests, conducted specifically to make the students aware of the use of online platforms. Apart from that, large deviation was found in marking of the two groups. This difference in marking proved that the examiners were not logically tuned with uniformity for the purpose of assessment.

Our effort was considered to be successful as the obtained marks of students had a tendency to follow Gaussian distribution

Twenty top scorers will be gifted a small experiment kit, consisting of a Convex Lens, a Concave Lens, a Convex Mirror, a Concave Mirror, a Prism, a Thermometer, a digital multimeter, a Galvanometer, a Mobile charger as a dc power supply, a 1000W heater coil, Resistances, Semiconductor diodes, Zener diodes etc. By using these materials and devices one can perform more than twenty experiments of Light, Heat, Electricity and Electronics. Each kit may be used by ten students. So our aim is to extend the scope of experimentation among 200 users. A workshop will be conducted on February 21, 2021 with the concerned teachers. In this workshop 20 experiments will be decided by all concerned for future activity.

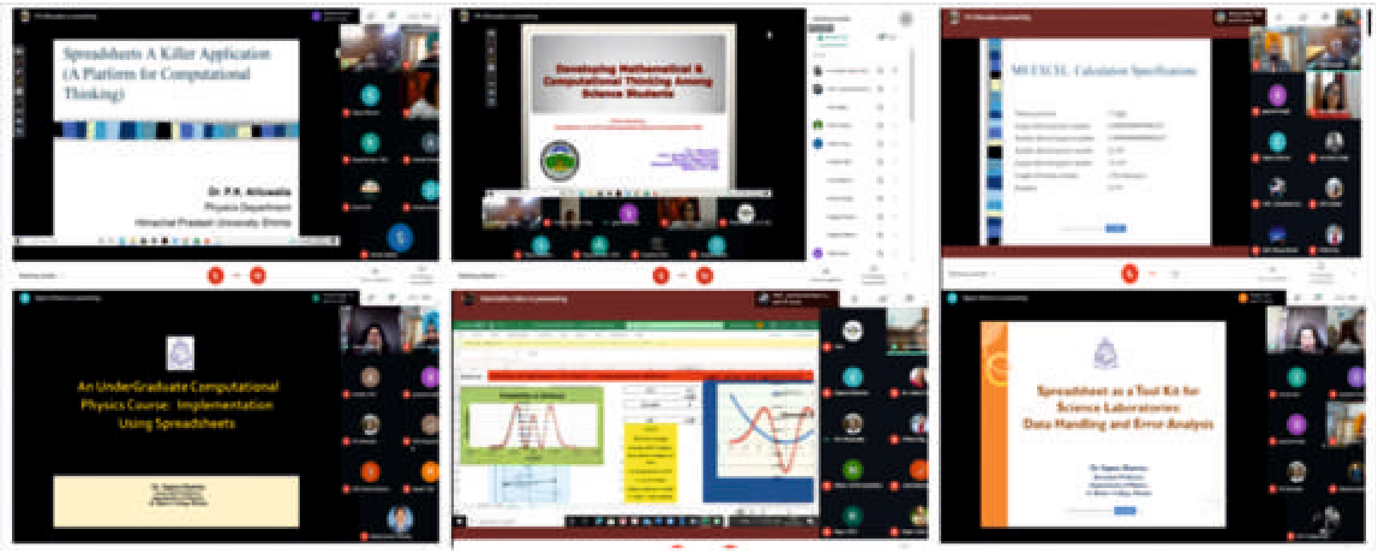
Our effort of spreading practical science through e-platform has set up a new trend of education. Dr. Khandelwal wished that a practical test is needed with theoretical examination in different entrance tests (IIT-JEE etc). This e-platform of taking practical examination may act as an instigator for policy makers to think in this direction and take it as a plausible and cost-effective solution in wider basis.

Prof Mukul Ranjan Roy, Director, Midnapore Institute of Education and an ardent admirer of Dr Khandelwal, who as the then Principal of Midnapore College provided all help to establish IAPT Midnapore College Centre for Scientific Culture, has also encouraged to conduct this activity and promised to support financial help for purchasing the experiment kits. It is interesting to note that this activity has motivated Prof Roy to take up similar programmes in his Institute.

DPKFSE gratefully acknowledges him and his Institute and thank ,Sanjoy Kumar Pal, Soumen Sarkar, BireshLayek and Bidyut Ghosh for preparing the report.

Subhash Samanta

Online workshop



Organised by: Department of Physics, DAV College, Bathinda (Punjab) via Google meet

Duration: January 27 to February 1, 2021

Time: 05:00 pm - 06:30pm daily

No. of registrations: 79 Successful participants: 52

Demonstrations: Microsoft's Excel/Spreadsheet a Tool for Enhancing Mathematical and Computational Skills of UG students.

Sponsored: By DBT Star College Scheme

Resource Persons: Day 1&2 Dr. P. K. Ahluwalia, Professor (Retd.), Department of Physics, Himachal Pradesh University Shimla. Day 3&4 Dr. Sapna Sharma, Associate Professor Department of Physics, St. Bede's College Shimla.Day 5&6 Dr. Sarmistha Sahu, Associate Professor (Retd.) Department of Physics, MLAC, Bengaluru, Karnataka

Coordinator: Dr. Kulwinder Singh Mann

In association with IAPT, Prof.Yashpal Association of Physics Students (YAPS), and sponsored by the DBT STAR College Scheme, the department of Physics of DAV College Bathinda organized a One Week inter departmental workshop. The workshop focused to train the participants for the optimal use of the spreadsheets for solving various kinds of complex problems using users' friendly computational capabilities of the MS-Excel. In the keynote address, Prof P K Ahluwalia highlighted the requirement of the new education policy in reference to computational skills of students. He informed that the MS-Excel offers a middle way for users to exploit the computational power of computers without the knowledge of any coding language. Dr. Sapna Sharma, demonstrated how to implement the spreadsheet for designing simulations and plotting graphs from the observational data collected in any experiment. Dr. Sarmistha Sahu described the Monte Carlo Method to calculate the value of Pi in playful way. The comparison between classical and quantum oscillators was explained with the help of simulations designed in MS-Excel. The workshop concluded with a vote of thanks by Dr. Gurpreet Singh, Head department of Physics.

K S Mann

INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Graduate Physics Examination 2021

Day and Date of Examination : Sunday, January 24, 2021

Time : 10 AM to 1 PM

Part A- Maximum Marks: 150 — Time for Part A : 60 minutes

Part B- Maximum Marks: 150 — Time for Part B : 120 minutes

Part A

25x6 = 150

Mark the correct option/options (Any number of options may be correct).
Marks will be awarded only if all the correct options are marked. No negative marking.

1. The electric field $\vec{E}(\vec{r})$ in a certain region of space varies proportional to the position vector $\vec{r}$ as $\vec{E}(\vec{r}) = \alpha r$. The volume charge density for absulute premittivitiy (ε) in this region of space is
   (a) $\rho = \alpha\varepsilon$
   (b) $\rho = 2\alpha\varepsilon$
   (c) $\rho = 3\alpha\varepsilon$
   (d) $\rho = \alpha\varepsilon r$

2. A particle of mass'm' is dropped from a height h = R above the earth surface where R is the radius of the earth. If ΔE and v represent the loss of it potential energy and gain in its velocity of reaching the earth surface respectively then.
   (a) $\Delta E = mgR$ and $v = \sqrt{gR}$
   (b) $\Delta E = mgR$ and $v = \sqrt{2gR}$
   (c) $\Delta E = \frac{mgR}{2}$ and $v = \sqrt{gR}$
   (d) $\Delta E = \frac{mgR}{2}$ and $v = \sqrt{2gR}$

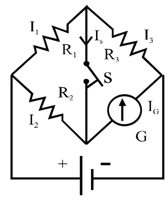
3. For a Vender Waal gas whose Vander Waal constants are a and b the
   (a) Boyle temperature is $T_B = \frac{a}{Rb}$
   (b) Temperature of inversion is $T_i = \frac{2a}{Rb}$
   (c) Critical temperature is $T_C = \frac{8a}{27\,Rb}$
   (d) Equation of stare for n mole is

   $$\left(P + \frac{a}{V^2}\right)(V - b) = nRT$$

4. Knowing that $i = \sqrt{-1}$ the value of $(i)^i$ is/are
   (a) non-zero
   (b) imaginary
   (c) sum of a non-zero real and a non-zero imaginary term
   (d) real

5. A light flat rectangular steel strip of length l = 1m, breadth b = 3 cm and thickness d = 0.2 mm and negligible mass is hinged at one end so as to remain horizontal. A dimensionless block of mass M = 2 kg is loaded at free the end. Now the free end is slightly depressed and released so as the mass M to execute simple harmonic motion. Taking the geometrical moment of Inertia of the metallicslab as $I_g = \frac{bd^3}{12}$ and Young's modulus of its material as $Y = 2 \times 10^{11}$ Nm^{-2} The time period of small oscillations is
   (a) $T = 2\pi\sqrt{\frac{4\,Ml^3}{Ybd^3}}$
   (b) $T = 2\pi\sqrt{\frac{Ml^3}{2YI_g}}$
   (c) $T = 2\pi\sqrt{\frac{Ml^3}{4YI_g}}$
   (d) T = 66.2 s

6. In the circuit shown if $R_1 \neq R_2$ and the reading in the galvanometer is the same with switch S open or closed. Which of the following is/are correct?
   (a) $I_G = I_1$
   (b) $I_G = I_2$
   (c) $I_G = I_3$
   (d) $I_G = I_2 + I_S$



7. Knowing that Lead (Pb) is fcc crystal with radius of atom r = 0.12 nm, estimate the number of atoms per square millimetre surface of (100) plane of Lead (Pb).
(a) 26.0×10^{12}
(b) 22.1×10^{12}
(c) 17.4×10^{12}
(d) 16.7×10^{12}

8. A LASER beam of wavelength 1.5 micron is used in a Michelson interferometer to obtain interference fringes. The fringes remained visible for a path length of 5.0 m. The lower limit on coherence time and spectral width respectively are
(a) 3.2×10^{-8} sec, 4.2×10^{-13} m
(b) 2.2×10^{-8} sec, 2.2×10^{-13} m
(c) 1.67×10^{-8} sec, 4.5×10^{-13} m
(d) 2.6×10^{-8} sec, 3.2×10^{-13} m

9. Pick up the correct option/s. The first time derivative of a
(a) vector of constant magnitude is always perpendicular to the vector itself.
(b) vector of constant direction is always perpendicular to the vector itself.
(c) vector of constant direction is always parallel to the vector itself.
(d) vector of constant magnitude is always parallel to the vector itself.

10. The isothermal compressibility for an ideal gas is defined as $K_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$
(a) The isothermal compressibility is = P (gas pressure)
(b) The isothermal compressibility is $=\frac{1}{P}$
(c) The adiabatic compressibility is $= \gamma P$
(d) The adiabatic compressibility is $=\frac{1}{\gamma P}$

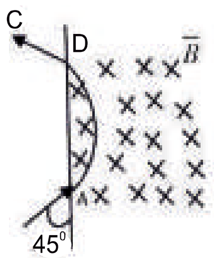
11. In a triclinic crystal, a lattice plane makes intercepts of length $a, \frac{b}{2}, 3c$ on the axes of x, y, z respectively. Miller indices of the plane are
(a) 163
(b) 136
(c) 361
(d) 326

12. Muons are elementary particles produced in the upper atmosphere and have a life time of τ = 2.2 μs. Muons are travelling vertically down towards the earth's surface at a speed of v = 0.998c. If for an observer on earth, the height of the atmosphere above the surface of earth is 10.4 km. Then which of the following statement(s) is/are true?
(a) The muons can never reach earth's surface
(b) The apparent thickness of the earth's atmosphere in muon's frame of reference is 0.96 km
(c) The lifetime of muons in earth's frame of reference is 34.8 μs.
(d) Muons travelling at a speed greater than 0.998c reach the earth's surface.

13. Mathematical formulation E = pc applies for
(a) electrons
(b) photon
(c) a mass less particle moving fast
(d) a particle moving with speed of light

14. In Fresnel's diffraction experiment
(a) the slit size is comparable to the wavelength of light used
(b) the source slit distance and the slit screen distance are comparable to the wave length of light
(c) diffraction grating cannot be used but zone plate is used
(d) the source size cannot largely exceed the slit size

15. A charged particle of charge q and mass m enters the region of magnetic field $\vec{B}$ with a velocity v at 45^0 from the straight boundary. After sometimes the particle comes out of the region at point D and goes along line DC.



(a) Inside the field region the charged particle moves in a circular path of radius $R = \frac{mv}{qB}$
(b) The straight distance AD is $= R\sqrt{2}$
(c) The time for which the particle is inside the region of magnetic field is $t = \frac{\pi m}{2qB}$
(d) If the direction of magnetic field $\vec{B}$ is reversed, the particle will never come out of the magnetic field region.

16. Consider a circular parallel plate capacitor of radius 'R' with separation 'd' between the plates (d<<R). The plates are placed symmetrically about the origin. If a sinusoidal voltage $V=V_0 \sin \omega t$ is applied between the plates, which of the following statement(s) is/are true?

(a) The maximum value of the Poynting vector at $r=R$ is $\frac{\varepsilon_0 \omega R}{4d^2} V_0^2$

(b) The average energy per cycle flowing out of the capacitor is zero.

(c) The magnetic field inside the capacitor is constant.

(d) The magnetic field lines inside the capacitor are circular with the curl being independent of radius of circle (r).

17. The nuclear reaction $\pi^+ + n = \Delta^0 + K^+$

(a) Conserves isotopic spin

(b) Conserves strangeness

(c) Conserves Baryon number

(d) Is possible through strong interaction only

18. A photon of frequency υ, strikes an electron of mass 'm_0' initially at rest. After scattering at an angle ϕ, the Photon loses half of its energy? If the Electron recoils at an angle θ which of the following is / are correct?

(a) $\cos\phi = 1 - \frac{m_0 c^2}{h\upsilon}$

(b) $\sin\phi = 1 - \frac{m_0 c^2}{h\upsilon}$

(c) The ratio of magnitudes of the momenta of the recoiled electron and the scattered photon is $\frac{\sin\phi}{\sin\theta}$

(d) Change in the photon wavelength is $\Delta\lambda = \frac{h}{m_0 c^2}(1 - 2\cos\phi)$

19. An emitter follower often used as an impedance matching circuit has

(a) common emitter

(b) common collector

(c) both input and output in phase

(d) negative feedback gain less than 1

20. Which of the following has/have the dimensions of resistance (Ω)

(a) $\frac{L}{CR}$

(b) $\frac{E}{H}$

(c) $\frac{\mu}{\varepsilon}$

(d) $\frac{B}{D}$

Where all symbols have their usual meaning.

21. An alkaline solution has an absorption maximum near $4950 A^0$ and a fluorescence maximum at $5250 \overset{0}{A}$. The energy lost in the process of absorption and re-emission of one quantum is

(a) 1.98×10^{-20} J

(b) 2.30×10^{-20} J

(c) 1.38×10^{-16} J

(d) 3.89×10^{-14} J

22. A star Alpha-Centauri initially has 10^{40} deuterons. In the star, the energy is produced via the process ${}_1^2H + {}_1^2H \longrightarrow {}_1^3H + {}_1^1H$ and ${}_1^2H + {}_1^3H \longrightarrow {}_2^4He + {}_0^1n$ where the

Mass $({}_2^4He) = 4.001u$, Mass $({}_1^2H) = 2.014u$,

Mass $({}_1^1H) = 1.007u$, Mass $({}_0^1n) = 1.008$ u,

If the average power radiated by the star is 10^{16} watt, the deuteron supply of the star is exhausted in a time of the order of

(a) 365 days

(b) 1.3×10^{12} second

(c) 4.1×10^4 year

(d) 3.15×10^7 second

23. The dominant mechanism for the motion of current carriers in a forward and reverse biased Silicon p-n junction diode are

(a) Drift in forward bias and diffusion in reverse bias

(b) Diffusion in forward bias and drift in reveres bias

(c) Diffusion in both forward and reverse bias

(d) Drift in both forward and reverse bias

24. The uncertainty in the position of an electron in its orbit hydrogen atom is given as $0.5A^0$. If r and Δp denote the radius and the uncertainty in the linear momentum of electron in the second Bohr orbit respectively. Then

(a) $r = 2.0\ A^0$ and $\Delta p = \frac{h}{\pi} \times 10^{10}$

(b) $r = 2.0\ A^0$ and $\Delta p = \frac{h}{2\pi} \times 10^{10}$

(c) $r = 1.0\ A^0$ and $\Delta p = \frac{h}{\pi} \times 10^{10}$

(d) $r = 1.0\ A^0$ and $\Delta p = \frac{h}{2\pi} \times 10^{10}$

25. In a uniformly doped abrupt p-n junction, the doping level on n-side is four times of that at p-side. If the depletion layer width and the diffusion length across the junction diode are denoted by x and L respectively, then choose the correct option (s)

(a) $\frac{x_n}{x_p} = \frac{2}{1}$ and $\frac{L_n}{L_p} = \frac{1}{2}$

(b) $\frac{x_n}{x_p} = \frac{1}{2}$ and $\frac{L_n}{L_p} = \frac{2}{1}$

(c) $\frac{x_n}{x_p} = \frac{1}{2}$ and $\frac{L_n}{L_p} = \frac{\sqrt{2}}{1}$

(d) $\frac{x_n}{x_p} = \frac{\sqrt{2}}{1}$ and $\frac{L_n}{L_p} = \frac{1}{2}$

Part B1

10x5 = 50

Answer all the following in brief (not more than 10 lines) with appropriate reasoning

B1. Microwaves are the electromagnetic radiations of wave length of the order of micrometer ($\lambda = 10^{-6}$m) in free space. Defend or refute.

B2. A flat sheet of glass (refractive index =1.5) is coated with a transparent material (refractive index = 1.25) with negligible thickness so that the light of wavelength 6000 A^0 (in vacuum) is not reflected at all. Defend or refute.

B3 It is necessary to rotate the apparatus / interferometer in Michelson Morley experiment to conclude its results. Defend or refute with appropriate reasoning.

B4. A diffraction grating with 8000 line per inch can exhibit diffraction upto fifth order when the wavelength of light is 625 nm. Defend or refute.

B5. The difference in the speed of the O-ray and E-ray in a uniaxial crystal is maximum in a direction perpendicular to the optic axis. Defend or refute.

B6. Distinguish between the precessional frequency and cyclotron frequency of proton moving in a perpendicular magnetic field.

B7. In order to get a Billiard ball of radius R to roll without sliding from start, the ball must be hit exactly $\frac{2}{5}$ R above the centre line.

B8. The luminosity of a rigid star in Orion constellation is 17000 times that of the Sun. The temperature of the rigid star is nearly 66000 K. Defend or refute.

B9. The fermi energy (E_f) of electron gas in a metal does not depend on size / Volume of the specimen however, it does depends on molecular concentration Justify.

B10. Design a logic circuit using basic logic gates with three inputs A,B,C such that the output Y goes to a low Logical value when A is high Logical value while the B and C are in different levels.

Part B2 **10x10 = 100**

Solve all the 10 problems. Each carries 10 marks.

P1.(a) Show that the acute angle between the diagonals of a cube is $\theta = \cos^{-1}\left(\frac{1}{3}\right)$

(b) Find the angular velocity $\vec{\omega}$ of a particle of mass m = 2 kg moving round in a circle with velocity $\vec{v} = 3\hat{i} - 4\hat{j} + 5\hat{k}\ ms^{-1}$ in terms of unit vectors $\hat{i}, \hat{j}$ & $\hat{k}$ when the radius vector is $\hat{r} = \hat{i} + 9\hat{j} - 8\hat{k}$ m. Also find its angular momentum at the same instant.

P2. Elaborate the concept of mechanical impedance of a mechanical oscillator subjected to a periodic force. What is the physical significance of mechanical impedance? Discuss the condition of resonance in a mechanical system.

P3. A real gas obeys an equation of state given by $P(V - nb) = nRT$ where n is the number of moles of the gas. Its heat capacity at constant volume is given by $C_v = n[C_0 - C_1T]$ where C_0 and C_1 are constants, and T is the absolute temperature. In a process, one mole of gas at a temperature T_1 and volume V_1 is heated at a constant pressure P_1 up to a temperature T_2 ($>T_1$). Determine

(a) The constant R and the final volume V_2
(b) The work done by the gas in this process.
(c) The heat supplied to the gas during this process.
(d) The net change in the entropy of the gas during this process

P4. Show that the energy flux (Energy flowing per second per unit area of cross-section) in a plane polarised electromagnetic wave, in free space, is the energy density times the wave velocity.

P5. Diffraction of a collimated beam of white light at N parallel equidistant slits in a plane (a plane transmission diffraction grating) provides intensity.

$$I = \left(\frac{A \sin \alpha}{\alpha}\right)^2 \left(\frac{\sin N\beta}{\sin \beta}\right)^2$$

Discuss the general variation of intensity on a distant screen. Explain the formation of spectra and obtain an expression for dispersive power of this system.

P6. A point object of mass m and charge q moving with velocity $v_o\hat{i}$ along x-axis, enters a magnetic field $B_o\hat{k}$. Determine

(a) The magnetic flux enclosed by the orbit of the particle
(b) The angular momentum (L) of the orbital motion of the particle and its magnetic dipole moment (μ)
(c) The ratio $\frac{\mu}{L}$

P7. Consider a quantum particle of mass m confined to the region $0 < x < L$ in a one dimensional potential well. If $\phi_0(x)$ and $\phi_1(x)$ are the normalised eigen functions of the ground state and the first excited state respectively, and if the wave function of the particle at t = 0 is

$$\Psi(x) = \frac{1}{\sqrt{2}}\{\phi_0(x) + \phi_1(x)\}$$

Determine the average energy of the particle.

P8. (a) Using the values hc = 197.3386 MeV × fm, Electron charge e = 1.602×10^{-19} C and $\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ SI units. Find

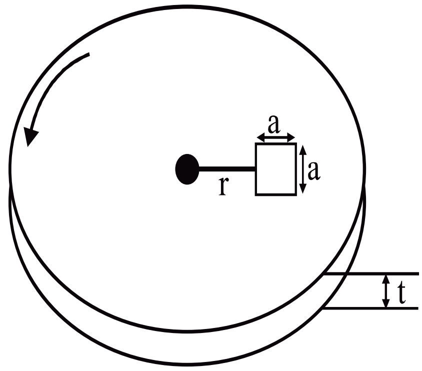
(i) the value of $\frac{e^2}{4\pi\varepsilon_0}$ in units of MeV fm

(ii) the value of the fine Structure constant α. Also express $\frac{1}{\alpha}$ in pure numeric.

(b) Eight distinguishable particles are distributed in two compartments. The first compartment is divided into 4 cells and the second into two cells. Each cell is of equal a priori probability and there is no restriction on the number of particles that can be contained in each cell. Calculate the thermodynamic probability of

(i) the most probable state and
(ii) the macro state (8,0)

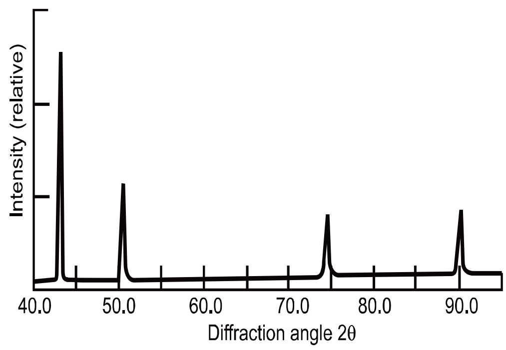
P9. An electromagnetic "eddy current" brake consists of a circular disk of conductivity σ and thickness t. It is rotating about an axis through its centre with a magnetic field $\vec{B}$ applied perpendicular to the plane of the disk over a small area a^2.



If the area a^2 is at a distance r from the axis of rotation, find an approximate expression for the torque tending to slow down the disk at the instant its angular velocity equals to ω.

P10.(a) Given that the two solution of the quadratic equation $x^2 - 10x + 31 = 0$ are $x = 5$ and $x = 8$. What is the base of the numbers?
The base of numbers in the decimal system in normal use is 10.

(b) The first four peaks of the x-ray $\lambda = 0.154$ nm diffraction pattern for copper which has a FCC crystal structure are found to be at Angle $2\theta_1 = 43.8^0$, $2\theta_2 = 50.8^0$, $2\theta_3 = 74.4^0$ and $2\theta_4 = 90.4^0$.



For each of these peaks, find
(a) Index (h, k, l)
(b) The interplanar spacing
(c) The atomic radius for Cu.

ANSWER KEY : NGPE - 2021 PART A

Question	Answer	Question	Answer	Question	Answer	Question	Answer
1	c	7	c	13	b, c, d	19	b, c, d
2	c	8	c	14	a, c, d	20	a, b, d
3	a, b, c	9	a, c	15	a, b, c	21	b
4	a, d	10	b, d	16	a, b, d	22	b, c
5	a	11	c	17	a, b, c, d	23	b
6	b, d	12	c, d	18	a, c	24	b
						25	b

Prof B P TYAGI
CCE

Dr A K SINGH
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