June 2015

APT TUNES

Bulletin of

Academy of Physics Teachers, Kerala

Contents

Editorial

Launched in 1999, by a team of teachers of physics in Kerala, Academy of Physics Teachers (APT) has grown into a professional organisation of college and university teachers. It has been organising a series of programmes such as short workshops, invited talks by eminent persons, talent search examinations for under graduate students and discussion on curriculum reforms. In the last few months the academy organised a series of programmes commemorating the hundred years of the Bohr Atom Model. Each programme was organised in collaboration with the Physics Department of some leading Colleges in Kerala and was partially financed by the Kerala State Council for Science, Technology and Environment. Another notable achievement was the organisation of a string of short workshops in topics related to curriculum with reputed resource persons from institutions such as IIT Chennai. This received enthusiastic support from the Physics community of Kerala.

In Kerala we are witnessing notable changes in the field of Physics education. First of all, after a long gap, a large number of young and talented faculty members have joined the colleges and they are enthusiastic to take up new challenges. In addition Kerala has witnessed the launching of new national level institutions such as the Indian Institute of Science Education and Research (IISER), and Indian Institute of Space Science and Technology (IIST), both at Thiruvananthapuram. These institutions are attracting tallented students and eminent faculty members. Lesser known and appreciated is the fact that a large number of post graduate departments of Physics in various colleges have turned into research centers attracting funds from central agencies and utilizing these funds for establishing R & D infrastructure. This is going to have a long time impact in the way Physics is taught and practised in India.

This issue of APT Tunes has the “International Year of Light” as the cover story. As usual this issue has a number of articles on developments in the field of R & D in Physics and Physics Education. This issue also includes reports of a multitude of activities organised by the academy.

Dr. N. Shaji
nshaji101@gmail.com

LIGHT-BASED TECHNOLOGIES RESPOND TO THE NEEDS OF HUMANKIND AND SOLVE GLOBAL CHALLENGES

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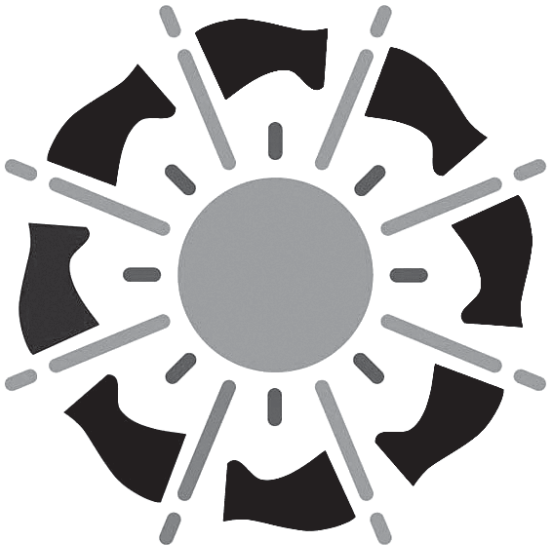
United Nations
Educational, Scientific and
Cultural Organization

International
Year of Light
2015



International Year of Light 2015

Sona Hosseini
Member of the International UNESCO Committee
"Optics Under 40" for the International Year of Light 2015

The International Year of Light and Light-Based Technologies (IYL 2015) is a global initiative adopted by the United Nations to raise awareness of the role of light in human history and civilization, anything from science, technology in physics, chemistry, and medical sciences to arts, architecture and human interactions. In the current times, IYL 2015 is about how optical technologies promote sustainable development and provide solutions to worldwide challenges in energy, education, agriculture, communications and health.

The goal of IYL 2015 is to highlight to the citizens of the world the importance of light and optical technologies in their lives, for their futures and for the development of society. During 2015, the IYL 2015 programs will promote improved public and political understanding of the central role of light in the modern world while also celebrating noteworthy anniversaries in 2015—from the first studies of optics 1,000 years ago to discoveries in optical communications that power the Internet today.

How IYL2015 started is a very interesting story. A resolution welcoming and endorsing an International Year of Light in 2015 was first adopted by the UNESCO Executive Board at its 190th session in October 2012. The IYL 2015 resolution was submitted to the United Nations Second Committee in November 2013 by the nation of Mexico, and delegates from both Mexico and New Zealand spoke in support of the submission. The resolution was adopted at the 68th session of the U.N. General Assembly in Paris with cosponsorship from 35 countries.

The IYL Global Secretariat is located at the International Centre of Theoretical Physics ICTP, in collaboration with the UNESCO International Basic Sciences Program. Many number of international scientific unions and the International Council of Science, and more than 100 partners from more than 85 countries are endorsing IYL 2015. Founding Scientific Sponsors of IYL 2015 are the American Physical Society (APS); The American Institute of Physics (AIP); the European Physical Society (EPS); the IEEE Photonics Society (IPS); SPIE, the international society for optics and photonics; the Lightsources.org International Network; the Institute of Physics (IOP); and The Optical Society (OSA).

The IYL 2015 was kicked off with the opening ceremonies that were held 19-20 January 2015 in Paris. ■

The blue sky is the limit!

Prof. C. Vijayan
Department of Physics, IIT Madras
www.physics.iitm.ac.in/~cvijayan

The International Year of Lightis a *delightful* occasion to reaffirm our fascination to the wonder world of light and color.
Imagine a dark colorless world — well, we can't, however much we try!

A few *light* remarks

After all, what is light? Not something to be taken *lightly*, that is all we know. Seriously, we don't fully understand yet the dual nature of light. Waves and particles are very different entities. We can interpret the results of an experiment on Compton effect easily if we consider photons and electrons as particles, whereas, we necessarily need to consider light as a wave if we want to interpret phenomena such as diffraction and interference! So, it is as if light looks into your laboratory record and behaves as particles on the day you do Compton effect experiment and then as waves on the day when you do diffraction experiment ! What happens then on Sundays, whenyou are not doing any experiment at all? What is light, then? Well, Physics is an experimental science and it is meaningless to talk about how light behaves when it is not involved in an experiment.We are reminded of the dilemma faced by Ezhuthachan, the great poet known also as the father of Malayalam language:

ഒന്നായ നിന്നെയിഹ
രണ്ടെന്നു കണ്ട–
ളവിലുണ്ടായൊരിണ്ടൽ
ബതമിണ്ടാവതല്ല മമ.

It is not only light that has a dual nature; matter also can behave as matter waves. Sir Joseph John Thomson got a Nobel Prize in Physics in 1906 for the discovery of the particle electron. His own son, Sir George Paget Thomson shared the Nobel prize (with a few others) thirtyone years later, for proving experimentally that electron can get diffracted and hence it behaves like a wave. Listen to what Richard Feynman has to say about this paradox"*Quantum mechanics is the description of the behavior of matter and light in all its details and, in particular, of the happenings on an atomic scale. Things on a very small scale behave like nothing that you have any direct experience about. They do not behave like waves, they do not behave like particles, they do not behave like clouds, or billiard balls, or weights on springs, or like anything that you have ever seen.*" However, in spite of all this confusion, technology keeps exploiting efficiently the various forms of light to make our lives happier and research continues on various aspects of light continues to bring in surprises after surprises. For example, one of such recent frontier is slowing of light; but then that is another topic; however, and you may get a quick and elementary introduction to this new frontier in a recent update, if interested [1].

Your eye and I …

Light and other forms of electromagnetic radiation carry energy as well as information and hence the technology of Photonics makes use of both these aspects. For example, research on solar energy and industrial lasers

***Raman's sky**: a scene from the Raman research Institute, Bangalore. Some of the molecules that vibrated within Raman may still be vibrating under the tree now!*

Picture source: http://photonics.cusat.edu/Article5.html

focuses on the energy aspects whereas optical communications, medical imaging and spectroscopy focus primarily on the information carrying capacity of photons. Each wavelength region of the spectrum opens up a window into the unknown. Gamma rays tell us about the nuclei, X-rays about inner electron transitions, visible light about outer electron transitions, infrared about molecular vibrations and microwaves about molecular rotations.The art of reading the message contained in these light waves is known as spectroscopy.

The most well-known branches of spectroscopy are those of absorption and fluorescence. Scattered light also brings valuable information. We are able to see the world and each other because everything can scatter light.In fact light scattering mechanisms around us are crucial for our own existence in this planet. Sun emits a variety of radiations and it is only a subset of it that reaches us down here. The various entities in the layers of atmosphere filter off several wavelengths (for example, ozone layer filters off most of the ultraviolet) and dust particles and the other impurities scatter off several other wavelengths. The shape of the body of any occupants of this planet has to be designed taking into consideration what wavelengths eventually reach us. For example, our eyes are merely optical detectors which are designed efficiently to receive the parts of spectrum available here on this planet. If the diameter of the dust particles in the atmospheres were a bit different, then the spectral content would have been a bit off into the infrared/microwave and we all would have had huge eyes or long ugly antenna instead of the beautiful eyes. So, the next time you think that the eyes of someone special to you look beautiful, you can marvel at the design characteristics of the detectors and sing an appropriate Hindi song : "*Taarifkarookyauski, jisnetumhebanaya…*". Whoever designed us animals in shapes most appropriate for and in tune with the planet's oddities of structure and composition deserves praise.

Let us now focus on just one simple aspect of light and color that had attracted human attention from time immemorial, namely, the blue color of the sky. Of course, the first name that comes to our mind is that of Sir. C. V. Raman, the pride of Indian Physics community. The original Nobel work of Raman did not get forgotten within a few years of getting the prize, but continues to grow in its scope extending to the frontiers of science, technology, industry and biomedical research, to name a few areas.

The *new* radiation

Man has always been fascinated by light and color. The red color of the apple is due to the red part of the sunlight being scattered into our eyes. But then the red is scattered as red and not green, fortunately for those who are too conscious of the color of the dress and *matching*. The color does not change normally in a scattering process called Rayleigh scattering where the molecules of the material do not take away or add to the energy content of the incident photons in a scattering event.

Raman scattering is a different kind of optical process. The Raman Effect was observed first as a weak

Raman explains his Effect to visitors
Picture source: http://biography-of.com/c-v-raman

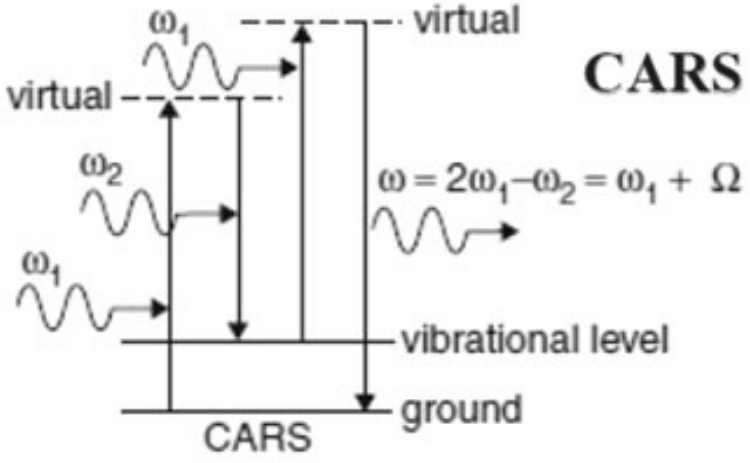
light emission from a liquid. The first thought was that the emission is from light being scattered by some impurity in the test tube. However, after washing thoroughly several times it was clear that the weak light emission could neither be washed away nor *wished* away! Then Raman realized that they were looking at an entirely new kind of emission process [2]. The Nobel Prize was a recognition to the understanding of a new process of inelastic light scattering.

Raman scattering is different from Rayleigh scattering in the sense the energy content of the incoming photon changes as light exchanges energy with a vibrating molecule. This happens through the interaction of the electric field of the light wave with the dipole moment of the molecule, provided the polarizability of the molecule undergoes a change during a given mode of vibration of the molecule [3].

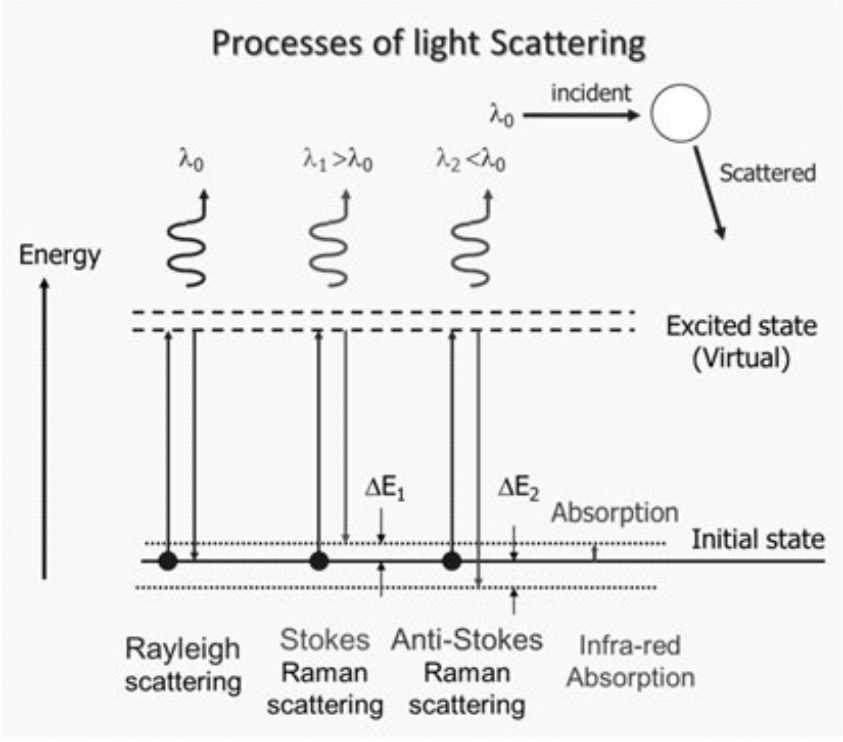
Forging ahead with cars and horses : *Ram*, *terekitnenam*!

Raman spectroscopy has been a very versatile and successful tool in the hands of the physicist, the chemist, the materials scientist and the medical and the industrial researchers as well. The availability of powerful lasers as light sources has revolutionized Raman spectroscopy, expanding its efficiency and potential. Subtle effects involving overtones and wave mixing could now be explored, apart from observing the familiar effects more clearly than with weaker light sources. New branches of spectroscopy such as Surface enhanced Raman Spectroscopy,Coherent Anti Stokes Raman Spectroscopy (CARS), Higher Order Raman Spectral Excitation Studies (HORSES) etc.

One of the recent areas where Raman spectroscopy is being used very successfully is that of the characterization of nanomaterials [4-9]. Phonon confinement in nanomaterials can be investigated through Raman spectroscopy. The LO phonon mode is found to be asymmetric and peak-shifted in several cases. The asymmetry is a measure of the extent of quantum confinement [7]. New low frequency modes also can



A schematic showing the principle of Coherent Anti-Stokes Raman Spectroscopy (CARS) Picture Source : Reference [5]



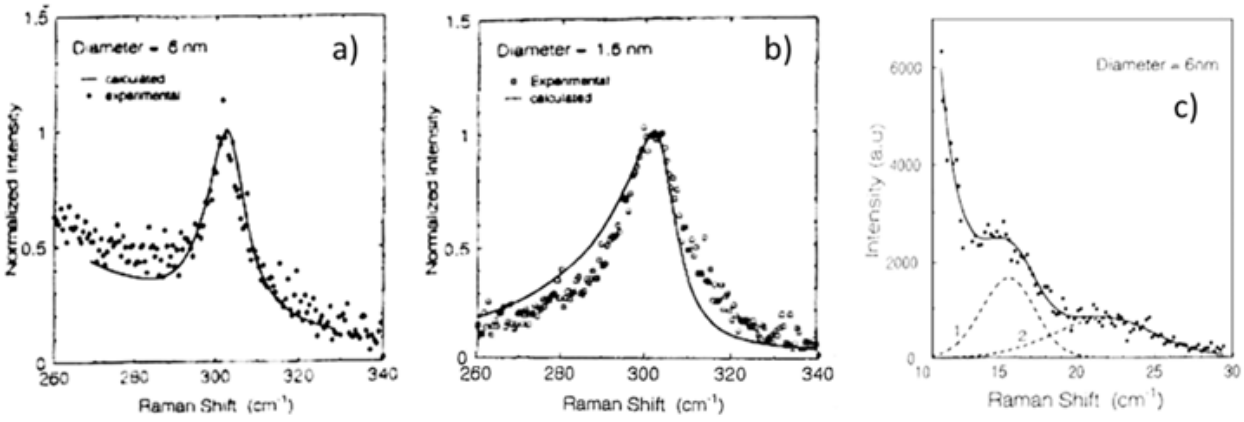
appear and the peak positions of these can be sued to determine mean particle size in quantum dot systems. Further, new surface modes also are seen as the relative number of atoms on the surface is much larger than that in the bulk in nanoclusters.

Raman spectroscopy is widely accepted as the main characterization technique for the structure of carbon-based nanomaterials such as nanotubes and graphene. The specific modes of vibrations in nanotubes give rise to characteristic Raman bands and they get modified in specific ways if the nanotubes are functionalized. Graphene is the monolayer of graphite and can be considered as the basic building block of all carbon-based nanostructures. This is basically a two-dimensional material with very interesting physical properties such as zero band gap and many features very different from those of three dimensional materials.

Raman spectroscopy reveals the characteristic peaks due two in-plane vibrations in graphene. The shape of these peaks is sensitive to the actual number of graphene layers [9]. Strictly speaking, graphene is a monolayer though people find some interesting properties for a-few-layer structures as well. More than a few layers render the material in the form of graphite.

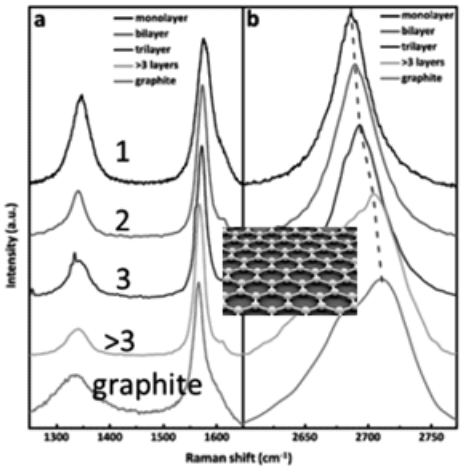
Looking beyond

Raman used to give inspiring lectures to students at all levels. He urges us to look beyond and to look behind so that we see what others have not seen yet [9]. He says that the best way to answer a question is to ask several



Raman spectra showing LO phonon mode in CdS nanoclusters of mean size 6 nm (a) and 1.6 nm(b) and low frequency acoustic modes of CdS nanoclusters of mean size 6 nm (c).

Picture source: Reference [7]



Raman bands for n-layered graphene and Graphite, Picture source: Reference [9]

others. Raman considers it as the challenge before man to try to understand all the wonders of nature. He says that there are only two ways to live: one is to live as if nothing is a miracle and the other is to live as if everything is a miracle! We researchers are fortunate that we get paid in our job to do something we like, something very interesting that always provides new challenges and opportunities, thrills and food for thought and thus it becomes our pleasant duty to make sincere attempts to unravel the miracles of Mother Nature. Budding scientists should often refresh themselves by looking at the yet unsolved mysteries of the unknown, taking inspiration from Raman's life and work. Grandmothers in Kerala used to advice idling youngsters by saying *"If you don't have any work, look up the sky and chant Ram, Ram!"* Now this acquires a new meaning and perhaps this is also as important as any other work! A nice way to celebrate the International Year of Light!

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Photo Gallery - APT Annual General Body Meeting


ACADEMY OF PHYSICS TEACHERS, KERALA
ANNUAL GENERAL BODY MEETING 2015


Invention of Calculus by Kerala Astronomers
Venketeswara Pai R


Sculpting Light
Holography and Applications
P.T.Ajith Kumar

Blue LEDs are Lighting Up the World

Anitta Rose Thomas and Reji Philip
Raman Research Institute
Sadashivanagar, Bangalore - 560080

The Royal Swedish Academy of Sciences awarded Nobel Prize in Physics 2014 to three Japanese scientists(Isamu Akasaki, Hiroshi Amano and Shuji Nakamura)who inventedthe blue light-emitting diode. Why did the blue LED win a Nobel Prize?

In the spirit of Alfred Nobel, the prize awards an invention of greatest benefit to mankind.The rules for the Nobel Prize in Physics require that the achievements must have been "tested by time".Regardingthe award for Blue LED, The Royal Swedish Academy of Sciences said the invention was just 20 years old (the first bright blue LED was invented in 1993)"but it has already contributed to create white light in an entirely new manner to the benefit of us all".Even though red and green light-emitting diodes were available for almost half a century, blue light was needed to really revolutionize lighting technology. Only the triad of red, green and blue can produce white light. However, blue light remained a challenge for three decades. Akasaki worked with Amano at Nagoya University while Nakamura was employed at Nichia Chemicals, a company located in Tokushima on the island of Shikoku. When they obtained bright blue light from their semiconductors, a fundamental transformation happened in illumination technology. While incandescent light bulbs had lit the 20th century,the 21st century will be lit by LED lamps.LEDs were commercially available since 1962 but white light-producing LEDs have only been available since 2006.

Light Emission from Semiconductors

A Light-Emitting-Diode (LED) is a P-N junction that emits light when biased in the forward direction (Figure 1). LED chip materials are combinations of elements from the 3rdand 5thcolumns of the Periodic Table. If a forward current is passed through a

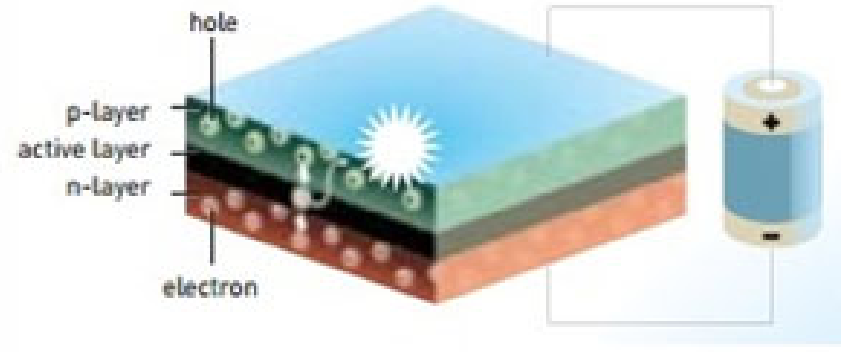

Figure 1: Working principle of the LED.

semiconductor diode, electrons and holes are injected into the P-type layer and N type layer respectively. Depending on the magnitude of the current, a recombination of charge carriers (electron and holes) takes place when an electron is de-excited from the conduction band to the valence band. When this recombination takes place, the surplus energy goes into the crystal as heat in Silicon and Germanium. In other semiconductors such as gallium arsenide, the released energy appears in the form of electromagnetic radiation, ranging from visible to infrared. The wavelength of this radiation will correspond to the energy band gap between the valence and conduction bands.

Some of the light generated within the LED will not be able to emerge due to internal absorption, Fresnel losses and internal reflection. Internal absorption occurs as photons travel from the junction region through the chip. Since limiting the range of this travel will reduce internal absorption, smaller LEDs will manifest increased conversion efficiencies. Fresnel losses and internal reflection are minimized by covering the LED chip with an optical coating whose index of refraction will bridge the indices of refraction between the chip and air. Light emissionfrom a semiconductor was first reported as early as in 1907 by Henry J. Round, a co-worker of Guglielmo Marconi. In the 1920s and 1930s, in the Soviet Union, Oleg V. Losev undertook more studies of light emission. However, Round and Losev lacked the academic knowledge to truly understand the phenomenon, because it would take a few decades more for the theoretical description of electroluminescence to be proposed. The red light-emitting diode which was invented by the end of the 1950s was used in digital watches and calculators, or as indicators of on/off-status in various appliances. At an early stage itself it was evident that a light-emitting diode with short wavelength, consisting of highly energetic photons – a blue diode – was needed to create white light. Even though many laboratories tried, success was not imminent.

Invention of the blue LED

The invention of the blue LED (Figure 2) was a technical triumph, and it made a large number of new applications possible. It was a huge technological achievement because until then, all the necessary properties for making sustainable blue light were not simultaneously achieved in a semiconductor. Gallium nitride (GaN) was identified as a semiconductor with the appropriate properties for producing blue light in the 1950s itself, but it quickly became clear that making GaN chips for use in an LED was challenging.

Si and GaAs are the two common semiconductor technologies, which have been established on bulk Si and GaAs single crystal wafers. One can grow bulk solid Si and GaAs crystals from the melt, from growing ice or solid water from the liquid form in a refrigerator. The problem with GaN and the other less known but equally important materialslike AlN and InN is that when heated they decompose and give off N_2 gas before melting. A typical growth temperature of 1400 K at a nitrogen background

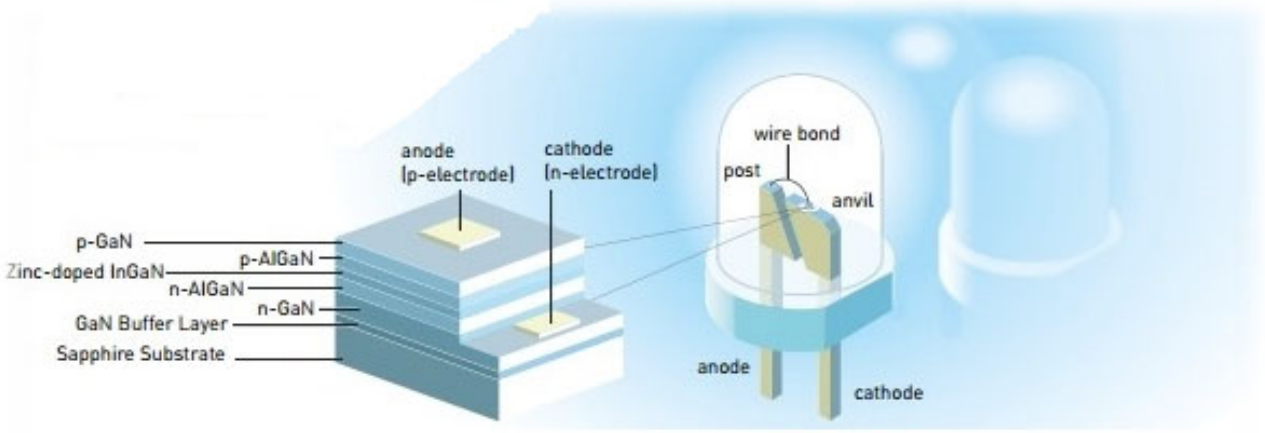

Figure 2: The Blue LED lamp. The LED consists of several different layers of GaN. Emission efficiency is increased by mixing Indium and Aluminium.

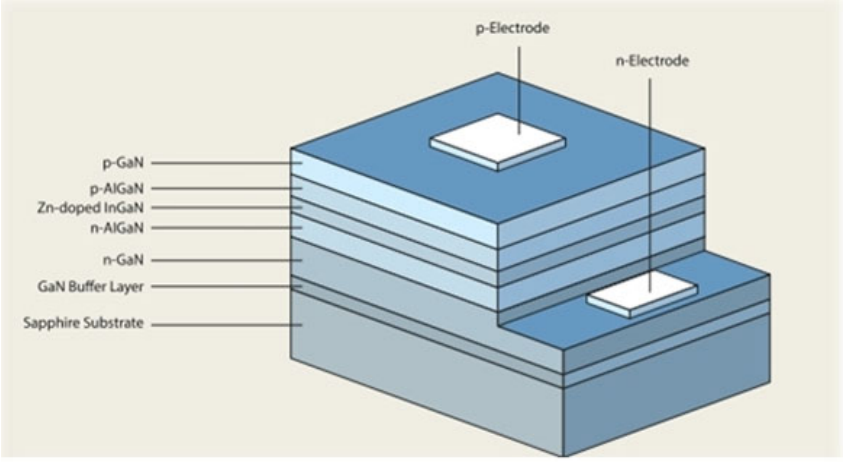

Figure 3: Structure of the heterojunction.

pressure of1000 atm is required for GaN to prevent the decomposition. While capable of producing tiny crystals for scientific purposes, such high pressures are not conducive for large-scale commercial manufacturing.In fact, by the early 1970s most scientists had stopped work on making LEDs from GaN.

However, during the early 1970s new methods for growing crystals were developed. Aluminium, Indium and Gallium, (III)-nitride films for device purposes had to be grown on substrates that were not III nitrides, or by a method commonly referred to as heteroepitaxy.For various reasons including stability at growth temperatures and symmetry similar to that of the III-nitride crystal structure on the surface, sapphire or aluminium oxide was the substrate that came closest to being used (it is still used today for growing LEDs).From1974 onwards, Isamu Akasaki, Hiroshi Amano and others investigated how these new methods could be used for making GaN crystals. A major problem for manufacturing blue LED was the difficulty to p-dope GaN in a controlled manner, but these scientists made the important observation that Zn-doped GaN emitted more light, indicating better p-doping. In a similar way, when Mg-doped GaN was irradiated with low energy electrons, it resulted in better p-doping properties. This was an important breakthrough and opened the way formaking p-n junctions in GaN. The effect of electron irradiation on Zn-doped GaN was that acceptors (such as Mg or Zn) formed complexes with hydrogen and thus become passive. Electron beams dissociate these complexes and activate the acceptors. Nakamura showed that even a simple thermal treatment (annealing) leads to efficient activation of Mg acceptors. Successful doping ofGaN crystals for practical use was finally achieved by late 1980s.

The next crucial step in developing efficient blue LEDs was the growth and p-doping of alloys (AlGaN, InGaN), which are necessary for producing heterojunctions (Figure 3). A key development that enabled this rapid progress to commercialization was the use of a double heterostructure containing GaN/InGaN/GaN.

Significance of the blue LED

The invention of efficient blue LEDs has led to the production of white light sources for illumination. When exciting a phosphor material with a blue LED, light is emitted in the green and red spectral ranges, which, combined with the blue light, appears as white. On the other hand, multiple LEDs of complementary colours (red, green and blue) can be used together as well. Both these technologies are used in today's high-efficiency white electroluminescent light sources.Thus blue LED has fundamentally transformed lighting technology. The two conventional methods of producing white light with LEDs are discussed below.

RGB Method:According to the RGB colour model, white light is produced by the proper mixture of red, green and blue light. The RGB white method produces white light by combining the output from red, green and blue LEDs (Figure 4). This is an additive colour method which is often counterintuitive for people accustomed to the everyday subtractive colour system of pigments, dyes, inks and other substances which present colour to the eye by reflection rather than emission. For example, while in subtractive colour systems green is a combination of yellow and blue,in additive systems red + green gives yellow, and no simple combination will yield green. Additive colour is a result of the way the eye detects colour, and is not a property of light itself.For instance, spectroscopically there is a vast difference between yellow light, with a

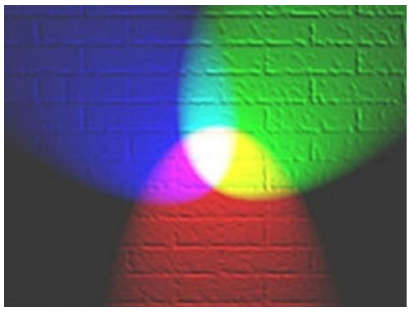

Figure 4: In additive colour mixing, red, green and blue mix together to give white light.

wavelength of approximately 580 nm, and a mixture of red and green light. However, we do not detect that difference because both stimulate our eyes in a similar manner. RGB white gives control over the exact colour of the light, butit is hardware-intensive since it requires three LEDs for operation.Moreover it tends to render pastel colours unnaturally, resulting in the poor colour rendering index of RGB white light.

Phosphor Method: In the Phosphor white method, white light is produced by combining a short wavelength LED such as blue or UV, with a yellow phosphor coating (Figure 5). The blue or UV photons generated in the LED either travels through the phosphor layer without alteration, or they are converted into yellow photons in the phosphor layer. The blue and yellow photons combine to generate white light (this was in fact discovered by Newton in the early 1700s). In some modules the yellow phosphor is remote. Phosphor white offers much better colour rendering than RGB white, often comparable to fluorescent sources. It is also much more efficient than RGB white. In a typical phosphor white manufacturing process, a phosphor coating is deposited on the LED die. The exact shade or colour temperature of white light produced by the LED is determined by the dominant wavelength of the blue LED and the composition of the phosphor.The thickness of the phosphor coating produces variations in the colour temperature of the LED. Colour variations can be minimized by controlling the thickness and composition of the phosphor layer during manufacturing.Over time, the blue die and the yellow phosphor will degrade. This results in the delivered light shifting in colour. It will also produce unexpected colours if the device is operated at a different operating temperature or current.

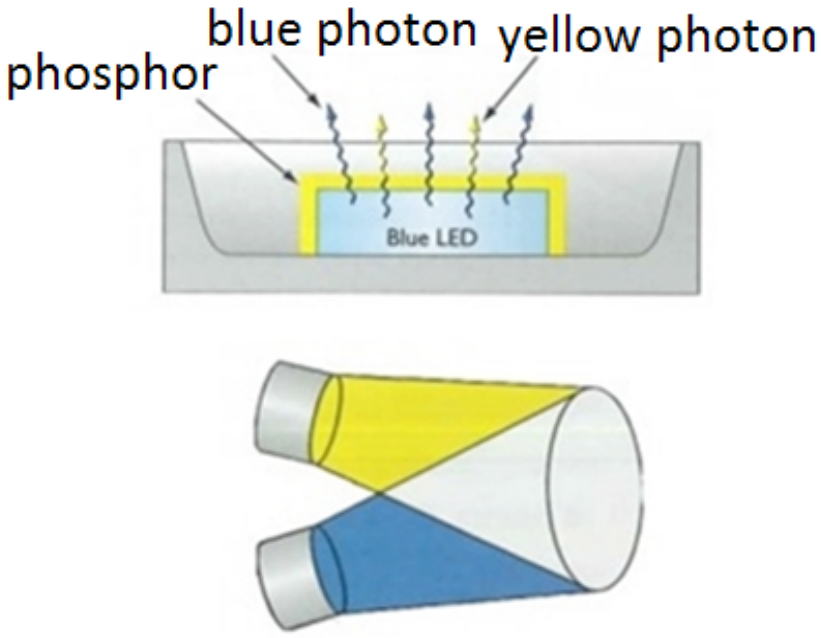

Figure 5: White light can be produced by combining yellow and blue light.

Future of LED lighting

Illumination technology is presently going through a revolution, namely the transition from light bulbs and fluorescent tubes to LEDs. The incandescent light bulb invented by Thomas Alva Edison in 1879 has a low efficiency of approximately 16 lm/W,indicating a conversion efficiency of 4% from electricity to light. The fluorescent tube containing mercury, invented by P. Cooper Hewitt in 1900, reaches an efficiency of 70lm/W. White LEDs currently reach above 300 lm/W, representing more than 50% wall plug efficiency. The highly energy-efficient LEDs contribute to saving the earth's resources, as about one fourth of world electricity consumption is used for lighting purposes. LED lamps are also flexible light sources in that millions of different colours can be produced,and the colours and intensity can be varied as required. Colourful LED panels of several hundred square metres in size can be computer-controlled to change colours and patterns very

Isamu Akasaki (left), Hiroshi Amano (center) and Shuji Nakamura display their medals after being jointly awarded the Nobel Prize in physics at a ceremony in Stockholm

quickly. The possibility to control the colour of light also implies that LED lamps can reproduce the alternations of natural light and follow our biological clocks. Greenhouse cultivation using artificial light is proven to be possible, with potential space applications.

GaN-based LEDs provide the dominant technology for back-illuminated liquid crystal displays in many mobile phones, tablets, laptops, computer monitors, TV screens, etc. Similarly, blue and UV-emitting GaN diode lasers are used in high-density DVDs (blu-ray discs), which have advanced the technology for storing music, pictures and movies. Future applications may include the use of UV-emitting AlGaN/GaN LEDs for water purification, as UV light destroys the DNA of bacteria, viruses and microorganisms. In countries with insufficient or non-existent electricity grids, electricity from solar panels stored in batteries during daylight can power white LEDs at night (this will be a direct transition from kerosene lamps to white LEDs). Blue LED research has also laid the foundation for a whole host of gallium nitride (GaN) technologies from blue lasers and the blue ray information storage system to GaN-based high-power and highspeed electronics. The sensitivity of GaN to ionizing radiation being low (like other group III nitrides), it is a suitable material for solar cell arrays on satellites. There could also be military and space applications as GaN devices have shown stability in radiation environments. GaN transistors make ideal power amplifiers at microwave frequencies since they can operate at much higher temperatures and work at much higher voltages compared to gallium arsenide (GaAs) transistors.

At the moment, more than 1.5 billion people worldwide do not have access to electricity grids. The LED lamp holds great promise to increase the quality of their lives, as the low power requirements imply that the lamp can be powered by cheap local solar power. Unlike some of the othercostly green technologies(electric cars, wind turbines etc.), LEDs are accessible to the majority of the people, and individuals can help greening the environment by opting for LED lighting at their homes and offices.

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A New Half-Light Half-Matter Quantum Particle - Applications in Quantum Technologies

M. Sabir
Department of Physics, CUSAT

Towards the end of December, 2014 news media all over the world flashed a report regarding the discovery of ***"a new kind of half-light half-matter quantum particle in atomically thin semiconductors placed in a light trapping microcavity"*** . The observations were done by a team of researchers at the City College of New York led by Prof. Vinod Menon. In addition to its fundamental importance, it is claimed that the discovery will find immediate applications in the emerging field of quantum technologies. The results of the studies appeared as a research paper entitled "*Strong light-matter coupling in two-dimensional atomic crystals* "in the January 2015 issue of the journal *Nature Photonics*.

What are these half-light half-matter quantum particles? In the more technical terminology these peculiar quantum states are referred to as '*exciton-polartons*' or '*cavity-polaritons*'. Theoretical analysis of such states in unbounded semiconducting media date back to Hopfield (1958) and in 2-dimensional confined structures to Agranovich (1967). Experimental demonstration of exciton-polariton was achieved in 1990's and at present it is an active area of research in Nanophotonics laboratories.

Semiconductor excitons, as we know, are the quasiparticles of bound electron-hole pair which are formed with the absorption of photons. Recombination of electrons and holes resulting in the decay of the excitons results in the emission of photons. Look at what can happen when a semiconducting material in the form of a 2-dimensional confined structure (a quantum well) is placed in a microcavity containing highly polished mirrors. Because of the smallness of its size (of the order of micrometers) what takes place here will be dominated by quantum effects. A photon produced in an exciton-decay gets trapped between the mirrors and can be reflected back into the quantum well where it will produce another exciton which soon decays into another photon and so on. In a very short time interval energy begins to cycle between light and matter making it difficult to say in which of the two forms energy is stored-light or matter. This is the exciton-polariton-*half-light half-matter*. When the interaction rate is engineered to be faster than the damping effects of light and matter entities one reaches the strong-coupling regime.

The research group at the City College in their experiment used thin semiconductor monolayers (thickness-a millionth of a single sheet of paper) made up of molybdenum and sulphur atoms arranged in a graphene-like structure. They sandwiched the 2-dimensional material in a light trapping structure (a standard semiconductor microcavity) and demonstrated the presence of exciton-polaritons in the system.What is remarkable and exciting about this work is how easily they could attain the strong coupling regime at room temperature.

Attainment of strong coupling at room temperature provides a setting for the development of practical polariton devices which will be of use in construction of logic gates and signal processors. It is hoped this discovery will stimulate further work leading to realization of practical platforms for quantum computing and quantum communications.

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APT Talent Search Examination 2013 - A Report

Dr. Malini K.A.
Vimala College, Thrissur

APT talent search examination conducted annually by APT is aimed to identify and encourage young talents in Physics. The APT TSE-2013 was conducted on 28th September 2013. This year's talent search examination is highlighted by the maximum number of centres and participants. There were 59 Colleges as centres and around 1900 students applied for the examination. Out of these 1453 students appeared for the examination. As usual the preliminary examination consisted of two parts. Part A containing 75 objectives questions and Part B of 10 descriptive problems. OMR sheets of Part A were evaluated with the help of Members of the Physics Department of Vimala College Thrissur. Part B answer sheet of students who have scored more than 35 in part A were evaluated by the coordinator. Part B of 147 students were evaluated. 27 students who secured the top marks in Part A and Part B were called for an interview on 11/01/2014, held at Department of Physics, CUSAT. The interview board included Dr. M K Jayaraj, Dr Jayaprakash, Dr Titus Mathew, Dr. K Y Shaju, Dr. N Shaji and Dr. Mini Krishna. 26 students appeared for the interview. The interview came to an end by 4.00 pm. All students performed well in the interview and the final rank list was prepared based on the marks in the interview and written examination taken together. Ms Ann Mary Mathew of Assumption College, Changanassery, Mr. Jobin Sebastian of St. Josephs College, Devagiri, Kozhikode and Mr Sharath R of The Cochin College, Cochin Secured first, second and third positions respectively.

Rank list of APT TSE 2013

1. Ann Mary Mathew, Assumption College Changanassery
2. Jobin Sebastain, St Josephs College Devagiri
3. Sharath R, Cochin College, Cochin
4. Ajith P. P, MES College Ponnani
5. Arya C S, Govt. Victoria College Palakkad
6. Ashish Anil, Catholicate college, Pathanamthitta
7. Aparna Sankar, Govt. Arts and Sci. College Meenchanda
8. Deephi.S Prabhu, KKTM College Kodungallore
9. Kevin Roy, MG College Iritty
10. Muhammed Azharudeen N, Sullamusallam Science College, Areacode
11. Rajani.K.Gangadharan, Christ College Irinjalakuda
12. Bhagyasree GS, St Josephs College Devagiri
13. Sreenidhi K.S, MES College Ponnani
14. Fazlu Rahman P P, PSMO Thirurangadi
15. Aathira Murali, Christ College Irinjalakuda
16. Indu Treesa Jochan, Assumption College Changanassery
17. Noble Lancy K, SH College Thevara
18. Aswathi .P, Govt. College, Madappally
19. Lekha Mary John, St Peters College Kolencherry
20. Anjana Korappath, Vimala college Thrissur
21. Jesna C K, KMM College kannur
22. Anooja.G, Christ College Irinjalakuda
23. Sachindas V, Govt. Victoria College Palakkad
24. Alsana P, PSMO Thirurangadi
25. Nandini K, Govt. Victoria College Palakkad
26. Hariprasad M G, MG College Iritty

The organisers of APT TSE 2013 is thankful to all regional coordinators for cooperation and support they extended for the examination. The support from the college authorities are also gratefully acknowledged. ■

APT Talent Search Examination 2014 - Brief Report

Prof. Anu Kuruvilla
Mercy College, Palakkad

Let me present here, a brief report on the conduct of the Talent Search Examination 2014. Conducted by APT. The 2014 version of Talent Search exam was conducted on 27th September 2014. Intimation was posted to more than 180 colleges with BSc Physics programme, spread all over Kerala. Out of these 78 colleges responded and more than 2500 applications were received. Out of these about 2350 students appeared for the exam, which was held at 61 centers. The written exam consisted of two parts; Part A with 75 objective type questions and Part B with 10 descriptive type questions. Out of the candidates who appeared for the exam. 111students who scored 40 and above marks in their Part A paper qualified for the evaluation of their Part B answers. Among these 111 students, the top 30. who secured the top marks in Part A and Part B put together, were called for an interview which was held at the Department of Physics, CUSAT on 17th january 2015. The interview board consisted of Dr. M.K.Jayaraj, Dr. Shaji N, Dr. Santhosh Potharay, Dr. Issac Paul, Dr. Malini, Dr. Mini Krishna, Dr. NijoVarghese, Dr. Poornima, Prof.Vikas. All the students fared well in the interview and the final rank list was prepared based on their performance in the written exam , interview and Quiz programme together. Dr.Jijo P. Ulahannan of Maharajas College, Ernakulam, conducted a wonderful quiz competition and special thanks to him. Thanks to all for their valued service. Sri Vishnu was the scorer and 6 MSc students of CUSAT helped the quiz master. Thanks to them also.

The First three prizes were won by:

1. APARNA SHANKER Govt. Arts and Science College, Meenchanda
2. NITHIN THOMAS St.Pauls College, Kalamassery
3. NITHIN SATHYAN Union Christian College, Aluva

The organizers are extremely thankful to the regional coordinators for their enthusiastic and whole hearted support towards the successful conduct of TSE-2014. In particular, as it happens every year. Dr.Devadhas of MG College Iritty has presented the maximum number of candidates this year too. 91 students from his college appeared for the exam. In addition, his name needs special recognition as he was very truthful to the position of regional coordinator and so enthusiastic that Kannur district presented the maximum number of candidates (501). So on behalf of the Academy of Physics Teachers and on my own behalf as the general coordinator, I express my heartiest sense of gratitude to all the 18 regional coordinators for making TSE 2014 a success. Special thanks are also due to the research scholars of the Dept of Physics. CUSAT, for their support at various stages. On behalf of Academy of Physics Teaachers once again congratulations and thanks to all, who made the Talent Search Examination, a grant success. Wishing your whole-hearted help in the coming years also. ■

Gaining a Competitive Edge in Physics

Jijo P.U. Ph D
Assistant Professor of Physics,
Maharaja's College, Ernakulam
E-mail : mia@ieee.org

Opportunities ahead

In an interview given to the American Physical Society (APS News, vol. 22, no. 9, Oct. 2013), Elon Musk, the founder of Tesla Motors and SpaceX said, "*study physics and learn how to reason from first principles rather than reason by analogy.*" He further elaborated, "Of necessity, physics had to develop a framework of thinking that would allow understanding counter-intuitive elements of reality. Something like quantum physics is not very intuitive, and in order to make progress, physics essentially evolved a framework of thinking that was very effective for coming to correct answers that are not obvious. And in order to do this, it requires quite a lot of mental exertion. One cannot conduct one's everyday life reasoning from first principles; it would just require too much mental energy. So I think you have to operate most of your life with reasoning by analogy or essentially copying other people with minor variations. But if you are trying to break new ground and be really innovative, that's where you have to apply first-principle thinking and try to identify the most fundamental truths in any particular arena and you reason up from there."

Many students who take up higher studies in physics are often unaware of the various opportunities that await them. Even if they do, they find it difficult to surmount such barriers as national level competitions. Many a times it is their lack of basic undestanding of the subject, and in other cases their lack of prepartion that prevent them from scoring well in such exams. In order to soar high, bulding a sound knowledge of the basics is advisable.

Discussed below are several tangible opportunities achievable with a single devoted preparation for a masters degree student in physics, and in certain cases for bright bachelors degree students, as well. Even though there are a wide variety of options for success before a physics graduate who has the twin potential of mathematical reasoning ability and applied practical skills, we will focuss on a few exclusive options for physicists.

Being competitive in the job market means good understanding of the subject as well as thorough prepartion for specific examinations. We will discuss a few exams that test your competence and further pave way for a good career in the subject through research and development. If you are looking for employment right away after graduation, every employer will test your abilities in the following areas:

- Verbal Abilities
- Quantitative Aptitude
- Qualitative Aptitude
- General Awareness

To measure your ablities in these areas, various examinations, written and oral, will be designed. They

invariably have the following structure:

- Reading
- Comprehension
- Analysis
- Writing
- Speaking (Personal Inverview)

Physics postgraduates can pursue their career in various government owned Scientific Research and Development Organizations such as Defense Research and Development Organization (DRDO), Physical Research Laboratory Ahmedabad, Nuclear Science Centre New Delhi, Saha Institute of Nuclear Physics Kolkata, Bhabha Atomic Research Centre (BARC) and Indian Space Research Organization (ISRO). Several other government organizations are also offering various jobs for these graduates. Some of those organizations:

- Oil and Natural Gas Corporation (ONGC),
- Bharat Heavy Electricals Limited (BHEL),
- National Thermal Power Corporation (NTPC).

We will discuss a few competitive exams that will launch your professional career in physics, either in academia or in research. If you can reach the level of competency to qualify any one of these, others in the list are also within your reach.

The JEST Exam

Applicants seeking admission for a Ph.D / Integrated Ph.D Programme in Physics or Theoretical Computer Science or Neuroscience in one of the Participating Institutes may appear for the Joint Entrance Screening Test (JEST). Participating Institutes have their own eligibility criteria. Applicants who are expected to complete their final examinations by August of each year are also eligible to appear for the JEST exam of that year. Basic requirement is M.Sc. in Physics or related disciplines. However, talented final year B.Sc. and first year M.Sc. in Physics / Electronics / Astronomy / Applied Mathematics students are also eligible to apply for select courses at select places. More details can be obtained from the website *www.jest.org.in* that offers the application form, exam schedule, syllabus and previous question papers.

The GATE Exam

The Indian Institute of Science (IISc) and seven Indian Institutes of Technology (IITs at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) jointly administer the conduct of GATE. The operations related to GATE in each of the 8 zones are managed by a zonal GATE Office at the IITs or IISc. A valid GATE score is essential for obtaining financial assistance during Master's programs and direct Doctoral programs in Engineering/Technology/Architecture, and Doctoral programs in relevant branches of Science in Institutes supported by the MHRD or other Government agencies. If admission is secured to any such institution following the MHRD guidelines, candidates can avail scholarship/assistance for their Masters or PhD study.

Several public sector undertakings (PSUs) have, in the past, used GATE scores for screening for providing a salaried employment. A select few such organizations are: Bhabha Atomic Research Centre, Bharat Heavy Electricals Limited, Indian Oil Corporation Limited, National Thermal Power Corporation, Power Grid India, etc. Also, various institutions abroad such as universities in Singapore give preference to GATE qualified students for admission into their Masters or Doctoral studies.

The DRDO Scientist Entry Test (SET)

DRDO SET, whenever required, is conducted in the month of September, depending on the requirements, in order to provide equal opportunity to all students from different educational institutions in view of the increasingly wide variation in the marking pattern of different educational institutions in the country. DRDO SET exam is of three hours duration consisting of two sections viz. Section 'A' of 100 questions to test the candidate's knowledge in the subject of Post Graduation and Section 'B' of 50 questions to the candidate's ability in analytical and qualitative skills, current affairs and general awareness to test the aptitude and scientific knowledge required for Applied Research &Development. DRDO SET exam is conducted only for those subjects where vacancies are sizable in number. Details of eligible candidates, examination schedule, result of the exam, schedule of interviews and list of selected candidates are made available from time to time on their website (www.rac.gov.in)

In cases, where very few vacancies are available, no SET exam is conducted and the individuals after shortlisting are directly called for the interview. The advertisement generally appears during the month of April / May every year.

Bhbha Atomic Research Centre (BARC)

BARC offers some of the best opportunities for physicists. Direct recruitments are usually limited and reserved for PhD holders. However, they run an excellent training school offering two different schemes as follows:

1. **One year Orientation Course for Engineering Graduates and Science post-Graduates (OCES). The program**will be conducted at BARC Training Schools situated at Mumbai, Kalpakkam, Indore and Hyderabad. A Trainee Scientific Officer (TSO) who scores a minimum of 50% aggregate marks on completion of the training program is declared to have passed the course successfully. Successful TSOs will be posted as Scientific Officers in one of the eleven DAE units.

Appointment in DAE units shall be as a 'Group A' Gazetted Officer of the Government of India except in NPCIL, UCIL AND BHAVINI which are governed by the service rules of Corporations. Allocation of a successful OCES TSO to a DAE unit is done based on performance in the OCES program. Apart from the DAE units listed above, DAE reserves the right to place a small number of TSOs to any other unit under the Atomic Energy Commission (AEC) or the Atomic Energy Regulatory Board (AERB).

Performance above a specified threshold in course work at the Training School will entitle TSOs to a Post-Graduate Diploma or could earn them credits towards M.Tech/ M.Phil/ PhD Programs of the Homi Bhabha National Institute (HBNI), a Deemed to be University.

2. **Two-year DAE Graduate Fellowship Scheme for Engineering Graduates and Physics Post-Graduates (DGFS).** Under this scheme, Engineering Graduates and Physics Post-Graduates who are selected for the BARC Training School program and who also have secured admission for M.Tech/ M.ChemEngg in select institutes and specializations are paid stipend and tuition fee to pursue a M.Tech/ M.ChemEngg degree while retaining their employment in DAE. After successful completion of one-year course work at the institute, fellows undertake project work, which is assigned by DAE and supervised jointly by a DAE and an institute guide. On successful completion of M.Tech/ M.ChemEngg, they are posted as Scientific Officers in DAE. On joining, they are required to first undertake a four-month Orientation Course (OCDF) at the BARC Training School, Mumbai. The DGFS fellows are enrolled and posted in one of the following units of DAE:BARC Mumbai, IGCAR Kalpakkam and RRCAT Indore.

Allocation of a DGFS fellow to a DAE unit is done at the beginning of the M.Tech/ M.ChemEngg program based on Selection Interview performance. **Selected candidates** are required to execute an agreement and a **Personal Indemnity Bond** to serve DAE for at least three years after completion of training.

Selection to OCES/DGFS is a two-step process : **Screening** to short-list candidates followed by **Selection Interview** of the short-listed candidates.

1) Screening for the Science disciplines is based on two alternative methods:

(a) **On the basis of GATE Score**: Candidates can apply on the basis of a valid GATE score (last two years). GATE cutoff score for short-listing candidates for Interview will be declared BARC in their website (**http://www.barconlineexam.in**).

(b) **On the basis of Online Exam:** Online Exam will be conducted during a selected period (second half of March for the 2014 exam).All candidates applying on the basis of GATE score can maximize their chances of being screened into the Selection Interview by applying additionally on the basis of the Online Exam, which will be held before the cut-off GATE scores are known. No Travel Allowance is paid for appearing in the Online Exam.

(c) **On the basis of Interview:** Candidates who completed their degree in **UNIVERSITY OF MUMBAI - DEPARTMENT OF ATOMIC ENERGY (CENTRE OF EXCELLENCE IN BASIC SCIENCES)** or in **NATIONAL INSTITUTE OF SCIENCE EDUCATION AND**

RESEARCH, BHUBANESHWAR are screened through interview only.

2) Selection Interviews of shortlisted candidates in disciplines other than Geology & Geophysics will be conducted in BARC Training School, Mumbai. Candidates are suggested to visit this website regularly for updates regarding this. **Final Selection** is solely on the basis of performance in **Selection Interview** subject to medical fitness.

The Oil and Natural Gas Corporation (ONGC)

Oil and Natural Gas Corporation (ONGC) is a Maharatna company. Almost every year it recruits people from different backgrounds. Since ONGC is involved in the exploration and production of hydrocarbons it recruits students with physics background for jobs that will be interdisciplinary in nature, along with Geophysics and Geology. One of the best jobs on offer is ONGC is Class-I executive (E-1) for which there were are four categories applicable to physics postgraduates, namely, E&T, Geophysics (Surface and Wells), and Reservoir. The Company offers one of the best compensation packages in cost to company (CTC) terms in the country with opportunity of merit-oriented advancement in a professionally managed organization focused on growth.

ONGC doesnot have a fixed schedule about the recruitment and Graduates Trainees exam like BARC, etc., but the notification comes once in two years. The 2010 exam had two parts: General awareness and subject. In 2013 a three hour long objective type exam was conducted across 14 cities including Kochi in the month of June. The exam had three sections – Concerned subject, General Awareness and an Aptitude test (comprising Reading Comprehension, Verbal/Non-verbal Reasoning, Numerical Abiity/Quantitative Aptitude, Data Interpretation, etc.). The question paper had 80 questions from the concerned subject, 40 questions in General Awareness and 30 questions in the Aptitute Test. The syllabus for the question paper shall be of UPSC for Engineering subjects, Civil Services for Management disciplines and MSc level for others.

Those who qualify for the written test (in 2013, it was 60% marks for GEN/OBC candidates and 40% for SC/ST & PWD candidates) will be called for psychometric test and interview. The final selection will be on the basis 100 marks (written test – 60, interview – 15, and qualification – 25). The application process is online and we can expect a notification, most probably, by March.

The Indian Oil Corporation (IOC)

Indian Oil Corporation is a Navaratna public sector company and is the largest commerical enterprise in India. If you can get at least three years industrial experience, the IOC occassionally calls for the post of Assistant Officers. Postgraduates in Physics, Chemistry or Mathematics can apply online for this post if they have experience in areas like processing, manufacturing, logistics, sales & distribution, services etc. However, experience in teaching, research and internship during or before postgraduation will not be counted as industrial experience. Applicants will be shortlisted on the basis of their GATE score for further selection process. The last application was called for in September 2012 and GATE 2013 score was used for shortlisting. Watchout for oncoming advertisements if you have a valid GATE score or have some plans to take the GATE exam soon. Age limit for this post is 30 and restrictions will be relaxed for SC/ST and OBC candidates based on the Presidential directive.

The CSIR-UGC NET Exam for JRF and LS

The CSIR-UGC NET Exam for Junior Research Fellowship and Eligibility for Lectureship has become the norm for all aspiring postgraduate students of science in India to lead a successful career in research or academia. The exam has a Single Paper Test having Multiple Choice Questions (MCQs) with three different parts. It is therefore important to practice the art of scoring in such exams and the only way to succeed is to get a good grasp of the fundamentals of the subject.

Applying for NET

The NET is held twice every year: in June/July and December. Keep an eye on the CSIR website (http://

csirhrdg.res.in) which will tell you about all that you need to apply for the test. Before filling in the form, make it a point to have all the details with you (especially the subject code and centre code) since you won't be able to change anything later on.

Writing the Exam

The physical sciences exam will be held in the morning session and will be of 3 hours duration. The pattern for the Single Paper MCQ test shall be as given below:-

- The MCQ test paper of each subject shall carry a maximum of 200 marks.
- The exam shall be for duration of three hours.
- The question paper shall be divided in three parts.

Part 'A' shall be common to all subjects including Engineering Sciences. This part **shall carry 20 questions** pertaining to General aptitude with emphasis on logical reasoning graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles etc. The candidates shall be required to **answer any 15 questions**. Each question shall be of two marks. The total marks allocated to this section shall be **30 out of 200**.

Part 'B' Part 'B' shall contain subject-related conventional MCQs. The

total marks allocated to this section shall be **70 out of 200**. The maximum number of questions to be attempted shall be in the range of 20-35.

Part 'C'Part 'C' shall contain higher value questions that may test the

candidate's knowledge of scientific concepts and/or application of the scientific concepts. The questions shall be of analytical nature where a candidate is expected to apply the scientific knowledge to arrive at the solution to the given scientific problem. The total marks allocated to this section shall be **100 out of 200**.

Important Points to Note:

- In all the subject areas of the NET **the actual number of questions asked and to be attempted in each section may vary from exam to exam**.
- There will be negative marking @25% (usually)for each wrong answer.
- To enable the candidates to go through the questions, thequestion paper booklet shall be distributed 15 minutes before the scheduled time of the exam.
- The answer sheet (OMR sheet)shall be distributed at the scheduled time of the exam.

General Strategy

Considering the new pattern, we find that the key part of the exam is the last one. Here we have 50% of the total marks allotted and the questions will be from advanced physics topics. The next priority should be given to Part 'B' that has 70 marks. First attempt the questions you are absolutely clear and then attempt the remaining questions. There is negative marking and it takes practice and patience to answer this paper promptly so that you should avoid questions which you cannot score. If you have time, recheck your answers and try to get the maximum out of section 'A'. To summarise:

- Section C carries 50% weight with 5 marks for each question.
- Section B carries 35% weight with 3 - 3.5 marks for each question.
- General aptitude section can be tackled with a little bit of practice with similar questions from public exams.

Cut-off Marks

There is no separate cut-off marks for Parts A, B, and C. However, Part C, and then B should be given more importance because of their higher weightage. As per the data given by CSIR after the publication of December 2013 exam, the following are the cut-off for JRF and LS for various categories:

JRF (NET)	
GEN/OBC	SC/ST
46%	36%

LS (NET)	
GEN/OBC	SC/ST
41%	31%

This can vary from exam to exam as the number of qualified candidates depend on the total number of applicants and their relative performance. UGC has fixed the total number to around 5% of the total number of

applicants. One need to workout how much they should score to get a minimum cut-off.

How to Avoid a Disaster?

The usual saying is, "when the going gets tough, only the tough get going." So cover the difficult, yet important, portions of the subject to score a maximum. Candidates with good preparation survive in all situations and objective type questions demand good practice (unless, of course, you are a genius)! One thing you will notice among all those who qualify the test in one sitting is that they all show a kind of passion towards the subject and that will surely drive their entire career.

Though we cannot say anything about the cut off marks, experience tells that one has to score well in all parts of the exam to get a JRF. Some may have a tendency to give it up feeling dejected about the first part of the exam. Be cool in your approach to the exam and never give up during the examination by doing things like answering all the multiple choice questions randomly based on luck or feeling dejected of your performance. There is plenty of time to prepare and perform well.

Why Negative Marking?

Negative marking is incorporated in any objective type examination to nullify the effect of gambling. If you look at it statistically, the maximum probable score one can get is 25% out of100 having four choices each. Remember, this is the maximum and sometimes there is a remote probability that you score a cent percentage. Rather, experience may tell you that you get relatively low score when you leave things to chance alone. Negative marking with ***one-fourth*** of the marks given to a correct answer tries to reduce the marks by chance.In examinations with objective type multiple choice questions (MCQs), there is a tendency called the '**Red Wire Syndrome'** which means that one may answer all questions whether he or she knows the correct answer or not. If we can classify the questions into three categories: 1) *Easy*, 2) *Fifty – Fifty*, and 3) Extremely *Lucky*, indicating one knows the correct answer, possible but some doubt still prevails, and almost impossible, respectively. The 'red wire syndrome'is the tendency to answer all the questions, which is disastrous, just like a child who touches a 'red hot wire' seeing it as something beautiful! Be careful as the section C has 5 marks per question and a wrong answer would award you -1.25 in return!

The key to success lies in answering all the 'easy' ones, and leaving out the 'extremely lucky' type. It is imperative to learn the art of intelligent guessing to answer the type 2. There is no magic key to do so. This evidently comes from one's experience and basic knowledge of the subject. So never ever find it insulting to go back to your basics (at least refer to some of the basic books in the list below). Also never forget to practice well using previous question papers of GATE, UPSC Civil Services, JEST, GRE (Physics), IIT JAM etc., so that you are prepared!

Syllabus Based Strategy

Part A (15 x 2 = 30 Marks)

This part shall carry **20 questions** pertaining to general aptitude with emphasis on logical reasoning, graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles etc.

If you go by the model question paper (never take it as it is), we can notice that it needs good practice if you are not familiar with such questions. A science student should not find them confusing (even if you do, there are choices).Refer to previous question papers of the Paper I of UGC NET (Arts & Humanities stream) examinations. Logical reasoning and numerical ability questions demand familiarity, clear concepts and practice to answer them. Refer to magazines and text books on the topic used by those who prepare for Bank PO, UPSC exam etc. There is no harm in taking some special assistance, if needed.

Let us set the target for this session as 12 correct answers out of 20 questions (i.e. 80% score). However, scoring 15/15 would add positively to your chances and that is not an impossible task!

Physics Core (Part B & C)

Before you proceed to master the syllabus and art of scoring in the core physics area, take a break and think about your basic physics understanding. If it is not good enough, it is always recommended that you lay the

foundation first and build further only on a solid ground. Some books and links are given below, but remember: "Working out your problems is the only key to success." Given that the entire test is objective, good fundamentals and a problem solving strategy can easily get you a JRF!

Recommendations for General Reading:

1. **NCERT Books on Physics** – Go down to whichever level you want to and read up to class XII. Never a waste of time! Don't worry about the costs: go to www.ncert.nic.in and download them as you wish!

2. **Fundamentals of Physics** – Resnick, Halliday and Walker: excellent introduction without much calculus. Lots of problems and review questions. Read the book throughout and workout as many basic problems as possible.

3. **Physics for Scientists and Engineers** - Raymond A. Serway & John W. Jewett: This best-selling, calculus-based text by award winning teachers is recognized for its carefully crafted, logical presentation of the basic concepts and principles of physics.

4. **Berkeley Physics Course, Vol. 1 - 5 (Tata McGraw-Hill):** A very good bridge to cross from school level physics to the graduate level. They would give the necessary background for all our advanced studies and all the books are written by masters of the subject.

5. **Calculus and Analytical Geometry** – Thomas and Finney (Pearson) {for those who want some basic math}.

6. **Concepts of Modern Physics** – Arthur Beiser (Tata McGraw-Hill): Your pocket book to success in modern physics. Master this book and you are guaranteed of success!

7. **"HOW to BECOME a GOOD THEORETICAL PHYSICIST"** by Gerard 't Hooft - A must read by the Nobel Laureate: http://www.phys.uu.nl/~thooft/theorist.html. This site contains a lot of free lecture notes and resources on several topics.

8. Feynmann Lectures on Physics (3 volumes): highly recommended texts compiled from the undergraduate lecture course given by Feynman at Caltech.

9. Jearle Walker: *The Flying Circus of Physics*, a book that poses (and answers) about a thousand questions concerned with everyday physics. The emphasis is strongly on phenomena that might be encountered in one's daily life *(www.flyingcircusofphysics.com)*.

Part B (20 x 3.5 = 70 Marks)

Syllabus

Mathematical Methods of Physics

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

Mathematical methods are important to anyone who wants to do well in advanced physics. Dimensional analysis is a powerful tool in the hands of a physicist and has helped many people win Noble prize by bringing out new theories for complex problems faced by physicists. Develop the concept of numbers, dimensions and unit along with a good understanding of scale in physics. Space and time scales are important to explain any physical phenomena.

Apart from linear algebra and calculus (start with NCERT), we should be comfortable with certain special functions that always arise in some form whenever we try to solve some real physical problems. Fourier series analysis and integral transforms are tools in the hands of physicist to crack any mathematical situation to easy manipulations and better understanding. Equally important are complex number analysis which help us in a big way.

A new addition is probability theory that is essential to physics, especially experimental physics, statistical mechanics and quantum theory. If you are not comfortable with the elementary ideas, read Statistics text books by NCERT. Especially class XI book is ideal. Central limit theorem and various statistical distributions are important in physics. So have a good understanding of

all these.

1. NCERT class XI - XII books on Mathematics & Statistics.
2. Mathematical Methods for Physicists – Arfken and Weber
3. Mathematical Methods for Physicists: A concise introduction - Tai L. Chow (Cambridge University Press - 2000)
4. Mathematical Techniques for Engineers and Scientists – Andrews and Phillips (SPIE Press)
5. Mathematical Methods for Scientists and Engineers – Donald A. McQuarrie (University Science Books: California)
6. Complex Variables – Churchill (McGraw-Hill)
7. Mathematical Methods in Classical and Quantum Physics – Tulsi Dass and Satish K. Sharma (University Press – 1998)

Classical Mechanics

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics-moment of inertia tensor. Non-inertial frames and pseudo-forces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity - Lorentz transformations, relativistic kinematics and mass–energy equivalence.

Not much to say about this basic paper in physics. The main aim is to go from basic laws of Newton to the general principles of Hamilton & Jacobi and through them solve almost all dynamical problems in the classical limits. Learn the tools and solve problems. Canonical transformations are powerful tools. Special relativity should be mastered and is crucial from the exam point of view. You should be comfortable solving all transformation equations and numerical problems in physics.

1. Mechanics – Landau and Lifshitz (Pergamon Press)
2. Classical Mechanics - R. Douglas Gregory (Cambridge University Press 2006).
3. Classical Mechanics – Goldstein, Poole and Safko (Pearson) 3rdEdn.
4. Lagrangian and Hamiltonian Mechanics – M. G. Calkin (World Scientific).
5. Relativity – The Special and General Theory – A. Einstein.
6. Introduction to Special Relativity – R. Resnick (Wiley).

Electromagnetic Theory

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces.Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

Solve Griffiths and you are done! Go topic by topic and not much to avoid here. This is a highly scoring area for those who have the basic knowledge of electromagnetics. Begin with Resnick and Halliday or Kraus and master Griffiths by solving problems. Maxwell's equations is the milestone but each among the four equations has a story to tell. Differentiate between conducting and non-conducting media and learn about the symmetry of fields and boundaries to be able to solve problems in the area. It is mostly a problem of defining your equations, and solving them using the appropriate boundary conditions. It will be worthwhile to notice that both electric and magnetic fields have many things in common (like both are not conservative fields) but they have fundamental differences (like the presence of electric monopole and absence of magnetic monopole). Fundamentals make good hunting ground for examiners. So be prepared! Also, never forget to look into the relativistic electrodynamics and different gauges used.

Notice the change in the syllabus which now includes some optics which can be had from Hecht. Daniel Fleisch introduces the heart and soul of EMT to an average student through his latest book, have a look at it, if you can. Irodov introduces the concepts of the subject briefly but aptly. It also has several worked out

examples and problems.

1. Basic Laws of Electromagnetism – I. E. Irodov (Mir Publishers).
2. Introduction to Electrodynamics – D. J. Griffiths (Prentice Hall).
3. Electromagnetics with Applications – Kraus and Fleisch (McGraw-Hill).
4. A Student's Guide to Maxwell's Equations - Daniel Fleisch (Cambridge University Press2008).
5. Modern Optics – Robert D. Guenther (Wiley - 1990).

Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.).Tunnelling through a barrier. Wave-function in coordinate and momentum representations.Commutators and Heisenberg uncertainty principle.Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli Exclusion Principle, spin-statistics connection.

Quantum mechanics is the heart of modern physics and some good mathematical concepts along with physical insight will make it interesting. Stick to the basics again and work out basic problems like the calculation of Eigen values, probabilities, expectation values etc. Commutation relations and conservation laws are a must. Remember the solutions to different basic problems like the free particle, one dimensional well, particle in a box and the harmonic oscillator. Angular momentum and coupling are important. Scattering may be difficult to bite but questions could be asked. There are plenty of books available that follows various strategies. A book like Modern Quantum Mechanics by Sakurai is quite refreshing, but from the examination point of view it is better to follow more general books considering the demands of the syllabus and examination patterns. Before going to dwell into the following or any serious book, have firm grip of the basics of quantum world using books such as Beiser and Resnick & Halliday.

First three books are sufficient for any level; and both Zttili and Griffiths have several good problems and examples to help you with the exam. If you need a more elaborate and different book, resort to Greiner

1. Quantum Mechanics – E. Merzbacher (John Wiley & Sons).
2. Quantum Mechanics: Concepts and Applications - Nouredine Zettili, 2nd Edition (John-Wiley, 2009).
3. Principles of Quantum Mechanics – R. Shankar (Kluwer Academic/Plenum Publishers).
4. Introduction to Quantum Mechanics - David J. Griffiths (Prentice Hall).
5. Textbook of Quantum Mechanics - P. M. Mathews and K. Venkatesan (Tata McGraw-Hill).
6. Quantum Mechanics an Introduction – Walter Greiner (Springer).
7. Modern Quantum Mechanics – J. J. Sakurai.

Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibrium. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Black body radiation and Planck's distribution law.

It is important to know the basic laws of thermodynamics and the relations that define thermodynamic variables which are obtainable otherwise using the methods of statistical mechanics. It will be better to use books like Pathria and Huang to crack the questions in this section. Develop basic idea of the partition function, ensembles and their classification (put the logic into your mind), and the need for different statistical approaches. The last part is important as we deal with microscopic particles everywhere in physics. It is always helpful if one can draw parallels between different topics in physics and find ways to understand the microscopic origin of macroscopic behaviour. Books # 1 – 4 are

for building your basics. I really liked Schroeder.

Mathematical techniques are important to solve all problems in statistical mechanics and so try to work out the appendices of Pathria or any other book that explains those techniques. Your job is done when you are able to obtain the 'partition function' of any system that you are considering. One can, in theory, obtain the thermodynamic variables required to understand the system under consideration from the partition function. The partition function depends on whether you have a closed system (canonical ensemble) or an open system (grand canonical ensemble). Have good grasp of probability theory and try to understand how it can be applied to various situations in microscopic systems such as Fermi and Bose systems.

1. An Introduction to Thermal Physics – Daniel V. Schroeder (Doring Kindersley India).
2. Fundamental of Statistical and Thermal Physics – P. Reif (McGraw-Hill).
3. Thermal Physics - Ralph Baierlein (Cambridge University Press).
4. Concepts in Thermal Physics - Stephen J. Blundell and Katherine M. Blundell (Oxford University Press 2006).
5. Introductory Statistical Mechanics – Bowley and Sanchez (Oxford)
6. Statistical Mechanics – R. K. Patria (Butterworth Heinemann).
7. Statistical Mechanics – K. Huang (Wiley).
8. Elementary Statistical Physics – C. Kittel (John Wiley & Sons).
9. Introduction to Modern Thermodynamics - Dilip Kondepudi (John Wiley & Sons).

Electronics and Experimental Methods

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Optoelectronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications.Digital techniques and applications (registers, counters, comparators and similar circuits).A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

Any good book covering the syllabus and all probable problems will do for this high scoring part. A good grasp of basic ideas in electronics is a prerequisite. Read books on experimental physics and data analysis (NCERT) to get an idea of the last topics in the syllabus.

1. Electronic Devices and Circuits - Bogart, Beasley and Rico.
2. Digital Principles and Applications – Malvino and Leech (McGraw-Hill).
3. Electronic Principles – A. P. Malvino (Tata McGraw-Hill).
4. Operational Amplifiers & Linear Integrated Circuits – R. Gayakawad (Pearson).
5. Introduction to Digital Circuits - Theodore F. Bogart.
6. Practical Physics - G. L. Squires, Cambridge University Press (2001), 4thEdn.
7. An Introduction to Experimental Physics, Colin Cook, Routledge (1996).

Part 'C'

I. Mathematical Methods of Physics

Syllabus: Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions). Elements of computational techniques: root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Solution of first order differential equation using Runge-Kutta method. Finite difference methods. Tensors. Introductory group theory: SU (2), O (3).

The thrust is on methods to solve differential equations which are crucial to the study of any Physics. I am sure that most of us do computational physics using numerical techniques. Be good at the basics of Taylor's series expansion. Most numerical methods are improvisation of the Euler's method. We can expect a problem based on Green's function method of solving mostly boundary value problems. Finally two important topics in advanced physics come to the fore: **Tensors** are unavoidable in the study of cosmology and **group theory** is highly essential in several areas like condensed matter physics, statistical

mechanics, quantum theory, spectroscopy and most importantly high energy physics. Books given in part B should be sufficient here as well. Give preference to solving problems in each area and have good basics of tensors and group theory.

II. Classical Mechanics

Syllabus: Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory.

It is not very difficult to cover these topics. Use standard books and try to find the ways to analyse dynamical problems using phase space diagrams. Some hindsight of analytical geometry and calculus will help you here. We can expect good but easily answerable questions from this section. Poisson bracket algebra and canonical transformations are good area of quantitative questions. Symmetry, a consequence of Noether's theorem, naturally leads to H-J theory and easy analysis of complex problems. Canonical transformations are relevant here as well. One should be comfortable enough to write the equations of motion using the Lagrangian and Hamiltonian approach. Next step is to use the appropriate transformation that will give the Hamiltonian that will be zero, indicating the constant momentum curves in the phase space diagram.

1. Classical Mechanics - R. Douglas Gregory (Cambridge University Press 2006).
2. Classical Mechanics – Goldstein, Poole and Safko (Pearson) 3rd Edn.
3. Lagrangian and Hamiltonian Mechanics – M. G. Calkin (World Scientific).

III. Electromagnetic Theory

Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials

Workout this section using Griffiths and Jackson(if possible). Give some preference to relativistic dynamics and develop the concepts of Lorentz invariance and **gauge invariance**. One should be comfortable with the concept of scalar and vector fields and their role in generating electromagnetic disturbances over time and space. These concepts are pretty useful in quantum field theory also.

IV. Quantum Mechanics

Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation

Not much to say about these topics. All are attempts to explain fine results from the labs and some elementary phenomena such as interaction between particles (light too!). We can easily cover these topics using books given in section B above. Try to practice questions based on these sections. A useful book could be the Schaum's Outlines in Quantum Mechanics which is a good practice book for these topics.

1. Modern Quantum Mechanics – J. J. Sakurai
2. Quantum Mechanics – E. Merzbacher (John Wiley & Sons).
3. Principles of Quantum Mechanics – R. Shankar (Kluwer Academic/Plenum Publishers).
4. Schaum's outlines – Quantum Mechanics – Y. Peleg, *et. el.* (Tata McGraw-Hill).

V. Thermodynamic and Statistical Physics

First-and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to non-equilibrium processes.

Not much to cover under this topic. I believe that the important topics in this section are the theory of dia, para and ferromagnetism; Ising model and BE condensation; all available from Patria and Huang. Get a grip of phase transitions from Zemansky and then workout the necessary statistical theory from other advanced books. These are not very easy to digest but worthy of an attempt. Non-equilibrium processes are crucial to many advanced research problems today. Develop a very good understanding of the Diffusion problem starting with statistical and thermodynamic

principles and is crucial to many problems in solid state physics and advanced physics problems.

Books

1. Thermodynamics – Zemansky.
2. Concepts in Thermal Physics - Stephen J. Blundell and Katherine M. Blundell (Oxford University Press 2006).
3. Introductory Statistical Mechanics – Bowley and Sanchez (Oxford)
4. Statistical Mechanics – R. K. Patria (Butterworth Heinemann).
5. Statistical Mechanics – K. Huang (Wiley).
6. Statistical Physics: An Introduction –D. Yoshioka (Springer).

VI. Electronics and Experimental Methods

Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

Considering the fact that experimental methods and data analysis are highly desirable for any future experimental physicist, this is beneficial for future researchers in today world of sophisticated experiments. Apart from that we can expect at least one good question from this section. Even though these topics are much beyond the grasp of most postgraduate students in colleges across the country, try to get some knowledge using the books given below or simply get to know about them by visiting the nearest university or Internet. It is often helpful if you can talk to some researcher about the needs for such sophisticated research methods.

1 Practical Physics - G. L. Squires, Cambridge University Press (2001).

2 An Introduction to Experimental Physics, Colin Cook, Routledge (1996).

VII. Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin.Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A& B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

This is a section that is much easier to learn and answer. One can expect some numerical calculations based on key fundamental regarding spectroscopic transitions. One has to be thorough with the origin of each region of the electromagnetic spectrum and the explanation offered by atomic and molecular physics to these phenomena. Basic requirements for the study of this topic are quantum mechanics, group theory and some electromagnetic theory.

Books 2 and 3 below can be helpful but if one wants to go more elaborately, *Eisberg and Resnick* may be helpful. One should be able to answer all questions related to this section, especially from different parts of spectroscopy. Reference #1 will be useful for other sections like Nuclear and Elementary Particle Physics too. J. M. Hollas gives an elaborative description of the subject if one is not content with *Barnwell*. Those who want some serious laser fundamentals are encouraged to use *Silfvast*.

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, R. Eisberg and R. Resnick (Wiley).
2. Molecular Spectroscopy – C. N. Barnwell (McGraw-Hill).
3. Modern Spectroscopy - J. Michael Hollas (John Wiley & Sons - 2004).
4. Laser Fundamentals – William T. Silfvast (Cambridge University Press - 2004).

VIII. Condensed Matter Physics

Bravais lattices. Reciprocal lattice. Diffraction and the

structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

This is a crucial paper worth spending time. In physics research, some of the most remarkable results were published in this area. So a good knowledge of the subject not only helps in the exam but also helps in a future career. Develop a good idea about the *spatial periodicity* which is highly relevant in the case of crystals. Many of their properties can be derived from the harmonic analysis, especially with the help of Fourier analysis. The section include simple theories in crystallography and superconductivity to acoustic and electric properties of matter, free electron theory, heat capacity models, band theory, theory of magnetism, etc.

Knowledge of statistical and quantum mechanics will be highly helpful. Most of the bulk properties are derived from microscopic analysis of matter. It is important to notice that the temperature dependence of many material characteristics such as heat capacity, electrical conductivity, and magnetic properties are obtained through quantum theory using statistical methods. Syllabus follows the contents of Kittel which is the bible of condensed matter physics but not a good text book. It contains the clue to any particular issues in the subject but make judicious use of other books as well. Azhcroft and Mermin give a good account of the Drude model and the electrical, thermal and optical properties of solids.

1. Introduction to Solid State Physics – C. Kittel (Wiley)
2. Solid State Physics – Ashcroft and Mermin.
3. Solid State Physics – Ali Omar (Pearson).
4. Problems and Solutions in Solid State Physics – S. O. Pillai (New Age).

IX. Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

There is not much change from the previous exam here. Only challenge here is the MCQ pattern which demands an objective approach to find the answer. Questions will be based on a detailed problem out of which we have to find possible answers. Nuclear physics, not *per se*, is not that highly challenging if you go by the exam pattern. Beware in mind that Nuclear Physics is a highly empirical science and much of the theoretical part is available for verification subject to highly sophisticated experiments. High energy reactions mostly deserve relativistic formulations. We can expect both quantitative and qualitative questions from this section. When going through the books we have to double check the fact that there is a constant struggle to explain the experimental evidences which is not quite easy considering the advanced mathematical description of the subatomic world which is invisible to direct human experience. We have to rely upon our intuitions rather than direct visual experience here.

Nuclear models, semi empirical mass formula, nuclear stability, and ideas of different counters can come in handy. In case of reactions and emissions, beta particle decay is important. Follow different mechanisms possible within a nucleus. Elementary particle physics can be tougher

for some but learn the classification of particles with the aid of some group theory and general reading. Learn to solve any nuclear or elementary particle reactions using the basic conservation laws used to group them. Hypercharge, Iso-spin, Baryon or Lepton Number, Strangeness, etc., are not that difficult to digest. Ideas of violation of parity, CPT, etc., will help. Questions from this section mostly follow the syllabus and ref. #1 and #2 are very useful to cover the syllabus. One can easily find books that give good coverage of nuclear physics.

Books

1. Introduction to Nuclear and Particle Physics – A. Das and T. Ferbel (World Scientific – 2005).
2. The Particle Hunters - Yuval Ne'eman and Yoram Kirsh (Cambridge University Press, 1996).
3. Subatomic Physics - Ernest M. Henley and Alejandro Garcia (World Scientific, 2007).
4. An Introduction to Nuclear Physics – W. N. Cottingham and D. A. Greenwood (Cambridge University Press, 2004).
5. Particles and Nuclei: An Introduction to the Physical Concepts – Bogdan Povh *et. al*. (Springer, 2006).
6. Introduction to Elementary Particle Physics – Khanna (Prentice Hall of India). ■

Prospects in Physics for B.Sc. Physics Students

Shaju K.Y.
Associate Professor, Department of Physics
Christ College, Irinjalakuda, Thrissur.

List of notable Indian Institutions offering M.Sc. - Ph.D. Integrated programmes.

1. TIFR, Mumbai, **http://univ.tifr.res.in/**

Tata Institute of Fundamental Research

Publication of Notification:

September- October

Nationwide Entrance Examination: December

Online payment link will be active upto November

DDs sent by post/courier will be accepted upto November

GATE Scored based applications to Systems Science:

Opens on : February 1

Closes on : March 25

Results of the Nationwide Entrance Examination: January

2. IMSc, Chennai, **http://www.imsc.res.in/phd_programme_physics**

Institute of Mathematical Science

Applicants for the PhD programme should have completed a Masters degree in the Physics by the time they actually join the programme. Applicants for the integrated PhD programme should have completed a Bachelors degree in Physics by the time they actually join the programme. Exceptional candidates with a Bachelors or Masters degree in other areas will also be considered for admission to the integrated PhD programme.

Admission to both of these programmes is based on the candidate's performance in Joint Entrance Screening Test (JEST) and interview.

The advertisement of the JEST examination is expected to appear in national newspapers in the last quarter of each year.

Those who have qualified for Junior Research Fellowship (JRF) of UGC-CSIR NET

examination or Graduate Aptitude Test in Engineering (GATE) may apply for direct interview.

3. IIA, Bangalore, **http://www.iiap.res.in/**

Indian Institute of Astrophysics

IIA has launched an integrated M.Sc - Ph.D Programme in Physics and Astrophysics in collaboration with Indira Gandhi National Open University (IGNOU), New Delhi. The programme will admit bright, highly motivated students with Bachelor's degree in Science/Engineering, selected on an all-India basis. Selected candidates will be offered a studentship of Rs.10,000/- pm, an annual book grant, accommodation,

and medical facilities during the M.Sc course. The programme will be conducted at IIA, Bangalore in the residential and face-to-face mode.

4. IISc, Bangalore, **http://www.iisc.ernet.in**

Indian Institute of Science

Admission is open for (i) Research Programmes [Ph D / M Sc (Engg)] (ii) Course Programmes [ME/M Tech/M Des /M.Mgt] (iii) Integrated Ph D Programmes and (iv) External Registration Programmes (Ph D only) at the Institute. Eligibility criteria, specialization, areas of research and other details are available at our website www.iisc.ernet.in/admissions. Candidates who are yet to complete their qualifying examinations and expect to complete all the requirements for the degree (including all examinations, project dissertation, viva-voce etc.) before July 31, are also eligible to apply.

5. CMI, Chennai, **http://www.cmi.ac.in/admissions/**

Chennai Mathematical Institute

Applications for August will open in early March.

Academic programmes offered at CMI

Note: From 2012, the B.Sc. (Hons.) Physics programme has been restructured as an integrated B.Sc. (Hons.) in Mathematics and Physics. There is a common entrance examination for both the B.Sc. (Hons.) programmes. You need not select your course at the time of applying. The choice can be made after admission.

6. HRI, Allahabad, **http://www.hri.res.in/~physjest/**

Harish-Chandra Research Institute

Admissions to the graduate programs in physics

HRI conducts a regular Ph.D. as well an integrated M.Sc.-Ph.D. program in physics. The regular Ph.D. program is open to students with a M.Sc. degree in physics, while the integrated program is open to candidates with a Bachelor's degree in science or engineering. For further details about the graduate programs in physics at HRI, click here Candidates for these programs will be selected through the Joint Entrance Screening Test (JEST) , followed by a written test and an interview at HRI. In addition, students who have qualified the NATIONAL ELIGIBILITY TEST (NET) under the CSIR - UGC JRF category in June or December would be considered for the written test and interview at HRI.

7. ARIES, Nainital, **http://www.aries.res.in/**

Aryabhatta Research Institute of Observational Sciences

Every year ARIES selects students for Ph. D. program in the field of Astronomy & Astrophysics, Solar Physics and Atmospheric Sciences.

The eligibility for Ph.D. Program at ARIES is following:

M.Sc. Physics/Astrophysics with minimum 55% and JEST/ CSIR-NET (JRF/LS)/ GATE Qualified

M.Sc. final year students can also apply provided they are expected to get their final exam results by August 1.

8. JNCASR, Bangalore, **http://www.jncasr.ac.in/**

Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) is a multidisciplinary research institute situated in Jakkur, a locality north of Bangalore, India. It is relatively young yet well-known around the Globe. Our mandate is to pursue and promote world-class research and training at the frontiers of Science and Engineering covering broad areas ranging from Materials to Genetics. It provides a vibrant academic ambience hosting more than 200 Researchers. The Centre is funded by the Department of Science and Technology, Government of India and is a deemed university.

JNCASR has a bright and diverse student body. At present, there are 282 students registered in the various academic programmes of the Centre. While the majority of these students are pursuing Ph. D. degree, we also have students enrolled in our Integrated Ph. D., M. S. / M. S. (Engg.) programmes. The student population at JNCASR is drawn from across the length and breadth of the country; in addition, we frequently have foreign students visiting the Centre under various exchange programmes.

9. IISER (TVM, BHOPAL, PUNE, MOHALI, KOLKATA)

http://www.iiser-admissions.in/

Candidates Offered Admission Through State and Central Boards Channel IISERs

To promote high quality scientific research and training, Ministry of Human Resource

Development (MHRD), Government of India has set up five Indian Institutes of Science Education and Research (IISERs)at Bhopal, Kolkata, Mohali, Pune and Thiruvananthapuram.

BS-MS Dual Degree Programme

It is a five year dual degree programme for bright and motivated students of science who have completed class XII. It integrates classroom learning with research and provides ample scope for multidisciplinary interactions. BS-MS students are eligible for either KVPY or INSPIRE scholarship.

Some notable institutions outside Kerala offering M.Sc. & Ph.D. Programmes in Physics

1. IIT's

a. IIT Ropar, Rupnagar, Punjab, www.iitrpr.ac.in
b. IIT Bhubaneswar, Bhubaneswar, Odisha, www.iitbbs.ac.in
c. IIT Bombay, Mumbai, Maharashtra, www.iitb.ac.in
d. IIT Delhi, New Delhi, www.iitd.ac.in
e. IIT Gandhinagar, Gandhinagar, Gujarat, www.iitgn.ac.in
f. IIT Guwahati, Guwahati, Assam, www.iitg.ac.in
g. IIT Hyderabad, Hyderabad, Andhra Pradesh, www.iith.ac.in
h. IIT Indore, Indore, Madhya Pradesh, www.iiti.ac.in
i. IIT Kanpur, Kanpur, Uttar Pradesh, www.iitk.ac.in
j. IIT Kharagpur, Kharagpur, West Bengal, www.iitkgp.ac.in
k. IIT Madras, Chennai, Tamil Nadu, www.iitm.ac.in
l. IIT Mandi, Mandi, Himachal Pradesh, www.iitmandi.ac.in
m. IIT Patna, Patna, Bihar, www.iitp.ac.in
n. IIT Jodhpur, Jodhpur, Rajasthan, www.iitj.ac.in
o. IIT Roorkee, Roorkee, Uttarakhand, www.iitr.ac.in
p. IIT (BHU) Varanasi, Varanasi, Uttar Pradesh, www.iitbhu.ac.in

2. University of Hyderabad. www.uohyd.ac.in
3. University of Delhi http://www.du.ac.in/index.html
4. Pondichery Central University http://www.pondiuni.edu.in/

Some Insitutions offering visiting programs for B.Sc. Students.
1. TIFR http://www.tifr.res.in/~vsrp/
2. BARC (Based on All India Essay Contest on Nuclear Science and Technology, July – August)
3. IIA, Bangalore
4. NIUS Physics programme by HBCSE,tifr.
5. IISc, Bangalore.

■

APT Workshop Series in Theoretical Physics

G. Harikrishnan
Assistant Professor, Department of Physics
Government College, Madappally, Vadakara

Introduction

The profile of physics teachers of arts and science colleges in Govt., aided and unaided sectors has been in the process of a change over for the last decade and within the next few years it would be exclusively composed of young generation. They are keen on learning the subject in depth, acquiring new teaching skills and adapting themselves to the new era with equal emphasis on teaching and research. It is to address the needs of this young generation of physics teachers and equip them attain mastery in their subject matter and vocation that Academy of Physics Teachers (APT) has envisioned the Workshop Series in Theoretical Physics. This series will span all the fundamental theoretical areas being taught at the PG level. There will be one weekend workshop (Saturday & Sunday) every alternate month, 3-day workshops during Christmas, Onam and summer holidays. All the resource persons collaborating in the realization of this series are adepts in both the understanding of the subject matter and the skill in transferring their knowledge to the audience. On each day of the workshop, there will be lecture sessions for the presentation of the topics and tutorial sessions for problem solving and discussions so that the participants would get sufficient opportunity to clear their doubts. The topics to be discussed in each workshop and the text books to be followed would be announced in advance and it would be advantageous to the participants if they come prepared by going through the relevant reading material. These workshops can play a crucial role in generating academic excellence among the young teachers. It is hoped that anyone interested in expanding one's knowledge base in physics and fine tuning one's teaching skills would be motivated to attend this series.

The plan of different workshop series is in the following order : I. Mathematical Physics, II. Classical Mechanics, III. Quantum Mechanics, IV. Statistical Mechanics, V. Electrodynamics and VI. Solid State Physics. For each area there will be 5 workshops to discuss the major topics. Thus, the series will consist of 30 workshops spanning over a period of more than 4 years. Each year there will be 7 workshops at different colleges in the state accessible to the participants from all over the state and even outside the state. As the resource persons will be available for discussions throughout the two or three days of the workshop, each workshop is designed as resident workshop to give the participants the advantage of interacting with the resource persons.

Those who want to join the series may contact by e-mail to ghkphysics@gmail.com or by phone to 9447855840. Those with gmail ID can also register for each workshop with their names and mail ID in the google spreadsheet given in the link : https://docs.google.com/spreadsheets/d/1qWGjxY3CWw8It0SxzoFm6IAuph

QYGYvvGv48Qz9JUqo/edit#gid=0

Series I : Mathematical Physics

Workshop 1 : Complex Analysis

Dates : 1-2 November 2014

Venue : Christ college, Irinjalakuda

Resource Person : Dr. S V M Satyanarayana, Dept. of Physics, Pondicherry Central University

Study material : Mathematical Methods for Physicists by Arfken and Weber

The workshop was inaugurated by Rev. Fr. Dr. Jose Thekkan C.M.I., Principal, Christ College, Irinjalakuda. Dr. Satyanarayana addressed the gathering pointing out the uniqueness and significance of this workshop series launched by APT. Prof.V P Anto, Head in charge of the Dept. of Physics presided over the function. Dr. Shaju K Y, Secretary of APT welcomed the gathering and G Harikrishnan, state coordinator of the workshop series, delivered the vote of thanks. There were 43 participants out of which 22 were resident participants. They had come together from different parts of the state and three of them were from Karnataka. The video recording of the classes were done on both days.

On the first day the classes started with the discussion on the motivation for the invention of complex numbers. It proceeded to stereographic projection and then on to analytic function. The alternate way of stating Cauchy-Reimann conditions, in the form of $\frac{\partial f}{\partial z^*} = 0$, sparked some interesting discussions. The logical progression from Cauchy integral theorem to Cauchy's integral formula and finally to the definition of the derivative of an analytic function was systematically established. Taylor and Laurent series expansions were discussed in detail. Lecture sessions on the first day ended with the classification of different types of singularities and the calculation of residue. During the tutorial sessions, many standard problems that are frequently being asked in the PhD entrance examinations and interviews, like finding the real and imaginary parts of $i^{\sqrt{i}}$, were analyzed. Many of the problems were directly connected to different physical phenomena. The second day began with the exposition of analytic continuation and then contour integration. Five major types of contour integration were taken up one by one and analyzed at length. Multivalued functions, branch points and branch cuts were then discussed. Green's function method of solving the inhomogeneous differential equation was illustrated by the problem of forced oscillator and quantum theory of scattering. In both cases, the evaluation of the Green's function involved contour integration. In the tutorial sessions, examples involving multivalued functions were considered.

The participants were supplied with the LaTex and pdf versions of the notes on Complex Analysis prepared by Dr. P. D. Shaju, Dept. of Physics, Christ college, Irinjalakuda.

Workshop 2 : Linear Algebra

Dates : 26-28 December 2014

Venue : St. Thomas college, Pala

Resource Person : Dr. S V M Satyanarayana, Dept. of Physics, Pondicherry Central University

Study material : Mathematical Methods for Physics and Engineering by Riley, Hobson and Bence

The workshop was inaugurated by the honourable Vice Chancellor of Mahatma Gandhi University, Dr, Babu Sebastian. The principal of the college, Rev. Fr. N V Joseph presided over the function. Dr. Satyanarayana and Dr. Shaju K Y talked on the occasion. Dr. Ison V Vanchipurackal, the local organizer of the workshop, welcomed the gathering and G Harikrishnan delivered the vote of thanks. There were 25 participants out of which 11 were resident participants.

On the first day the discussion began with the definition of linear vector space. Different classes of examples of linear vector space were subsequently discussed in detail, each class further consisting of many sub-classes. The real line, the set of n x n matrices, the set of all polynomials on a plane, the set of all solutions to the n-th order linear differential equation, the set of all periodic functions etc. are some of the classes of examples analyzed in detail. Concepts like linear independence, span, sub-space, direct sum and direct product of vector spaces etc. were introduced methodically. On the second day, starting from the several ways of defining the norm of a vector, the discussion proceeded to inner product, orthogonality and Gram-Schmidt orthogonalization procedure.

Special functions were shown as naturally emerging from the Gram-Schmidt orthogonalization of monomial basis, depending on the choice of the domain and the weight factor. In contrast to this, the reciprocal basis in solid state physics was shown to be the consequence of demanding a change of basis from the direct lattice set to another non-orthogonal set that enables the determination of the expansion coefficients. Completeness of the basis set as well as the completeness of the vector space were minutely established. At this stage, the idea of linear transformation and the four distinct vector spaces associated with every linear transformation were introduced. The third day began with the listing of the different types of matrices and their properties. Inner product and outer product were further considered using the Dirac's bra-ket notation and the significance of the projection matrix or projection operator was brought out. Linear operator was formally introduced. The consequence of the change of basis on the vector space and the linear operator was established. The idea of the similarity transformation of the linear operator during change of basis led to the discussion of the diagonalization of a matrix and its significance under the change of basis. As the last topic, the different rules of solving a set of linear algebraic equations and their relative merits in machine based computation were discussed. Throughout those three days the participants had the wonderful experience of looking at diverse areas of physics under the over arching theme of linear algebra. The workshop was a celebration of the wonderful breadth and reach of this subject.

On the second and third days, there were short sessions on the Introduction to LaTex taken by Dr. Shaju K Y. If more participants show enthusiasm, such short sessions on diverse skills can be incorporated into this series as and when time permits. The video recording of the classes were done by Dr. Shaju K Y.

Workshop 3 : Tensor Analysis

Dates : 14-15 February 2015

Venue : Union Christian College, Aluva

Resource Person : (1) Dr. S V M Satyanarayana, Dept. of Physics, Pondicherry Central University

(2) Dr. S S Nania Mohammed, Dept. of Physics, Govt. Arts college, Udumalpetta, Tamil Nadu

Study material : Mathematical Methods for Physics and Engineering by Riley, Hobson and Bence

The number of participants was 61, of which 25 were resident participants. All the lectures were scheduled on the first day of the workshop and all the tutorials on the second day. Dr. S.V.M. Satyanarayana, the resource person of the first day, was introduced by Harikrishnan G, state coordinator of the workshop series. The academic sessions were started right away without any formal inauguration. Dr. Satya narayana first presented the motivation for defining tensors in a particular way, in terms of their transformation under rotation of the coordinate axes. Early on, he introduced the concept of one-form to place the discussion on as general a footing as possible. He established that vector and one-form were linear operators acting on each other to produce scalars. Then he introduced a tensor of rank (m+n) as a scalar-valued function of m one-forms and n vectors. Metric tensor and its properties were dealt with in detail. In this way, after establishing the context, the definitions of the contravariant tensor and covariant tensor were introduced. Different 4-vectors encountered in Special Relativity were introduced one by one in covariant notation. The continuity equation, Maxwell's equations and Klein-Gordon equation were re-expressed in covariant notation. The analytically demanding problem of birefringence was discussed at length. The idea of the contraction of a tensor was introduced. There was also a brief exposition of the derivative of a tensor in terms of the Christoffel symbols.

On the second day, the tutorials were conducted by Dr. S. S. Naina Mohammed. Starting from the simple examples of Einstein summation convention, he moved on to the properties of symmetric and skew-symmetric tensors, Kronecker delta function and Levi-Civita tensor and the different invariant quantities related to electromagnetic field tensor, metric tensor etc. Prof. A.Benny Cherian, Principal of U.C. College, addressed the participants informally in between the academic sessions.

On the second day, a brief

session after lunch was put aside for a discussion on UG and PG physics curriculum. The discussion was moderated by Prof. Shaji, Head, Dept. of Physics, Maharajas college, Eranakulam. In his introduction Prof. Shaji touched upon many aspects of theory and experiments where the existing curriculum could be improved by incorporating many innovative ideas and practices. Dr. Anila E I, Head, Dept. of Physics, U.C. college, was the local organizer of the workshop. The video recording of the classes were done by Dr. Shaju K Y, secretary of APT. These videos, along with the videos of the first two workshops, had been uploaded in youtube under the title, "Satya's Lectures on Physics" where it would be freely available for all the students and teachers.

Workshop 4 : Differential Equations.

Venue : Farook college, Kozhikode

Dates : 10-12 April 2015

Resource persons : (1) Dr. S. Sivakumar, Scientist-G, Materials Physics Division, IGCAR, Kalpakkam

and (2) Dr. A. Basherrudin Mahmud Ahmed, School of Physics, Madurai Kamaraj University. There were 33 participants in the workshop, out of which 13 were resident participants.

On the first day, Dr. K.K. Abdullah, Head, Department of Physics, Farook college, welcomed the gathering. The resource persons were introduced by G. Harikrishnan, state coordinator of the APT workshop series. There was no formal inaugural session and the classes started right away. In his first lecture, Dr. Sivakumar introduced three different techniques used for solving differential equations, to be frequently employed in his later lectures : Laplace transform, Fourier transform and Dirac Delta function. In his second lecture he started with linear first order ordinary differential equations (ODE) and showed how a solution in terms of the integrating factor emerged. He discussed the statements of the existence and uniqueness theorems for the solutions and illustrated the meaning of the uniqueness theorem. Among nonlinear first order ODEs, he discussed specific techniques of solving them if they belonged to (i) separable equations and (ii) exact equations. Special types of nonlinear equations like Bernoulli equation and Ricatti equation were also considered. The case of coupled first order ODEs and their solutions in terms of the exponential function of a unique matrix were discussed at length. In the tutorial sessions, Dr. Basheer discussed different examples of each type of equation introduced in the lectures. In the beginning of the afternoon session the principal of the college, Prof. E.P.Imbichikoya, addressed the gathering. In his third lecture Dr. Sivakumar considered linear second order ODE with constant coefficients. He showed the method of variation of parameters to construct a second solution in terms of one fundamental solution.

On the second day, in his fourth lecture, Dr. Sivakumar exhaustively discussed the method of solving differential equations using Laplace transforms. He started with first order homogeneous ODE. He also demonstrated in which cases solution technique using Laplace transforms, or any transforms, would not work. He then moved over to first order inhomogeneous ODE and illustrated its solution using Laplace transforms. He then considered second order homogeneous ODE and demonstrated the method of solving it with Laplace transforms. He also introduced the idea of Wronskian and showed its emergence and usefulness in the context of second order homogeneous ODE. The subsequent tutorial sessions covered many examples of the concepts and techniques introduced in the lecture. One particular example of forced harmonic oscillator illustrated the case of solving a second order inhomogeneous ODE with Laplace transforms. In his fifth lecture Dr. Sivakumar discussed second order homogeneous ODE with variable coefficients and introduced the technique of power series solution. He demonstrated the ratio test for convergence of the infinite power series. In the evening Dr. Sivakumar gave a special lecture on Quantum Interference.

On the third day, in his sixth lecture Dr. Sivakumar considered second order inhomogeneous ODE and demonstrated a general method to construct the particular solution from the fundamental solutions of the corresponding homogeneous equation. He then moved over to the topic of self-adjoint operator and the nature of its solutions. To give proper moorings to this subject, he gave a brief recapitulation of

vector space and inner product space and finally came to self-adjoint operator. He introduced Sturm-Liouville equation and illustrated the case of a classical harmonic oscillator. He discussed the emergence of the various special functions as the eigenfunctions of Strum-Liouville operator under specific choices of the domain and weight functions. Again the tutorial sessions complemented the lecture with a detailed illustration of the power series solution. In his seventh lecture, Dr. Sivakumar discussed the Green's function technique of solving a second order inhomogeneous ODE. He also considered the perturbative technique of solving a quantum mechanical system like coupled oscillator. Dr. K.K. Abdullah, Head, Department of Physics, Farook college, delivered the vote of thanks to the two resource persons and the participants.

Thanks to the authorities of Farook college and the staff of Physics Dept. at Farook college for all the efforts and support in realizing this workshop. Thanks to the resource persons.

Workshop 5 :

Group Theory

15-17 May 2015

Providence Women's College, Kozhikode

On the first day, Dr. Mini Balakrishnan, head of the department of physics, Providence Women's college, Kozhikode, welcomed the gathering. Principal of the college, Dr. Sr. Neetha inaugurated the workshop. Dr.S.V.M. Satyanarayana was the resource person. In the two lecture sessions he introduced systematically the basic definitions and concepts in the group theory and discussed different examples in the two tutorial sessions.

On the second day, in the lecture sessions, he discussed concepts like automorphism, homomorphism, isomorphism, direct product and semi-direct product. Then he moved on to the group representation theory. Many related ideas like equivalent representation, orthogonal and unitary representations, reducible and irreducible representations, decomposable and indecomposable representations etc. were discussed in detail. A succinct and elegant proof of Schur's Lemma was presented. The subsequent tutorial sessions consisted of many illustrations of the points raised in the lectures.

On the third day, he continued the previous day's discussion by the discussion of the great orthogonality theorem. The way to apply great orthogonality theorem in an actual physical situation was illustrated in detail by a complete discussion of the symmetries of the ammonia molecule. This was followed by the discussion of continuous groups. The properties of different types of continuous groups were discussed at length. Generators of continuous groups were also discussed.

There was also a one hour special lecture by Dr. Satyanarayana on the second day afternoon, sharing his experiences and ideas in the teaching of physics. The workshop was attended by 37 teachers from different parts of the state and one from Tamil Nadu. The lectures were video recorded by hired professionals and the edited videos were later uploaded in youtube, making it freely available to the community of teachers and students.

APT Workshops planned for 2015-2016
[Classical Mechanics : I-V, Quantum Mechanics : I-II]

No.	Topic	Venue	Dates
I	Lagrangian Dynamics	Vimala college, Thrissur	27-28 June 2015
II	Hamiltonian Dynamics	S.B. college, Changanassery	22-24 August 2015
III	Central force problem	Christ college, Irinjalakuda	10-11 October 2015
IV	Rigid body dynamics and Small oscillations	Christ college, Irinjalakuda	19-21 December 2015
V	Special Theory of Relativity	U.C. college, Aluva	14-15 February 2016
VI	Postulates of Quantum Mechanics and One dimensional systems	Farook college, Kozhikode	8-10 April 2016
VII	Angular momentum formalism and Hydrogen atom	Providence Women's college, Kozhikode	13-15 May 2016

100th Year of Bohr's Atom Model Year long celebrations throughout Kerala - A Report

Shaju K.Y.
Secretary, APT, State Co-ordinator

Niels Bohr first postulated his ideas in 1913 about the atom, which later found significance, while explaining the quantum mechanical behavior of atoms. This paved way to Electronics, Computer science, Information Technology etc. which form the foundation of modern science. World celebrated the centenary of Bohr atom model in 2013 and Academy of Physics Teachers (APT) also participated in this festival of science. In 2005 APT celebrated WYP (World Year of Physics) and IYA (International Year of Astronomy), in 2009.

The project, submitted to Kerala State Council for Science, Technology & Environment (KSCSTE), Thiruvananthapuram in association with Christ College, Irinjalakuda, Mr.Shaju K.Y, Associate Professor, Christ College being the State level Programme Co-ordinator, got sanctioned in March 2014.

The project was envisaged to conduct National / State level seminars, workshops, demonstrations and competitions in the 14 district centers of Kerala to popularize the basic science studies and in turn to enhance the scientific temperament among the students and the public. Prof. G.Harikrishnan, Govt. College, Madappally, Prof. Shaju K.Y., Christ College, Irinjalakuda, Prof. Issac Paul., S B Changanacherry and Prof. K. C. Ajith Prasad., M G College, TVM extended their whole hearted co-operation for the smooth conduct of the project as regional Co-ordinators. Details of the activities conducted at the various institutions all over the State are given below.

Inauguration

Cochin University of Science and Technology, Ernakulam 28-02-2014 to 01-03-2014

Resource Persons

Rev.Fr.Dr. Jose Thekkan CMI, Christ College, Thrissur. – Inaugural Address

Dr. Rajeev N. Kini, IISER, TVM - "Ultrafast Spectroscopy of Semiconductors"

Dr. Vineeth Chandrasekharan Nair, VSSC, TVM - "From Bohr to bores, A Journey"

Dr. K.B. Jinesh, IIST, TVM - "From Bohr to Bohr: Evolutions of Nano Technology"

Prof. Dr. P.S. Anil Kumar IISc, Bangalore - "From MOSFET to spin-FET"

Co-ordinator - Prof.Dr. M.K.Jayaraj, Dept. of Physics, CUSAT.

PRNSS College, Kannur 10-10-2014

Resource Persons

Dr. V P N Nampoori, Emeritus Professor, ISP, CUSAT - "Genesis of quanta"

Mr. K.B Roy, Govt. Sanskrit

College, Pattambi - "Bohr atom model; A groundbreaking trilogy'

Co-ordinator

Prof. Deepa. K., PRNSS College.

MES Ponnani College, Malapuram 13-10-2014

Resource Person

Prof. K. Suresh Babu, Govt. College, Madappally

- " Evolution of atom model and discoveries of physical phenomena"

- "Physics through problems"

Co-ordinator - Prof.K. Safna, MES College, Ponnani.

Govt. College, Madappally, Kozhikode 15-10-2014

Resource Persons

Prof. K. Pappootty, State Encyclopedia Institute - "Quantisation as a revolution in Physics"

Prof. Roy K.B., Govt Sanskrit College, Pattambi – "Evolution of atom models"

Prof.K.Suresh Babu, Govt. College, Madappally – "Revolutions in physics through ages"

Co-ordinator - Prof. Suneera T.P., Govt. College, Madappally

Vimala College, Thrissur 17-10-2014

Resource Persons

Prof. V P N Nampoori, Professor Emeritus ISP ,CUSAT " 100 years of Bohr Atom Model"

Prof. P C Thomas – "Opportunities in Science Higher Education"

M.Sc. Students – Presentation on " A journey through Atom Models"

Co-ordinator - Dr.Malini K.A.,Vimala College.

W.M.O. Arts &Science College, Wayanad 21-10-2014

Resource Persons

Prof.. Sreejith P., WMO College - 'History of Atoms: From Democritus to Bohr'

Prof. Biju K. G. WMO College - ' Energy quantization and wave particle duality'

Co-ordinator - Prof. Najumunnisa T., WMO College.

Nehru Arts and Science College, Kanhangad, Kasargod 7-11-2014

Resource Persons

Dr. T. R. AnanthaKrishnan, CUSAT – "Physics in daily life"

Prof. Rajeesh P., NAS College - Chemistry Stage Show.

Dr. A. Mohanan, NAS College co-ordinated Lab visits

Co-ordinator - Dr. K.M. Udayanandan, NAS College.

Mercy College, Palakkad 26-11-2014

Resource Persons

Prof.T.R. Ananthakrishnan, CUSAT - 'Physics Stage Show'

Dr. Lakshmi M., Mercy College - 'Fundamentals of Electronics'

Ms.Nandini S.G. , I M.Sc. - 'Bohr Atom Model'

Co-ordinator - Prof. Anu Kuruvilla, Mercy College.

St.Thomas College, Kozhenchery, Pathanathitta 28 – 29, Nov. 2014

Resource Persons

Prof. Dr. K Babu Joseph, former Vice Chancellor, CUSAT - "Physical Foundations of QM"

Dr. K. C. Ajith Prasad, M. G. College, TVM - "Need for studying Quantum Mechanics"

Prof. Dr. Moncy V. John, St. Thomas College - "Quantum States and Measurements"

Prof. Rajan K. John, CMS College - " Methods and Practices for Quantum Mechanics"

Prof. Dr. Susan Mathew - "Approximation Methods used in QM"

Mr, Blesson George, CMS College - Problem solving session I

Sri. Sanu Simon, St. Thomas College - Problem solving session II.

Co-ordinator - Prof. Dr. Ninan Sajeeth Philip, Mercy College.

Newman College, Thodupuzha, Idukki 29-11-2014

Resource Persons

Dr. Joe Jacob, Newman College - 'History of atoms:

from Democritus to Bohr'

Prof. S. Sankararaman - Nirmala College – "Evolution of atom model"

Prof. Louis J Prathazham, Newman College – Demonstration of basic Physics experiments.

Co-ordinator - Prof. Louis J Prathazham , Newman College.

M.G. College, Thiruvananthapuram 10-11 Dec. 2014

Resource Persons

Prof. V P N Nampoori, ISP ,CUSAT - " Bohr Atom Model – A quantum leap"

Prof. V P N Nampoori, ISP ,CUSAT-" Introduction to linear vector spaces and special functions.

Dr.P.Sethumadhavan, M G College - "Introduction to Tensors"

Co-ordinator - Dr. K C Ajithprasad, M G College.

Maharajas College, Ernakulam 02-12-2014

Resource Persons

Dr. Hrebesh M.S., NUI, USA – "Affordable Tomographic Imaging Application with OCT"

Dr. Jijo P. Ulahannan, Maharajas College - Physics Quiz

Co-ordinator - Dr.A.S. Asha, Maharajas College

St.Thomas College, Pala, Kottayam 15-12-2014

Resource Persons

Dr. K.B. Jinesh, IIST, Trivandrum - "Evolutions in nanotechnology: enough room at the bottom"

Dr. Ison V. Vanchipurackal, St. Thomas College - "Nobel winning blue LED"

Dr. K.Indulekha, M.G. University, Kottayam - "Atoms"

Dr. Ison V V – Co-ordinated Lab visits.

Co-ordinator - Dr. Ison V. Vanchipurackal, St. Thomas College.

S.B.College, Changanacherry, Kottayam 30-12-2014

Resource Persons

Dr. Lijo Jose. K, SB College, Changanassery – "An Introduction to Earths near space environment"

Dr. Mathew Abraham, CMS College - "Applications of Physics in day to day life".

Co-ordinator - Dr.Issac Paul, S B College.

S.N. College for Women, Kollam 20-01-2014

Resource Person

Dr. B. Premlet, Physics Author - "Bohr Atom Model"

Dr. B. Premlet - Physics Quiz competition for plus two students.

Co-ordinator - Dr. Nisha.J.Tharayil, S N College

S.D.Collge, Alappuzha 21-01-2014

Resource Persons

Dr. K.P Satish, Govt. Brennen College, Talasserry - "100 Years of Atom"

Dr.Sreejith K.Pisharady, S D College - "Virtual Lab"

Co-ordinator Dr.Sreekanth J. Varma, S D College.

Valedictory Program Christ College, Irinjalakuda, Thrissur 24-01-2014

Resource Persons

Prof. T. N. Vasudevan, University of Calicut – "Symmetry in Physics - A search for parallels in science and arts)"

Prof. M K Jayaraj, CUSAT – "Nobel winning Blue LED"

Prof. K.R. Janardanan, NSS College, Nenmara - "100 years of Bohr Atom"

Prof. Shaju K. Y. – Co-ordinated Lab visits.

Co-ordinator - Prof. V. P. Anto, Christ College.

I conclude this report by extending my heartfelt thanks to KSCSTE, TVM for the financial support given to the project. I would like to thank Prof. M.K. Jayaraj, President and all other Office Bearers and Members of APT for giving me the responsibility to be the Project Co-ordinator. I would like to express my sincere feeling of gratitude to the Management, Principal and Staff of Christ College for their timely support. Thanks to all regional and district co-ordinators for the smooth conduct of the project. Finally I thank each and every one who co-operated with this project for making it a grant success.
Jai Hind! ■

Academy of Physics Teachers, Kerala

(A Professional Body of College and University Physics Teachers). Reg. No. KTM 1051/99

CONDUCTS

ALL KERALA PHYSICS TALENT SEARCH EXAMINATION 2015
For B Sc. (Physics) Students
(Physics Core - 1st, 2nd or 3rd Year)

ON 19th September 2015
At Selected Centre's All Over Kerala

OBJECTIVE

The objective of the **All Kerala Physics Talent Search Examination** is to:

- Identify and recognize talented Physics students
- Help them develop an awareness and confidence about where they stand compared to their peers
- Motivate and orient students towards research and career avenues in Physics by providing opportunities to interact with academicians and scientists
- Orient students towards right scientific attitude of learning Science, in particular Physics

INCENTIVES

- The first three toppers will be awarded cash prizes, books and mementos. Those selected for interview will be given merit certificates.
- The top scorers will be given opportunities to interact with eminent scientists and academicians which may provide immense exposure to career development
- The top three students will be given chance to do summer research fellowship at various prestigious institutes.

EXAMINATION PATTERN

The examination consists of three parts:

- Written Examination
- Interview
- Quiz

WRITTEN EXAMINATION

The written examination consists of two parts: **PART A** consists of 75 multiple choice questions. There will be NO negative marking. Answers should be blackened using an HB pencil in the sheet provided along with the question paper. The question in this section will be based on plus two level Physics (90%) and Mathematics (10%). Time allotted: 100 minutes.

PART B will have 10 problem questions which are to be answered in separate sheets provided along with the question paper. No additional sheets will be provided. Time allotted: 60 minutes. Credit will be given for correct steps and formulae. 10 percent (or 100 toppers among the total candidates who appeared for the PART A, whichever is less) of the top scorers in PART A will be qualified for evaluation of their PART B answers.

INTERVIEW and QUIZ

The top thirty students in the written examination will be called for interview and quiz programme at CUSAT, Kochi. The ranks will be decided based on the performances during these programmes. No TA/DA will be given for this programme.

ELIGIBILITY FOR PARTICIPATION

Any B.Sc. Physics student in the state of Kerala in his/her 1st, 2nd or 3rd year of study can participate.

REGISTRATION

Application forms for the Talent Search Examination is available with the regional co-

ordinators. Application form in original or its photocopy can be used. Filled-in application forms can be submitted to regional co-ordinators where the candidate intends to take the examination or to the state co-ordinator directly.

REGISTRATION FEE

Registration fee for the Talent Search Examination is Rs. 60/-. The fee has to be paid by way of online/ core banking at

APT account No.: 10585371156

SBI Kottayam

IFSC Code: SBIN0001891

or as DD drawn in favour of "APT Kerala", payable at Kottayam. For all students at each centre, only one DD is required. In addition to the registration fee, each candidate should pay Rs. 10/- to the regional/ local coordinator to meet the local expenses for the conduction of examination in the respective centres.

Last Date for Submission of

Application: *18th August 2015*.

Date and Time of Examination:

Saturday 19th September 2015

from 10.00 a.m. to 1 p.m.

Application forms can also be downloaded from the website www.aptkerala.org.

The address of the state co-ordinator is:

Dr.Sudheesh P.
Department of Physics,
VTM NSS College, Dhanuvachapuram,
Thiruvananthapuram -695 503,
Mob: 9961848608
E-mail: sudheeshp9@gmail.com

Any further details can be had from:

- Dr. M. K. Jayaraj, (President, APT), Dept. of Physics, CUSAT, Kochi; 9447972704, mkj@cusat.ac.in
- Prof. Shaju K Y , (Secretary, APT) Dept. of Physics, Christ College, Irinjalakuda, 9446721949, shajuky@gmail.com

UNIVERSITY CO-ORDINATORS:

- Kannur : Dr.K.V.Devadhasan, M.G. College, Iritty, 9447372926
- Calicut : Prof.G.Harikrishnan, Govt.College, Madappally, 9447855840
- M.G.: Dr.Ison Vanchipurackal, St.Thomas College, Pala, 9446126926.
- Kerala : Prof.Vipin Das, University College, Thiruvananthapuram, 9447034759.

REGIONAL CO-ORDINATORS:

- Dr. Ajith Prasad, M. G. College, Thiruvananthapuram, 9447247997
- Prof. Mini B. Nair, St. Thomas College, Ranni, Pathanamthitta 9446657736
- Prof. Merin George, Bishop Moore College, Mavelikara, 9400203003
- Prof. Benny Joseph, S. B. College Changanachery, 9447763647
- Prof. Ganesh Chandra Prabhu, D B College, Talayolaparambu; 9495688207
- Dr. S. Sankararaman, Nirmala College, Muvattupuzha; 9447421844
- Prof. Shaju K Y, Christ College, Irinjalakuda, 9446721949
- Prof. Joy P. M., St. Thomas College, Thrissur, 9446143106
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