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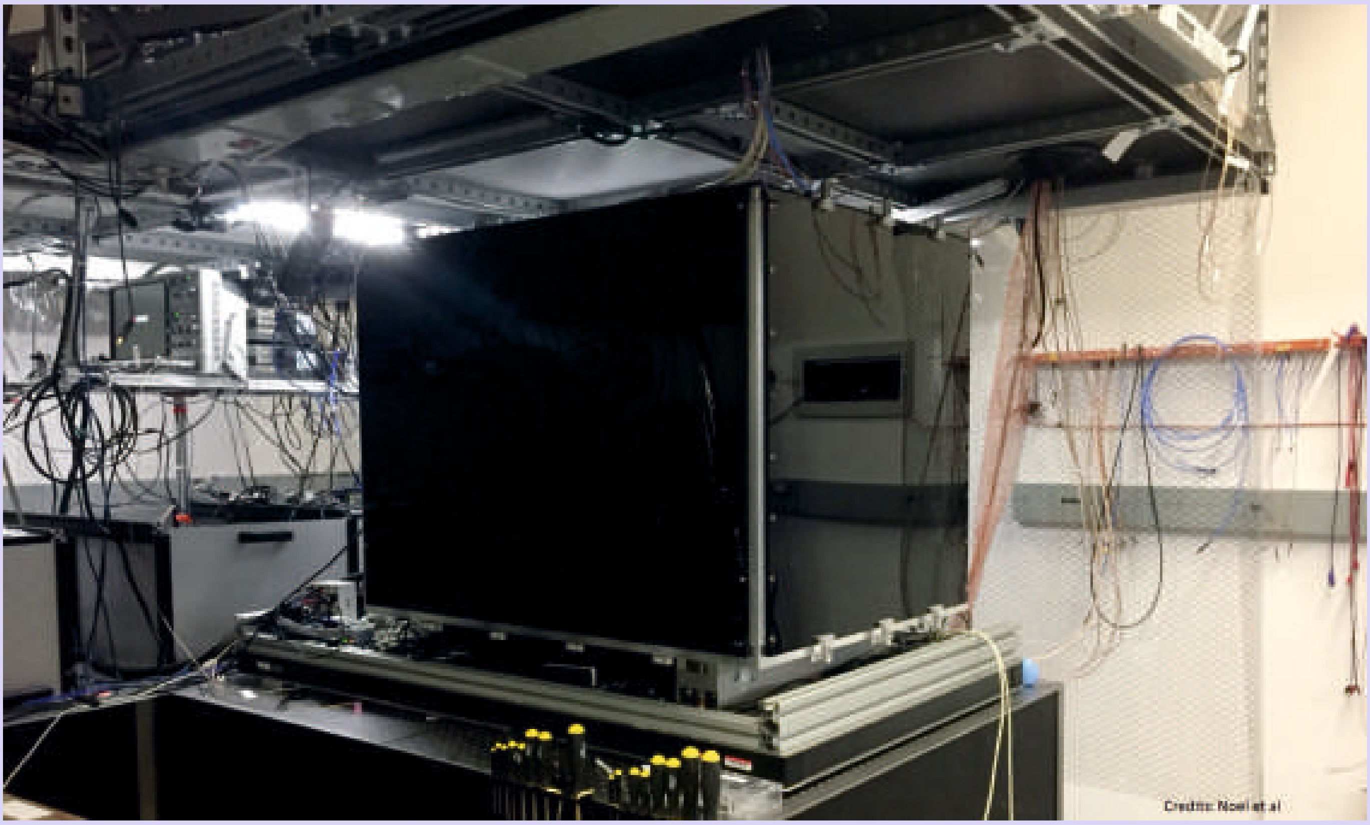

Trapped-ion quantum computers are quantum devices in which trapped ions vibrate together and are fully isolated from the external environment. These computers can be particularly useful for investigating and realizing various quantum physics states.Researchers have recently used a trapped-ion quantum computer (in cover picture) to realize two measurement-induced quantum phases, namely the pure phase and mixed or coding phase during a purification phase transition. Their findingscontribute to the experimental understanding of many-body quantum systems.

Using their trapped-ion quantum computer, the team was able to probe both the pure phase of the purification phase transition and the mixed or coding phase. In the first of these states, the system is rapidly projected to a pure state, which is related to the measurement outcomes. In the second, the system's initial state is partly encoded into a quantum error correcting coding space, which retains the system's memory of its original conditions for a longer time.

(https://phys.org/news/2022-06-quantum-phases-trapped-ion.html)

The Story Of Cosmology Through Postal Stamps 22

ASTRO NAVIGATION

LONGITUDE AND LATITUDE

Longitude and latitude are the geographical coordinate system which help to determine the position, time and date at a given location on the Earth. The prime meridian, which passes from Greenwich is 0⁰ Longitude, dividing earth in east and west. While equator is 0⁰ Latitude which divide the Earth into northern and southern hemisphere.

Latitude and Longitude of a point on the earth is measured with the reference of the geographical position of a celestial body as indicated in the table of nautical or air almanac for that year. Latitude is measured by measuring the altitude of the sun at noon or altitude of Polaris or any other celestial body when crossing the meridian or lunar distance

Royal observatory of Greenwich had prepared astronomical method for determination of Longitude. In 1850 Astronomer Royal-George Airy fixed the longitude of Greenwich on position of Transit Circle as 0⁰. This reference time zone now called GMT, and this reference meridian as Prime meridian or International Date Line

Struve Geodetic Arc –
A chain of surveying triangulation which yielded accurate measurement of a meridian.

This was established by F.G.W.Struv (1826-1855) to establish exact size and shape of the Earth.

It stretches 2820 km, from Hammerfest of Norway to Black sea, Ukraine

Margin Strips of Miniature Sheet -depict survey tools: sextant, theodolite, alidade and meridian circle

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The Bulletin is the official organ of the IAPT. It is a monthly journal devoted to upgrading physics education at all levels through dissemination of didactical information on physics and related areas. Further, the Bulletin also highlights information about the activities of IAPT.

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Letter to Editor…..

Postal Stamps Collection an innovative Creative Tool to Education

As a Stamp collector myself I have been reading with interest **The story of Cosmology through postal stamps** series published since last year by Yogesh Bhatnagar on inside cover pages of IAPT

How the ancient astronomy was depicted by Renaissance painters like Raphael and Michelangelo, Medieval astronomy, revival of astronomy,Galileo series were very informative.

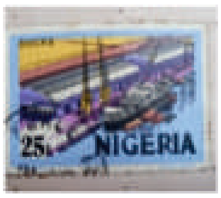
Also it depicts stamps from across various continents (Mexico, Egypt, Bhutan,Maldives, Bangladesh, Turkey, India) in a thematic fashion.

Interdisciplinary and multidisciplinary are the buzz words today in higher education and stamps showing origin of Islamic Astronomy, Mayan and Aztec Cultures, Egyptian and Babylonian monuments giving clue of astronomical observations, Indian astronomy, China and the far East, etc. joins history, science, philosophy, geography etc. disciplines.

Recently while I was reading *The Hindu* Newspaper of 1955, 1956 in Mumbai archives I saw every Sunday of '*The Hindu*' Newspaper carried a special small section on stamps. One such article '**Ship stamps by philatelist**' on page IV of *The Hindu* dated December 4, 1955 stated "Ships on stamps have an appeal which is possibly unrivalled by any other subject. Infact, ship stamps are so numerous that they can be separated into Native craft, sailing ship, liners, Naval Vessels, historic and famous ships……"

In Physics Buoyancy Law states "Upward force exerted by fluid that opposes the weight of immersed object" guides the basics of ships floating.

Below are some Maritime theme related stamps from my collection.



Neeta M. Khandpekar
Department of History, University of Mumbai

PHYSICS NEWS

Controlling non-classical mechanical states in a phononic waveguide architecture

Most quantum computing technologies rely on the ability to produce, manipulate and detect non-classical states of light. Non-classical states are quantum states that cannot directly be produced using conventional sources of light, such as lamps and lasers, and can thus not be described by the theory of classical electromagnetism.These unconventional states include squeezed states, entangled states and states with a negative Wigner function. The ability to similarly control the states of phononic systems, those involving acoustics and vibration, could open interesting possibilities for the development of new quantum technologies, including devices for quantum sensing and quantum information processing.

Researchers have recently introduced a strategy that could be used to achieve a high level of control over phononic waveguides. This strategycould enable the use of phononic waveguides in quantum technology, similarly to how optical fibers and waveguides are used today.

Read more at :https://phys.org/news/2022-06-non-classical-mechanical-states-phononic-waveguide.html

Original paper : Nature Physics (2022). DOI: 10.1038/s41567-022-01612-0

Study observes the coexistence of topological edge states and superconductivity in stanene films

Stanene is a topological insulator comprised of atoms typically arranged in a similar pattern to those inside graphene. Stanene films have been found to be promising for the realization of numerous intriguing physics phases, including the quantum spin Hall phase and intrinsic superconductivity.Some theoretical studies also suggested that these films could host topological superconductivity, a state that is particularly valuable for the development of quantum computing technology. So far, however, topological edge states in stanene had not been reliably and consistently observed in experimental settings.

Researchers have recently demonstrated the coexistence of topological edge states and superconductivity in one to five-layer stanene films placed on the Bi(111) substrate. Their observations could have important implications for the development of Stanene-based quantum devices.

Read more at :https://phys.org/news/2022-06-coexistence-topological-edge-states-superconductivity.html

Original paper : Physical Review Letters (2022). DOI: 10.1103/PhysRevLett.128.206802

Magnetizing laser-driven inertial fusion implosions

Nuclear fusion is a widely studied process through which atomic nuclei of a low atomic number fuse together to form a heavier nucleus, while releasing a large amount of energy. Nuclear fusion reactions can be produced using a method known as inertial confinement fusion, which entails the use of powerful lasers to implode a fuel capsule and produce plasma.

Researchers have recently showed what happens to this implosion when one applies a strong magnetic field to the fuel capsule used for inertial confinement fusion. Their paperdemonstrates that strong magnetic fields flatten the shape of inertial fusion implosions.The recent work by this team of researchers provides new valuable insight about inertial fusion implosions and the effects that magnetic fields can have on them. In the future, the method they outlined could be used by other teams to produce strongly magnetized electrons and ions in experimental settings, using high-powered lasers.

Read more at :https://phys.org/news/2022-06-magnetizing-laser-driven-inertial-fusion-implosions.html

Original paper : Physical Review Letters (2022). DOI: 10.1103/PhysRevLett.128.195002

Pankaj Bhardwaj
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ARTICLE

Using Excel sheet to calculate the errors in Physics experiments

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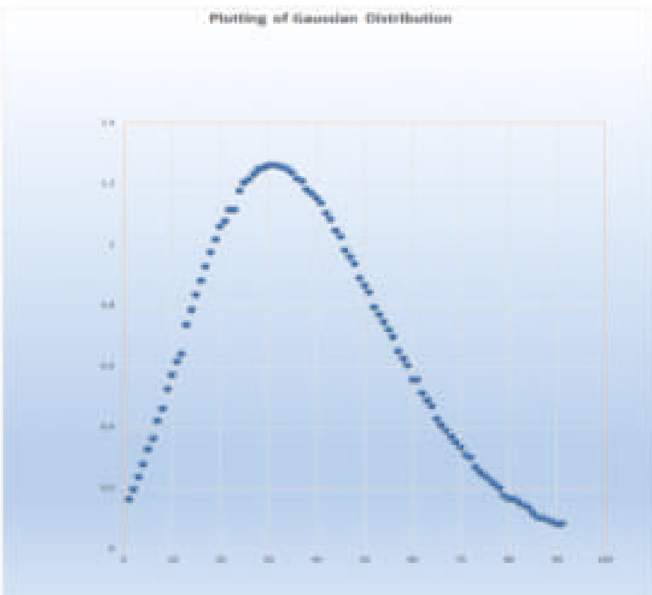
Abstract:

***Teaching Physics** is fascinating to the young undergraduates. As the subject is close to nature, the concepts can be well described, explained and demonstrated with the real life situations. As it is an application oriented subject, learners would appreciate it better if it is a demonstrative lecture instead of a pure lecture method. With my teaching experience spanning more than three decades, experimenting with different methods of teaching, evolving different procedures, I have found **simulations** are of great help. They provide a comprehensive understanding of the concepts with a scope for exploring. The present situation of the whole world experiencing **COVID-19 pandemic conditions**, these simulations allowed to continue the learning process without any interruption. In this paper the simulation of a simple pendulum and experimental determination of acceleration gravity in different planets is explained. Also the error estimation in the calculations and plotting of a **Normal distribution** curve with the help of **Excel sheet** is explain*

Introduction: When a particular experiment is performed ,record the observations and calculate a given parameter, one tends to get a value different from the actual value. That means there is a deviation from the actual results. This deviation is referred to as the error in calculation. For example , if we perform a simple pendulum experiment to calculate the acceleration due to gravity, the expected value is 9.8 m/sec^2. Most often one doesn't get an accurate value. There are many reasons for this: inaccuracy in taking the observations, place where the experiment is conducted, the observer's ability to take precise values. The experiment is considered accurate if it is performed correctly, not the one which gives a value close to the actual value. Precision and accuracy are very important in conducting experiments. Precision can be the possible errors in the result of an observation , accuracy refers to the error in the results due to variations in the laboratory equipment, place where it is conducted. The best experiment is the one which reduces the gap between precision and accuracy. Possible errors in Simple pendulum experiment: The proper timing of starting and stopping a stop watch, counting the number of oscillations, instrument error,random error.

Due to pandemic conditions, I have introduced simulations and virtual laboratories to my students with which the present experiment on Simple Pendulum and calculation of 'g' , the acceleration due to gravity was carried out.

Students were asked to perform the experiment at different times, with large number of sample data, and instructed to plot the graph using excel , plotting normal distribution. The results were very encouraging and a smooth distribution was obtained.



Scope and extendibility: The experiment can be performed on different planets like Mercury,Jupiter, Moon and compared with the theoretical values. There is also a provision for varying the mass of the bob and observe the changes. With these simulations , students are able to get the overview of the experiment and the behaviour of the pendulum on different planets.

Plotting Gaussian Distribution - Simple pendulum				
Length (L) in m	Time Period T in secs	Normal Distribution	Mean	Standard Deviation
0.1	0.63	0.165605	1.2668	0.3159365
0.11	0.66	0.199635		
0.12	0.69	0.238499		
0.13	0.72	0.282371		
0.14	0.75	0.331313		
0.15	0.77	0.366725		
0.16	0.8	0.423869		
0.17	0.82	0.464498		
0.18	0.85	0.528869		
0.19	0.87	0.573785		
0.2	0.89	0.620026		
0.21	0.9	0.643558		
0.22	0.94	0.739515		
0.23	0.96	0.787982		
0.24	0.98	0.836268		
0.25	1	0.883962		
0.26	1.02	0.93064		
0.27	1.04	0.975865		
0.28	1.06	1.019194		
0.29	1.08	1.06019		
0.3	1.09	1.079679		
0.31	1.11	1.116377		
0.32	1.11	1.116377		
0.33	1.15	1.179295		
0.34	1.17	1.204808		
0.35	1.18	1.215942		
0.36	1.2	1.234802		
0.37	1.22	1.24894		
0.38	1.23	1.254184		
0.39	1.25	1.260941		
0.4	1.26	1.262435		
0.41	1.28	1.261631		
0.42	1.3	1.255784		
0.43	1.31	1.25099		
0.44	1.33	1.23773		
0.45	1.35	1.219713		
0.46	1.36	1.208985		
0.47	1.38	1.184247		
0.48	1.39	1.170308		
0.49	1.4	1.155375		
0.5	1.41	1.139491		
0.51	1.43	1.105048		
0.52	1.44	1.086584		
0.53	1.46	1.047425		
0.54	1.47	1.026834		
0.55	1.49	0.983897		
0.56	1.5	0.96166		
0.57	1.51	0.938984		
0.58	1.53	0.892538		
0.59	1.54	0.868876		
0.6	1.55	0.844996		
0.61	1.57	0.796787		
0.62	1.58	0.772562		
0.63	1.59	0.748323		
0.64	1.6	0.724119		
0.65	1.61	0.699997		
0.66	1.63	0.652172		
0.67	1.64	0.628555		
0.68	1.65	0.605185		
0.69	1.67	0.559338		
0.7	1.67	0.559338		
0.71	1.69	0.514896		
0.72	1.7	0.493275		
0.73	1.71	0.47209		
0.74	1.73	0.431111		
0.75	1.74	0.411357		
0.76	1.75	0.392115		
0.77	1.76	0.373398		
0.78	1.77	0.355219		
0.79	1.78	0.337587		
0.8	1.795	0.312179		
0.81	1.8	0.30399		
0.82	1.82	0.272641		
0.83	1.83	0.257814		
0.84	1.84	0.243548		
0.85	1.85	0.229841		
0.86	1.86	0.216689		
0.87	1.87	0.204084		
0.88	1.89	0.180489		
0.89	1.9	0.16948		
0.9	1.9	0.16948		
0.91	1.91	0.158984		
0.92	1.92	0.148988		
0.93	1.93	0.13948		
0.94	1.95	0.12188		
0.95	1.97	0.106075		
0.96	1.97	0.106075		
0.97	1.98	0.09881		
0.98	1.99	0.09195		
0.99	2	0.085481		
1	2	0.085481		

1. https://reference.wolfram.com/applications/eda/ExperimentalErrorsAndErrorAnalysis.html
2. https://manoa.hawaii.edu/exploringourfluidearth/physical/world-ocean/map-distortion/practices-science-scientific-error
3. **https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html**

Reviewing the teaching-learning process of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics through a Pedagogical-Problem-Solution-Model (PPSM) for undergraduate Physics-minor students

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Abstract

Statistical mechanics, unarguably, is one of the toughest fields in physics.It involves quantum mechanics and classical (Lagrangian and Hamiltonian) mechanics,in addition to the basic knowledge of physics and mathematics. Consequently, teaching of statistical mechanicsto undergraduate students of physics minor and other branches (e.g., geophysics, biophysics, and chemical physics) is a challenging task for instructors as students may not enough background of advanced level physics. Therefore, holistic teaching-learning process between the instructor and students of statistical mechanics requires a pedagogically different approach from course instructor. In this paper,a Pedagogical-Problem-Solution-Model (PPSM) is presented and the concept of Maxwell-Boltzmann (M-B), Bose-Einstein (B-E), and Fermi-Dirac (F-D) statistics of a thermodynamic is reviewed under the frame-work of this model.The model is discussed without assuming the formal knowledge of quantum or classical mechanics. It is suggested that PPSM could be used as the most efficient and effective model to understand critical topics of science and technology in classroom. Course curriculum should emphasize more on it, rather than merely presenting the ideas and focusing on lengthy derivations of mathematical formulae.

Keywords: Entropy, microstates, macrostates, M-B, B-E, & F-D statistics, Pedagogical-Problem-Solution-Model (PPSM).

1 Introduction

Statistical mechanics is one of the comprehensive fields of physics. It provides information about the thermodynamic properties (or parameters) (e.g., pressure, temperature etc.) of an isolated system atthermal equilibrium in terms of the microscopic parameters(or behaviors)of the particles (atoms, molecules, and electrons) (i.e., distributions of particles in various energy levels as well as energy states)constituting the system [1-3]. Therefore, besides basic knowledge of thermodynamics and mathematics, it demandsidea of advanced level of other branches of physics such as Hamiltonian and Lagrangian formulations (classical mechanics), energy band/level, uncertainty principle, wave functions, Schrodinger equations, symmetry of wavefunctions, and particle in a one and a three dimensional boxes (i.e., solid state physics and quantum mechanics). Many of the popular textbooks or particular chapter of textbooks written on this special topic is very much suitable for upper undergraduate physics major and graduatestudentsas they already have the necessary and sufficient prerequisites in line with the curriculum [1-5]. However, thisis not always the case; statistical mechanics, covering many topics, is taught as one of the modules of a physics paper and without the above prerequisites to the physics-minor undergraduate students, who are pursuing professional and other courses (e.g.,chemistry, mathematics, biological/life sciences, biophysics, earth sciences/geophysics, chemical physics, computer science, environmental, applied and engineering physics, and B.Sc.B.Ed). Therefore, a pedagogically ‘different approach’ is needed by the course instructor to explain the fundamental concepts of statistical mechanics and Maxwell-Boltzmann (M-B), Bose-Einstein (B-E), and Fermi-Dirac (F-D) statistics.Here, we present a “Pedagogical-Problem-Solution-Model (PPSM)” as the different approach to make the teaching-learning process a true dialogbetween the instructor and students ofstatistical mechanics.

2. Concept of the PPSM

In this model, the instructor should (i) review the related background of topic (physics), (ii) avoid quantitative analysis and qualitatively discuss pedagogically the underlying concept of the topic, (iii) state and explain the significance of mathematical/physical formulae, (iv) formulate a basic problem, and (v) solve the problem interactively with students, (vi) go back to concepts and re-discuss, and (vi) iterate the entire process with problems of increasing complexity. This holistic teaching methodology will make the teaching-learning process a true dialog between the instructor and studentsas well as will generate the curiosity and skill among students to tackle critical and important topics. Though this is a time consuming process, the instructor should focus on this model and if necessary, conduct additional classes. It will enhance the aptitude and critical thinking ability of students to tackle any problem beyond their courses/programs.

3. Development of the PPSM model

In his section, the model has been developed using M-B, B-E, and F-D statistics, assuming the basic knowledge of thermodynamics and without the formal knowledge of advanced branches of other physics. First, a few basic concepts of statistical mechanics and thermodynamics such as energy levels, energy states, macrostates, microstates, relation between thermodynamic and statistical entropy, time and ensemble average, Ergodic hypothesis, and the three statistics and distribution functions have been discussed qualitatively. Then a problem has been formulated with increasing complexity. And finally, the problem has been solved extensively along with detailed discussion.

3.1. Qualitative review and discussion of thermodynamics and fundamentals of statistical mechanics

3.1.1. ***Atoms or molecules and particles***: A system composed of atoms or molecules, which are considered as particles. They areidentical (properties are same), andareeither classical (distinguishable) or quantum (non-distinguishable) in nature [5-8].Classical distinguishable particles obey M-B statistics, whereas quantum non-distinguishable particles obey either B-Estatistics, known as Bosons, or F-D statistics, known as Fermions. Examples of classical particles are gas molecules at room temperature. Phonon, photon, and deuteron are the examples of Bosons, whereas electron, neutron, and proton are the examples of Fermions [8-10, 14-18].

3.1.2. ***Energy level and energy state***:A system has many particles (*N*)and energy levels ($\varepsilon_i,\ i = 1, 2, ...$). Each energy level has a finite unit of energy. Example of such energy unit is eV (electron-volt).Here, ε_i represents the i^{th} energy level. The particles are distributed among the energy levels under certain constraints/conditions [1-18]. The energy levels are discrete and equally spaced, and can be thought of shelves [7-15]. Further, each shelve(i.e., energy level) can be thought of consisting of equal boxes having the same energy (i.e., energy of that energy level) [8]. These boxes are called*energy states* or *quantum states* or *energy boxes* and the number of boxes associated with a particular energy level is known as the *degree of degeneracy*, or *fold of degeneracy*, or *simply degeneracy*(g_i) of that particular energy level(ε_i). An energy level can be non-degenerate or degenerate, i.e., it can have only one box (non-degenerate energy level) or several boxes (degenerate energy level) [8-10]. Non-degenerate energy level implies that the energy level has only one quantum state or in other words, the energy level itself can be thought of an energy state.For example, degeneracy $g = 3$ of an energy level implies that the energy level has 3 quantum states (or 3 energy states or 3 energy boxes), whereas $g = 1$ indicates that the energy level is non-degenerate or the degeneracy of that energy level is one. The Figure 1schematically represents the energy levels (ε_i),degeneracies $(g_i)$and number of particles(n_i) in an energy levelof an arbitrary system [6-10].n_i(i.e., number of particles in an energy levelε_i) is also known as the *occupancy* of that energy level [8]. It is worthwhile to mention that we generally talk about a system, which is isolated and at thermal equilibrium. An isolated system is defined as system of fixed mass and energy and there is no interaction between the system (a quantity of mater or a region in space under investigation) and the surroundings (everything external to system). Other types of thermodynamic systems are closed (a system of fixed mass but energy can be transferred into or out of the system) and open (transfer of both matter and energy can take place through boundary) systems. Boundary separates the system from surroundings [1-18].

Energy level (ε_i)	Degeneracy (g_i) of each energy level	Number of particles (n_i) in each energy level (ε_i)	Energy level with degeneracy and particles (occupancy)
$\varepsilon_4 = 4$	$g_4 = 3$	4	00| 0 |0
$\varepsilon_3 = 3$	$g_3 = 2$	2	0|0
$\varepsilon_2 = 2$	$g_2 = 4$	5	0 |00| 0 | 0
$\varepsilon_1 = 1$	$g_1 = 1$	3	000

Fig. 1: Schematic representation of energy levels, degeneracies, and particle occupancies.

3.1.3.*Thermodynamics and statistical mechanics*:Thermodynamics (or classical thermodynamics) enables us to know the *thermodynamics properties* (also known as *macroscopic properties* or *bulk properties*) of a system without the knowledge of the detail behavior of the constituents (particles) of the system [15-20].An isolated system at thermodynamic equilibriumis characterized by itsmacroscopic/thermodynamic properties (temperature *T*,pressure *P*, volume *V*, total number of particles *N*, and total energy *E*), which can be measured in a laboratory through suitable experimental techniques [1, 8-10, 14-18].These parameters do not change with time as the system is in thermal equilibrium.Statistical mechanics(or statistical thermodynamics), on the other hand, directly deals with the detail behavior (i.e., *microscopicproperties*) of the particles (i.e., distribution of particles in various energy levels and energy states) and provides information about the thermodynamical properties (*T*,*P*, *V*, *N*, and *E*) of the system [1-20]. Thus, the sole objective of statistical mechanics is to present us the bulk properties of a system by analyzing its microscopic parameters (behavior of the particles) [1-20].

3.1.4.*Determination of macrostatesand two constraints*: Particles in a system can be distributed in various possible ways among theavailable energy levels (ε_i) with the following two constraints [1-20]:

(i) Total number of particles (*N*) of the system must be constant, i.e.,

$$\sum_i n_i = n_1 + n_2 + n_3 + \dots = N \qquad \dots (1)$$

where$n_i$is the number of particles in energy level ε_i, i.e., $n_1$particles in energy level ε_1, $n_2$particles in energy level $\varepsilon_2$etc., such that total number *N* remains fixed.

(ii) Total energy (*E*) of the system must be constant, i.e.,

$$\sum_i n_i\varepsilon_i = n_1\varepsilon_1 + n_2\varepsilon_2 + n_3\varepsilon_3 + \dots = E \qquad \dots (2)$$

where$n_1$is the number of particles in energy level $\varepsilon_1$with degeneracy $g_1$and the total energy of the particles in the 1st energy level is $n_1\varepsilon_1$,

$n_2$is the number of particles in energy level $\varepsilon_2$with degeneracy $g_2$and the total energy of the particles in the 2nd energy levelis $n_2\varepsilon_2$,

…….

$n_i$is the total number of particles in the energy level $\varepsilon_i$with degeneracy $g_i$and the total energy of the particles in the i^{th} energy level is $n_i\varepsilon_i$.

This suggests thatthe particles have to be distributed in such a way that the total number of particles (*N*) and total energy (*E*)of the system at thermal equilibrium remain constant and there could be several such distributions.In other words, it can be said that how many ways the fixed amount of energy *E*of a system can be shared among *N* particles at thermal equilibrium temperature *T*[15-18].Each distribution of particles among the various energy levels with the two constraints is known as *macrostate* (D_j) [20]. D_j is the j^{th} distributionof particles among the energy levels. j = 1, 2, 3,..and$j \neq i$. Thus, $D_j$depends on $n_i$and can be calculated as $D_j = \{n_i\} = \{n_1, n_2, n_3, n_4, \ldots.\}$. It is pertinent to note that other thermodynamic parametersmay vary with macrostate [20], such as entropy. However, *V*, *N*, and *E*do not vary as the system is isolated and at thermal equilibrium. This is why constraints related to *N* and *E*are considered in determining the number of macrostate of a system. Furthermore, degeneracy (g_i) of an energy level does not play any role in case of M-B and B-E statistics as there is no restriction (limit) on the number of particles that can be placed in an energy level (n_i) or quantum states (g_i) with the above two constraints. But, this is not true for F-D statistics. In F-D statistics, the restriction is one particle per quantum state. This means that an energy level of degeneracy 3 can accommodate at most three particles-one particle in each quantum state [14-18]. It is important to note that *statistical mechanical macrostates*are the distributions of particles among various energy levels,whereas the *thermodynamicalmacrostates*are *P*, *V*,*N*, *E* etc., and relations among them (such as *PV* = *RT*, *R* is universal gas constant). Therefore, it wise to use the term *thermodynamic properties* or *thermodynamic parameters* or *bulk properties* when we deal with the properties of a thermodynamic system.

3.1.5.*Microstates*: Particlesin a particular macrostate(D_j) can be distributed/arrangedin a variety of possible ways into various energy states (g_i). Thenumber of arrangements(or distributions) of particles among the quantum states of a given macorstateis known as *microstates*(Ω) of that particular macrostate. This, in turn,signifies that a particular macrostate can have numerous microstates. The microstates are associated with a particular macrostate, so they also satisfy the above two constraintsand depend on the degeneracies of energy levels.Therefore,the number of microstates of j^{th}macrostate (D_j)can be represented as $\Omega_{D_j}(g_i, n_i)$. Microstates are also known as *thermodynamic probability* or *statistical weight* or *multiplicities* or *complexions* [7-9].Therefore, it can be said that microstates do not alter the thermodynamic properties of a systemthough they are continuously changing. They merely provide the detail picture of arrangements of the particles among the quantum states. In other words, it can be said that information about the thermodynamic properties (*T*, *P* etc.,) of a system can be extracted from its microscopic parameters (microstates) [1-18]. Therefore, the cardinal aim of statistical mechanics is to determine the macrostates (i.e., distribution of particles among various energy levels) and the associated microstates (i.e., arrangement or distribution of particles among energy states of a particular macrostate) [1-4, 7-10, 11].Figure 2 shows thethermodynamical and statistical mechanical components of an isolated system at thermal equilibrium.

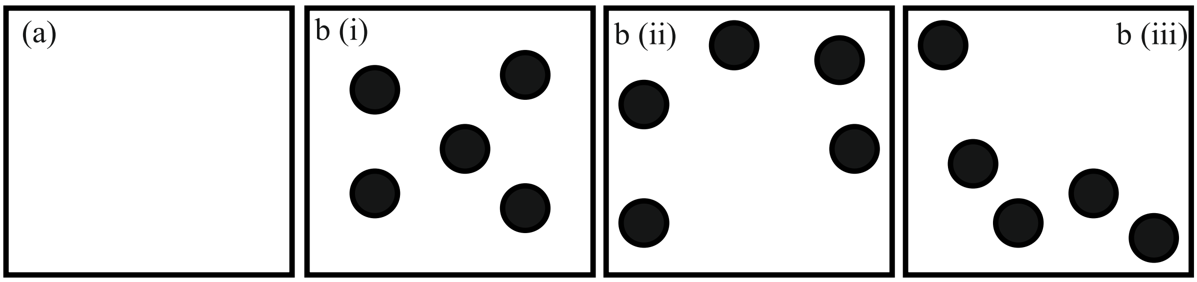

Fig. 2: (a) Thermodynamics is only concerned about the macroscopic properties (*N*, *V*, *P*, *T*, *E* etc.) and is not concerned about the behavior of particles of an isolated system at thermal equilibrium.

b) Statistical mechanics directly deals with the behavior of particles (microscopic parameters) (i.e., distribution of particles) and provides information about the macroscopic properties of the same isolated system at thermal equilibrium. Distributions of 5 particles inside the same system at 3 different instances are shown in (i), (ii), and (iii).

3.1.6.*Entropy and thermodynamic probability*: Entropy (*S*) (thermodynamic property) connects thermodynamics to statistical mechanics. According to thermodynamics, entropy of a thermodynamic system at constant volume and energy is a maximum when the system is in equilibrium. Whereas, it is well known from statistical mechanics that total thermodynamic probability (Ω) is maximum when such a system is in equilibrium. Therefore, according to Boltzmann, there is a relationship between *S* and Ω, i.e., $S = f(\Omega)$ and the relation between them is $S = k_B \ln\Omega$ where $k_B = 1.381 \times 10^{-23}$ J/K is Boltzmann's constant [14-18].

3.1.7.*Ensemble average, time average, and Ergodic hypothesis*:A collection of large number of identical particles is known as a system. A collection of very large number of such identical and independent systemsis known as an ensemble. In order to determine the average or mean value of physical quantity, we can follow one of these two methods – either (i)we can consider an ensemble of large number of identical and independent systems which are same from macroscopic view point (e.g., *N*, *V*, and *E* are constant) and average the quantity over these systems at one instant, known as ensemble average, or (ii) we can monitor a single system over a very long period of time during which the physical quantity changes from one value to another as it goes through all different microstates and then take the average of this quantity over the time, known as time average. Therefore, in case of time average, all microstates can be considered as independent and identical systems and hence, forman ensemble of large identical and independent systems which are different from microscopic point of view but same from macroscopic point of view. According to Ergodic hypothesis, ensemble average and time average are same, i.e., the mean or average value of physical quantityover ensemble average is equal to the time average of single system, and it is one of the basic assumptions (or postulates) of statistical mechanics [5-10].

3.1.8.*Equally a priori probability*: All the microstates of a system in statistical (thermal) equilibrium are equally probable, i.e., an isolated system in thermal equilibrium is equally likely to be in any of its accessible microstates fulfilling the macroscopic conditions ($\sum_i n_i = N$ and $\sum_i n_i\varepsilon_i = E$) or in other words each microstate occurs with equal probability. This is known as equally a priori probability and is the 2nd postulate of statistical mechanics [5-10].

3.1.9.*Mathematical formulae of three statistics and their importance*:The following three formulae are used to calculate the total number of microstates $[\Omega_{D_j}(g_i, n_i)]$ associated with a particular macrostate$D_j$for classical (distinguishable) particles, Boson, and Fermions, and are known as Maxwell-Boltzmann (M-B), Bose-Einstein (B-E), and Fermi-Dirac (F-D) statistics, respectively [1-20].

$$\Omega_{D_j}^{M-B}(g_i, n_i) = N!\prod_i \frac{{g_i}^{n_i}}{n_i!} = N!\left(\frac{{g_1}^{n_1}}{n_1!}\right)\left(\frac{{g_2}^{n_2}}{n_2!}\right)\cdots \quad \text{M-Bstatistics} \ \ldots(3)$$

$$\Omega_{D_j}^{B-E}(g_i, n_i) = \prod_i \frac{(n_i + g_i - 1)!}{n_i!\,(g_i - 1)!} = \frac{(n_1 + g_1 - 1)!}{n_1!\,(g_1 - 1)!}\frac{(n_2 + g_2 - 1)!}{n_2!\,(g_2 - 1)!}\cdots \quad \text{B-Estatistics}\ldots(4)$$

$$\Omega_{D_j}^{F-D}(g_i, n_i) = \prod_i \frac{g_i!}{n_i!\,(g_i - n_i)!} \qquad \text{F-D statistics …(5)}$$

$$= \frac{g_1!}{n_1!\,(g_1 - n_1)!}\frac{g_2!}{n_2!\,(g_2 - n_2)!}\cdots$$

3.1.10.*The three distribution functions*: It is important to note that these three statistics can be applied to a system of a few particles and energy levels. For a system comprised of very large number of particles and energy levels, the three statistics are replaced by corresponding distribution functions.This is because the energy levels are very closely spaced (i.e., separations between them is very small), so they form a continuum. Therefore, it becomes an extremely difficult procedure to identify the macrostates (i.e., various distributions of particles among energy levels) and the corresponding microstates [1]. The three distributions functions can be generalized into a single function as [8-10]

$$f(\varepsilon_i) = \frac{n_i}{g_i} = \frac{1}{e^{\alpha+\beta\varepsilon_i}+d} = \frac{1}{e^{\beta(\varepsilon_i-\mu)}+d} \qquad \text{... (6)}$$

Where, $\alpha(= -\beta\mu)$ and $\beta(= 1/k_B\text{T})$ are Lagrange's multiplier and μ is chemical potential. The distribution function $f(\varepsilon_i)$ represents the most probable occupation number (or average number)of each state of energy $\varepsilon_i$for a system of particles (classical, Bosons, or Fermions) or if selected randomly from the system,the probability that a particle will have energy ε_i is $f(\varepsilon_i)$ in thermal equilibrium at temperature T. The total number of particles then can be written as

$$N = \sum_i n_i = \sum_i \frac{g_i}{e^{\beta(\varepsilon_i-\mu)} + d} \qquad \text{… (6a)}$$

Hence, the three functions are:

$$f_{M-B}(\varepsilon_i) = \frac{n_i}{g_i} = \frac{1}{e^{\frac{(\varepsilon_i-\mu)}{k_BT}}} \qquad \text{M – B distribution } (d = 0) \qquad \text{… (6b)}$$

$$f_{B-E}(\varepsilon_i) = \frac{n_i}{g_i} = \frac{1}{e^{\frac{(\varepsilon_i-\mu)}{k_BT}}-1} \qquad \text{B – E distribution } (d = -1) \qquad \text{… (6c)}$$

$$f_{B-E}(\varepsilon_i) = \frac{n_i}{g_i} = \frac{1}{e^{\frac{(\varepsilon_i-\mu)}{k_BT}}+1} = \frac{1}{e^{\frac{(\varepsilon_i-\varepsilon_F)}{k_BT}}+1} \qquad \text{F – D distribution } (d = +1) \qquad \text{… (6d)}$$

Here,$\varepsilon_F$is Fermi energy

In the classical limit (i.e., $g_i \gg n_i$) or at high temperature, B-E and F-D distribution functions (statistics) approach to M-B statistics. Furthermore, if a is the separation between particles and λ is thermal de Broglie wavelength ($\lambda = \frac{h}{\sqrt{2\pi m k_B T}}$; h is Planck's constant and m is mass of particle) then the conditions for three statistics are:

(i) $a \gg \lambda$: M – B statistics (distribution), (ii) $a \approx \lambda$: B – E statistics, and (iii) $a \ll \lambda$: F – D statistics. In other words, if Δx is quantum (position) uncertainty of particle, then (i) $\Delta x \gg \lambda$ for M – B statistics (distribution), (ii) $\Delta x \approx \lambda$ for B – E statistics, and (iii) $\Delta x \ll \lambda$ for F – D statistics, respectively [15-20].

3.2. Formulation of aproblemwith increasing complexity, its solution, and discussion

In this section, anisolated thermodynamic system with fixed energy level and fixed particle number is taken. The energy level have various degrees of degeneracies. Macrostates and microstates associated with each macrostate have been calculated and discussed extensively for all the three statistics.

3.2.1. Problem

Consider a system composed of four identical particles (N = 4) and it has four energy levels ($\varepsilon_i, i = 1, 2, 3, \text{and } 4$). The energiesof energy levels are 1, 2, 3, and 4 units, i.e., $\varepsilon_1 = 1, \varepsilon_2 = 2, \varepsilon_3 = 3$, and$\varepsilon_4 = 4$ units.The four particles have been distributed among these four energy levels. The total energy (E) of the system is 10 units, i.e., the particles have been distributed in such a way that the system has a constant total energy of 10 units. Assume that the particles are (I) classical and distinguishable, i.e., they obey Maxwell-Boltzmann statistics, (II) indistinguishable Boson, i.e., they obey Bose-Einstein (B-E) statistics, and (III) indistinguishable Fermions, i.e., they obey Fermi-Dirac (F-D) statistics. Calculate the number ofpossible macrostates(D_j), i.e., the number of possible distributions of four particles among the four energy levels and the number of possible microstates $\left[\Omega_{D_j}(g_i, n_i)\right]$ (i.e., the number of possible distributions of particles among the quantum states) associated with each macrostate, if the degeneracies of the energy levels are:

A.$g_1 = 1\ (\varepsilon_1),\ g_2 = 2\ (\varepsilon_2),\ g_3 = 1\ (\varepsilon_3), \text{and} g_4 = 2(\varepsilon_4)$,

B.$g_1 = 1\ (\varepsilon_1),\ g_2 = 2\ (\varepsilon_2),\ g_3 = 2\ (\varepsilon_3), \text{and} g_4 = 1(\varepsilon_4)$, and

C. $g_1 = 1\ (\varepsilon_1),\ g_2 = 2\ (\varepsilon_2),\ g_3 = 3\ (\varepsilon_3), \text{and} g_4 = 4(\varepsilon_4)$.

Discuss the results. Consider that the particles are identical, and the system is isolated and at thermal equilibrium.

3.2.2.Solution and discussion:Here, it is given that the system is isolated and in thermal equilibrium.The two constraints are:

$$\sum_i n_i = n_1 + n_2 + n_3 + n_4 = N = 4 \text{ and}$$

$$\sum_i n_i \varepsilon_i = n_1\varepsilon_1 + n_2\varepsilon_2 + n_3\varepsilon_3 + n_4\varepsilon_4 = n_1 1 + n_2 2 + n_3 3 + n_4 4 = E = 10 \text{ units}$$

Therefore, the four particles need to be distributed among the four energy levels in such a way that total energy E of the system always remains constant of 10 units.

I. Maxwell-Boltzmann statistics for classicaldistinguishable particles:

In M-B statistics, there is no restriction on number of particles that can be placed in an energy level (ε_i) or energy state (g_i). Therefore, degeneracyof an energy level is not considered in determining the number of macrostates in this statistics.

Distributions of particles among various energy levels (ε_i), i.e., macrostates $D_j^{M-B} = \{n_i\}= \{n_1, n_2, n_3, n_4\}$, shown in Table 1, are same for all the three cases. Here, n_1 , n_2 , n_3 , andn_4 are the number of particles in energy levels ε_1 , ε_2 , ε_3 , andε_4 , respectively.Particles are represented by open circles.There are total five macrostates which are $D_1^{M-B} = \{2, 0, 0, 2\}$, $D_2^{M-B} = \{1, 1, 1, 1\}$, $D_3^{M-B} = \{0, 3, 0, 1\}$, $D_4^{M-B} = \{1, 0, 3, 0\}$, and $D_5^{M-B} = \{0, 2, 2, 0\}$ in each case.

Table 1: Distributions of particles among various energy levels (ε_i), i.e., macrostates $D_j^{M-B} = \{n_i\} = \{n_1, n_2, n_3, n_4\}$ for all the three cases.

Energy levels (ε_i)	Macrostates, $D_j^{M-B} = \{n_i\} = \{n_1, n_2, n_3, n_4\}$				
	$D_1^{M-B} = \{2, 0, 0, 2\}$	$D_2^{M-B} = \{1, 1, 1, 1\}$	$D_3^{M-B} = \{0, 3, 0, 1\}$	$D_4^{M-B} = \{1, 0, 3, 0\}$	$D_5^{M-B} = \{0, 2, 2, 0\}$
$\varepsilon_4 = 4$	OO	O	–	O	–
$\varepsilon_3 = 3$	–	O	OOO	–	OO
$\varepsilon_2 = 2$	–	O	–	OOO	OO
$\varepsilon_1 = 1$	OO	O	O	–	–

The total number of microstates $\Omega_{D_j}^{M-B}(g_i, n_i)$, i.e., total number of various arrangements of 4 identical distinguishable classical particles among various energy states (g_i) associated with a particular macrostate $D_j^{M-B} = \{n_i\} = \{n_1, n_2, n_3, n_4\}$ can be calculated using the formula 3 as:

$$\Omega_{D_j}^{M-B}(g_i, n_i) = N! \prod_i \frac{g_i^{n_i}}{n_i!} = N! \left(\frac{g_1^{n_1}}{n_1!}\right)\left(\frac{g_2^{n_2}}{n_2!}\right) = N! \left(\frac{g_1^{n_1}}{n_1!}\right)\left(\frac{g_2^{n_2}}{n_2!}\right)\left(\frac{g_3^{n_3}}{n_3!}\right)\left(\frac{g_4^{n_4}}{n_4!}\right)$$

Table2 shows the total number of microstates associated with each macrostate for all the three cases, calculated using the above formula.It can be seen form Table 2 that number of microstates strongly depends on the degeneracy of an energy level. Among all the possible macrostates and microstates, the macrostate$D_2^{M-B} = \{1, 1, 1, 1\}$ in case C has maximum number of microstates (576).Table 3 shows the microstates associated with each macrostate for Case A for all the five macrostates.Since the particles are distinguishable, the four particles are denoted as A, B, C, and D, though they are identical (same properties) [8, 10, 11].

Table 2: Total number of microstates associated with each macrostate$\Omega_{D_j}^{M-B}(g_i, n_i)$ for all the three cases.

(D_j)**Case A**	$\left[\Omega_{D_j}^{M-B}(g_i, n_i)\right]_{\text{Case A}} = 4!\left(\frac{1^{n_1}}{n_1!}\right)\left(\frac{2^{n_2}}{n_2!}\right)\left(\frac{1^{n_3}}{n_3!}\right)\left(\frac{2^{n_4}}{n_4!}\right)$
$D_1^{M-B} = \{2, 0, 0, 2\}$	$\Omega_{D_1}^{M-B}(g_i, n_i) = \Omega_{\{2,0,0,2\}}^{M-B} = 4!\left(\frac{1^2}{2!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{1^0}{0!}\right)\left(\frac{2^2}{2!}\right) = 24$
$D_2^{M-B} = \{1, 1, 1, 1\}$	$\Omega_{D_2}^{M-B}(g_i, n_i) = \Omega_{\{1,1,1,1\}}^{M-B} = 4!\left(\frac{1^2}{1!}\right)\left(\frac{2^1}{1!}\right)\left(\frac{1^1}{1!}\right)\left(\frac{2^1}{1!}\right) = 96$
$D_3^{M-B} = \{0, 3, 0, 1\}$	$\Omega_{D_3}^{M-B}(g_i, n_i) = \Omega_{\{0,3,0,1\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^3}{3!}\right)\left(\frac{1^0}{0!}\right)\left(\frac{2^1}{1!}\right) = 64$
$D_4^{M-B} = \{1, 0, 3, 0\}$	$\Omega_{D_4}^{M-B}(g_i, n_i) = \Omega_{\{1,0,3,0\}}^{M-B} = 4!\left(\frac{1^1}{1!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{2^3}{3!}\right)\left(\frac{1^0}{0!}\right) = 4$
$D_5^{M-B} = \{0, 2, 2, 0\}$	$\Omega_{D_5}^{M-B}(g_i, n_i) = \Omega_{\{0,2,2,0\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^2}{2!}\right)\left(\frac{2^2}{2!}\right)\left(\frac{1^0}{0!}\right) = 24$
Total number of microstates of the systemfor case A=24 + 96 + 64 + 4 + 24 = 212	
(D_j)**Case B**	$\left[\Omega_{D_j}^{M-B}(g_i, n_i)\right]_{\text{Case B}} = 4!\left(\frac{1^{n_1}}{n_1!}\right)\left(\frac{2^{n_2}}{n_2!}\right)\left(\frac{2^{n_3}}{n_3!}\right)\left(\frac{1^{n_4}}{n_4!}\right)$
$D_1^{M-B} = \{2, 0, 0, 2\}$	$\Omega_{D_1}^{M-B}(g_i, n_i) = \Omega_{\{2,0,0,2\}}^{M-B} = 4!\left(\frac{1^2}{2!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{1^2}{2!}\right) = 6$

$D_2^{M-B} = \{1,1,1,1\}$	$\Omega_{D_2}^{M-B}(g_i,n_i) = \Omega_{\{1,1,1,1\}}^{M-B} = 4!\left(\frac{1^2}{1!}\right)\left(\frac{2^1}{1!}\right)\left(\frac{2^1}{1!}\right)\left(\frac{1^1}{1!}\right) = 96$
$D_3^{M-B} = \{0,3,0,1\}$	$\Omega_{D_3}^{M-B}(g_i,n_i) = \Omega_{\{0,3,0,1\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^3}{3!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{1^1}{1!}\right) = 32$
$D_4^{M-B} = \{1,0,3,0\}$	$\Omega_{D_4}^{M-B}(g_i,n_i) = \Omega_{\{1,0,3,0\}}^{M-B} = 4!\left(\frac{1^1}{1!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{2^3}{3!}\right)\left(\frac{1^0}{0!}\right) = 32$
$D_5^{M-B} = \{0,2,2,0\}$	$\Omega_{D_5}^{M-B}(g_i,n_i) = \Omega_{\{0,2,2,0\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^2}{2!}\right)\left(\frac{2^2}{2!}\right)\left(\frac{1^0}{0!}\right) = 96$
Total number of microstates of the system for case B = 6 + 96 + 32 + 32 + 96 = 262	
(D_j) **Case C**	$\left[\Omega_{D_j}^{M-B}(g_i,n_i)\right]_{\text{Case C}} = 4!\left(\frac{1^{n_1}}{n_1!}\right)\left(\frac{2^{n_2}}{n_2!}\right)\left(\frac{3^{n_3}}{n_3!}\right)\left(\frac{4^{n_4}}{n_4!}\right)$
$D_1^{M-B} = \{2,0,0,2\}$	$\Omega_{D_1}^{M-B}(g_i,n_i) = \Omega_{\{2,0,0,2\}}^{M-B} = 4!\left(\frac{1^2}{2!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{3^0}{0!}\right)\left(\frac{4^2}{2!}\right) = 96$
$D_2^{M-B} = \{1,1,1,1\}$	$\Omega_{D_2}^{M-B}(g_i,n_i) = \Omega_{\{1,1,1,1\}}^{M-B} = 4!\left(\frac{1^2}{1!}\right)\left(\frac{2^1}{1!}\right)\left(\frac{3^1}{1!}\right)\left(\frac{4^1}{1!}\right) = 576$
$D_3^{M-B} = \{0,3,0,1\}$	$\Omega_{D_3}^{M-B}(g_i,n_i) = \Omega_{\{0,3,0,1\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^3}{3!}\right)\left(\frac{3^0}{0!}\right)\left(\frac{4^1}{1!}\right) = 128$
$D_4^{M-B} = \{1,0,3,0\}$	$\Omega_{D_4}^{M-B}(g_i,n_i) = \Omega_{\{1,0,3,0\}}^{M-B} = 4!\left(\frac{1^1}{1!}\right)\left(\frac{2^0}{0!}\right)\left(\frac{3^3}{3!}\right)\left(\frac{4^0}{0!}\right) = 108$
$D_5^{M-B} = \{0,2,2,0\}$	$\Omega_{D_5}^{M-B}(g_i,n_i) = \Omega_{\{0,2,2,0\}}^{M-B} = 4!\left(\frac{1^0}{0!}\right)\left(\frac{2^2}{2!}\right)\left(\frac{3^2}{2!}\right)\left(\frac{4^0}{0!}\right) = 216$
Total number of microstates of the systemfor case C = 96 + 576 + 128 + 108 + 216 = 1124	

Table 3: A few possible microstates associated with each macrostate for all the macrostates of Case A for classical particles obeying M-B statistics.

Energy level (ε_i)	Degeneracy (g_i)	9 of 24 microstates of D_1^{M-B} = {2, 0, 0, 2}								
		1	2	3	4	5	6	7	8	9
$\varepsilon_4 = 4$	$g_4 = 2$	CD| –	BD| –	BC| –	AB| –	AD| –	AC| –	A|B	A|D	A|C
$\varepsilon_3 = 3$	$g_3 = 1$	–	–	–	–	–	–	–	–	–
$\varepsilon_2 = 2$	$g_2 = 2$	–| –	–| –	–| –	–| –	–| –	–| –	–| –	–| –	–| –
$\varepsilon_1 = 1$	$g_1 = 1$	AB	AC	AD	CD	CB	BD	CD	CB	BD

Energy level (ε_i)	Degeneracy (g_i)	9 of 96 microstates associated with the D_2^{M-B} = {1, 1, 1, 1}.								
		1	2	3	4	5	6	7	8	9
$\varepsilon_4 = 4$	$g_4 = 2$	C| –	C| –	–|C	–|C	–|C	C| –	D| –	D| –	–|D
$\varepsilon_3 = 3$	$g_3 = 1$	D	D	D	A	A	A	B	B	B
$\varepsilon_2 = 2$	$g_2 = 2$	B| –	–|B	B| –	B| –	–|B	–|B	–|A	A| –	A| –
$\varepsilon_1 = 1$	$g_1 = 1$	A	A	A	D	D	D	C	C	C

Energy level (ε_i)	Degeneracy (g_i)	9 of 64 microstates of $D_3^{M-B} = \{0,3,0,1\}$								
		1	2	3	4	5	6	7	8	9
$\varepsilon_4 = 4$	$g_2 = 2$	A| –	A| –	A| –	D| –	D| –	–|B	B| –	C| –	–|C
$\varepsilon_3 = 3$	$g_1 = 1$	–	–	–	–	–	–	–	–	–

$\varepsilon_2 = 2$	$g_3 = 2$	BCD|−	C|BD	BD|C	AB|C	C|AB	C|AD	D|AC	D|AB	AB|D
$\varepsilon_1 = 1$	$g_1 = 1$	−	−	−	−	−	−	−	−	−

Energy level (ε_i)	Degeneracy (g_i)	4 microstates of D_4^{M-B} = {1, 0, 3, 0}			
		1	2	3	4
$\varepsilon_4 = 4$	$g_4 = 2$	−|−	−|−	−|−	−|−
$\varepsilon_3 = 3$	$g_3 = 1$	BCD	ACD	ABD	ABC
$\varepsilon_2 = 2$	$g_2 = 2$	−|−	−|−	−|−	−|−
$\varepsilon_1 = 1$	$g_1 = 1$	A	B	C	D

Energy level (ε_i)	Degeneracy (g_i)	7 of 24 microstates of D_5^{M-B} = {0, 2, 2, 0}						
		1	2	3	4	5	6	7
$\varepsilon_4 = 4$	$g_4 = 2$	−|−	−|−	−|−	−|−	−|−	−|−	−|−
$\varepsilon_3 = 3$	$g_3 = 1$	CD	CD	AB	AB	CD	AB	AB
$\varepsilon_2 = 2$	$g_2 = 2$	AB|−	−|AB	CD|−	−|CD	A|B	C|D	D|C
$\varepsilon_1 = 1$	$g_1 = 1$	−	−	−	−	−	−	−

It should be noted that interchanging the orderof the particles in the same quantum state does not produce an extra microstate, i.e., BCD, BDC, DCB etc., produce the same microstate. Similarly, AB or BA in the same quantum state is same. This duplication of microstatehasbeen taken care by formula 3.

II. Bose-Einstein statistics for indistinguishable particles (Bosons):

In B-E statistics, similar to M-B statistics, there is no restriction on number of particles that a energy state/energy level can accommodate as Bosons do not obey Pauli's exclusion principle. Therefore, again degeneracy(g_i) of an energy level (ε_i) is not considered in determining the number of macrostates in B-E statistics. The five macrostates, $D_1^{B-E} = \{2,0,0,2\}$, $D_2^{B-E} = \{1,1,1,1\}$, $D_3^{B-E} = \{0,3,0,1\}$, $D_4^{B-E} = \{1,0,3,0\}$,and $D_5^{B-E} = \{0,2,2,0\}$, are shown in Table 4.

Table4: 5 macrostates of 4 Bosons distributed in 4 energy levels for all the three cases.

	5 macrostates				
Energy levels (ε_i)	$D_1^{B-E} = \{2,0,0,2\}$	$D_2^{B-E} = \{1,1,1,1\}$	$D_3^{B-E} = \{0,3,0,1\}$	$D_4^{B-E} = \{1,0,3,0\}$	$D_5^{B-E} = \{0,2,2,0\}$
$\varepsilon_4 = 4$	00	0	0	−	−
$\varepsilon_3 = 3$	−	0	−	000	00
$\varepsilon_2 = 2$	−	0	000	−	00
$\varepsilon_1 = 1$	00	0	−	0	−

The total number of microstates associated with each macrostate, shown in Table 5, can be calculated using the formula 4 as:

$$\left[\Omega_{D_j}^{B-E}(g_i,n_i)\right]_{\text{Case A}} = \prod_i \frac{(n_i+g_i-1)!}{n_i!\,(g_i-1)!} = \frac{(n_1+1-1)!}{n_1!\,(1-1)!}\frac{(n_2+2-1)!}{n_2!\,(2-1)!}\frac{(n_3+1-1)!}{n_3!\,(1-1)!}\frac{(n_4+2-1)!}{n_4!\,(2-1)!}$$

$$= \frac{(n_1)!}{n_1!\,0!}\frac{(n_2+1)!}{n_2!\,1!}\frac{(n_3)!}{n_3!\,0!}\frac{(n_4+1)!}{n_4!\,1!} = \frac{(n_2+1)!}{n_2!}\frac{(n_4+1)!}{n_4!}$$

$$\left[\Omega_{D_j}^{B-E}(g_i,n_i)\right]_{\text{Case B}} = \prod_i \frac{(n_i+g_i-1)!}{n_i!\,(g_i-1)!} = \frac{(n_1+1-1)!}{n_1!\,(1-1)!}\frac{(n_2+2-1)!}{n_2!\,(2-1)!}\frac{(n_3+2-1)!}{n_3!\,(2-1)!}\frac{(n_4+1-1)!}{n_4!\,(1-1)!}$$

$$= \frac{(n_1+1-1)!}{n_1!\,0!}\frac{(n_2+2-1)!}{n_2!\,1!}\frac{(n_3+2-1)!}{n_3!\,1!}\frac{(n_4+1-1)!}{n_4!\,0!} = \frac{(n_2+1)!}{n_2!}\frac{(n_3+1)!}{n_3!}$$

$$\left[\Omega_{D_j}^{B-E}(g_i,n_i)\right]_{\text{Case C}} = \prod_i \frac{(n_i+g_i-1)!}{n_i!\,(g_i-1)!} = \frac{(n_1+1-1)!}{n_1!\,(1-1)!}\frac{(n_2+2-1)!}{n_2!\,(2-1)!}\frac{(n_3+3-1)!}{n_3!\,(2-1)!}\frac{(n_4+4-1)!}{n_4!\,(1-1)!}$$

$$= \frac{(n_1)!}{n_1!}\frac{(n_2+1)!}{n_2!}\frac{(n_3+2)!}{n_3!}\frac{(n_4+3)!}{n_4!} = \frac{(n_2+1)!}{n_2!}\frac{(n_3+2)!}{n_3!}\frac{(n_4+3)!}{n_4!}$$

It can be seen from above that only degenerate energy levels appear in the final formula of microstates in case of B-E statistics.

Table 5: Total number of microstates associated with each macrostate$\Omega_{D_j}^{\mathrm{B-E}}(g_i,n_i)$.

Macrostates(D_j) Case A	Total number of microstates associated with each macrostate $\Omega_{D_j}^{\mathrm{B-E}}(g_i,n_i) = \prod_i \frac{(n_i+g_i-1)!}{n_i!\,(g_i-1)!} = \frac{(n_2+1)!}{n_2!}\frac{(n_4+1)!}{n_4!}$
$D_1^{B-E} = \{2,0,0,2\}$	$\left[\Omega_{D_j}^{\mathrm{B-E}}(g_i,n_i)\right]_{Case\ A} = \Omega_{\{2,0,0,2\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(2+1)!}{0!} = 6$
$D_2^{B-E} = \{1,1,1,1\}$	$\Omega_{D_2}^{B-E}(g_i,n_i) = \Omega_{\{1,1,1,1\}}^{B-E} = \frac{(1+1)!}{1!}\frac{(1+1)!}{1!} = 4$
$D_3^{B-E} = \{0,3,0,1\}$	$\Omega_{D_3}^{B-E}(g_i,n_i) = \Omega_{\{0,3,0,1\}}^{B-E} = \frac{(3+1)!}{3!}\frac{(1+1)!}{1!} = 4$
$D_4^{B-E} = \{1,0,3,0\}$	$\Omega_{D_4}^{B-E}(g_i,n_i) = \Omega_{\{1,0,3,0\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(0+1)!}{0!} = 1$
$D_5^{B-E} = \{0,2,2,0\}$	$\Omega_{D_5}^{B-E}(g_i,n_i) = \Omega_{\{0,2,2,0\}}^{B-E} = \frac{(2+1)!}{2!}\frac{(0+1)!}{0!} = 3$
Total number of microstates of the systemfor case A = 6 + 4 + 4 + 1 + 3 = 18	
Macrostates(D_j) Case B	Total number of microstates associated with each macrostate $\left[\Omega_{D_j}^{\mathrm{B-E}}(g_i,n_i)\right]_{Case\ B} = \prod_i \frac{(n_i+g_i-1)!}{n_i!\,(g_i-1)!} = \frac{(n_2+1)!}{n_2!}\frac{(n_3+1)!}{n_3!}$
$D_1^{B-E} = \{2,0,0,2\}$	$\Omega_{D_1}^{B-E}(g_i,n_i) = \Omega_{\{2,0,0,2\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(0+1)!}{0!} = 1$
$D_2^{B-E} = \{1,1,1,1\}$	$\Omega_{D_2}^{B-E}(g_i,n_i) = \Omega_{\{1,1,1,1\}}^{B-E} = \frac{(1+1)!}{1!}\frac{(1+1)!}{1!} = 4$
$D_3^{B-E} = \{0,3,0,1\}$	$\Omega_{D_3}^{B-E}(g_i,n_i) = \Omega_{\{0,3,0,1\}}^{B-E} = \frac{(3+1)!}{3!}\frac{(0+1)!}{0!} = 4$
$D_4^{B-E} = \{1,0,3,0\}$	$\Omega_{D_4}^{B-E}(g_i,n_i) = \Omega_{\{1,0,3,0\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(3+1)!}{3!} = 4$

$D_5^{B-E} = \{0,2,2,0\}$	$\Omega_{D_5}^{B-E}(g_i,n_i) = \Omega_{\{0,2,2,0\}}^{B-E} = \frac{(2+1)!}{2!}\frac{(2+1)!}{2!} = 9$
Total number of microstates of the systemfor case B = 1 + 4 + 4 + 4 + 9 = 22	
Macrostates(D_j) Case C	Total number of microstates associated with each macrostate $\left[\Omega_{D_j}^{\mathrm{B-E}}(g_i,n_i)\right]_{Case\ C} = \frac{(n_2+1)!}{n_2!}\frac{(n_3+2)!}{n_3!}\frac{(n_4+3)!}{n_4!}$
$D_1^{B-E} = \{2,0,0,2\}$	$\Omega_{D_1}^{B-E}(g_i,n_i) = \Omega_{\{2,0,0,2\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(0+2)!}{0!}\frac{(2+3)!}{2!} = 120$
$D_2^{B-E} = \{1,1,1,1\}$	$\Omega_{D_2}^{B-E}(g_i,n_i) = \Omega_{\{1,1,1,1\}}^{B-E} = \frac{(1+1)!}{1!}\frac{(1+2)!}{1!}\frac{(1+3)!}{1!} = 72$
$D_3^{B-E} = \{0,3,0,1\}$	$\Omega_{D_3}^{B-E}(g_i,n_i) = \Omega_{\{0,3,0,1\}}^{B-E} = \frac{(3+1)!}{3!}\frac{(0+2)!}{0!}\frac{(1+3)!}{1!} = 192$
$D_4^{B-E} = \{1,0,3,0\}$	$\Omega_{D_4}^{B-E}(g_i,n_i) = \Omega_{\{1,0,3,0\}}^{B-E} = \frac{(0+1)!}{0!}\frac{(3+2)!}{3!}\frac{(0+3)!}{0!} = 120$
$D_5^{B-E} = \{0,2,2,0\}$	$\Omega_{D_5}^{B-E}(g_i,n_i) = \Omega_{\{0,2,2,0\}}^{B-E} = \frac{(2+1)!}{2!}\frac{(2+2)!}{2!}\frac{(0+3)!}{0!} = 216$
Total number of microstates of the systemfor case C = 120 + 72 + 192 + 120 + 216 = 720	

It should be further noted that though the total number of microstates associated with macrostates $D_2^{B-E} = \{1,1,1,1\}$ and $D_3^{B-E} = \{0,3,0,1\}$ are same (i.e., 4) in cases A and B, the arrangement of particles among the quantum states are different due to different generacies. Tables 6 shows the microstates associated with each of the 5 macrostates for 4 Bosons for case B. Since the particles are indistinguishable therefore, an interchange of the order of particles in the same quantum state (g_i) does not generate an extra microstate.

Table 6: Microstates associated with each macrostate for 4 Bosons for case B.

Energy level (ε_i)	Degeneracy (g_i)	1 microstate of $D_1^{B-E} = \{2,0,0,2\}$	4 microstates of $D_2^{B-E} = \{1,1,1,1\}$: 1	2	3	4
$\varepsilon_4 = 4$	$g_4 = 1$	00	0	0	0	0
$\varepsilon_3 = 3$	$g_3 = 2$	−|−	0|−	0|−	−|0	−|0
$\varepsilon_2 = 2$	$g_2 = 2$	−|−	0|−	−|0	−|0	0|−
$\varepsilon_1 = 1$	$g_1 = 1$	00	0	0	0	0

Energy level (ε_i)	Degeneracy (g_i)	4 microstates of $D_3^{B-E} = \{0,3,0,1\}$: 1	2	3	4	4 microstates of $D_4^{B-E} = \{1,0,3,0\}$: 1	2	3	4
$\varepsilon_4 = 4$	$g_4 = 1$	0	0	0	0	−	−	−	−
$\varepsilon_3 = 3$	$g_3 = 2$	−	−	−	−	0|00	00|0	−|000	000|−
$\varepsilon_2 = 2$	$g_2 = 2$	00|0	0|00	000|−	−|000	−|−	−|−	−|−	−|−
$\varepsilon_1 = 1$	$g_1 = 1$	−	−	−	−	0	0	0	0

Energy level (ε_i)	Degeneracy (g_i)	9 microstates of $D_5^{B-E} = \{0,2,2,0\}$.: 1	2	3	4	5	6	7	8	9
$\varepsilon_4 = 4$	$g_4 = 1$	−	−	−	−	−	−	−	−	−

$\varepsilon_3 = 3$	$g_3 = 2$	00|−	−|00	−|00	00|−	00|−	0|0	−|00	0|0	0|0
$\varepsilon_2 = 2$	$g_2 = 2$	00|−	−|00	00|−	−|00	0|0	0|0	0|0	00|−	−|00
$\varepsilon_1 = 1$	$g_1 = 1$	−	−	−	−	−	−	−	−	−

III. Fermi-Dirac statistics for indistinguishable particles (Fermions):

F-D statistics allows one particle per quantum state, unlike M-B and B-E statistics, as Fermions obey Pauli's exclusion principle.Consequently, in calculating the macrostates in this case, one has to pay attention to the degeneracy of energy levels. Therefore, following the above two constraints, only one macrostate $D_1^{F-D} = \{1, 1, 1, 1\}$ for case A, 2 macrostates $D_1^{F-D} = \{1, 1, 1, 1\}$ and $D_2^{F-D} = \{0, 2, 2, 0\}$ for case B, and three macrostates$D_1^{F-D} = \{1, 1, 1, 1\}$,$D_2^{F-D} = \{0, 2, 2, 0\}$, and $D_3^{F-D} = \{1, 0, 3, 0\}$for case C, respectively are possible. The micorstates associated with each of the macrostates, shown in Table 7, can be calculated using the formula 5 as

$$\Omega_{D_j}^{\mathrm{F-D}}(g_i, n_i) = \prod_i \frac{g_i!}{n_i!\,(g_i - n_i)!} = \frac{g_1!}{n_1!\,(g_1 - n_1)!}\frac{g_2!}{n_2!\,(g_2 - n_2)!}\frac{g_3!}{n_3!\,(g_3 - n_3)!}\frac{g_4!}{n_4!\,(g_4 - n_4)!}$$

Table 7: Number of microstates $\Omega_{D_j}^{F-D}(g_i, n_i)$associated with each macrostate$\left(D_j^{F-D}\right)$ for all three cases.

$\left(D_j^{F-D}\right)_{\text{Case A}}$	$\left[\Omega_{D_j}^{\mathrm{F-D}}(g_i, n_i)\right]_{\text{Case A}} = \frac{1!}{n_1!\,(1 - n_1)!}\frac{2!}{n_2!\,(2 - n_2)!}\frac{1!}{n_3!\,(1 - n_3)!}\frac{2!}{n_4!\,(2 - n_4)!}$
$D_1^{F-D} = \{1, 1, 1, 1\}$	$\Omega_{D_1}^{F-D}(g_i, n_i) = \Omega_{\{1,1,1,1\}}^{F-D} = \frac{1!}{1!\,(1 - 1)!}\frac{2!}{1!\,(2 - 1)!}\frac{1!}{1!\,(1 - 1)!}\frac{2!}{1!\,(2 - 1)!} = 4$
Total number of microstates of the system for case A = 4	
$\left(D_j^{F-D}\right)_{\text{Case B}}$	$\left[\Omega_{D_j}^{\mathrm{F-D}}(g_i, n_i)\right]_{\text{Case B}} = \frac{1!}{n_1!\,(1 - n_1)!}\frac{2!}{n_2!\,(2 - n_2)!}\frac{2!}{n_3!\,(2 - n_3)!}\frac{1!}{n_4!\,(1 - n_4)!}$
$D_1^{F-D} = \{1, 1, 1, 1\}$	$\Omega_{D_1}^{F-D}(g_i, n_i) = \Omega_{\{1,1,1,1\}}^{F-D} = \frac{1!}{1!\,(1 - 1)!}\frac{2!}{1!\,(2 - 1)!}\frac{2!}{1!\,(2 - 1)!}\frac{1!}{1!\,(1 - 1)!} = 4$
$D_2^{F-D} = \{0, 2, 2, 0\}$	$\Omega_{D_2}^{F-D}(g_i, n_i) = \Omega_{\{0,2,2,0\}}^{F-D} = \frac{1!}{0!\,(1 - 0)!}\frac{2!}{2!\,(2 - 2)!}\frac{2!}{2!\,(2 - 2)!}\frac{1!}{0!\,(1 - 0)!} = 1$
Total number of microstates of the system for case B = 4 + 1 = 5	
$\left(D_j^{F-D}\right)_{\text{Case C}}$	$\left[\Omega_{D_j}^{\mathrm{F-D}}(g_i, n_i)\right]_{\text{Case C}} = \frac{1!}{n_1!\,(1 - n_1)!}\frac{2!}{n_2!\,(2 - n_2)!}\frac{3!}{n_3!\,(3 - n_3)!}\frac{4!}{n_4!\,(4 - n_4)!}$
$D_1^{F-D} = \{1, 1, 1, 1\}$	$\Omega_{D_1}^{F-D}(g_i, n_i) = \Omega_{\{1,1,1,1\}}^{F-D} = \frac{1!}{1!\,(1 - 1)!}\frac{2!}{1!\,(2 - 1)!}\frac{3!}{1!\,(3 - 1)!}\frac{4!}{1!\,(4 - 1)!} = 24$

$D_2^{F-D} = \{0, 2, 2, 0\}$	$\Omega_{D_2}^{F-D}(g_i, n_i) = \Omega_{\{0,2,2,0\}}^{F-D} = \frac{1!}{0!\,(1-0)!}\frac{2!}{2!\,(2-2)!}\frac{3!}{2!\,(3-2)!}\frac{4!}{0!\,(4-0)!} = 3$
$D_3^{F-D} = \{1, 0, 3, 0\}$	$\Omega_{D_3}^{F-D}(g_i, n_i) = \Omega_{\{1,0,3,0\}}^{F-D} = \frac{1!}{1!\,(1-1)!}\frac{2!}{0!\,(2-0)!}\frac{3!}{3!\,(3-3)!}\frac{4!}{0!\,(4-0)!} = 1$
Total number of microstates of the system for case C = 24 + 3 + 1 = 28	

It can be seen form the Table 7 that the macrostate$D_1^{F-D} = \{1, 1, 1, 1\}$ is common in all the three cases, but in case C the total number of microstates associated with this particular macrostate is 24 due to the increase of degeneracy, suggesting that number of microstates strongly depends on the degree of degeneracy.Table 8 shows the macrostates and their corresponding microstates of 4 Fermions sharing total energy of 10 units for all the three cases.

Table 8:Macrostates and their associated microstates for all the three cases.

Energy level (ε_i)	Degeneracy (g_i)	$D_1^{F-D} = \{1, 1, 1, 1\}$ Case A	4 microstates of $D_1^{F-D} = \{1, 1, 1, 1\}$			
			1	2	3	4
$\varepsilon_4 = 4$	$g_4 = 2$	0	0|−	0|−	−|0	−|0
$\varepsilon_3 = 3$	$g_3 = 1$	0	0	0	0	0
$\varepsilon_2 = 2$	$g_2 = 2$	0	0|−	−|0	−|0	0|−
$\varepsilon_1 = 1$	$g_1 = 1$	0	0	0	0	0

Energy level (ε_i)	Degeneracy (g_i)	$D_1^{F-D} = \{1, 1, 1, 1\}$ Case B	4 microstates of $D_1^{F-D} = \{1, 1, 1, 1\}$				$D_2^{F-D} = \{0, 2, 2, 0\}$	1 microstate of $D_2^{F-D} = \{0, 2, 2, 0\}$
			1	2	3	4		
$\varepsilon_4 = 4$	$g_4 = 1$	0	0	0	0	0	−	−
$\varepsilon_3 = 3$	$g_3 = 2$	0	0|−	0|−	−|0	−|0	00	0|0
$\varepsilon_2 = 2$	$g_2 = 2$	0	0|−	−|0	−|0	0|−	00	0|0
$\varepsilon_1 = 1$	$g_1 = 1$	0	0	0	0	0	−	−

Energy level (ε_i)	Degeneracy (g_i)	$D_1^{F-D} = \{1, 1, 1, 1\}$ Case C	3 of 24 microstates of $D_1^{F-D} = \{1, 1, 1, 1\}$		
			1	2	3
$\varepsilon_4 = 4$	$g_4 = 4$	0	−|0|−|−	0|−|−|−	−|−|0|−
$\varepsilon_3 = 3$	$g_3 = 3$	0	0|−|−	0|−	−|0
$\varepsilon_2 = 2$	$g_2 = 2$	0	0|−	−|0	−|0
$\varepsilon_1 = 1$	$g_1 = 1$	0	0	0	0

Energy level (ε_i)	Degeneracy (g_i)	$D_2^{F-D} = \{0, 2, 2, 0\}$ Case C	3 microstates of $D_2^{F-D} = \{0, 2, 2, 0\}$		
			1	2	3
$\varepsilon_4 = 4$	$g_4 = 4$	−	−|−|−|−	−|−|−|−	−|−|−|−
$\varepsilon_3 = 3$	$g_3 = 3$	00	0|0|−	−|0|0	0|−|0
$\varepsilon_2 = 2$	$g_2 = 2$	00	0|0	0|0	0|0
$\varepsilon_1 = 1$	$g_1 = 1$	−	−	−	−

Energy level (ε_i)	Degeneracy (g_i)	$D_3^{F-D} = \{1,0,3,0\}$ Case C	1 microstate of $D_3^{F-D} = \{1,0,3,0\}$
$\varepsilon_4 = 4$	$g_4 = 4$	$\underline{-}$	$\underline{-\vert-\vert-\vert-}$
$\varepsilon_3 = 3$	$g_3 = 3$	$\underline{000}$	$\underline{0\vert 0\vert 0}$
$\varepsilon_2 = 2$	$g_2 = 2$	$\underline{-}$	$\underline{-\vert-}$
$\varepsilon_1 = 1$	$g_1 = 1$	$\underline{0}$	$\underline{0}$

Discussion of results:

(i) Total number of microstates Ω_{Total}: The total number of microstates of the system (Ω_{Total}) is calculated by summing over all the possible microstates of all the macrostates:

$$\Omega_{\text{Total}} = \sum_j \Omega_{D_j} = \Omega_{D_1} + \Omega_{D_2} + \Omega_{D_3} + \ldots. \qquad \ldots (7)$$

Therefore, Ω_{Total} for the particles following M-B statistics for case A can be calculated as

$$\left[\Omega_{Total}^{M-B}\right]_{\text{Case A}} = \sum_{j=1}^{5} \Omega_{D_j}^{M-B} = \Omega_{D_1}^{M-B} + \Omega_{D_2}^{M-B} + \Omega_{D_3}^{M-B} + \Omega_{D_4}^{M-B} + \Omega_{D_5}^{M-B} = 212$$

Similarly, Ω_{Total} for other cases and for other two statistics can be easily determined from equation 6 and are given in Tables 2, 5, and 7.

(ii) Equally a priori probability: According to equally a priori probability, all the 212 microstates in case A of a system of 4 particles obeying M-B statistics are equally probable. The system in statistical (thermodynamic) equilibrium will go through all the microstates with equal probability since the particles are always in random motion though the thermodynamics properties (V, E, and N)do not vary over time. Similar conclusions can be drawn for cases B and C and for other two statistics.

(iii) Entropy, thermodynamic probability, and most probable macrostate: The entropy (S) of a system can be calculated using the Boltzmann's formula: $S = k_B \ln\Omega$ where $k_B = 1.381 \times 10^{-2}$ J/K is Boltzmann's constant and Ω is thermodynamic probability (or number of microstates of a particular macrostate) [20-21]. This is also known as *statistical definition of entropy* as it connects thermodynamics to statistical mechanics. Entropy of a system in a particular macrostate can be calculated as [1]:

$$S = k_B \ln \Omega_{D_j} \qquad \ldots (8)$$

$\therefore S = k_B \ln \Omega_{D_j} = 1.381 \times 10^{-23} \times 3.18 \approx 4.4 \times 10^{-23}$for macrostate $D_1^{M-B} = \{2,0,0,2\}$ of case A in M-B statistics.

Similarly, entropy of the system for other macrostatesand for other cases of M-B statistics, and for other statistics can be determined using formula 8.

Entropy of the whole system (S_{Total}), i.e., considering all the microstates of all the possible macrostates can be determined from

$$S_{\text{Total}} = k_B \ln\Omega_{\text{Total}} \qquad \ldots (9)$$

$\therefore S_{\text{Total}} = k_B \ln\Omega_{\text{Total}} \approx 7.40 \times 10^{-23}$for case A (5 macrostates and 212 microstates) in M-B statistics.

Similarly, entropy of the whole system for other two cases (B & C) of M-B statistics and for other two statistics (B-E & F-D) can be determined using formula 9.

From thermodynamics, we know that a system in equilibrium has maximum entropy [18-21]. The macrostate$D_2^{M-B} = \{1, 1, 1, 1\}$ has 96 microstates in case A of M-B statistics. Consequently, the system in this macrostate will have maximum entropy, indicating that the system will more likely be in this macrostate. Hence, this macrostate is the most probable macrostate.

In case B of M-B statistics, the two macrostates$D_2^{M-B} = \{1, 1, 1, 1\}$ and $D_5^{M-B} = \{0, 2, 2, 0\}$has 96 microstates each. Therefore, these two macrostates are the most probable macrostates. The most probable macrostate in case C is$D_2^{M-B} = \{1, 1, 1, 1\}$. Similar the most probable macrostate for other two statistics can be easily found from Tables 5 and 7. Another important feature is that number of microstates decreases as we move from distinguishable to indistinguishable particles, indicating that indistinguishable particles intend to stay together than the distinguishable ones. The main purpose of statistical mechanics is to find the most probable distribution of particles among the various energy levels (i.e., most probable macrostate) at thermal equilibrium.

4. Conclusion

In summary, teaching-learning process of understanding M-B, B-E, and F-D statistics have been discussed through aPedagogical-Problem-Solution-Model (PPSM). This model is particularly helpful for those students, who have physics have as a minor paper and do not have formal knowledge of advanced (quantum and classical mechanics). However, it can be applied to undergraduate students of any branch of science, engineering, and technology. It is hoped that thismodel will make the teaching-learning process more pragmatic, interactive and productive.

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National Anveshika Experimental Skill Test

A unique test embodying the principles of NEP National Anveshika Experimental Skill Test is a unique competition in which thousands of school and college students participate and the evaluation is based on their skills to perform physics experiments. The test is conducted every year by National Anveshika Network of India (NANI), IAPT under the guidance of Padmashri Dr H. C Verma, the renowned professor of physics from IIT, Kanpur. The test is open to school students of grades IX to XII and for the college students pursuing pure sciences at the graduation and post-graduation level. There is no fee at any stage.

The various rounds of NAEST 2022:

The First round, *The Screening round*, will be conducted between 22nd July to 28th July 2022. It is a video based round which shortlists students based on their keen observational and analytical skills.

The videos are of maximum 1 minute duration and depict interesting situations around us. The questions are multiple choice questions with one or more correct option.

The second round, *The Prelims Round*, is scheduled from 11th August to 31st August 2022. This is an experiment-based round for students short-listed from the first round from a given region. In this round the students perform innovative experiments for which partial guidelines are provided.

Critical and creative thinking is encouraged with special credit for exploring beyond what is asked.

The third and fourth rounds are Semi-finals & Finals to be conducted in October 2022 at Shiksha Sopan, Kanpur. Students selected from different regions based on their performance in the second round, enter the semi-finals where they appear for more challenging innovative experiments. It is ensured that each student completes the experiment, with or without support in form of hint providing questions. Around ten students selected from the semi-finals appear for the finals. Both the rounds assess the ability of students to learn in new circumstances. Finally, based on their final performance, three national winners are declared who are felicitated at the annual convention of IAPT.

There is no limit on the number of participants from an organization. The students are required to register individually at https://naest.shiksha-sopan.org/ . An early registration on the website is of great advantage for them. From time-to-time videos based on some concept of physics and related questions will be posted on the website. They can view the videos and post their queries which are answered by Dr H C Verma and his team of instructors. This gives them an opportunity to greatly enhance their understanding of the subject. They can then appear for the online video-based screening round. If selected for the next round - The prelims round - they are required to perform three innovative experiments at home with materials available at home; the experiments with guidelines are emailed to them directly on their registered email ID. Based on evaluation of their reports submitted with photos and videos, selected students from this round enter the Semi-final and Final rounds at Kanpur.

New milestones created by online mode The online mode of NAEST evolved as a response to unprecedented COVID situation in which the traditional school/college labs were closed for almost 2 years. The supposed disadvantage of nonavailability of labs was turned on its head into the biggest possible opportunity. It removed the restrictions imposed by a traditional lab where given equipment limits the abilities of a student.

Hundreds of students could perform experiments at home without any sophisticated equipment, without any prior infrastructure and with joy and excitement – A big milestone.

There is a common perception among physics educators that serious experimental work can only be performed with standardized equipment available in labs - a myth totally debunked by NAEST.

Student after student expressed excitement, deep appreciation, gratitude and wonder at how indepth experimentation is possible to carry out with simple things and at home. Without exception, they expressed excitement at doing experiments whose procedure and result was not known. The boredom of predictability was for the first time removed from a physics experiment!

Every home became a lab, a thrilling lab, where a student had full freedom to explore and create his own set up and procedure to solve a challenge! For the first time, a process was set up to test how well a student can think in a new situation, not how well a student can follow guided instructions and regurgitate what is already known.

NEAST experiments set the student free from constraints of learning only what is taught and learning only when taught; they enabled a student to learn, unlearn and relearn at his will and choice, to go beyond and devise his/her own solution to a problem.

The uniqueness of each child was evaluated, acknowledged, and rewarded without any disadvantage

of prior content knowledge – another milestone to celebrate.

The test indeed is a test of ability to think imaginatively, ability to solve problems and not of content knowledge and recall. This is well established by the fact that among the 10 toppers every year there are students from grades 9, 10, 11, 12, B.Sc. and M.Sc. – all were given the same experiments to perform!

Assessment that promotes learning and development

The whole exercise is geared towards self-learning and growth throughout the period of testing. The students have the freedom to consult books, internet, parents & teachers to gain knowledge of the content area and then explore solutions.

A call for action

There is a deep appreciation all around and a realization of the huge possibility online mode of NAEST has thrown up – serious investigatory, experimental physics is possible even at home, even in times of COVID.

This also offers the flexibility and options NEP 2020 envisions to offer to the learners.

Through this document we appeal to you to take note of this path breaking test. We request you to take all possible initiatives at your end to ensure maximum participation of students in this unique competition.

ANNOUNCEMENT

National Competition In Computational Physics - 2022 (Physics Simulations & software-based Physics Experiments) (NCICP – 2022)

The annual IAPT competition NCICP 2022 will be held during the Annual IAPT Convention. The details of venue and dates of IAPT Convention-2022 will be made available in due course of time.

Last date for submitting entry to NCICP is **31st August 2022**.

Preface

Now-a-days computers play a pivotal role in the teaching-learning process through the use of carrying out physics simulations, virtual experiments, analysis of experimental results, acquisition of data, smartphone apps and so on. Computers also find applications in numerical computations, data analysis, solving complex numerical problems in Physics and iterative calculations. Through NCICP IAPT provides a platform to the physics students and teachers to show their proficiency in using appropriate software for the development of innovative physics experiments/ simulations through this national-level competition.

About the Competition

This competition will be held in two categories: (a) Student, and (b) Teacher.

A. STUDENT Category: The competition is open to the students of UG/PG level.
B. TEACHER Category: The teachers at School level, as well as the UG and PG levels are eligible to participate in the competition. The participant can be even an M.Phil. / Ph.D. awarded / pursuing student or a scientist from regional / national laboratory or a science communicator in recognized institutions, etc. He / She needs not be an IAPT member.

The work to be presented should be original one. A few selected entries will be invited for demonstrations at the annual IAPT Convention, and the participants will be paid travelling expenses for coming to the convention venue as per IAPT rules. In case of a group-participation the team leader will be eligible to receive TA from IAPT. The selected participants must physically attend the competition with the setup of experiment, for final evaluation to be made during the Annual IAPT Convention -2022.

The **best three presentations** in **each category** will be given cash awards of Rs. 7000/- , Rs. 5000/- &Rs. 3000/- , respectively and a certificate. ***DECISION OF THE JUDGES WILL BE FINAL.***

Theme of the Competition:

INNOVATION (i.e. new idea, new method, new device, new algorithm involving physics) is the main theme.The following kinds of Physics-based Simulations/Experiments are included in this competition:

1. ***Experiments with software based modellingusing Android phone / PC/ smartphone***
2. ***Experiments with transducers /sensors /actuators/PID interfaced with Microprocessors /PC***
3. ***Experiments using ARDUINOcoupled withAndroid phone / PC***
4. ***Solving physics problems by simulations or by adopting numerical techniques (by using Psilab/Matlab/ Mathematica, Spreadsheets, Fortran, C++, Python etc.)***

How to register

The detailed entry should be submitted via the Google Form:https://forms.gle/KTWeXmnrhqv4JB4Y7

An individual / the team leader in case of a group (*Max. four members*) must submit the following information:

1. Title of presentation,
2. Name(s) of the participant(s),
3. Institutional affiliation of each participant,
4. Address for correspondence,
5. Mobile Number(s)
6. Incorporate the following declaration; "The proposed work is original, designed and developed by the participant(s) and not published / submitted elsewhere." Below the team leader must put signatures.

What to do next

(i) An individual / the team leader in case of a Group must submit One pdf file, as is described in the following points, to the Google Classroom as an attachment. The links of the Google Classrooms (separately for Students [Category A] & Teachers [Category B]) are mentioned in the Google Form. Participants have to click the appropriate link before submission of the Google Form.

(ii) The file must be named as 'Expt-A/B-first name of the team leader'.pdf. Mind that mention A or B correctly for STUDENT and TEACHER categories, respectively

(iii) It should contain detailed write up of their work (along with the computer program, if any), i.e. detailed theory with diagrams, procedure, observations, calculations, graphs, results and references. In the case of physics simulations, the report should include statement of the problem, formulation of the problem, flowchart, code/worksheet, test cases and visualisation of results using Gnuplot or such OpenSource software. There is no limit on the number of pages. The participant(s) should write his/her (their) name(s), affiliation(s), email(s) at the end of this file. Please mention the innovation you have incorporated with its importance regarding applications.

(iv) Please use Times New Roman (font size 12, spacing 1.5) and margins should be appropriate (1 inch each side).

(v) **To encourage quality participation from different Regional councils, RCs should conduct state level competitions and forward the best entries before the closing date.**

The abstracts of selected experiments will be published in IAPT monthly Bulletin (ISSN 2277-8950) after the Annual Convention.

Last date for entries to reach is July 31, 2022. Your cooperation to abide by the last date will be highly appreciated.

For any query:

Dr. Pradipta Panchadhyayee
Coordinator, NCSPE-2022
Associate Professor, Department of Physics (UG & PG)
Prabhat Kumar College, Contai; PO:Karkuli DSO, Dist-PurbaMedinipur, WB, 721404
Mail id: ncicp2022@gmail.com
WhatsApp:(+91) 9476161100


अमर उजाला
जोश! सच का!
NAEST
2022
National Anveshika Experimental Skill Test
Eligibility Criteria : -
Junior : Std IX - XII
Senior : B.Sc & M.Sc
Registration Begin
1 JUNE 2022
Register @
naest.shiksha-sopan.org
Find More Info:
80811 76889
naest@shiksha-sopan.org
Organised By
National Anveshika Network of India, Shiksha Sopan, Kanpur
National Co-Ordinator :- Padma Shri H.C Verma

Prof. C. K. Majumdar (1938–2000)
Founder-Director, SNBNCBS, Kolkata

C. K. MAJUMDAR MEMORIAL WORKSHOP IN PHYSICS 2022

Organized jointly by

Indian Association of Physics Teachers (Regional Council 15)
and
S. N. Bose National Centre for Basic Sciences (SNBNCBS), Kolkata

The Workshop will be held in SNBNCBS in hybrid non-residential mode

From July 12, 2022, To July 21, 2022.

Advisory Committee

Samit Kumar Ray
IIT, Kharagpur, and President, IAPT RC 15

Tanusri Saha Dasgupta
Director, SNBNCBS, Kolkata

Jayanta K Bhattacharjee
IACS, Kolkata

Amitava Raychaudhuri
University of Calcutta, Kolkata

P K Ahluwalia
President, IAPT

Indrani Bose
Bose Institute, Kolkata

Gour P Das
St-Xavier's College

Birendra Nath Das
IAPT

Subhas Chandra Samanta
IAPT

Bhupati Chakrabarti
EC member, IAPT

Makhanlal Nanda Goswami
EC member, IAPT

Organizing Committee

Joint Conveners

Saswati Dasgupta
Formerly of Rammohan College, Kolkata

Kalyan Mandal
SNBNCBS, Kolkata

Members

Achintya Pal
Vice-President, IAPT RC 15

Pradipta Panchadhyayee
Secretary, IAPT RC 15

Nitesh Kumar
SNBNCBS, Kolkata

Pradip S Pachfule
SNBNCBS, Kolkata

Tapas Baug
SNBNCBS, Kolkata

Sakuntala Chatterjee
SNBNCBS, Kolkata

Surajit Chakrabarti
Formerly of MMC College, Kolkata

Jonaki Choudhury
Formerly of Lady Brabourne College, Kolkata

Lachhima Gupta
Formerly of Lady Brabourne College, Kolkata

Manimala Das
Formerly of Netaji Subhas Open University

Debapriyo Syam
Formerly of Presidency College, Kolkata

Mita Choudhury
Formerly of Asansol Girls' College, Bardhaman

Lipika Santra
Bangabasi College, Kolkata

Sukla Chakrabarti
Ananda Mohan College, Kolkata

- Eligibility : Students appearing in the final B.Sc. with Physics hons/major and the students in the 1st year of M.Sc. (Physics) or equivalent
- Workshop will be non-residential.
- Workshop will be in hybrid (both on-line and off-line) mode.
- Number of registered participants : 100 (Online mode 50; Offline mode 50)
- Registration fee for selected students : (For off-line participants : Rs. 200/- and for on-line participants : Rs. 100/-)
- Last date for receipt of application : June 15, 2022
- Applications should reach only through the link mentioned below

The Workshop is aimed at motivating physics students in advancing their knowledge through inspiring lectures delivered by eminent scientists. Sessions on experiments will be conducted by experienced teachers using simple appliances and computer softwares.

Link for Application : https://forms.gle/xgQJMYr3wpZADFKC8

Before you start to fill out:

Scan the marksheets of the last two semester examinations (UG Honours/Major) and save pdf copies. Now get ready for filling up the form.

Contact Persons : Saswati Dasgupta (saswati_dg@yahoo.com) [09836388638] • Kalyan Mandal (kalyan@bose.res.in) [09163958703] • Sukla Chakraborty (sukla.amc@gmail.com) [09433061636]

Asian Physics Olympiad (APHO)
(Indian Team)

This year the Asian Physics Olympiad was hosted by our country. The event was organized by IAPT APhO Cell at Dehradun from 21st May to 31st May 2022. Because of pandemic situation all over the world for the last two years, APhO-2022 was conducted in ON LINE mode. The participating students, Leaders and Observers of each country were required to assemble together at some suitable venue in the respective country. The Indian Team consisting of 8 students, 2 Leaders and 2 Scientific Observers, participated in APhO-2022 from Ramniranjan Jhunjhunwala College, Mumbai. I was entrusted the responsibility to organize APhO for the Indian Team at Mumbai.

Based on the performance in IOQ part 1 (equivalent to NSEP) and IOQ part 2 (equivalent to INPhO), the following 8 students were selected to represent India at APhO-2022.

1) Mahit Gadhiwala, Scholar English Academy, Surat
2) Divyanshu Malu, KIIT International School, Bhubaneswar
3) Anilesh Bansal, Delhi Public School, Faridabad
4) Polisetty Karthikeya, Sri Chaitanya Co-Ed Jr. College, Gudavalli
5) Harsh Jakhar, Bal Vidya Niketan Sr. Sec. School, Chandigarh
6) Arudeep Kumar, Adarsh Vikas Vidyalaya, Patna
7) Abhijit Anand, Disha Drlphi Public School, Kota
8) Dheeraj Kurkanda, Narayana Jr. College, Hyderabad

Prof. Rekha Ghorpade, Mumbai and Prof. Usha Singh,Indore worked as the Leaders of the Indian Team. Further Prof. C. K. Desai, Pune and Prof. Leena Joshi, Mumbai were the Scientific Observers at this event. Principal Dr. Himanshu Dawada provided enthusiastic support to the idea of conducting APhO-2022 at Jhunjhunwala College, Mumbai. Under his leadership the entire programme was successfully organized from 21st May to 31st May 2022. Prin. Dawada and staff of the college offered a very warm and heartful welcome to the eight participating students.

Prof.Neeta Srivastava, the HOD-Physics provided active cooperation through out the event. All the members of the Indian Team were greatly benefited by her guidance and training. Prof. Rekha Ghorpade, Leader of the Indian Team, no doubt played a central role in coordinating academic and organizational requirements of the programme. Contribution of the other Leader Prof. Usha Singh greatly enhanced the utility of the event aimed at promoting excellence in physics among the students selected to compete in APhO-2022. Scientific Observers Prof. C. K. Desai and Prof. Leena Joshi played a crucial role to ensure that the entire event was executed satisfactorily as planned.

My grateful thanks to Prof. Kiran Kolwankar and Prof. Hemant Vernekar for efficient handling of the computer systems necessary for on-line organization of the event without a single mistake and without slightest delay. I am grateful to Supervisors Prof. Adwait Kulkarni, Prof. Rohit Choudhari, Prof. Rehanuddin Shaikh and Prof. Sanjay Vishwakarma for their tireless work throughout the programme to help the participating students to get printed question papers available on-line just before the start of the exams. Also the answer Sheets of the students were uploaded efficiently at the right time by this team of supervisors.

I am extremely thankful to Dr. Anwesh Mazumdar (National Coordinator, Science Olympiads) for his help in providing accommodation to APHO students and supervisors in HBCSE hostel. All the participating students were quite sincere and faced the competition confidently. This year we could not provide any trainingto the students due to delayed schedule of CBSE, IIT-JEE and other examinations in the country. Still the performance of our students produced one Silver Medal, four Bronze Medals and one Honorable Mention. The overall results of individual students are as follows-

(i) Divyanshu Malu ….. Silver Medal

(ii) Mahit Gadhiwala ….. Bronze Medal

(iii) Anilesh Bansal ….. Bronze Medal

(iv) Harsh Jakhar ….. Bronze Medal

(v) Dheeraj Kurkunda ….. Bronze Medal

(vi) Polisetty Karthikeya ….. Honorable Mention

My heartful congratulations to all these medalists.

M. L. Ogalapurkar
Coordinator, APhO-2022 (Indian Team)
And Member, IAPT APhO Cell

Summer School in Physics

Mumbai SubRC-8B organized a 10-day summer school in theoretical Physics in collaboration with Wilson College from 1st June to 11th June 2022. The aim of summer school was to orient the students towards problem solving. The areas of problem solving were: optics, statistical mechanics, electrostatics and relativity. This is the sixth year of organizing such summer schools in Physics.

In all 38 students registered for the programme from following colleges: (Wilson College (6), Ruparel College (12), Jai Hind College (7), K. J.Somaiya College (4), St. Xavier's College (3), S.I.E.S. College (2) and one each from KC College, Sathaye College, Ruia College and Vivekanand Education Society's College)

The guest for inaugural lecture was Prof. B. N. Jagatap (Retired from BARC). He gave lecture on **"We and Sustainability Science"**. He focused on how local problems can be addressed by science students through their understanding of science. He gave various illustrative examples and his own experience in this field. Vice principal of Wilson College and EC members of Mumbai sub-regional council were present for the function.

The Summer School in general focused on enhancing physics problem solving capabilities of students. Resource persons had prepared daily problem sheets and students were encouraged to solve the problems themselves. Some assignments were also assigned through google classroom. It was indeed a pleasure to see students interacting and solving problems for more than six hours daily for these ten days. We also involved three facilitators who along with resource persons helped the participants in problem solving by providing hints at individual or group level. Facilitators also helped in evaluating home assignments.

The resource persons were:

- Relativity: Ms.Hemalatha Deshpande (retired from Vivekanand College)
- Electrostatics: Mr. Ganesh Madkaikar (D. G. Ruparel College)
- Statistical mechanics: Dr.ShyamalaBodhane (retired from St. Xavier's college) and Dr Shantanu Kadam (Dnyanasadhana college)
- Optics: Mr. Mahesh Shetti (Wilson College)

The three facilitators were Mr. Rohit Patil, Ms. Ninisha Patil and Ms. Shareen Khan (all three alumni of Wilson College Physics Department).

Following enrichment sessions were also conducted:

- Dr. Atul Mody on k-transform method in relativity, which gave an alternate method to connect with the topic of relativity.
- Dr. Vinita Navalkar on "Photography: writing with light" which provided value addition to the topic of optics by connecting it to the real-life application.
- Mr. A. M. Shaker on "Essentials in Experimental Physics" which oriented students for laboratory practices as with coming academic year, full fledge offline labs will start.
- Prof. H. G. Salunke from BARC on "applications of statistical mechanics" which connected the theme of statistical mechanics with its real life applications and modelling.

Students were served breakfast, lunch and evening tea, daily as a part of local hospitality for all days. The day would start at 8:30 am and end by 5pm, after addressing difficulties of participants in specific areas of various assignments.

The valedictory function for the Summer School was on 11th June 2022. Prof. H. G. Salunke was the chief guest and Prof. Anna Pratima Nikalje, Principal of Wilson College presided over. General Secretary Ms Rekha Ghorpade was the special invitee. She is also ex-officio member of Mumbai Sub RC. Mumbai EC members viz Dr.Atul Mody (President), Dr. K.G.Bhole (Secretary), Dr.Shyamala Bodhane (Treasurer) hosted the programme. Dr. Bodhane coordinated the Valedictory. Mr. Mahesh Shetti presented the report of the 10-day Summer School. Some student participants and one facilitator expressed their observations of the 10-day programme. Dignitaries spoke to encourage students and organisers. Certificates to all the participants were given away at the hands of dignitaries. Students who showed consistent performance in class, proactively helped peers and submitted timely home assignments were given Merit Certificates at the hands of Wilson College Principal, Prof. Anna Nikalje. Prof. Hemlatha Deshpande proposed the vote of thanks.

Mahesh Shetti
Coordinator

NATIONAL GRADUATE PHYSICS EXMINATION - 2022

The examination was conducted by IAPT on 27.03.2022 at 223 centres in India with an enrolment of 6400 students.

STATE TOPPERS (TOP 1% OF THE STATE ENROLMENT)

Sr. no.	Centre No.	Roll No.	Candidates Name	Gen	Class	College
	Delhi					
1	G-1109	22457	HARSHIT SETHI	M	BSc III	ST. STEPHEN'S COLLEGE, UNIVERSITY OF DELHI (DL)
	Haryana					
2	G-1212	22011	ANNU	F	BSc III	GOVT COLLEGE FOR WOMEN ROHTAK (HR)
3	G-1212	22010	SHEETAL	F	BSc III	GOVT COLLEGE FOR WOMEN ROHTAK (HR)
	Punjab					
4	G-1433	22404	R. DEVANARAYANAN	M	BSc II	LOVELY PROFESSIONAL UNIVERSITY PHAGWARA (Pb)
5	G-2200	22407	UTKARSH BAJPAI	M	Int. MSc III	INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH MOHALI (Pb)
6	G-1435	22009	HARJAGANJOT KAUR	F	BSc III	AKAL UNIVERSITY TALWANDI SABO (Pb)
	Chandigarh					
7	G-1606	22406	SHIVANGI	F	BSc III	PANJAB UNIVERSITY CHANDIGARH
	Himanchal Prades					
8	G-1712	22401	PIYUSH DOGRA	M	BSc III	GOVT. PG COLLEGE SOLAN (HP)
	Jammu & Kashmir					
9	G-1817	22408	SHAKIR SHAFI	M	BSc II	GOVT DEGREE COLLEGE BOYS ANANTNAG (J&K)
10	G-1817	22409	MUZAMIL RASHID LONE	M	BSc II	GOVT DEGREE COLLEGE BOYS ANANTNAG (J&K)
	Uttar Pradesh & U					
11	G-2129	22438	SHRADDHANJALI CHOUDHURY	F	BSc III	BANARAS HINDU UNIVERSITY VARANASI (UP)
12	G-2188	22407	ABHIJITH REDDY DASARI	M	B Tech II	I.I.T. ROORKEE (UK)
13	G-2188	22414	SHIVAM SINGH ASWAL	M	Int .M.Sc.II	I.I.T. ROORKEE (UK)
14	G-2129	22401	SHIVANI	F	BSc III	MAHILA MAHAVIDALYA, BANARAS HINDU UNIVERSITY VARANASI (UP)
15	G-2161	22005	DEVESH YADAV	M	BSc II	EWING CHRISTIASN COLLEGE ALLAHABAD (UP)
16	G-2210	22001	KAUSTUBH SINGH	M	B.Sc. II	SHIV NADAR UNIVERSITY (UP)
17	G-2188	22423	HARSHINI PARANJAPE	F	Int.M.Sc.III	I.I.T. ROORKEE (UK)
18	G-2210	22403	BHUMI VERMA	F	BSc III	SHARDA UNIVERCITY GREATER NOIDA (UP)
19	G-2129	22413	SAURABH RAI	M	BSc III	INSTITUTE OF SCIENCE, BANARAS HINDU UNIVERSITY VARANASI (UP)
20	G-2188	22412	RAJNISH KUMAR JHA	M	Int .M.Sc.II	I.I.T. ROORKEE (UK)
	Rajasthan					
21	G-3117	22007	KESHAV MISHRA	M	BSc I	UNIVSERSITY MAHARAJA COLLEGE JAIPUR (RJ)
	Gujarat					
22	G-3607	22405	BARIYA HET KALPESHKUMAR	M	BSc II	MAHARAJA SAYAJIRAO UNIVERSITY VADODARA (GJ)
23	G-3609	22020	PATEL SAGARKUMAR BALVANTRAY	M	BSc III	B. P. BARIA SCIENCE INSTITUTE NAVSARI (GJ)
24	G-3604	22401	SAKSHI TRIVEDI	F	BSc III	ST. XAVIERS COLLEGE NAVRANGPURA, AHMEDABAD (GJ)

	Goa					
25	G-4004	22404	JAIMUNNISA KAMALSAB KANIKYANAV	F	BSc III	CARMEL COLLEGE FOR WOMEN NUVEM (GOA)
	Maharashtra					
26	G-4172	22001	NISHANT	M	BSc III	WILSON COLLEGE CHOWPATTY, MUMBAI (MH)
27	G-4187	22010	Ku. SAMIKSHA DONGE	F	BSc III	GURU NANAK COLLEGE OF SCIENCE BALLARPUR (MH)
28	G-4227	22028	RANE RENUKA VILAS	F	BSc III	SHRI SH KELKAR COLLEGE OF ARTS,COMMERCE AND SCIENCE DEVGAD (MH)
29	G-4213	22414	KSHITIJ VERMA	M	Int. MSc I	INDIAN INSTITUTE OF SCIENCE EDUCATION & RESEARCH PUNE (MH)
30	G-4223	22011	ADITYA SANTOSH GAGARE	M	B.Sc. II	SIR PARASHURAM BHAU COLLEGE PUNE (MH)
31	G-4162	22401	SHREYAS BAKARE	M	BSc II	INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH PUNE (MH)
32	G-4187	22007	Ku. KRUTIKA KASTURE	F	BSc III	GURU NANAK COLLEGE OF SCIENCE BALLARPUR (MH)
33	G-4213	22421	ANIKET SENGUPTA	M	BSc II	INDIAN INSTITUTE OF SCIENCE EDUCATION & RESEARCH PUNE (MH)
34	G-4187	22008	Ku. AMITA SATPUTE	F	BSc III	GURU NANAK COLLEGE OF SCIENCE BALLARPUR (MH)
35	G-4244	22065	SAKSHIASHOKRAOKORAT	F	B. Sc. II	SHRI Dr. R G RATHOD ARTS & SCIENCE COLLEGE MURTIZAPUR (MH)
36	G-4246	22015	RAZAUL RARIM	M	BSc III	AKI'S POONA COLLEGE OF ARTS, SCIENCE & COMMERCE CAMP PUNE (MH)
37	G-4246	22017	JIBRAN ATTAR	M	BSc II	AKI'S POONA COLLEGE OF ARTS, SCIENCE & COMMERCE CAMP PUNE (MH)
	Chattishgarh & MP					
38	G-4543	22401	RAJNISH KUMAR TANDON	M	BSc III	GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (CG)
39	G-4543	22405	GULDEEP GAVEL	M	BSc III	GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (CG)
	Andhra Pradesh					
40	G-5153	22403	SHIVAM KUMAR	M	BSc III	INDIAN INSTITUTE OF SCIENCE EDUCATION & REASEARCH TIRUPATI (AP)
41	G-5148	22041	CH VINAY KUMAR	M	BSc I	SRI GCSR COLLEGE SRIKAKULAM (AP)
42	G-5153	22407	KSHITIJ SINHA	M	BSc III	INDIAN INSTITUTE OF SCIENCE EDUCATION & REASEARCH TIRUPATI (AP)
	Karnataka					
43	G-5628	22411	ARYAN HINGWE	M	BSc II	INDIAN INSTITUTE OF SCIENCE BANGALORE (KA)
44	G-5640	22402	SAGAR J C	M	BSc III	ST. JOSEPH'S COLLEGE (AUTONOMOUS) BENGALURU (KA)
45	G-5658	22406	TANUSHREE .N	F	BSc I	BASAVESHWARA COLLEGE OF COMMERCE, ARTS & SCIENCE RAJAJINAGAR (KA)
	Tamilnadu					
46	G-6111	22003	S. JAIDEEP VIMAL JOTHI	M	B.Sc. III	ST. XAVIER'S COLLEGE (AUTONOMUS) PALAYAMKOTTAI (TN)
47	G-6158	22061	VIDHYA E.	F	BSc I	GOBI ARTS AND SCIENCE COLLEGE (AUTONOMOUS) GOBICHETTIPALAYAM (TN)
48	G-6160	22055	SNEHA M	F	BSc II	SRI GVG VISALAKSHI COLLEGE FOR WOMEN UDUMALPET (TN)
49	G-6151	22018	NAVEENA .S	F	B.Sc. III	VELLALAR COLLEGE FOR WOMEN ERODE (TN)
50	G-6157	22043	ARUNA DEVI	F	BSc II	V V VANNIAPERUMAL COLLEGE FOR WOMEN VIRDHUNAGAR (TN)
51	G-6102	22401	ASRAR AHMED	M	BSc II	ST. JOSEPH'S COLLEGE TRICHY (TN)
52	G-6158	22126	SUGANYA. G	F	BSc II	GOBI ARTS AND SCIENCE COLLEGE (AUTONOMOUS) GOBICHETTIPALAYAM (TN)
53	G-6176	22017	R.S. VARSHA	F	B.Sc III	NESAMONY MEMORIAL CHRISTIAN COLLEGE MARTHANDAM (TN)
54	G-6107	22002	S. AISHWARYA	F	BSc III	FATIMA COLLEGE MADURAI (TN)
55	G-6107	22038	N. SUSMITHA	F	BSc III	FATIMA COLLEGE MADURAI (TN)
56	G-6141	22004	SIDDARTH	M	BSc III	NALLAMUTHU GOUNDER MAHALINGAM COLLEGE POLLACHI COIMBATORE (TN)
57	G-6172	22005	RACHNA A	F	BSc III	STELLA MARIS COLLEGE CHENNAI (TN)
58	G-6190	22015	VISHNUPRIYA R	F	BSc III	JUSTICE BASHEER AHMED SAYEED COLLEGE FOR WOMEN (AUTONOMOUS) (TN)

		Kerala				
59	G-6804	22401	MEGHA K M	F	BSc III	UNION CHRISTIAN COLLEGE ALUVA (KL)
60	G-6858	22042	ARCHANA SANTHOSH	F	BSc III	CKG MEMORIAL GOVERNMENT COLLEGE PERAMBRA (KL)
61	G-6814	22444	HUDA THASNEEM A M	F	Bc III	PROVIDENCE WOMEN'S COLLEGE MALAPARAMBA, KOZHIKODE (KL)
		West Bangal				
62	G-7103	22426	SAPTAPARNA MAIKAP	F	BSc III	MIDNAPORE COLLEGE MIDNAPORE (WB)
63	G-7110	22022	KRITTIKA SARKAR	F	B.Sc. I	LADY BRABOURNE COLLEGE KOLKATA (WB)
64	G-7103	22024	SOMASHREE JANA	F	BSc II	MIDNAPORE COLLEGE MIDNAPORE (WB)
65	G-7103	22026	RISHIKESH MAITY	M	BSc III	MIDNAPORE COLLEGE MIDNAPORE (WB)
66	G-7129	22472	ANANYA BANDYOPADHYAY	F	BSc III	ST. XAVIER'S COLLEGE (AUTONOMOUS) KOLKATA (WB)
		Odisha				
67	G-7522	22018	ROHAN PATTANAYAK	M	BSc III	FAKIR MOHAN (AUTONOMOUS) COLLEGE BALASORE (OD)
68	G-7543	22018	ABHA VISHWAKARMA	F	Int. MSc I	NATIONAL INSTITUTE OF SCIENCE EDUCATION AND RESEARCH BHUBANESWAR (OD)
69	G-7543	22028	ANISH DASH	M	Int. MSc I	NATIONAL INSTITUTE OF SCIENCE EDUCATION AND RESEARCH BHUBANESWAR (OD)
70	G-7543	22049	ANNA BINOY	F	Int. MSc I	NATIONAL INSTITUTE OF SCIENCE EDUCATION AND RESEARCH BHUBANESWAR (OD)
		Assam				
71	G-7821	22008	SHYAMALIMA SARMA	F	BSc III	GUWAHATI COLLEGE GUWAHATI (AS)
72	G-7817	22017	PARASHIMANI KALITA	M	BSc III	RANGIA COLLEGE RANGIA KAMRUP (AS)
		Tripura				
73	G-7909	22405	PALLABI SAHA	F	BSc III	WOMEN'S COLLEGE AGARTALA (TR)
		Bihar & JH				
74	G-8131	22408	DEWESH KUMAR CHOUDHARY	M	BSc III	DEEP NARAYAN SINGH COLLEGE BHUSIA, RAJOUN, BANKA (BR)

Prof B P Tyagi
Chief Coordinator (Examination)
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NATIONAL GRADUATE PHYSICS EXAMINATION - 2022
Registered centres of NGPE - 2022

S No	Centre	NAME OF INSTITUTION (REGISTERED CENTRES)	On line	Off line	TOTAL
1	G-1102	SHIVAJI COLLEGE , UNIVERSITY OF DELHI		21	**21**
2	G-1109	MIRANDA HOUSE, UNIVERSITY OF DELHI	67	13	**80**
3	G-1203	DAYAL SINGH COLLEGE KARNAL (HR)	7	101	**108**
4	G-1212	GOVT COLLEGE FOR WOMEN ROHTAK (HR)	1	35	**36**
5	G-1221	J. V. M. G. R. R. COLLEGE CHARKHI DADRI, BHIWANI (HR)		10	**10**
6	G-1226	ADARSH MAHILLA MAHAVIDYALAYA BHIWANI (HR)	4	19	**23**
7	G-1405	KHALSA COLLEGE AMRITSAR (Pb)	2	32	**34**
8	G-1410	HANSRAJ MAHILA MAHAVIDYALYA JALANDHAR (Pb)		10	**10**
9	G-1414	KHALSA COLLEGE WOMEN LUDHIYANA (Pb)	2	46	**48**
10	G-1422	KANYA MAHA VIDYALAYA JALANDHAR (Pb)		26	**26**
11	G-1427	S D COLLEGE BARNALA (Pb)	2	43	**45**
12	G-1429	D A V COLLEGE BATHINDA (Pb)	2	4	**6**
13	G-1431	GURU NANAK COLLEGE FOR GIRLS SRI MUKTSAR SAHIB (Pb)		45	**45**
14	G-1433	LOVELY PROFESSIONAL UNIVERSITY PHAGWARA (Pb)	9		**9**
15	G-1435	AKAL UNIVERSITY TALWANDI, SABO BATHINDA (Pb)		23	**23**
16	G-1437	PUNJABI UNIVERSITY PATIALA (Pb)	27		**27**
17	G-1605	G.G.D.S.D. COLLEGE SECTOR 32 – C, CHANDIGARH	6	22	**28**
18	G-1606	P.G. GOVT COLLEGE FOR GIRLS SECTOR-11, CHANDIGARH	12	15	**27**
19	G-1703	GOVT. DEGREE COLLEGE DHARAMSHALA (HP)	11		**11**
20	G-1712	GOVT. PG COLLEGE SOLAN (HP)	2	4	**6**
21	G-1724	RAJKIYA KANYA MAHAVIDHYALYA SHIMLA (HP)	6		**6**
22	G-1726	GOVERNMENT COLLEGE BARSAR, HAMIRPUR HP		27	**27**
23	G-1727	GOVERNMENT DEGREE COLLEGE SHAHPUR, DIST KANGRA (HP)		11	**11**
24	G-1805	GOVERNMENT COLLEGE OF WOMEN PARADE, JAMMU (J&K)		34	**34**
25	G-1809	GCW GANDINAGAR, JAMMU (J&K)	18	15	**33**
26	G-1817	GOVT DEGREE COLLEGE BOYS ANANTNAG (J&K)	15		**15**
27	G-1820	J & K INSTITUTE OF MATHEMATICAL SCIENCES GOGJI BAGH SRINAGAR (J&K)	2	7	**9**
28	G-1823	GOVERNMENT DEGREE COLLEGE BILLAWAR (J&K)		5	**5**
29	G-1825	SCHOOL OF PHYSICS SMVD UNIVERSITY KATRA (J&K)	30		**30**
30	G-1826	GOVERNMENT DEGREE COLLEGE MENDHAR, POONCH (J&K)		24	**24**
31	G-2101	ALIGARH MUSLIM UNIVERSITY ALIGARH (UP)	4	8	**12**
32	G-2103	D B S COLLEGE KANPUR (UP)	2	6	**8**
33	G-2104	D B S (PG) COLLEGE KARANPUR, DEHRADUN (UTTARAKHAND)	11	12	**23**
34	G-2106	S D COLLEGE MUZAFFARNAGAR (UP)		16	**16**
35	G-2108	MMH COLLEGE GHAZIABAD (UP)	3	15	**18**
36	G-2112	RCU GOVERNMENT PG COLLEGE UTTARKASHI (UTTARAKHAND)		19	**19**
37	G-2121	HINDU COLLEGE MORADABAD (UP)	1	14	**15**
38	G-2129	BANARAS HINDU UNIVERSITY VARANASI (UP)	35		**35**
39	G-2135	MS COLLEGE SAHARANPUR (UP)	5	6	**11**
40	G-2142	D.D.U. GORAKHPUR UNIVERSITY GORAKHPUR (UP)	6	69	**75**

41	G-2151	VARDHAMAN (PG) COLLEGE BIJNOR (UP)	18	30	**48**
42	G-2154	D A V COLLEGE MUZAFFAR NAGAR (UP)	1	4	**5**
43	G-2161	EWING CHRISTIASN COLLEGE ALLAHABAD (UP)	12	21	**33**
44	G-2167	Dept. OF PHYSICS, SHUATS PRAYAGRAJ (UP)		10	**10**
45	G-2172	BAREILLY COLLEGE BAREILLY (UP)	5	20	**25**
46	G-2173	S S COLLEGE SHAHJAHANPUR (UP)	1	68	**69**
47	G-2177	KNIPSS SULTANPUR (UP)		100	**100**
48	G-2188	I.I.T ROORKEE (UTTARAKHAND)	26		**26**
49	G-2190	NATIONAL PG COLLEGE LUCKNOW (UP)	5	124	**129**
50	G-2196	ISABELLA THOBURN COLLEGE LUCKNOW (UP)	14		**14**
51	G-2198	K N GOVT PG COLLEGE GYANPUR BHADOHI (UP)		68	**68**
52	G-2199	S G R R (PG) COLLEGE DEHRADUN (UTTARAKHAND)	8	13	**21**
53	G-2200	ST JOHN'S COLLEGE AGRA (UP)	8	3	**11**
54	G-2201	KB (PG) COLLEGE MIRJAPUR (UP)		17	**17**
55	G-2203	GOVT. PG COLLEGE BERINAGH, DISTT- PITHORAGARH (UTTARAKHAND)		18	**18**
56	G-2204	K L DAV PG COLLEGE ROORKEE (UTTARAKHAND)	1	8	**9**
57	G-2205	ARMY CADET COLLEGE IMA DEHRADUN (UTTARAKHAND)		20	**20**
58	G-2209	GOVT. PG COLLEGE BUDAUN (UP)	1	36	**37**
59	G-2210	SHIV NADAR UNIVERSITY (UP)	11	10	**21**
60	G-2217	MAHAMAYA GOVT DEGREE COLLEGE KAUSHAMBI (UP)		40	**40**
61	G-2218	PROF. RAJENDRA SINGH(RAJJU BHAIYA) INSTITUTE OF PHYSICAL SCIENCES FOR STUDY AND RESEARCH, V.B.S.P.UNIVERSITY, JAUNPUR (UP)		20	**20**
62	G-2219	GOVERNMENT PG COLLEGE OBRA SONBHDRA UP		22	**22**
63	G-3117	DEPT. OF PHYS. RAJASTHAN UNIVERSITY (JAIPUR)	11	19	**30**
64	G-3118	DEPT. OF PHYS. IIS(DEEMED TO BE UNIVERSITY), JAIPUR	2	34	**36**
65	G-3119	REGIONAL INSTITUTE OF EDUCATION (AJMAR)	2	12	**14**
66	G-3120	SS JAIN SUBODH PG (AUTO) COLLEGE (JAIPUR)	5	45	**50**
67	G-3601	H & HB KOTAK INSITUTE OF SCIENCE RAJKOT (GUJ)		48	**48**
68	G-3604	M.G SCIENCE INSTITUTE, NAVRANGPURA, AHMEDABAD (GUJ)	9	15	**24**
69	G-3606	J & J COLLEGE OF SCIENCE NADIAD (GUJ)		19	**19**
70	G-3607	THE M.S. UNIVERSITY OF BARODA, VADODARA (GUJ)	12		**12**
71	G-3609	B.P.BARIA SCIENCE INSTITUTE, NAVSARI (GUJ)		58	**58**
72	G-3611	V.P. & R.P.T.P. SCIENCE COLLEGE VALLABH VIDYANAGAR (GUJ)	13	14	**27**
73	G-3619	BAHAUDDIN SCIENCE COLLEGE JUNAGADH (GUJ)		30	**30**
74	G-3621	CHRIST COLLEGE RAJKOT (GUJ)		12	**12**
75	G-3624	SIR P T SARVAJANIK COLLEGE OF SCICENCE SURAT (GUJ)	9	5	**14**
76	G-3626	SHETH M N SCIENCE COLLEGE PATAN (NORTH GUJARAT)		27	**27**
77	G-3631	BHAVAN'S SHRI I.L. PANDYA ARTS, SCIENCE AND SMT. J.M. SHAH COMMERCE COLLEGE DAKOR, KHEDA (GUJ)		30	**30**
78	G-3639	M.N. COLLEGE VISNAGAR (GUJ)	2	3	**5**
79	G-4004	CARMEL COLLEGE FOR WOMEN NUVEM (GOA)	20		**20**
80	G-4102	RAMNARAIN RUIA COLLEGE MATUNGA, MUMBAI (MH)	44		**44**

81	G-4105	FERGUSSON COLLEGE PUNE (MH)	40		**40**
82	G-4106	SANGAMESHWAR COLLEGE SOLAPUR (MH)		48	**48**
83	G-4107	DBF DAYANAND COLLEGE OF ARTS AND SCIENCE SOLAPUR (MH)		28	**28**
84	G-4114	GOVT INSTITUTE OF SCIENCE NAGPUR (MH)	11	4	**15**
85	G-4117	SMT. C H M COLLEGE ULHASNAGAR THANE (MH)	8		**8**
86	G-4118	R N JHUNJHUNWALA COLLEGE (AUTO) GHATKOPAR (W) MUMBAI (MH)		7	**7**
87	G-4128	RNC ARTS JDB COMMERCE & NSC SCIENCE COLLEGE NASHIK ROAD(MH)		22	**22**
88	G-4159	YOGESHWARI MAHAVIDYALYA, AMBAJOGAI DIST BEED (MH)		12	**12**
89	G-4161	N E S RATNAM COLLEGE BHANDUP MUMBAI (MH)		25	**25**
90	G-4162	VIVEKANAND COLLEGE KOLHAPUR (MH)	1		**1**
91	G-4163	SHIVAJI ARTS, COMMERCE AND SCIENCE COLLEGE KANNAD Dt., AURANGABAD (MH)	1	18	**19**
92	G-4172	K.J. SOMAIYA COLLEGE OF SCIENCE & COMMERCE MUMBAI (MH)		5	**5**
93	G-4177	HARIBHAI V. DESAI COLLEGE OF ARTS, SCIENCE & COMMERCE, PUNE (MH)		8	**8**
94	G-4187	GURU NANAK COLLEGE OF SCIENCE BALLARPUR (MH)	1	11	**12**
95	G-4194	P.V.P COLLEGE PRAVARANAGAR DIST AHMEDNAGAR (MH)	2	23	**25**
96	G-4195	THAKUR COLLEGE OF SCIENCE AND COMMERCE KANDIVALI MUMBAI (MH)		20	**20**
97	G-4198	M P H MAHILA MAHAVIDYALAYA MALE GAON, NASIK (MH)		20	**20**
98	G-4200	H.P.T. ARTS & R.Y.K. SCIENCE COLLEGE NASHIK (MH)	8	57	**65**
99	G-4202	SANGOLA COLLEGE SANGOLA DIST SOLAPUR (MH)		11	**11**
100	G-4208	S.M. MOHOTA COLLEGE OF SCIENCE NAGPUR (MH)		8	**8**
101	G-4210	K.B.P COLLEGE ISLAMPUR (MH)		15	**15**
102	G-4213	INDIAN INSTITUTE OF SCIENCE EDUCATION & RESEARCH PUNE (MH)	41		**41**
103	G-4216	ANNASAHEB WAGHIRE COLLEGE OTUR Dt PUNE (MH)		13	**13**
104	G-4218	JANKIDEVI BAJAJ COLLEGE OF SCIENCE, WARDHA (MH)		11	**11**
105	G-4223	SIR PARASHURAMBHAU COLLEGE PUNE (MH)	2	14	**16**
106	G-4227	SHRI S H KELKAR COLLEGE OF ARTS & SCIENCE DEVGAD SINDHUDURG (MH)		34	**34**
107	G-4230	ANNASAHEB AWATE COLLEGE MANCHAR, PUNE (MH)		21	**21**
108	G-4231	DEGREE COLLEGE OF ARTS, SCIENCE & COMM. JAMBUL PHATA CHIKLOLI, AMBARNATH, THANE (MH)		10	**10**
109	G-4235	BALWANT COLLEGE VITA (MH)		17	**17**
110	G-4236	RANI LAXMIBAI MAHAVIDHYALAYA PAROLA DIST- JALGAON (MH)		20	**20**
111	G-4238	GOKHALE EDUCATION SOCIETY'S ARTS, COMM. & SCIENCE COLLEGE PALGHAR (MH)		15	**15**
112	G-4244	SHRI Dr. R G RATHOD ARTS & SCI. COLLEGE MURTIZAPUR (MH)		98	**98**
113	G-4246	AKI'S POONA COLLEGE OF ARTS, SCIENCE AND COMMERCE CAMP PUNE (MH)		18	**18**
114	G-4247	VIDYA PRASTISHTHAN'S ARTS SCIENCE & COMMERCE COLLEGE VIDYANAGARI, BARAMATI, PUNE (MH)	1	23	**24**
115	G-4249	K.R.T ARTS, B.H COMMERCE AND A.M SCIENCE COLLEGE NASHIK(MH)		18	**18**
116	G-4250	MUNGASAJI MAHARAJ MAHAVIDYALAYA, DARWHA (MH)		22	**22**

117	G-4251	ARTS, COMMERCE AND SCIENCE COLLEGE, MAREGAON, DIST. YAVATMAL (MH)		50	**50**
118	G-4252	LATE RAJKAMALJI BHARTI ARTS, COMMERCE AND SMT. SUSHILABAI R. BHARTI SCIENCE COLLEGE ARNI, DIST. YAVATMAL (MH)	2	16	**18**
119	G-4253	SHRI VITTHAL RUKHMINI COLLEGE SAWANA, DIST. YAVATMAL (MH)		21	**21**
120	G-4502	K. G. ARTS & SCIENCE COLLEGE RAIGARH (CG)		12	**12**
121	G-4524	HOLY CROSS WOMEN'S COLLEGE AMBIKAPUR (CG)		65	**65**
122	G-4537	St ALOYSIUS COLLEGE JABALPUR (MP)	1	13	**14**
123	G-4542	ST. THOMAS COLLEGE RUABANDHA BHILAI (CG)	6		**6**
124	G-4543	GURU GHASIDAS VISHWAVIDHYALAYA KONI, BILASPUR (CG)	7		**7**
125	G-4553	SHRI VAISHNAV INSTITUTE OF MANAGEMENT INDORE (MP)	2	16	**18**
126	G-4556	GOVT. NAGARJUN P.G. COLLEGE OF SCIENCE RAIPUR (CG)	12		**12**
127	G-4565	INSITITUTE FOR EXCELLENCE IN HIGHER EDUCATION, KALIYASOT DAM KOLAR ROAD, BHOPAL	7		**7**
128	G-5108	M.R COLLEGE VIZIANAGARAM (AP)	2	47	**49**
129	G-5146	SCHOOL OF PHYSICS UNIVERSITY OF HYDERABAD HYDERABAD (TS)	7		**7**
130	G-5148	SRI GCSR COLLEGE (AP)		86	**86**
131	G-5153	INDIAN INSTITUTE OF SCIENCE EDUCATION&REASEARCH TIRUPATI (AP)	17		**17**
132	G-5158	SRI SATHYA SAI INSITUTE OF HIGHER LEARNING, ANANTAPUR CAMPUS (AP)	4		**4**
133	G-5615	MES COLLEGE OF ARTS, COMMERCE AND SCIENCE, BENGALURU		10	**10**
134	G-5625	P C JABIN SCIENCE COLLEGE VIDYANAGAR HUBBLI (KR)	1	49	**50**
135	G-5628	MAHARANI LAKSHMI AMMANI COLLEGE FOR WOMEN AUTO BANGLOARE	14	18	**32**
136	G-5631	POORNAPRAJNA COLLEGE UDUPI KARNATAKA	2	29	**31**
137	G-5632	REGIONAL INSTITUTE OF EDUCATION MANASAGANGOTRI MYSORE	4		**4**
138	G-5635	ST. PHILOMENA'S COLLEGE (AUTO) MYSORE		12	**12**
139	G-5638	KARNATAK ARTS ,SCIENCE AND COMMERCE COLLGE BIDAR (KA)		44	**44**
140	G-5640	ST. JOSEPH'S COLLEGE (AUTONOMOUS), BENGALURU, KARNATAKA	2	7	**9**
141	G-5658	BASAVESHWARA COLLEGE OF COMMERCE ARTS & SCIENCE BENGALURU	13		13
142	G-5659	KLE'S S. NIJALINGAPPA COLLEGE RAJAJINAGAR BGANGALORE (KA)	1	11	**12**
143	G-5660	UNIVERSITY COLLEGE OF SCIENCE TUMKUR UNIVERSITY (KARNATAKA)	2	10	**12**
144	G-5662	JSS ARTS SCIENCE AND COMMERCE COLLEGE GOKAK (KA)		12	**12**
145	G-5663	D V S COLLEGE OF ARTS AND SCIENCE SHIMOGHAA (KR)	1	46	**47**
146	G-5664	SECAB'S A.R.S. INAMDAR ARTS, SCIENCE & COMMERCE COLLEGE FOR WOMEN, VIJAYAPUR (KR)	1		**1**
147	G-5665	CENTRAL UNIVERSITY OF KARNATAKA KADAGANCHI, KALABURAGI (KR)	1		**1**
148	G-6102	SEETHA LAKSHMAI RAMASWAMI COLLEGE TIRUCHIRAPPALI (TN)	7	46	**53**
149	G-6107	FATIMA COLLEGE MADURAI (TN)		73	**73**
150	G-6109	AYYA NADAR JANAKI AMMAL COLLEGE, SIVAKASI (TN)		38	**38**

151	G-6110	THE S.F.R. COLLEGE FOR WOMEN SIVAKASI (TN)		38	**38**
152	G-6111	ST. XAVIER'S COLLEGE (AUTO), PALAYAMKOTTAI, TIRUNELVELI		34	**34**
153	G-6114	LADY DOAK COLLEGE TALLAKULAM, MADURAI (TN)	23		**23**
154	G-6131	ARUL ANANDAR COLLEGE KARUMATHUR (TN)	46		**46**
155	G-6134	SARASWATHI NARAYANAN COLLEGE MADURAI (TN)		71	**71**
156	G-6135	HOLY CROSS COLLEGE NAGERCOIL (TN)	1	54	**55**
157	G-6137	THE MADURA COLLEGE MADHURAI (TN)	1	36	**37**
158	G-6140	SRI RAMAKRISHNA MISSION VIDYALAYA COLLEGE CAS COIMBATORE (TN)		16	**16**
159	G-6141	N.G.M COLLEGE POLLACHI, COIMBATORE (TN)		30	**30**
160	G-6151	VELLALAR COLLEGE FOR WOMEN ERODE (TN)	1	79	**80**
161	G-6157	V V VANNIAPERUMAL COLLEGE FOR WOMEN VIRDHUNAGAR (TN)		76	**76**
162	G-6158	GOBI ARTS AND SCIENCE COLLEGE (AUTONOMOUS) GOBICHETTIPALAYAM (TN)		228	**228**
163	G-6160	SRI GVG VISALAKSHI COLLEGE FOR WOMEN UDUMALPET (TN)		85	**85**
164	G-6161	ST. JOHN'S COLLEGE PALAYAMKOTTAI (TN)		40	**40**
165	G-6163	WOMEN'S CHRISHAN COLLEGE NAGERCOIL (TN)		54	**54**
166	G-6165	SRI KALISWARI COLLEGE (AUTO) SIVAKASI (TN)		30	**30**
167	G-6172	STELLA MARIS COLLEGE CHENNAI (TN)	13	19	**32**
168	G-6173	SRI SARDA COLLEGE FOR WOMEN (AUTONOMUS) TIRUNELVELI (TN)		80	**80**
169	G-6176	NESAMONY MEMORIAL CHRISTIAN COLLEGE MARTHANDAM (TN)		17	**17**
170	G-6189	CHEVALIER T.THOMAS ELIZABETH COLLEGE FOR WOMEN PERAMBUR, CHENNAI (TN)		13	**13**
171	G-6190	JUSTICE BASHEER AHMED SAYEED COLLEGE FOR WOMEN (Autonomous) CHENNAI (TN)		34	**34**
172	G-6801	GOVT. VICTORIA COLLEGE PALAKKAD (KR)	1	18	**19**
173	G-6804	UNION CHRISTIAN COLLEGE ALUVA (KR)	14		**14**
174	G-6813	ST. XAVIER’S COLLEGE FOR WOMEN ALUVA (KR)		16	**16**
175	G-6814	FAROOK COLLEGE (AUTO) KOZHIKKODE (KR)	45		**45**
176	G-6829	MORNING STAR HOME SCIENCE COLLEGE ANGAMALY S, ERANAKULAM (KR)		13	**13**
177	G-6837	ASSUMPTION COLLEGE (AUTO) CHANGANACHERRY (KR)		23	**23**
178	G-6838	SULLAMUSSALAM SCIENCE COLLEGE AREEKODE (KR)		18	**18**
179	G-6841	MAR ATHANASIUS COLLEGE KOTHAMANGALAM (KR)	3		**3**
180	G-6842	BHARAT MATA COLLAGE THRIKKAKARA (KR)		15	**15**
181	G-6843	VIMALA COLLEGE (AUTONOMOUS) THRISSUR (KR)	5	18	**23**
182	G-6844	ST. DOMINIC'S COLLEGE KANJIRAPALLY (KR)		20	**20**
183	G-6849	MOUNT SEENA COLLEGE OF ARTS & SCIENCE AKALUR, PALAKKAD (KR)		13	**13**
184	G-6856	MAHATAMA GANDHI COLLEGE IRITTY, KANNUR (KR)		26	**26**
185	G-6858	CKG MEMORIAL GOVERNMENT COLLEGE PERAMBRA (KR)		42	**42**
186	G-7103	MIDNAPORE COLLEGE MIDNAPORE (WB)	39	36	**75**
187	G-7108	PRABHAT KUMAR COLLEGE CONTAI (WB)	1	30	**31**

188	G-7110	LADY BRABOURNE COLLEGE KOLKATA (WB)	10	22	**32**
189	G-7113	R. K. MISSION VIDYAMNDIRA BELUR MATH, HOWRAH (WB)	16		**16**
190	G-7114	MALDA COLLEGE MALDA (WB)	5	16	**21**
191	G-7120	BURDWAN RAJ COLLEGE BURDWAN (WB)	13		**13**
192	G-7124	R K M V CENTENARY COLLEGE RAHARA (WB)	50		**50**
193	G-7129	BANGABASI COLLEGE KOLKATA (WB)	71		**71**
194	G-7135	BIDHAN CHANDRA COLLEGE ASANSOL (WB)	25	17	**42**
195	G-7137	SURYA SEN MAHAVIDYALAYA SILIGURI (WB)	10		**10**
196	G-7501	B.J.B AUTONOMOUS UNIVERSITY BHUBANESWAR (OD)	9	27	**36**
197	G-7502	RAVENSHAW UNIVERSITY CUTTACK (OD)	16		**16**
198	G-7517	MUNICIPAL COLLEGE ROURKELA (OD)	4	31	**35**
199	G-7522	FAKIR MOHAN (AUTONOMOUS) COLLEGE BALASORE (OD)	3	21	**24**
200	G-7524	BANKI COLLEGE AUTONOMOUS BANKI, CUTTACK (OD)		13	**13**
201	G-7532	COLLEGE OF BASIC SCIENCE AND HUMANITIES OUAT, BHBANESHWAR		12	**12**
202	G-7542	NAYAGARH AUTONOMOUS COLLEGE NAYAGARH (ODISHA)	1	15	**16**
203	G-7543	NISER BHUBANESWAR JATNI, KHURDA (OD)	2	80	**82**
204	G-7549	MAHARISHI COLLEGE OF NATURAL LAW SAHID NAGAR, BHUBANESWAR		13	**13**
205	G-7555	RAJENDRA UNIVERSITY BALANGIR (OD)		16	**16**
206	G-7556	RAYAGADA(AUTO) COLLEGE RAYAGADA (OD)		27	**27**
207	G-7558	IISER BERHAMPUR (OD)	21		**21**
208	G-7560	GOVT. COLLEGE (AUTONOMOUS) ANGUL (OD)	39		**39**
209	G-7562	ANCHAL COLLEGE PADAMPUR (OD)		25	**25**
210	G-7801	GURUCHARAN COLLEGE SILCHAR (AS)	2	7	**9**
211	G-7805	GOALPARA COLLEGE GOALPARA (AS)		18	**18**
212	G-7807	PRAGJYOTISH COLLEGE SANTIPUR, GUWAHATI (AS)	18	20	**38**
213	G-7810	DAKSHIN KAMRUP COLLEGE MIRZA KAMRUP (AS)		47	**47**
214	G-7817	RANGIA COLLEGE GUWAHATI, KAMRUP (AS)		23	**23**
215	G-7818	TANGLA COLLEGE TANGLA (AS)	1	10	**11**
216	G-7821	GUWAHATI COLLEGE BAMUNIMAIDAN GUWAHATI (AS)		11	**11**
217	G-7906	ISWARCHANDRA VIDYASAGAR COLLEGE BELONIA, TRIPURA	22		**22**
218	G-7909	RAMTHAKUR COLLEGE AGARTALA, TRIPURA	5	18	**23**
219	G-7910	RAMKRISHNA MAHAVIDYALAYA UNAKOTI, TRIPURA	1	12	**13**
220	G-8125	RAM LAKHAN SINGH YADAV COLLEGE KOKAR, RANCHI (JH)	9	37	**46**
221	G-8128	CENTRAL UNIVERSITY OF SOUNTH BIHAR GAYA (BR)	3		**3**
222	G-8131	COLLEGE OF COMMERCE, ARTS AND SCIENCE PATILIPUTRA UNIVERSITY KANKARBAGH, PATNA (BR)	12		**12**
223	G-8134	MARKHAM COLLEGE OF COMMERCE HAZARIBAG (JH)	3	25	**28**
		Total Enrolment Student (Online+Offline)	**1328**	**5072**	**6400**

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The Twin Paradox

Einstein had a girl friend; Jane,
Who was the twin sister of Ane.
He planned to test his 'paradox' on them,
Which he thought was an intellectual gem.

He sent Jane in a spaceship-very far,
On a mission to a bright- distant star.
He set her speed very close to 'c',
To test his paradox, that was the key!

Ane was left behind on the Earth. Confined to a cage,
So that, on Jane's return; he could compare their age.
His theory predicted Jane would age slow!
But his experiment was set to receive a blow.

Years passed and Einstein grew old.
So did Ane - sick and cold.
Soon everyone started worrying about Jane,
Also wondered whether Einstein was sane!

After tens and hundreds of days,
A space-capsule fell from space.
Inside, Einstein found a girl; young, sweet and bright.
He claimed she was Jane, who proved his theory 'right'!

Not allowing the girl to speak even a word,
He quickly disappeared with her into the crowd!
A truth was never told until his death,
That Jane's return was only a myth!

That girl; believe me, wasn't Jane at all,
But an astronaut from USSR, experimenting the 'freefall'!

Krishna Mohan
Asst. Prof,
Maharani's Science College, Mysuru

INDIAN ASSOCIATION OF PHYSICS TEACHERS

(Registered under Section XXI of Societies Act 1860, Regd. No. K 1448)

Membership Form

(PLEASE FILL IN CAPITAL LETTERS)

To,
Secretary IAPT
Regd. Office
Kanpur-208017

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I wish to join IAPT as a

1) Life Member 2) Annual Member 3) Student Member

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Mobile No...**Email ID** ....

Sincerely yours

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The Story Of Cosmology Through Postal Stamps 24

OBSERVATIONAL ASTRONOMY

OPTICAL TELESCOPE

Invention of telescope credited to Hans Lippet who used lenses to design refracting telescope. Later Galileo improved the vison up to 30X magnification and used it for some important astronomical observations (1608). It was further improved by Kepler (1611). Christian Huygens made another improvement if Keplerian telescope and made some important astronomical discoveries. Newton has been credited with construction of first practical reflecting telescope.

In 1611 Kepler improved Gallian telescope in which he used combination of two convex lens than one convex and one concave as by Galileo

Christiaan Huygens in 1655 design a 50-power refracting telescope and discovered first of Saturn's moon Titan position of titan is marked in his sketch

Joseph Ritter von Fraunhofer (1787-1826) made chromatic telescope objective lenses to minimise chromatic aberration

Oval commemorative Cancellation on a postcard depict refractive telescope

Stamped picture postcard with special cancellation- illustrate "women looking at the stars"- describe the popularity of telescope in public

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