

**Report of NIUS Teacher Development Workshop
on Thermal Physics and Statistical Mechanics
CESME, HBCSE
(Under PMMMNMTT scheme of MHRD)**

Date: December 10-13, 2019



**Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research
December 2019**

NIUS Teacher Development Workshop on Thermal and Statistical Physics

held at HBCSE from 10-13 December, 2019

Summary:

The NIUS Teacher Development Workshop on Thermal and Statistical Physics was held at HBCSE during 10 to 13 December, 2019, as part of CESME (HBCSE) activities under PMMMNMTT scheme of MHRD. In all 49 undergraduate and postgraduate college teachers (out of 75 invited) participated in the workshop. The aim of this workshop was to augment the understanding of teachers' knowledge in selected areas of thermal physics and statistical mechanics. The workshop started with lectures on the basics of thermal physics and then progressed to a few advanced topics in statistical mechanics. They were also exposed to some activity-based modules on topics in elementary thermodynamics. The topics covered in the workshop were in sync with UG and PG level syllabi in most universities in India so that teachers could readily implement the gains from the workshop in their classrooms. This was an opportunity to explore teachers' ideas on advanced topics such as partition function and quantum statistics. For this, the focus was on the applications of advanced level statistics, e.g., Ising model, Ensemble theory, Bose-Einstein condensate, phase transition, Van der Waals equation, and fluid phase transition.

Detailed description of workshop sessions:

Inauguration: Introduction to HBCSE and NIUS programme – Prof. K. Subramaniam (Centre Director) and Prof. Anwesh Mazumdar (NC, Science Olympiad)

Prof. K Subramaniam welcomed the participants, and gave brief introduction about HBCSE. He informed them about various programmes run by HBCSE like CESME, NIUS, BESTM, Olympiads, etc.

This was followed by Prof. Mazumdar's briefing about the National Initiative on Undergraduate Science (NIUS) programme. He informed the participants about the extended nurture programme under NIUS through research projects for undergraduate students.

Topic 2: Second Law of Thermodynamics – Dr. Praveen Pathak (4 sessions)

Dr. Pathak started the session by revisiting the mathematics of combinatorics. He illustrated the example of coin toss and a solid exchanging heat. This led to the statistical definition of entropy.

The next session was conducted in the NIUS Computational Facility. The participants were guided to make use of spreadsheet to find entropy, energy, magnetization, temperature and specific heat for two level system in paramagnets. The tutorials which were conducted on the

next two days comprised of numericals to reinvigorate the concept of partition function, average number of particles and average energy of a system where particles either obey Maxwell-Boltzmann, or Bose-Einstein or Fermi-Dirac statistics. He also gave examples of Bose-Einstein condensation, and Fermi energy.

Topic 3: Fundamentals of Statistical Mechanics – Prof. H. S. Mani (2 sessions)

Prof. Mani formulated the basic principles of statistical mechanics. The first session started with the derivation of Stirling's Approximation. He derived the probability distribution, and extended the discussion on ergodic hypothesis.

In the next session on the second day of the workshop, he introduced the concepts of ensemble theory, phase space and Liouville's Theorem. Finally, he analytically solved the average energy and specific heat in a multilevel system.

Topic 4: Two Level System and Ising Model – Prof. Vijay Singh (2 sessions)

Prof. Singh carried the theme of two-level systems and gave examples ranging from Sanskrit Prosody, Pingala's work to HOMO LUMO (*highest occupied molecular orbital and lowest unoccupied molecular orbital*). He introduced Mean Field Approximation in 1D by Ising model. He showed the degeneracy in frustrated lattice statistically.

In the next session, he described Bragg-Williams approximation and evaluated the internal energy and entropy in terms of the probability of up and down spins. He derived magnetization and showed susceptibility divergence.

Topic 5: Quantum Statistics and its Applications – Prof. Rajdeep Sensarma (2 sessions)

Prof. Sensarma explained the grand canonical ensemble. He explained dispersion relations and density of states, and showed interesting results of Bose-Einstein condensation. He also introduced the Debye model and Gibbs-Duhem Equation.

Topic 6: Physics Education Research and Activity-based modules in Thermodynamics – Mr. Shirish Pathare (1 session)

In this session, Mr. Pathare introduced his work in Physics Education Research in the field of elementary thermodynamics. He explained the alternative conceptions that students have in thermodynamics i.e. heat as fluid, or heat as energy content of the system. Activities based on

heat flow, adiabatic compression and isothermal compression related to the first law of thermodynamics were carried out by the teachers in groups in the physics laboratory.

Topic 7: Thermodynamics of Open Systems – Prof. Arvind Kumar (2 sessions)

Prof. Kumar started with a brief introduction about the three types of systems – Isolated, Closed and Open, and then delved deeper into a discussion of Open Systems. He explained Gibbs Free Energy and Helmholtz Free Energy, and their equilibrium and spontaneity criteria. He explained phase transition between two open systems which together acts as a closed system. This finally led to the idea of chemical potential in terms of chemical equilibrium.

Topic 8: Liquid-Gas Transition and the Van der Waals equation – Prof. Dibyendu Das (2 sessions)

Prof. Das started with the explanation of limitations of ideal gas equation when the temperature falls below critical temperature. He introduced Van der Waals real gas equation as a solution, and derived it. He also showed its relation to mean field theory and virial expansion. He ended the session by demonstrating various aspects of fluid phase transition.

Topic 9: Epistemic Understanding of Derivations in Physics - Prof. Anwesh Mazumdar

In this session, Prof. Mazumdar introduced the work done at HBCSE on physics education research in the area of epistemic understanding of students. The teachers were administered a tool to measure epistemic clarity regarding derivations in Physics. A large survey of this tool on students have illustrated students' difficulties in identifying the epistemic categories of physical, mathematical and nominal warrants of propositions in a derivation. He emphasized how making explicit the epistemic character of different steps in a derivation by the teacher can help in students' understanding.

Main points of feedback received from teachers:

1. The entire activity was an academic enrichment exercise and motivating for us to apply in our teaching and encourages us to attend more such workshops in future. The tutorial-based lectures were interesting.
2. We would really appreciate if more workshops on some other topics would be held every year for undergraduate teachers.
3. More tutorials should be included.

Photographs from various sessions of the workshop:





Annexure A: List of Teacher Participants

Sr. No.	Name	Gender	Designation	Name Of Institution
1	Abhishek A S	Male	Assistant Professor	GSSSIETW, Mysore
2	Afshaan Shaikh	Female	Asst. Professor	Rizvi College Of Engineering
3	Ajay Pratap Singh	Male	Assistant Professor	Deshabndhu College , University Of Delhi
4	Anuj Vijay	Male	Professor	Institute Of Applied Sciences & Humanities, Gla University
5	Ashish Tyagi	Male	Teacher	Swami Shraddhanand College
6	Ashok Kumar Pathak	Male	Associate Professor	Ewing Christian College, Constituent College Of University Of Allahabad
7	Ashutosh Vishwa	Male	Assistant Professor	Atma Ram Sanathan Dharma College, University Of Delhi
8	Basim M B	Male	Assistant Professor	Psmo College, Tirurangadi
9	Bhavna Vidhani	Female	Teacher	Hansraj College
10	Bhupendra Singh	Male	Assistant Professor	Atma Ram Sanatan Dharma College
11	C. A. Safeeque	Male	Associate Professor	Sullamussalam Science College
12	Deepu Joseph	Male	Assistant Professor	Nirmalagiri College
13	Deepu Thomas	Other	Teacher	Nirmalagiri College
14	Devendra Kumar Singh	Male	Teacher	Udai Pratap College, Varanasi
15	Dheeraj Jogindersingh	Male	Teacher	Gokhale Education Society's, Arts, Commerce And Science College
16	Disha Wadhawan	Female	Teacher	Daulat Ram College, University Of Delhi
17	Harish Shetty	Male	Lecturer	Abdul Razzak Kalsekar Technical Campus
18	I D Sharma	Male	Assistant Professor,	C C R (Pg) College Muzaffarnagar
19	Jafar M P	Male	Assistant Professor	Sir Syed College
20	Jyoti Chauhan	Female	Assistant Professor	Delhi University
21	Kamad Nath Shandilya	Male	Teacher	Dept. Of Physics, B.N.College
22	Kamlesh Kumar Sharma	Male	Assistant Professor	Invertis University, Bareilly
23	Krishna Gopal	Male	Assistant Professor	Rajdhani College(University Of Delhi)
24	Kulkarni Sudhir Nilkanth	Male	Associate Professor	Doodsakhar Mahavidyalaya, Bidri
25	Meenal Gupta	Female	Teacher	Sharda University
26	Muhammed Abdurahman K	Male	Teacher	M.E.S Ponnani College

Sr. No.	Name	Gender	Designation	Name Of Institution
27	Muhammed Shibu.K	Male	Teacher	M.E.S.K.V.M College Vallanchery
28	Neeru Sehdev	Female	Teacher	Daulat Ram College, University Of Delhi
29	Neetu Agrawal	Female	Assistant Professor	Daulat Ram College, University Of Delhi
30	Pankaj A. Nagpure	Male	Teacher	Shri Shivaji Science College Amravati
31	Poonam Jain	Female	Assistant Professor	Sri Aurobindo College ,University Of Delhi
32	Pramod Kumar	Male	Teacher	S. S. Jain Subodh P. G. (Autonomous) College, Jaipur
33	Prashant Thapliyal	Male	Teacher	Army Cadet College Indian Military Academy Dehradun
34	Prashanta Kumar Khandai	Male	Teacher	Ewing Christian College
35	Pura Ram	Male	Teacher	University Of Rajasthan
36	Ramesh Chandra Huika	Male	Lecturer In Physics	Rayagada Autonomous College Rayagada
37	Rucha A. Naik	Female	Teacher	K. J. Somaiya College Of Science And Commerce
38	Sangeeta D Gadre	Female	Teacher Associate Professor	Kirori Mal College
39	Sapna Sharma	Female	Teacher	St. Bede's College
40	Satish Kumar Rajouria	Male	Assistant Professor	Zakir Husain Delhi College, University Of Delhi
41	Shikha Shah	Female	Assistant Professor	K.E.T.'S V. G. Vaze College
42	Sudheesh V D	Male	Assistant Professor	Nss College Nemmara
43	Suraj Parwani	Male	Assistant Professor	Govt Holkar Science College Indore
44	Sushil Deonath Charpe	Male	Assistant Professor	J D Patil Sangludkar Mahavidyalaya, Daryapur
45	Sweta Sharma	Female	Teacher	The Graduate School College For Women
46	Tarun Choudhari	Male	Assistant Professor	Daulat Ram College
47	Yashpal Singh Katharria	Male	Assistant Professor	IIITDM
48	Yogesh Kumar	Male	Assistant Professor	Deshbandhu College,University Of Delhi
49	Yogesh Kumar	Male	Assistant Professor	Arsd College, University Of Delhi

Annexure B: Time Table of the workshop

Homi Bhabha Centre for Science Education NIUS Teacher Development Workshop on Thermal Physics and Statistical Mechanics December 10 - 13, 2019 Venue - NIUS G4 Schedule			
Date	Time	Speaker	Title
Dec 10	9:00 - 9:30		Registration and Briefing
	9:30 - 11:00	PP	Second Law of Thermodynamics
	11:00 - 11:30		Tea
	11:30 - 13:00	HSM	Statistical Mechanics – Fundamental 1
	13:0 - 14:00		Lunch
	14:00-15:30	VS	Two-level System
	15:30-16:00		Tea
	16:00-17:30	VS	Ising Model: Mean Field Approximation
	17:30 - 18:00		Snacks
Dec 11	9:30 - 11:00	PP	Tutorial
	11:00 - 11:30		Tea
	11:30 - 13:00	HSM	Statistical Mechanics – Fundamental 2
	13:0 - 14:00		Lunch
	14:00-15:30	PP	Applications of Second Law of Thermodynamics
	15:30-16:00		Tea
	16:00-17:30	RS	Quantum Statistics and its Applications
		17:30 - 18:00	
Dec 12	9:30 - 11:00	RS	Quantum Statistics and its Applications
	11:00 - 11:30		Tea
	11:30 - 13:00	SRP	Physics Education Research In Thermodynamics
	13:0 - 14:00		Lunch
	14:00-15:30	SRP	Physics Education Research In Thermodynamics
	15:30-16:00		Tea
	16:00-17:30	AK	Thermodynamics of Open Systems
		17:30 - 18:00	
Dec 13	9:30 - 11:00	DD	Liquid-Gas transition and the Van der Waals equation
	11:00 - 11:30		Tea
	11:30 - 13:00	DD	Liquid-Gas transition and the Van der Waals equation
	13:0 - 14:00		Lunch
	14:00-15:30	PP	Tutorial
	15:30-16:00		Tea
		16:00	

Resource Persons

AJ	Avinash Jadhav	PP	Praveen Pathak
AK	Arvind Kumar	RS	Rajdeep Sensarma
AM	Anwesh Mazumdar	SRP	Shirish Pathare
BL	Bhagyashri Latad	SS	Sadashiv Shirodkar
DD	Dibyendu Das	VS	Vijay Singh
HSM	H S Mani	YP	Yogita Patel