
Final report on

Science Academies' Refresher Course in Statistical Physics

Held at Sir P.T. Sarvajanik College of Science, Surat,
10 - 22 June, 2019

Sponsored by:

Indian Academy of Sciences, Bangalore

Indian National Science Academy, New Delhi

The National Academy of Sciences, Allahabad



Introduction:

The course was advertised in the Current Science. There were 69 applications received. Initial invitations were sent to all who applied. Twenty-four outstation participants finally came for the course. These were across all parts of India like Jammu and Kashmir, Maharashtra, Karnataka, Kerala, Madhya Pradesh, Uttar Pradesh, Delhi, West Bengal, Rajasthan, Haryana and Andhra Pradesh and eight local participants. (List of participants is attached as Annexure A).

Course Director: Prof. Deepak Dhar, Professor, Department of Physics, IISER, Pune.

Course Coordinator: Dr. Pruthul Desai, Principal, Sir P T Sarvajanik College of Science, Surat.

Lecturers:

Prof. R Rajesh (IMSc, Chennai)

Prof. Rahul Marathe (IIT, Delhi)

Prof. Sudhir Jain (BARC, Mumbai)

Prof. Kavita Jain (JNCASR, Bengaluru)

Prof. Kabir Ramola (TIFR, Hyderabad)

Prof. Chandan Dasgupta (IISc, Bengaluru)

The afternoon tutorial sessions were conducted by D. Dhar.

Inaugural Function:

The inaugural ceremony of the Course was held on 10th June, 2019 at the Taramoti Hall, Sir P T Sarvajanik College of Science, Surat. The programme started with welcome address by the Course Coordinator Dr. Pruthul Desai. Dr. Desai warmly welcomed all the participants and wished them a fruitful and enriching time during the conduction of course. He also acknowledged the support extended by the three academies in sponsoring the course. His speech was followed by felicitation of the lecturers. After this, Prof. Deepak



Dhar, addressed the participants. He noted that the teaching in our educational system seems to be geared for the best students and the median student does not benefit much from his/her three years in the University. This has to change. The lecturer has to make efforts to increase the effectiveness of the education. He noted that the participants have already been informed that the Course will use the reverse classroom technique and this is an experiment here. He urged the participants to come prepared for the lectures and that the experiment will succeed only with their active cooperation.

The reversed classroom technique:

The Refresher Course was designed with new instruction technique, called “Flipped Classroom” method with the aim to make classroom more interactive and having active participation from participants. Briefly, there were no formal lectures. At least 2-3 days before lecture, the participants were given a short write up on what will be discussed in the next class, some reading material and some sample problems. They were asked to read and come prepared during the next session. During the lectures conceptual difficulties faced by the participants or an alternative method of getting answers were discussed. Most of the lecture sessions were interactive with ample time spent on discussions and doubt clearing.

The course had 6 basic modules and the resource person had dealt with the topic listed below. Each module had 4 lectures of 90 minutes duration each. The first two modules were from June 10-13, June 14-18 and the last ones during June 19-22. The modules were:

1. Basic principles and general results [Prof. R. Rajesh] [June 10-13]
2. Probability theory and applications [Prof. R. Marathe] [June 10-13]
3. Quantum statistics: Bose and Fermi distributions, Bose condensation [Prof. Sudhir Jain] [July 14-18]
4. Critical phenomena and renormalization group theory [Prof. Kavita Jain] [June 14-18]
5. Markov processes and Computer simulations [Prof. Kabir Ramola] [June 19-22]

6. Introduction to Non-equilibrium statistical physics [Prof. C. Dasgupta] [June 19-22]

➤ **Prof. R. Rajesh:**

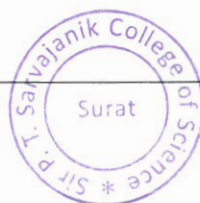
Prof. R. Rajesh He started his module with the question “what is the role of statistical mechanics?” The preparatory material for the lecture that was already circulated to participants had questions about finding the size of atom and size of universe. He explained the role of statistical mechanics at different size scale. He discussed the characterization of state of system, microstates and macrostates. The microcanonical, canonical and grand canonical ensembles were introduced, using examples of noninteracting spins, a particle in a one dimensional box, harmonic oscillator, higher dimensional boxes, etc. Liouville’s theorem for phase space density etc. was discussed.

➤ **Prof. R. Marathe:**

Prof. R. Marathe’s module was about probability theory and its applications. He started with the question that where do we use probability? He then introduced the notions of sample point and sample space, and using the example of successive throws of a dice, he explained microstate and macrostates. Explicit examples of calculation of probability were given. He asked the participants to come to the blackboard to solve numericals. He discussed the mean, median, variance, Bernoulli’s trials, Poisson distribution, Binomial distribution, Geometrical distribution, Gaussian distribution and worked out several problems related to those topics.

➤ **Prof. Kavita Jain:**

Prof. Kavita Jain lectures started with ideal gas theory. This was followed by phase diagram, critical point, gas-liquid transition, magnetic transition, Gibbs free energy and Maxwell construction. Phase transitions were introduced using the Ising model, she discussed spontaneous magnetization, correlation function and critical exponents.



➤ **Prof. Sudhir Jain:**

With Prof. Sudhir Jain participants explored Quantum statistical mechanics. He started with a discussion of the difference between classical and Quantum Statistical mechanics. Then he discussed about Quantum Statistical principle and role of Heisenberg's matrix mechanics and the role of dynamical variable in Quantum statistical mechanics. He talked about Fermi distribution function and also explain various problems related to finding the eigenfunctions of two non-interacting particles in a one-dimensional box of length L as well as calculating the microstate available to the system in range of energies. He also explained about Bose distribution function and its application to statistical Quantum mechanics.

➤ **Prof. Kabir Ramola:**

Prof. Kabir Ramola had begun his talk by introducing "Random Walk". He had also discussed central limit theorem and Markov Process. Markov processes are among the most important of all random processes. A stochastic process is a sequence of events in which the outcome at any stage depends on some probability. Further, he had included Master equation- Fundamental equation for Markov Process, Markov Property- Memorylessness, Detailed balance, Markov Matrix for random walk, etc.

➤ **Prof. Chandan Dasgupta:**

With Prof. Chandan Dasgupta participants explored Non-Equilibrium Statistical Mechanics. He had discussed Harmonic oscillator in 1-D, Fluctuation Dissipation Relation in equilibrium state and Separation of time scale. Further, Prof. Dasgupta elucidated Brownian motion.

➤ **Tutorial session by Prof. Deepak Dhar:**

Every day post lunch sessions were tutorial sessions. In these sessions, which were generally free format, the participants could ask any difficulties related to the morning lectures, or even other questions. Several basic conceptual issues dealing with the the participants questions about the harmonic oscillator, Heisenberg

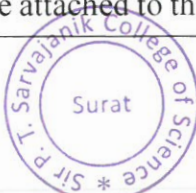
uncertainty principle, were discussed. Also, some slightly more advanced concepts were introduced, such as the singular probability measures Devil's staircase, the meaning of free energy, entropy, Gibb's Paradox, etc. were discussed.

- The time in the afternoon (about 3/2 hours) was left free for participants to prepare for the next day's lectures. Participants were divided into small groups. The resource persons and course director were available to help them in this period. These sessions were very interactive. Participants were involved in animated discussions throughout all the tutorials sessions. This also gave the participants to meet, and discuss with the resource persons on a one-to-one basis.
- During last three days the post lunch session was allotted for the Presentation by the Participants. All the participants had given presentations for 7-10 minutes on topic selected by them. Two winners, one from student category and one from Teacher category were selected for best presentation. They were felicitated on valedictory function with a book.
- Besides, a field trip was also arranged to visit places like Statue of Unity- World's tallest statue and Sardar Sarovar Dam on 16th June (Sunday). All the participants along with resource persons and faculty members of college had enjoyed the trip.

Valedictory Function:

The Valedictory function was held on the last day (22nd June, 2019). The participant were invited to give their personal impressions and comments for the course. They shared their experience and also gave suggestions. After this, the certificates of paerticipation were distributed by Mr. Ghansyamprasad Sanadhya, Secretary of the Sarvajanic Education Society, Prof. Deepak Dhar presented the respective Course Report. Course Coordinator Dr. Pruthul Desai, proposed the vote of thanks to the management of the College, Course Director, resource persons, the participants, all the three academies and the college staff.

Overall Evaluation: At the end of the course, Feedback was obtained from the participants. These feedback forms are attached to this report (Annexure B). On the whole,



the feedback has been positive. The lecture sessions were liked by all the participants and they have found them useful. For the questions about level of lectures, preparation of the lecturer and answers to questions, most of the grades given by participants are between 4 and 5 (out of 5). For food arrangements, most of the participants found them excellent. Faculty members of Sir P T Sarvajanic College of Science also attended lectures and were enthusiastic about them. On the whole all the participants have expressed appreciation of the philosophy of the course, and the efforts of the resource persons.

In the view of the organizers (DD and PD), the course was *not* a great success. The main problem was that the participants were not used to the “reversed classroom” technique and in spite of strong admonitions, the majority of participants did not put in the effort required to make the technique work. There is some psychological barrier that has to be crossed to accept a new technique. All the resource person tried very hard to engage the participants and get them to do the limited number of assigned problems ahead of the lecture or in the afternoon session after the lecture but, only with a limited success. The same feeling was expressed privately by resource persons to us. In many cases, towards the end, the resource persons had to revert to the traditional lecture mode, as most of the participants had not done the required preparation.

The participants have said that they liked the Course, and benefited from it and there is no reason to doubt this. We think that the course was comparable to other similar courses that the Academies run. But we were hoping that it would be much better. Perhaps we were too ambitious in the planning stages, and did not achieve as much as we would have liked.

Would we try the reversed classroom again? The answer would have to be, “Not without some adaptation”.




Principal
Sir P. T. Sarvajanic College of Science
Surat