Classical Mechanics. K. N. Srinivasa Rao, Universities Press (India) Pvt Ltd, 3-5-819, Hyderguda, Hyderabad 500 029. 2003. 346 pp. Price: Rs 355.

During the training phase of a student aspiring to be a theoretical physicist, classical mechanics plays a pivotal role. It provides the first real taste of going beyond the summary of phenomenological regularities to formulating more fundamental laws and applying them to make accurate quantitative predictions, the obvious example of this process being observations of planetary orbits summarized in the Kepler's laws followed by the more fundamental Newton's laws of motion and of gravitational force. A student also encounters, for the first time, the distinction between kinematics and dynamics, the role of frame(s) of references, configuration and phase spaces, the concepts of momentum and energy and their conservation, etc. Subsequent refinements such as special relativity, general relativity and quantum mechanics draw heavily on these ideas. While one certainly has classical theories of fields, classical mechanics usually refers to systems of finitely many degrees of freedom – be it a system of 'material points' or a 'rigid body'. It is therefore important to be clear about the basics of classical mechanics and the book by Srinivasa Rao provides an excellent exposure to the subject.

As declared by the author himself, the book is not a standard textbook. It does not give 'exercises' at the end of each chapter and it is not tailored to any particular 'syllabus'. While most of the topics in more standard textbooks are discussed in this book, the emphasis and the weightage received by different topics are quite different. By not confining to a 'textbook mould', the author has freed himself and concentrated on a lucid presentation of the chosen subject matter itself.

The book begins with kinematics of a point particle relative to a frame of reference. It then discusses, with examples, transformations of frames of references emphasizing the kinematical equivalence of all frames of references. There is then a nice discussion of the physical notion of force (interactions), particularly emphasizing its frame-independent nature. Since interactions are frame-independent while the acceleration is not, the proportionality between these can only be valid in a special (class of) reference frame leading to the abstract definition of an inertial frame as one in which Newton's second law is observed.

There are then two separate chapters devoted to worked out, physically interesting examples of motion relative to an inertial frame and a non-inertial frame. The distinctive examples treated in the former include motion of a satellite (including its 'paradoxical' aspect of atmospheric friction increasing its speed) and estimates of launch velocity for a mission to Mars. The examples of motion relative to a non-inertial frame include the eastward deviation of a freely falling particle and a detailed discussion of Foucault's pendulum.

The next three chapters on rigid bodies are where the author's passion for the subject manifests most strongly. There is a separate chapter devoted to necessary mathematical preliminaries mostly involving matrices and elliptic functions. A fair amount of space is devoted to kinematics of rigid bodies – Eular's theorems, Hamilton's theorem, Chasles theorem and the Burnside–Wiener theorem. I confess, I learnt some of these (in particular the Chales theorem) in such detail for the first time from this book. One may wonder why so much emphasis on these theorems? One reason could be practical, namely, efficient methods of computation of motions of rigid bodies. But I think there is another import of these theorems. They establish that the configuration space of a rigid body is the Euclidean group in three dimensions (three translations and three rotations) which is not the six dimensional space ^{6}. Furthermore, since rigid bodies are also used to physically specify a reference frame, e.g. a laboratory, this also establishes that the class of kinematically equivalent frames at a single instance is related by the natural action of the Euclidean group. Mathematically of course, this is the group of invariance of the usual Euclidean distance in three dimensions. It would have been pedagogically nicer if some comments about the importance of these theorems had been included. The examples of rigid-body dynamics have been discussed in detail and particularly there is a nice discussion of Foucault gyroscope and the gyrocompass. I also liked the remark about the discrepancy in the precessional motion of the earth being attributed to the earth not being a rigid body in the strict sense, illustrating how rigid body idealizations can actually be only approximations.

After the detailed analysis of rigid-body motion, the author goes on to discuss somewhat more traditional topics, more commonly referred to as the Lagrangian and Hamiltonian formulations. As in earlier chapters, there is a clear elucidation of the concept of virtual displacements as well a clear enunciation of the D'Alembert's, Hamilton's and the Maupertuis' principles. The careful derivation of the canonical equations of motion from the modified Hamilton's principle is particularly noteworthy. This and the last chapter on small oscillations, however, are treated in comparatively less detail.

On the whole, the book presents the basic concepts of classical mechanics in explicit and clear fashion with lots of illustrations. Although the overall style is closer to a mathematical presentation, the physical basis of the concepts is explained carefully and a reference to actual observations is made in many places. It is highly recommended to any serious graduate student of physics and would also be useful to teachers of the subject. The author views this book as a 'companion volume' to the more standard textbooks. I would like to put it a bit more strongly as a 'must-read' companion volume.

G. Date

The Institute of Mathematical Sciences,
CIT Campus, Tharamani,
Chennai, 600 113, India
e-mail: shyam@imsc.res.in

City of Light – The Story of Fiber Optics. Jeff Hecht. Oxford University Press, New York. 1999.

The 'Serendipity of science' could well have been a sub-title for this fascinating tale of the coming of fibre optics by Jeff Hecht in the Sloan Technology Series. As the editor of a professional journal, Hecht has covered lasers and fibre optics for two decades. In this book he recounts, in masterly fashion, the breakthroughs in technology that have brought about a revolution in communication. He brings a light and humourous touch as he sketches the persona of the main players on the world stage – from geniuses and technocrats to conmen who were out to make a quick buck.

Delving through the pre-history of the subject, Hecht discovered that 'The man who first guided light' was a Frenchman Daniel Colladon and not John Tyndall as commonly believed. Colladon's first experiments were conducted in 1841, long before Tyndall's demonstration at the Royal Institution in 1854. The idea had reached Tyndall, as Hecht speculates, through Faraday, who spent the year 1841 recuperating in Switzerland. Light pipes became a great attraction at the Paris Opera, as luminous fountains in London and at the Universal Exposition at Paris in 1889.

It seems all so simple now – what could be more natural than sending light through glass fibres! But when it was first proposed by Kao and Hockham in 1966, Bell Laboratories, the world leader in the field of communications, shrugged-off the idea and kept digging trenches in the ground for clumsy millimetre-wave metal guides. Surprisingly, Standard Telephone Laboratories, UK, who employed Kao and Hockham, did likewise and put their proposal on a back-burner.

One could not blame the planners. Microwaves in the form of radar had won the Second World War. At frequencies of a few gigaherz 10^9 Hz), they travelled in straight lines and could be beamed between towers 50 km apart. To increase capacity, the next logical step was to increase the carrier frequency by a factor of ten, so that the wavelength would go down from centimetre to millimetre and the bandwidth increase accordingly. Atmospheric absorption and dimensional tolerances, measured in microns (10^{-4} cm), posed horrendous problems. But the British Post Office and US laboratories persisted. It all seems absurd in hindsight, but technology has its own inexorable momentum. Field trials for millimetre wave communication were conducted in 1975, deemed a 'success' and the project was unceremoniously closed!

The alternative was optical communication. Glass had been around for centuries. Invented by the Egyptians and Babylonians around 2500 BC, it had been made into an art form by the Venetians. Still the best available glass in the early sixties soaked up light like a sponge – in a distance of 20 m 99% of the light was gone. In 100 m, only ten billionth of the signal remained. Why not send light through metal pipes like microwaves? This again proved an intractable proposition.

Charles Townes, a Professor at Columbia University in nearby New York City had invented the maser and propounded the principle of the laser in the fifties. In 1960, the first working ruby laser, a unique coherent light source was demonstrated by Theodore Maiman at Hughes Research Lab. This was soon followed by Ali Javan who invented the helium–neon laser at Bell Labs. So what? There was no 'killer' application in sight. The laser was an invention with nowhere to go outside research laboratories.

Soon afterwards, in 1962 came the 'compact' semiconductor laser, invented by three independent groups in the US within a few months of each other. It proved principles in physics – that gases such as helium and neon, and solids like ruby were not the only materials that could form a laser. But beyond this, the semiconductor laser was a cumbersome beast. It required hundreds of amperes of direct current and had to be cooled with liquid nitrogen to emit pulses of a few microseconds. Worse still they often failed within a few seconds, apparently without any reason.

Translucent glass and lasers that lasted minutes at best, were these the ingredients of a successful new technology? No gambler in Las Vegas would have hazarded a bet. Yet, as Jeff Hecht describes, the 1980 Winter Olympics from nearby Lake Placid was sent around the world through optical fibres. In less than a decade fibres had crossed the Atlantic and started threatening the monopoly of satellite communication. This success story has many heroes – glass technologists, optical designers, semiconductor physicists and prescient technocrats who had faith in fibre optics against all odds.

How did the dirty glass of the sixties get transformed into the almost lossless conduit of the nineties? The principle of total internal reflection obviously came to many minds, but it had its pitfalls. One group tried a metal outer coating as a reflector and came to grief – it just did not work as the metal absorbed light. Fibres with tailored refractive indices were the answer; but how to draw kilometres of fibres with core dimensions of a few microns? Many battles were fought on the issue of graded index vs step index fibres, with the latter winning out in the end for long-distance communication. Among the pioneers in fabricating low-loss glass fibres were Robert Maurer of Corning, John MacChesney at Bell Labs and Masahara Horiguchi of NTT who perfected inside and outside vapour deposition processes. Quite a few laboratories, as Hecht recounts, burnt down due to the hazards of high temperature chemistry.

At one time the fibres showed losses that mysteriously increased with time. The problem hit British Telecom like a sledge-hammer. It was painfully traced as due to hydrogen generated by high-voltage cables. Not all fibres were affected – it was only those with phosphorus doping in the core which reacted with hydrogen forming chemical bonds that absorbed light. This was ultimately set right using germanium instead of phosphorus as dopant, to give the required increase in the refractive index.

Technology has now advanced to the stage that any arbitrary refractive index profile can be achieved to fight the twin bogies of attenuation, i.e. loss of light, and dispersion which creates signal distortion. Realizing the potential, albeit rather late, Corning Glass and later Bell Labs mustered their resources and a battle for patents ensued. The first successful transmission was however demonstrated by GT&E near Boston. The Post Office Research Laboratory in the UK also played a major role. Hecht narrates the story of how a lightning strike disabled military communication in Southwest England allowing a fledgling, a fibre optics line to show its worth. The military was immediately won over by the immunity to interference, which has proved to be one of its strengths.

A related early development was the use of fibre bundles for imaging, which has given birth to the vast field of endoscopy in medicine. One of the pioneers in this field was the dashing entrepreneur Narinder Singh Kapany. Hecht writes, 'Kapany had attended an Indian University, worked in a military optics factory, studied optics for a year at Imperial College and worked for a Glasgow optics company. He hoped eventually to return to India to start his own optical business'. Kapany was recruited by Harold Hopkins, a bright young faculty at Imperial College, London as a graduate student. Hopinks got a Royal Society grant of 1500 GBP to make image-transmitting bundles, half of the amount being earmarked for the graduate assistantship. The biggest challenge in their project was assembling 10,000 to 20,000 fibres into a bundle with their ends aligned to carry an image. They spent months assembling equipment to wind fibres and getting it to function properly. In November 1953, they sent a paper to *Nature* which was published in January 1954 together with a paper by van Heel. Unfortunately, Hopkins and Kapany fell to quarrelling even before Kapany finished his dissertation in 1955. Hopkins claimed the Kapany was nothing more than 'a pair of hands', while Kapany thought the 'Professor was too much a theorist to appreciate his practical skills'.

Kapany moved to the University of Rochester and then the Illinois Institute of Technology, eventually setting up his own company. He also authored the first book on the subject *Fibre Optics – Principles and Applications*, published by Academic Press in 1967. As a tireless crusader for fibre optics, he called sending an image through a knotted bundle of optical fibres his 'Indian optical rope trick'. Hopkins and van Heel abandoned fibre optics soon after their initial papers, but Kapany went on to write 45 papers in a decade and acquire ten patents. His company Optics Technology based in California, built one of the first lasers used in eye surgery and became one of the first to mass produce He–Ne lasers. Hecht recognizes him as a charismatic figure in the field and a tireless crusader.

Serendipity stepped in with the simultaneous development of the laser light source and the ultra-pure glass fibre as a medium to convey the message. In 1970, Zhores Alferov and his group at the Ioffe Institute were the first to fabricate a semiconductor laser that worked continuously at room temperature. This was recognized by the award of a Nobel Prize in 2002. The wavelength for communication shifted three times in a decade – from the original 0.85 μm dictated by the available GaAs source, to 1.3 μm where dispersion was minimum and then to the current 1.55 μm where the loss is a minimum of 0.2 dB/km. Horiguchi and Osanai of NTT Japan were the discoverers of this low-loss window at 1.55 μm. Each change required new materials for sources and detectors. Serendipity stepped in again as long wavelength 1.3 and 1.55 μm sources, first demonstrated by Jim Hsieh at Lincoln Laboratories, although requiring quaternary compositions consisting of InGaAsP, proved robust with no lifetime problems at all. There was improved performance and distance-coverage with each generation.

An unforeseen hazard appeared during the first trials of long-distance underwater cables. Sudden shorts appeared that knocked out the repeater cable. Was it sea water getting in? The cables had to be hauled out and they showed unmistakably the teeth marks of sharks! A minor discovery was that sharks swam as deep as 1 km; but why did they attack the optical fibres and not the coaxial cables? Apparently, it was the electrical fields around the repeaters that attracted them. Use of strong steel tape that shielded the electric field solved that problem.

Fourth-generation systems are all-optical erbium-doped fibres as amplifiers. In fact, soliton waves have been sent many times around the world without the need for any amplification. Wavelength-division multiplexing has increased the capacity of each fibre by sending over 100 channels at slightly different wavelengths. Hecht has not gone beyond existing technology and speculates on the prospects of IR transmitting fibres, while 'fibre-to-the-home' still remains a challenge and a dream. What began as a small community of believers in fibre optics has, according to the author, now burgeoned into a 'City of light'.

D. N. BOSE

University of Calcutta,
Kolkata 700 073, India
e-mail: tutubose@yahoo.co.in

Principles of Radiometry in Radioactive Metal Exploration. B. K. Bhaumik, T. Bhattacharya, A. A. P. S. R. Acharyulu, D. Srinivas and M. K. Sandilya. Physics Laboratory, Eastern Region, Department of Atomic Energy, AMD Complex, Khasmahal, Jamshedpur 831 002. 2004. 292 pp. Price: Rs 600.

This book, as stated by the authors in the preface, is intended for earth sciences students with physics background. The book is in six chapters, some written by the authors together, and some by individual authors.

An introduction to the concept of radioactivity, relevant for study of subsequent chapters, is given in the first chapter. It includes discussions on different decay schemes, decay and transmutation equations, geochronologic principles and different units of radioactivity.

Chapter 2 introduces radiation detectors useful for terrestrial radiation detection and encompasses radiation classification, detection principles, choice of detectors and description of different detector types, including scintillation- and Geiger Muller tube detectors.

Chapter 3 deals with radiation survey meters in airborne surveys, jeep-borne surveys, soil surveys, etc. Airborne survey is covered in detail and includes data acquisition, processing and interpretation.

Chapter 4, in its first part, illustrates gamma ray-, radiation- and rock spectrometry and describes, in the appendix, precision estimate for gamma-ray spectrometric data. The second part of this chapter deals with actual concentration estimation of uranium by total beta and total gamma counting methods.

Chapter 5 describes in detail the natural gamma-ray log and incorporates fundamentals of passive logging borehole; theory, calibration and limitations of gross counting gamma log; counting rate meter – its working principles, advantages and disadvantages.

Finally, chapter 6 gives major instrumental modules: log probe and counting rate meters, statistical analysis of the latter type; and shot hole- and shielded-hole logging.

Indian case histories have been mentioned in appropriate contexts, e.g. chapter 3 mentions ROAC (radon on activated charcoal) vs eU (radium equivalent to uranium) plot for Singhbhum area; chapter 4 includes a note on the disequilibrium factor for different uranium deposits in India and chapter 5 discusses gamma log calibration method using model borehole at Jaduguda.

The book is written in simple language. A subject index of moderate detail is provided at the end of the book. An adequate balance between theoretical and practical aspects in radioactivity survey is presented in the book. The advantage of such a book is that one can understand the theory behind radioactivity survey and can also get into its detail by looking at the bibliography, if interested. After each chapter, a bibliography is provided with a good number of references of recent past. The bibliography should have been written with more care; lack of uni-