The Collected Papers of Albert Einstein – The Berlin Years: Writings 1914–1917. Volume 6. A. J. Kox, Martin J. Klein and Robert Schulmann, eds. Princeton University Press, 41, William Street, Princeton, NJ 08540, USA. 1996. 626 pp. Price: Clothbound $85.

The programme of publishing the collected papers of Albert Einstein has been on since the mid-eighties or so, as a joint effort of Princeton University Press and the Hebrew University, Jerusalem, where most of the Einstein archives are held. This is a massive project expected to finally comprise a total of some forty volumes. Some are devoted to Einstein's voluminous correspondence in various phases of his life, others to his scientific papers divided into significant periods. Along with the so-called documentary edition containing the documents in their original languages, mainly German, a series of invaluable English translations is also being produced by Princeton University Press. Volumes 1, 2 and 3 of the latter have been reviewed in *Current Science*, 1996, **71**, 78 and Volume 5 in *Current Science*, 1995, **69**, 882.

The present volume published in 1996 is the sixth in the Documentary Edition series, and covers the period 1914–1917. This was the start of Einstein's Berlin Years. In early 1912, he had become Professor at the ETH in Zurich, but in April 1914 Einstein moved to Berlin to accept a specially created research professorship, with no teaching duties, at the University of Berlin, under the aegis of the Prussian Academy of Sciences. From the physics point of view this period is most important because the general theory of relativity (GTR) reached its final formulation, and the two fundamental papers on the processes of absorption and emission of photons by matter appeared. This volume has all the original papers in German (except for one in English), and the editors Kox, Klein and Schulmann have added extremely illuminating footnotes, commentary and historical material often bringing matters up to date to present times. It is amusing to notice that many of these papers were published in about a week after submission to the journal concerned – far away indeed from the situation today!

The major part of the contents of the volume deal with the progress of Einstein's ideas on GTR. Three early papers with Marcel Grossmann are concerned with formulations in which the subtle interplay between the mathematics and the physics of general covariance was still far from clear. Indeed in these early papers and up to a few days before the final formulation on 25 November 1915, Einstein had convinced himself that the sought-for field equations for gravitation should allow unambiguous determination of the metric tensor components for given energy momentum tensor as source, and for given boundary conditions. For this reason, the permitted degree of covariance under general coordinate transformations was at various stages limited in different ways – at one point, linear transformations alone; then transformations with unimodular Jacobians alone; and finally imposition of the requirement that the determinant of the metric tensor itself be unity! Later Einstein realized that in some of these restricted versions even rotational covariance would be lost. For these reasons, almost all the earlier papers on GTR (including a review) in this volume are of purely historical value. As one sees the ideas slowly gather strength till they finally break through into transparent clarity, one appreciates the depth of meaning in Einstein's later statement: 'But the years of anxious searching in the dark, with their intense longing, their alternations of confidence and exhaustion and the final emergence into light – only those who have experienced it can understand that.'

At an earlier stage it is amusing to see that after Einstein's inaugural lecture to the Prussian Academy in July 1914, in the discussion, Max Planck wondered why it was necessary to generalize special relativity to include the possibility of accelerated or noninertial observers! Only now may we smile at such incidents.

The first and classic systematic exposition of GTR, Document no. 30, appeared in May 1916; later it appeared as a book as well. The 'summation convention' was used here for the first time.

The full German text of Einstein's first popular exposition of both special and general relativity, completed in 1916 and published in 1917, is given in this volume. This book went through many editions and translations and at various stages Einstein added appendices and extra material in abundance.

The first application of GTR to cosmology, and the introduction of the cosmological constant, date to February 1917, and are reproduced as Document no.43. There are also some short notes on Hamilton's variational principle for GTR. It was only as late as 1931 that Einstein admitted to a change of heart and withdrew the cosmological constant as unnecessary and unjustified.

Around the same period that he was struggling with the formulation of GTR, Einstein also undertook some experiments with Wander Johannes de Haas (son-in-law of Lorentz) to prove the existence of Ampere's circulating molecular currents. More than a century earlier, Ampere had suggested that microscopic current loops were the ultimate sources of magnetism, and Einstein and de Haas set out to prove this by ingenious experiments. While they were in a sense successful, it must be remembered that this was well before the discovery of the spin of the electron and its associated magnetic moment; so later the limitations of the Einstein–de Haas work in the quantitative sense slowly became clear. All the original papers by Einstein and de Haas, and some by the former alone, are included in this volume.

Turning to quantum theory, there are three significant papers. The first two relate to Einstein's persistent attempts to derive Planck's Law in various ways; they introduce his famous A and B coefficients, the concept of stimulated emission (basic to functioning of lasers today) and also the concept of photon momentum. Einstein was very pleased with these efforts since he wrote to Michele Besso: 'A splendid idea on the absorption and emission of radiation has dawned on me'. The third one on quantum theory attempts an invariant formulation of the Bohr–Sommerfeld–Epstein quantization conditions of the old quantum theory – here Einstein was trying to free himself from the limitation to separable and integrable systems, and to express the quantization in a global and invariant manner. It is interesting and amazing that these ideas of his in 1917 find echoes in the dynamics of chaotic systems today.

Other highlights of this volume are

Einstein's first ever political statement – 'Manifesto to the Europeans' dated mid-October 1914 – lecture notes for courses given in winter 1914–1915 on relativity, and notes by a student on the Wolfskehl Lectures given at Gottingen in 1915.

The quality of production of this volume, as one might expect, is excellent. One awaits with anticipation and eagerness the appearance of its companion English translation.

N. MUKUNDA

Centre for Theoretical Studies,
Indian Institute of Science,
Bangalore 560 012, India

Physics for Engineers. M. R. Srinivasan, New Age International Publishers, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002. 1996. 519 pp. Price not known.

How much physics should be included in the curriculum of a 4-year undergraduate course in engineering? What kind of physics should be taught, and how should it be sequenced?

These questions are important – not only in their own right, but also because they are relevant to a relatively large segment of our student population. After all, a degree in engineering or medicine is widely regarded in our society as one of the pre-requisites for eternal bliss (the others being a fair bride with a handsome dowry, male offspring, non-stop film music on loudspeakers, and a national cricket team that always wins). They are also questions that have no easy answers. One gathers from the book under review, however, that for students of engineering in Karnataka the study of physics is restricted to a single semester in the first year. The stated aim of the book is to provide a comprehensive text geared to meet this requirement, taking 'the syllabus as a guide for the organization' of the book.

It is at once evident that this places severe constraints on the author. On the one hand, there is his laudable and unexceptionable value system – he urges students to study physics in more detail and depth, with the assurance that 'a proper study of physics would certainly enhance your capabilities as an engineer'. On the other hand, there is the syllabus 'to be covered' – preparing the students to perform the rituals attendant upon the examination system – namely, the appeasement of minor deities named derivations, numericals, short notes, objectives, and so on! The gap between these two poles has become virtually unbridgeable. The author has opted to cater to the second system. Within the parameters chosen, the outcome is a reasonably good book. To understand its limitations, however, it is necessary to understand the two major problems posed by the system, and how they affect even the best of efforts in our textbook scene.

The first difficulty is the inability or unwillingness (or both) of most of our students (and, one might add, many of our teachers) to work out intermediate steps on their own. This has led to the stabilization of a ruthlessly efficient engine: a (vicious) cycle of spoon-feeding and regurgitation in which the working substance is a litany of trivial algebra and arithmetic. Textbooks that do not work out all the steps explicitly are shunned – they are either 'foreign books' or 'foreign-type books' that are 'not suitable for our conditions'. The 'successful' textbooks are poorly printed, excessively bulky hack works that waste a lot of paper and convey little of real substance, let alone challenge the ingenuity or inspire the imagination of the student. Worked out problems most often comprise little more than routine substitution of numerical values in formulas and subsequent simplification in excruciating detail – the argument being that our students only understand material presented in this manner. This is identical to the way our film-makers justify the nauseating trash they purvey as 'what the audience out there wants'. The creation of a vicious cycle in each case is then a mathematical certainty.

The second difficulty is in striking a balance between 'theory' and 'application', especially within the strong constraints posed by a curriculum in which the time allotted to physics is quite meagre. As technology progresses, it becomes necessary to incorporate at least some of the advances into the already abbreviated (4-year instead of the earlier 5-year) BE or B Tech programme (examples: computer-aided design, robotics, . . .). How is this done? Almost always, by removing or reducing portions perceived as unessential, or at least less essential. This is how the 'pure' science part of the engineering curriculum has shrunk over the past 15 years or so – in physics, from a rough average of at least 8 semester-long courses to no more than 3, more often 2, or even 1 (as seems to be the case in Karnataka, and elsewhere too). What happens next in such a situation in tragic: inexorably, what is 'old' gets identified with what is obsolete, and what is new gets confounded with what is relevant. The baby gets thrown out with the bath water: the study of basic principles is eliminated in favour of an inevitably superficial coverage of a patchwork quilt of topics regarded as modern and hence 'relevant' and 'application-oriented', in the fond hope that students who merely hear the magic words or acronyms will automatically become the suppliers of the 'deliverables' of 'futuristic technology'!

It is perhaps considerations along these lines that have dictated the structure of the syllabi of various universities, which the book under review presumably reflects. The sequence of chapters reads: acoustics, nondestructive testing , geometrical optics, interference, diffraction and polarization, fibre optics, laser (*sic*), vacuum science and technology,. . . . This is followed by electronic structure of atoms, semiconductors, dielectric materials, magnetic materials, superconductivity, and *then* magnetism and electricity! Heat and thermodynamics comes next, and then comes the final chapter, basic electronic components – essentially a description of different kinds of resistors, capacitors and inductors. With such a quixotic sequencing of topics, the treatment can only be a largely descriptive listing of facts. Can the average student taking such a course be blamed, then, if he goes away with the impression that physics (which he 'cleared' in his first year by writing short notes on any three out of the following five: noise and its insulation, electron microscope, holography, diffusion pump, energy band theory of crystals (*sic*)) is just a grab bag of disconnected topics like the ones listed above, with little or no unified perspective or guiding principle, half of which can be ignored as it 'was asked last year' and the rest of which is best forgotten in favour of 'real engineering'?!