

## A Down to Earth Exposition

### Matrices and Tensors Made Easy

**Arvind**



*Matrices and Tensors in Physics*  
A W Joshi  
New Age International Publishers  
Ltd, and Wiley Eastern Ltd,  
New Delhi, pp.342, Rs.135.

While writing this review, I asked myself: when does one first encounter matrices as a student of physics, and how well equipped is one to handle them? I recalled that the moment of inertia was the first matrix I encountered, and even though I had learnt about matrices in detail at the plus 2 level, I felt rather ill equipped to grasp their significance. Tensors are always projected as difficult and something which mainly general relativists have to learn.

An early introduction to matrix language helps in appreciating concepts like moment of inertia, polarizability, normal modes of systems of coupled oscillators and gives a deeper insight into the unifying principles of classical physics. Understanding the role of rotations in identifying the principal moments of inertia or the basis in which the polarizability tensor ( $3 \times 3$  matrix) is diagonal, is very important and requires a familiarity with matrices. In the long run, familiarity with the powerful techniques of matrix algebra makes it easy to learn quantum mechanics. Several modern books on quantum mechanics start with systems with a finite number of energy levels and use matrix algebra to

introduce quantum concepts instead of following the more standard approach of differential equations. The book by JJ Sakurai (*Modern Quantum Mechanics*) is one such example.

Tensors may also be very helpful in handling things as simple as cross products of vectors; the introduction of the completely antisymmetric third rank tensor  $\epsilon_{jkl}$  makes life so simple in many elementary calculations involving cross products that one finds oneself using tensors without trepidation! The covariant formulation of electromagnetic theory is a beautiful example where the simple use of tensors gives a lot of insight into the structure of Maxwell's equations.

It is thus very important to have access to a good text book on matrices and tensors which presents the material in a clear and application oriented style. This is the slot that this book fits into; it requires a knowledge of plus 2 level mathematics and introduces most of what is needed to start understanding those areas of physics which use matrix and tensor language. It is best suited for B.Sc. and M.Sc. physics students.

The book starts by introducing elementary notions of vector spaces and defines matrices as acting on these spaces. This in itself is a useful departure (from the physics angle) from the plus 2 level approach of directly dealing with matrices. This makes the transition to higher rank tensors easier. Topics like determinants and the solution of sets of linear equations using matrix techniques, which the



reader is likely to be familiar with at some level, are dealt with in detail. The important and useful procedures of diagonalising symmetric/hermitian matrices using orthogonal/unitary matrices, the significance of eigenvalues and the correspondence of hermitian symmetric matrices with quadratic forms is discussed in fair detail and no background is assumed. Useful ways of partitioning a matrix into submatrices and using this to simplify problems are also discussed.

The subject of tensor algebra and tensor calculus is built up from scratch. Explicit details are provided so that the reader does not get scared. This is important as most students are daunted by tensors. The concepts of covariant and contravariant tensors are developed and applications to special relativity and the covariant formulation of electromagnetic theory are worked out in detail. A preliminary discussion on covariant differentiation, Christoffel symbols and

curvature prepares the reader interested in learning more about general relativity.

Most of the problems in the book are rather routine. It may be necessary to have a number of standard problems to reinforce basic ideas but it is equally essential to give thought provoking problems; this is one major shortcoming of the book. Some introduction to the coordinate independent approach may also have been useful. Elasticity could have been discussed while dealing with the applications of tensors.

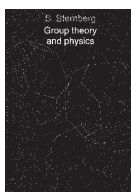
On the whole the book is written with a down to earth approach, giving useful material without getting lost in detailed proofs and at the same time maintaining the requisite mathematical rigour. It should serve as a useful text book/reference for B.Sc as well as M.Sc students. The price is very reasonable.

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## A Mathematician Looks at Physics

An Introduction to Group Theory and its Applications

**Vishwambhar Pati**



*Group Theory and Physics,*  
S Sternberg,  
Cambridge University Press, 1994  
pp. 427. £ 50

That geometry and physics are closely interlinked human endeavours harking back to antiquity is well known. What is not so well known is that group theory, in an implicit way, is also at least as old. For example, the notion of congruence in Euclidean geometry, in modern language would be called equivalence under the group  $E(2)$  of rigid motions of the Euclidean plane. Much later, when geometries other than the Euclidean were discovered, they spawned their own