

# Selected Solutions for *An Introduction to Tensors and Group Theory for Physicists, 2nd ed.*

October 3, 2018

## Introduction

This is an incomplete, evolving solutions manual to [Jee15]. Note that this is the second edition of this text, and that exercise and problem numbering differs between editions. Solutions posted here have primarily been written by students in courses I taught in the UC Berkeley Physics department between 2012 and 2016. If you are interested in improving existing solutions or adding new ones of your own, please email me at nadirj@princeton.edu.

## 1 A Quick Introduction to Tensors

### 2 Vector Spaces

**Exercise 2.1 :** Verify equation 2.7, which states

$$\Delta_{S^2} Y(\theta, \phi) = -l(l+1)Y(\theta, \phi).$$

**Solution:** Pick a vector  $f \in \mathcal{H}_l(\mathbb{R}^3)$ . This function has two useful properties: in spherical coordinates, we may write our function as  $f(r, \theta, \phi) = r^l Y(\theta, \phi)$  – this is a property of  $P_l(\mathbb{R}^3)$ , which contains  $\mathcal{H}_l(\mathbb{R}^3)$  as a subspace. And, since we have chosen it from  $\mathcal{H}_l(\mathbb{R}^3)$ , it satisfies  $\Delta f = 0$ . We write the Laplacian explicitly and combine terms

$$\begin{aligned}\Delta f &= \left( \frac{\partial^2}{\partial r^2} + \frac{2}{r} \frac{\partial}{\partial r} + \frac{1}{r^2} \Delta_{S^2} \right) r^l Y(\theta, \phi) \\ &= l(l-1)r^{l-2}Y + \frac{2}{r}lr^{l-1}Y + r^{l-2}\Delta_{S^2}Y \\ &= l(l-1)r^{l-2}Y + 2lr^{l-2}Y + r^{l-2}\Delta_{S^2}Y \\ &= l(l+1)r^{l-2}Y + r^{l-2}\Delta_{S^2}Y\end{aligned}$$

But we know this quantity is equal to zero. Therefore,

$$\Delta_{S^2} Y(\theta, \phi) = -l(l+1)Y(\theta, \phi)$$

as claimed. Thus all harmonic  $l$ -degree polynomials correspond to a matching spherical harmonic, which corresponds to the restriction of the said polynomial to the unit sphere.

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**Exercise 2.3 :** Given a vector  $v$  and a finite basis  $\mathcal{B} = \{e_i\}_{i=1, \dots, n}$ , show that the expression of  $v$  as a linear combination of the  $e_i$  is unique.

**Solution:** Suppose that our representation of  $v$  in the basis  $\mathcal{B}$  is explicitly given by  $v = a^i e_i$ , where the  $a^i$  are scalars in the appropriate field. Now, suppose that there exists another representation of  $v$  in the same basis, given by  $v = b^i e_i$ . Then we may write:

$$\begin{aligned}v - v &= 0 \\ &= a^i e_i - b^i e_i \\ &= (a^i - b^i) e_i\end{aligned}$$

# Group Theory Solution Manual

**John G. Ratcliffe**



## Group Theory Solution Manual:

**Student Solution Manual for Mathematical Methods for Physics and Engineering Third Edition** K. F. Riley, M. P. Hobson, 2006-03-06 Mathematical Methods for Physics and Engineering Third Edition is a highly acclaimed undergraduate textbook that teaches all the mathematics for an undergraduate course in any of the physical sciences As well as lucid descriptions of all the topics and many worked examples it contains over 800 exercises New stand alone chapters give a systematic account of the special functions of physical science cover an extended range of practical applications of complex variables and give an introduction to quantum operators This solutions manual accompanies the third edition of Mathematical Methods for Physics and Engineering It contains complete worked solutions to over 400 exercises in the main textbook the odd numbered exercises that are provided with hints and answers The even numbered exercises have no hints answers or worked solutions and are intended for unaided homework problems full solutions are available to instructors on a password protected web site [www.cambridge.org/9780521679718](http://www.cambridge.org/9780521679718) [Solution Manual to Accompany Volume I of Quantum Mechanics](#) by Cohen-Tannoudji, Diu and Laloë Guillaume Merle, Oliver J. Harper, Philippe Ribiere, 2023-07-19 Solution Manual to Accompany Volume I of Quantum Mechanics by Cohen Tannoudji Diu and Lalo Grasp the fundamentals of quantum mechanics with this essential set of solutions Quantum mechanics with its counter intuitive premises and its radical variations from classical mechanics or electrodynamics is both among the most important components of a modern physics education and one of the most challenging It demands both a theoretical grounding and a grasp of mathematical technique that take time and effort to master Students working through quantum mechanics curricula generally practice by working through increasingly difficult problem sets such as those found in the seminal Quantum Mechanics volumes by Cohen Tannoudji Diu and Lalo This solution manual accompanies Volume I and offers the long awaited detailed solutions to all 69 problems in this text Its accessible format provides explicit explanations of every step focusing on both the physical theory and the formal mathematics to ensure students grasp all pertinent concepts It also includes guidance for transferring the solution approaches to comparable problems in quantum mechanics Readers also benefit from Approximately 70 figures to clarify key steps and concepts Detailed explanations of problems concerning quantum mechanics postulates mathematical tools properties of angular momentum and more This solution manual is a must have for students in physics chemistry or the materials sciences looking to master these challenging problems as well as for instructors looking for pedagogical approaches to the subject *Chemistry Lab Manual* Neena Sinha, R Rangarajan, R P Manchanda, R K Gupta, Rajesh Kumar, Lab Manual [Abstract Algebra Manual](#) Ayman Badawi, 2004 This is the most current textbook in teaching the basic concepts of abstract algebra The author finds that there are many students who just memorise a theorem without having the ability to apply it to a given problem Therefore this is a hands on manual where many typical algebraic problems are provided for students to be able to apply the theorems and to actually practice the methods they have learned Each chapter

begins with a statement of a major result in Group and Ring Theory followed by problems and solutions Contents Tools and Major Results of Groups Problems in Group Theory Tools and Major Results of Ring Theory Problems in Ring Theory Index

**Hard Bound Lab Manual Chemistry** Neena Sinha, R Rangarajan, R P Manchanda, R K Gupta, Rajesh Kumar, Lab Manuals **Molecular Physics and Elements of Quantum Chemistry** Hermann Haken, Hans Christoph Wolf, 2013-04-18 Since the publication of the first edition of this book there have been many important new developments in the field of molecular physics The new methods and results which are most significant for students are treated extensively in this second edition Among these are in particular single molecule spectroscopy and the field of molecular electronics which is in a stage of rapid development including the areas of electroluminescence and organic light emitting diodes In addition we have extended and corrected the earlier material in a number of places We have also included exercises in this new edition they will allow students to deepen their understanding and offer a basis for further individual study The complete solutions to the exercises can be found on the Internet under [www.springeronline.com](http://www.springeronline.com) 3 540 40792 S We are grateful to Mr C D Bachem and Dr Th Schneider of the Springer Verlag for their continuous and very agreeable cooperation during the preparation of the book We thank our colleague Prof W D Brewer for his competent translation Stuttgart February 2004 H Haken H C Wolf Preface to the First Edition This textbook is intended for use by students of physics physical chemistry and theoretical chemistry The reader is presumed to have a basic knowledge of atomic and quantum physics at the level provided for example by the first few chapters in our book The Physics of Atoms and Quanta *A Laboratory Manual of General Chemistry for Use in Colleges* William Crowell Bray, Wendell Mitchell Latimer, 1921 **Introduction to Abstract Algebra** W. Keith Nicholson, 2012-03-20 Praise for the Third Edition an expository masterpiece of the highest didactic value that has gained additional attractivity through the various improvements Zentralblatt MATH The Fourth Edition of Introduction to Abstract Algebra continues to provide an accessible approach to the basic structures of abstract algebra groups rings and fields The book's unique presentation helps readers advance to abstract theory by presenting concrete examples of induction number theory integers modulo  $n$  and permutations before the abstract structures are defined Readers can immediately begin to perform computations using abstract concepts that are developed in greater detail later in the text The Fourth Edition features important concepts as well as specialized topics including The treatment of nilpotent groups including the Frattini and Fitting subgroups Symmetric polynomials The proof of the fundamental theorem of algebra using symmetric polynomials The proof of Wedderburn's theorem on finite division rings The proof of the Wedderburn Artin theorem Throughout the book worked examples and real world problems illustrate concepts and their applications facilitating a complete understanding for readers regardless of their background in mathematics A wealth of computational and theoretical exercises ranging from basic to complex allows readers to test their comprehension of the material In addition detailed historical notes and biographies of mathematicians provide context for and illuminate the discussion of key topics A

solutions manual is also available for readers who would like access to partial solutions to the book's exercises

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**Group Theory In Physics: Problems And Solutions** Michael Aivazis, Wu-ki Tung, 1991-06-25. This solutions booklet is a supplement to the text book *Group Theory in Physics* by Wu Ki Tung. It will be useful to lecturers and students taking the subject as detailed solutions are given.

**Rings, Monoids and Module Theory** Ayman Badawi, Jim Coykendall, 2022-03-11. This book contains select papers on rings, monoids, and module theory which are presented at the 3rd International Conference on Mathematics and Statistics AUS ICMS 2020 held at the American University of Sharjah, United Arab Emirates, from 6-9 February 2020. This conference was held in honour of the work of the distinguished algebraist Daniel D. Anderson. Many participants and colleagues from around the world felt it appropriate to acknowledge his broad and sweeping contributions to research in algebra by writing an edited volume in his honor. The topics covered are inevitably a cross-section of the vast expansion of modern algebra. The book is divided into two sections: surveys and recent research developments, with each section hopefully offering symbiotic utility to the reader. The book contains a balanced mix of survey papers which will enable expert and non-expert alike to get a good overview of developments across a range of areas of algebra. The book is expected to be of interest to both beginning graduate students and experienced researchers.

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