root system lie algebra

root system lie algebra is a fundamental concept in the field of mathematics, particularly in the study of Lie algebras and algebraic groups. Understanding root systems is crucial for delving into the structure and representation theory of Lie algebras. This article explores the definition and significance of root systems in Lie algebra, their classification, properties, and applications. Additionally, we will examine the relationships between root systems and various algebraic structures, providing a comprehensive overview for readers interested in this intricate mathematical domain.

Definition of Root Systems

A root system in the context of Lie algebra is a finite set of vectors, known as roots, that satisfy specific symmetrical properties within a Euclidean space. Formally, a root system is associated with a Lie algebra and is defined relative to a Cartan subalgebra, which is a maximal abelian subalgebra. The roots are typically represented as linear functionals on the Cartan subalgebra, and their geometric interpretation is vital for understanding the structure of the Lie algebra itself.

Root systems are characterized by certain axioms that ensure their geometric coherence. Specifically, for a root system R in a vector space, the following properties must hold:

- For any root α in R, the reflection through the hyperplane orthogonal to α maps R onto itself.
- The set of roots is closed under the operation of taking negatives, meaning if α is a root, then $-\alpha$ is also a root.
- The roots can be expressed in terms of simple roots, which serve as a basis for the root system and are linearly independent.

Classification of Root Systems

Root systems are classified into several types based on their geometric and algebraic properties. The classification is essential for understanding the relationships between different Lie algebras. The main classifications include finite root systems, affine root systems, and Kac-Moody root systems.

Finite Root Systems

Finite root systems correspond to finite-dimensional semisimple Lie algebras. They can be classified further into types based on their Dynkin diagrams, which provide a graphical representation of the relationships between the simple roots. The classical finite root systems include:

- Type A_n: Associated with special linear groups.
- Type B_n: Related to orthogonal groups.
- Type C_n: Corresponding to symplectic groups.
- Type D_n: Associated with even orthogonal groups.
- Type E_6, E_7, E_8: Exceptional root systems.
- Type F_4: Another exceptional case.
- Type G_2: A small exceptional system.

Affine Root Systems

Affine root systems extend finite root systems by adding an additional dimension, allowing for infinite structures. These systems are vital in the study of affine Lie algebras and can be visualized as a periodic arrangement of roots in a higher-dimensional space. They are classified into various types, analogous to finite systems, and play a significant role in algebraic geometry and mathematical physics.

Kac-Moody Root Systems

Kac-Moody root systems generalize finite and affine root systems and can be infinite-dimensional. These systems arise in the context of Kac-Moody algebras, which are important in representation theory and theoretical physics. The classification of Kac-Moody root systems includes various Dynkin diagrams, similar to finite systems but allowing for loops and multiple edges.

Properties of Root Systems

Root systems possess several intriguing properties that are crucial for their applications in Lie theory and algebraic geometry. Understanding these properties helps in the analysis and manipulation of the structures derived from root systems.

Orthogonality and Length

One of the primary properties of root systems is the orthogonality of roots. Simple roots can be chosen such that they maintain specific angles with each other, often characterized by their lengths. The concept of root length is essential, as it determines the geometry of the entire root system. Roots can be classified as short or long, which affects the structure of the corresponding Lie algebra.

Weight Systems

Associated with root systems are weight systems, which describe how representations of the Lie algebra act on vector spaces. Weights are linear combinations of the roots and play a vital role in representation theory. Understanding the relationships between roots and weights is key to determining the representations of a Lie algebra.

Applications of Root Systems in Mathematics

Root systems have far-reaching implications in various areas of mathematics, particularly in the study of Lie algebras, algebraic groups, and representation theory. Their applications extend to theoretical physics, particularly in string theory and quantum mechanics.

Representation Theory

In representation theory, root systems facilitate the classification of representations of semisimple Lie algebras. The structure of root systems helps in determining the decompositions of representations into irreducible components. Understanding the weights associated with a representation allows mathematicians to explore symmetry and invariance within algebraic structures.

Algebraic Groups

Root systems are also critical in the study of algebraic groups. They provide the foundation for defining algebraic groups in terms of their Lie algebras. The correspondence between root systems and algebraic groups enables the classification of these groups, which is vital in both pure and applied mathematics.

Conclusion

Root system lie algebra is a pivotal concept that bridges various domains in mathematics, including algebra, geometry, and representation theory. The classification and properties of root systems not only enhance our understanding of Lie algebras but also inform their applications in multiple mathematical contexts. As the study of root systems continues to evolve, their significance in both theoretical and applied mathematics remains profound.

Q: What is a root system in Lie algebra?

A: A root system in Lie algebra is a finite set of vectors that satisfy specific symmetrical properties within a Euclidean space, defined relative to a Cartan subalgebra of the Lie algebra.

Q: How are root systems classified?

A: Root systems are classified into finite root systems, affine root systems, and Kac-Moody root systems, based on their geometric and algebraic properties.

Q: What is the significance of simple roots?

A: Simple roots serve as a basis for root systems and are linearly independent, playing a crucial role in the structure of the corresponding Lie algebra.

Q: What are the applications of root systems in representation theory?

A: In representation theory, root systems help classify representations of semisimple Lie algebras and determine their decompositions into irreducible components.

Q: Can root systems be infinite?

A: Yes, Kac-Moody root systems can be infinite-dimensional, extending the concepts of finite and affine root systems.

Q: What role do weights play in root systems?

A: Weights, which are linear combinations of roots, describe how representations of the Lie algebra act on vector spaces and are essential for understanding the algebra's structure.

Q: How do root systems relate to algebraic groups?

A: Root systems provide the foundation for defining algebraic groups in terms of their Lie algebras, facilitating the classification of these groups.

Q: What is the geometric interpretation of root systems?

A: Root systems can be visualized as arrangements of vectors in a Euclidean space, with properties like orthogonality and reflection defining their geometric structure.

Q: What are the classical types of finite root systems?

A: The classical types of finite root systems include \(A_n, B_n, C_n, D_n, E_6, E_7, E_8, F_4, \) and \(G_2 \), each associated with different algebraic groups.

Q: Why are root systems important in theoretical physics?

A: Root systems play a significant role in theoretical physics, particularly in string theory and quantum mechanics, where symmetry and algebraic structures are crucial for formulating theories.

Root System Lie Algebra

root system lie algebra: The Classification of Root Systems and Its Application to Lie Algebras Melanie Laine Mol, 2011 The goal of this thesis is to understand the classification of complex semisimple Lie algebras through the use of root systems. To begin, the basic ideas of Lie theory are established. We restrict our attention to matrix Lie groups and their associated Lie algebras. The existence and uniqueness is shown for an important structure, the Cartan subalgebra, in order to discuss the root space decomposition. The roots associated to the Cartan subalgebra are described geometrically as a subset of a finite dimensional vector space with additional restrictions on the lengths of the vectors and the angles between them. From these parameters, a Cartan matrix is formed and used as a way of storing the information about the root system. This information can be represented graphically by a Dynkin diagrams. The process of arriving at a Dynkin from the starting point of a complex semisimple Lie algebra is the first component of this thesis and is given as a concise survey of the references. The next component involves the classification of Dynkin diagrams. The types of Dynkin diagrams are limited by the angles occurring between two roots. With this limitation, we may entirely classify the possible Dynkin diagrams associated to root systems. The complete classification of Dynkin diagrams is given, including new lemmas and properties. From each Dynkin diagram a root system is constructed, showing the bijection from root systems to Dynkin diagrams. We show that every root system arises from a complex semisimple Lie algebra, and conversely that every complex semisimple Lie algebra has an associated root system, to obtain the classification.

root system lie algebra: The Theory of Zeta-Functions of Root Systems Yasushi Komori, Kohji Matsumoto, Hirofumi Tsumura, 2024-01-02 The contents of this book was created by the authors as a simultaneous generalization of Witten zeta-functions, Mordell–Tornheim multiple zeta-functions, and Euler–Zagier multiple zeta-functions. Zeta-functions of root systems are defined by certain multiple series, given in terms of root systems. Therefore, they intrinsically have the action of associated Weyl groups. The exposition begins with a brief introduction to the theory of Lie algebras and root systems and then provides the definition of zeta-functions of root systems, explicit examples associated with various simple Lie algebras, meromorphic continuation and recursive analytic structure described by Dynkin diagrams, special values at integer points, functional relations, and the background given by the action of Weyl groups. In particular, an explicit form of Witten’s volume formula is provided. It is shown that various relations among special values of Euler–Zagier multiple zeta-functions—which usually are called multiple zeta values (MZVs) and are quite important in connection with Zagier’s conjecture—are just special cases of various functional relations among zeta-functions of root systems. The authors further provide other applications to the theory of MZVs and also introduce generalizations with Dirichlet characters, and with certain congruence conditions. The book concludes with a brief description of other relevant topics.

root system lie algebra: *Algebraic Integrability of Nonlinear Dynamical Systems on Manifolds* A.K. Prykarpatsky, I.V. Mykytiuk, 2013-04-09 In recent times it has been stated that many dynamical systems of classical mathematical physics and mechanics are endowed with symplectic structures, given in the majority of cases by Poisson brackets. Very often such Poisson structures on corresponding manifolds are canonical, which gives rise to the possibility of producing their hidden group theoretical essence for many completely integrable dynamical systems. It is a well understood fact that great part of comprehensive integrability theories of nonlinear dynamical systems on manifolds is based on Lie-algebraic ideas, by means of which, in particular, the classification of such compatibly bi Hamiltonian and isospectrally Lax type integrable systems has been carried out. Many chapters of this book are devoted to their description, but to our regret so far the work has not been completed. Hereby our main goal in each analysed case consists in separating the basic algebraic essence responsible for the complete integrability, and which is, at the same time, in some sense universal, i. e. , characteristic for all of them. Integrability analysis in the framework of a gradient-holonomic algorithm, devised in this book, is fulfilled through three stages: 1) finding a symplectic structure (Poisson bracket) transforming an original dynamical system into a Hamiltonian form; 2) finding first integrals (action variables or conservation laws); 3) defining an additional set of variables and some functional operator quantities with completely controlled evolutions (for instance, as Lax type representation).

root system lie algebra: *Reflection Groups and Invariant Theory* Richard Kane, 2013-03-09 Reflection Groups and their invariant theory provide the main themes of this book and the first two parts focus on these topics. The first 13 chapters deal with reflection groups (Coxeter groups and Weyl groups) in Euclidean Space while the next thirteen chapters study the invariant theory of pseudo-reflection groups. The third part of the book studies conjugacy classes of the elements in reflection and pseudo-reflection groups. The book has evolved from various graduate courses given by the author over the past 10 years. It is intended to be a graduate text, accessible to students with a basic background in algebra. Richard Kane is a professor of mathematics at the University of Western Ontario. His research interests are algebra and algebraic topology. Professor Kane is a former President of the Canadian Mathematical Society.

root system lie algebra: *Companion Encyclopedia of the History and Philosophy of the Mathematical Sciences* Ivor Grattan-Guiness, 2004-11-11 First published in 2004. This book examines the history and philosophy of the mathematical sciences in a cultural context, tracing their evolution from ancient times up to the twentieth century. Includes 176 articles contributed by authors of 18 nationalities. With a chronological table of main events in the development of mathematics. Has a fully integrated index of people, events and topics; as well as annotated bibliographies of both classic and contemporary sources and provide unique coverage of Ancient and non-Western traditions of mathematics. Presented in Two Volumes.

root system lie algebra: Companion Encyclopedia of the History and Philosophy of the Mathematical Sciences Ivor Grattan-Guinness, 2002-09-11 * Examines the history and philosophy of the mathematical sciences in a cultural context, tracing their evolution from ancient times up to the twentieth century * 176 articles contributed by authors of 18 nationalities * Chronological table of main events in the development of mathematics * Fully integrated index of people, events and topics * Annotated bibliographies of both classic and contemporary sources * Unique coverage of Ancient and non-Western traditions of mathematics

root system lie algebra: Lie Algebras: Theory and Algorithms W.A. de Graaf, 2000-02-04 The aim of the present work is two-fold. Firstly it aims at a giving an account of many existing algorithms for calculating with finite-dimensional Lie algebras. Secondly, the book provides an introduction into the theory of finite-dimensional Lie algebras. These two subject areas are intimately related. First of all, the algorithmic perspective often invites a different approach to the theoretical material than the one taken in various other monographs (e.g., [42], [48], [77], [86]). Indeed, on various occasions the knowledge of certain algorithms allows us to obtain a straightforward proof of theoretical results (we mention the proof of the Poincaré-Birkhoff-Witt theorem and the proof of Iwasawa's theorem as examples). Also proofs that contain algorithmic constructions are explicitly formulated as algorithms (an example is the isomorphism theorem for semisimple Lie algebras that constructs an isomorphism in case it exists). Secondly, the algorithms can be used to arrive at a better understanding of the theory. Performing the algorithms in concrete examples, calculating with the concepts involved, really brings the theory of life.

root system lie algebra: Parabolic Geometries I Andreas Čap, Jan Slovák, 2024-07-29 Parabolic geometries encompass a very diverse class of geometric structures, including such important examples as conformal, projective, and almost quaternionic structures, hypersurface type CR-structures and various types of generic distributions. The characteristic feature of parabolic geometries is an equivalent description by a Cartan geometry modeled on a generalized flag manifold (the quotient of a semisimple Lie group by a parabolic subgroup). Background on differential geometry, with a view towards Cartan connections, and on semisimple Lie algebras and their representations, which play a crucial role in the theory, is collected in two introductory chapters. The main part discusses the equivalence between Cartan connections and underlying structures, including a complete proof of Kostant's version of the Bott–Borel–Weil theorem, which is used as an important tool. For many examples, the complete description of the geometry and its basic invariants is worked out in detail. The constructions of correspondence spaces and twistor spaces and analogs of the Fefferman construction are presented both in general and in several examples. The last chapter studies Weyl structures, which provide classes of distinguished connections as well as an equivalent description of the Cartan connection in terms of data associated to the underlying geometry. Several applications are discussed throughout the text.

root system lie algebra: *Graduate Algebra: Noncommutative View* Louis Halle Rowen, 2008 This book is an expanded text for a graduate course in commutative algebra, focusing on the algebraic underpinnings of algebraic geometry and of number theory. Accordingly, the theory of affine algebras is featured, treated both directly and via the theory of Noetherian and Artinian modules, and the theory of graded algebras is included to provide the foundation for projective varieties. Major topics include the theory of modules over a principal ideal domain, and its applications to matrix theory (including the Jordan decomposition), the Galois theory of field extensions, transcendence degree, the prime spectrum of an algebra, localization, and the classical theory of Noetherian and Artinian rings. Later chapters include some algebraic theory of elliptic curves (featuring the Mordell-Weil theorem) and valuation theory, including local fields. One feature of the book is an extension of the text through a series of appendices. This permits the inclusion of more advanced material, such as transcendental field extensions, the discriminant and resultant, the theory of Dedekind domains, and basic theorems of rings of algebraic integers. An extended appendix on derivations includes the Jacobian conjecture and Makar-Limanov's theory of locally nilpotent derivations. Gröbner bases can be found in another appendix. Exercises provide a further extension of the text. The book can be used both as a textbook and as a reference source.

root system lie algebra: Selected Papers of E. B. Dynkin with Commentary Evgeniĭ Borisovich Dynkin, Gary M. Seitz, 2000 Eugene Dynkin is a rare example of a contemporary mathematician who has achieved results in two quite different areas of research: algebra and probability. In both areas, his ideas constitute an essential part of modern mathematical knowledge and form a basis for further development. Although his last work in algebra was published in 1955, his contributions continue to influence current research in algebra and in the physics of elementary particles. His work in probability is part of both the historical and the modern development of the topic.

root system lie algebra: Group Representation for Quantum Theory Masahito Hayashi, 2016-11-18 This book explains the group representation theory for quantum theory in the language of quantum theory. As is well known, group representation theory is very strong tool for quantum theory, in particular, angular momentum, hydrogen-type Hamiltonian, spin-orbit interaction, quark model, quantum optics, and quantum information processing including quantum error correction. To describe a big picture of application of representation theory to quantum theory, the book needs to contain the following six topics, permutation group, SU(2) and SU(d), Heisenberg representation, squeezing operation, Discrete Heisenberg representation, and the relation with Fourier transform from a unified viewpoint by including projective representation. Unfortunately, although there are so many good mathematical books for a part of six topics, no book contains all of these topics because they are too segmentalized. Further, some of them are written in an abstract way in mathematical style and, often, the materials are too segmented. At least, the notation is not familiar to people working with quantum theory. Others are good elementary books, but do not deal with topics related to quantum theory. In particular, such elementary books do not cover projective representation, which is more important in quantum theory. On the other hand, there are several books for physicists. However, these books are too simple and lack the detailed discussion. Hence, they are not useful for advanced study even in physics. To resolve this issue, this book starts with the basic mathematics for quantum theory. Then, it introduces the basics of group representation and discusses the case of the finite groups, the symmetric group, e.g. Next, this book discusses Lie group and Lie algebra. This part starts with the basics knowledge, and proceeds to the special groups, e.g., SU(2), SU(1,1), and SU(d). After the special groups, it explains concrete applications to physical systems, e.g., angular momentum, hydrogen-type Hamiltonian, spin-orbit interaction, and quark model. Then, it proceeds to the general theory for Lie group and Lie algebra. Using this knowledge, this book explains the Bosonic system, which has the symmetries of Heisenberg group and the squeezing symmetry by SL(2,R) and Sp(2n,R). Finally, as the discrete version, this book treats the discrete Heisenberg representation which is related to quantum error correction. To enhance readers' undersnding, this book contains 54 figures, 23 tables, and 111 exercises with solutions.

root system lie algebra: *Integrable Systems: From Classical to Quantum* John P. Harnad, Gert Sabidussi, Pavel Winternitz, 2000 This volume presents the papers based upon lectures given at the 1999 Séminaire de Mathémathiques Supérieurs held in Montreal. It includes contributions from many of the most active researchers in the field. This subject has been in a remarkably active state of development throughout the past three decades, resulting in new motivation for study in r s3risingly different directions. Beyond the intrinsic interest in the study of integrable models of many-particle systems, spin chains, lattice and field theory models at both the classical and the quantum level, and completely solvable models in statistical mechanics, there have been new applications in relation to a number of other fields of current interest. These fields include theoretical physics and pure mathematics, for example the Seiberg-Witten approach to supersymmetric Yang-Mills theory, the spectral theory of random matrices, topological models of quantum gravity, conformal field theory, mirror symmetry, quantum cohomology, etc. This collection gives a nice cross-section of the current state of the work in the area of integrable systems which is presented by some of the leading active researchers in this field. The scope and quality of the articles in this volume make this a valuable resource for those interested in an up-to-date introduction and an overview of many of the main areas of study in the theory of integral systems.

root system lie algebra: Algebraic Foundations of Non-Commutative Differential Geometry and Quantum Groups Ludwig Pittner, 2009-01-29 Quantum groups and quantum algebras as well as non-commutative differential geometry are important in mathematics and considered to be useful tools for model building in statistical and quantum physics. This book, addressing scientists and postgraduates, contains a detailed and rather complete presentation of the algebraic framework. Introductory chapters deal with background material such as Lie and Hopf superalgebras, Lie super-bialgebras, or formal power series. Great care was taken to present a reliable collection of formulae and to unify the notation, making this volume a useful work of reference for mathematicians and mathematical physicists.

root system lie algebra: Taming the Infinite Ian Stewart, 2015-04-07 From ancient Babylon to the last great unsolved problems, Ian Stewart brings us his definitive history of mathematics. In his famous straightforward style, Professor Stewart explains each major development--from the first number systems to chaos theory--and considers how each affected society and changed everyday life forever. Maintaining a personal touch, he introduces all of the outstanding mathematicians of history, from the key Babylonians, Greeks and Egyptians, via Newton and Descartes, to Fermat, Babbage and Godel, and demystifies math's key concepts without recourse to complicated formulae. Written to provide a captivating historic narrative for the non-mathematician, Taming the Infinite is packed with fascinating nuggets and quirky asides, and contains 100 illustrations and diagrams to illuminate and aid understanding of a subject many dread, but which has made our world what it is today.

root system lie algebra: A Conceptual History of Space and Symmetry Pietro Giuseppe Fré, 2018-09-14 This book presents the author’s personal historical perspective and conceptual analysis on symmetry and geometry. The author enlightens with modern views the historical process which led to the contemporary vision of space and symmetry that are used in theoretical physics and in particular in such abstract and advanced descriptions of the physical world as those provided by supergravity. The book is written intertwining storytelling and philosophical argumentation with some essential technical material. The author argues that symmetry and geometry are inextricably entangled and their current meaning is the result of a long process of abstraction which was determined through history and can be understood within the analytic system of thought of western civilization that started with the Ancient Greeks. The evolution of geometry and symmetry theory in the last forty years has been deeply and constructively influenced by supersymmetry/supergravity and the allied constructions of strings and branes. Further advances in theoretical physics cannot be based simply on the Galilean method of interrogating nature and then formulating a testable theory to explain the observed phenomena. One ought to interrogate human thought, meaning frontier-line mathematics concerned with geometry and symmetry in order to find there the threads of so far unobserved correspondences, reinterpretations and renewed conceptions.

root system lie algebra: Handbook of Geometry and Topology of Singularities I José Luis Cisneros Molina, Dũng Tráng Lê, José Seade, 2020-10-24 This volume consists of ten articles which provide an in-depth and reader-friendly survey of some of the foundational aspects of singularity theory. Authored by world experts, the various contributions deal with both classical material and modern developments, covering a wide range of topics which are linked to each other in fundamental ways. Singularities are ubiquitous in mathematics and science in general. Singularity theory interacts energetically with the rest of mathematics, acting as a crucible where different types of mathematical problems interact, surprising connections are born and simple questions lead to ideas which resonate in other parts of the subject. This is the first volume in a series which aims to provide an accessible account of the state-of-the-art of the subject, its frontiers, and its interactions with other areas of research. The book is addressed to graduate students and newcomers to the theory, as well as to specialists who can use it as a guidebook.

root system lie algebra: The Monodromy Group Henryk Zoladek, 2006-08-10 In singularity theory and algebraic geometry the monodromy group is embodied in the Picard-Lefschetz formula and the Picard-Fuchs equations. It has applications in the weakened 16th Hilbert problem and in mixed Hodge structures. In the theory of systems of linear differential equations one has the Riemann-Hilbert problem, the Stokes phenomena and the hypergeometric functions with their multidimensional generalizations. In the theory of homomorphic foliations there appear the Ecalle-Voronin-Martinet-Ramis moduli. On the other hand, there is a deep connection of monodromy theory with Galois theory of differential equations and algebraic functions. All this is presented in this book, underlining the unifying role of the monodromy group. The material is addressed to a wide audience, ranging from specialists in the theory of ordinary differential equations to algebraic geometers. The book contains a lot of results which are usually spread in many sources. Readers can quickly get introduced to modern and vital mathematical theories, such as singularity theory, analytic theory of ordinary differential equations, holomorphic foliations, Galois theory, and parts of algebraic geometry, without searching in vast literature.

root system lie algebra: *The Geometry of Infinite-Dimensional Groups* Boris Khesin, Robert Wendt, 2008-09-28 This monograph gives an overview of various classes of infinite-dimensional Lie groups and their applications in Hamiltonian mechanics, fluid dynamics, integrable systems, gauge theory, and complex geometry. The text includes many exercises and open questions.

root system lie algebra: *Operational Quantum Theory I* Heinrich Saller, 2007-06-10 Operational Quantum Theory I is a distinguished work on quantum theory at an advanced algebraic level. The classically oriented hierarchy with objects such as particles as the primary focus, and interactions of these objects as the secondary focus is reversed with the operational interactions as basic quantum structures. Quantum theory, specifically nonrelativistic quantum mechanics, is developed from the theory of Lie group and Lie algebra operations acting on both finite and infinite dimensional vector spaces. In this book, time and space related finite dimensional representation structures and simple Lie operations, and as a non-relativistic application, the Kepler problem which has long fascinated quantum theorists, are dealt with in some detail. Operational Quantum Theory I features many structures which allow the reader to better understand the applications of operational quantum theory, and to provide conceptually appropriate descriptions of the subject. Operational Quantum Theory I aims to understand more deeply on an operational basis what one is working with in nonrelativistic quantum theory, but also suggests new approaches to the characteristic problems of quantum mechanics.

root system lie algebra: *Encyclopaedia of Mathematics* Michiel Hazewinkel, 2013-12-20

Related to root system lie algebra

□□ ROOT □□□□□□□□□□□□□ - □□ □□ ROOT □□□□□□□□□□□□□□□□□□ ROOT □□□□□□□□□ OPPO □□□□□□□□□□□

2021□□□□□□□root□□root□□□□□□□□□□ - □□ □□□□root□□□□□□□□□□□ SELinux □□□□□ enforcing□□□□□□□□□□ □app□□□□□root□□□□□□app□□□□□□□□□□□□□□□□□□□□□system□□□□□

□□□□□□□□□□□□□□□□□root□ -** □□ □□□□Android□root□□□□□□□□□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□ □□□□□□□□□□root□□ □□□□□□□□□□

□□root□□□□□□□□□□□□□root□□ - □□ □□root□□□□□□□□□□□□□root□□ □□□□□□□□□□□□□□root□□□□□□□□□□□□□□□root □□ □□□□□□□□□□□□□□□□□□□root□□□□ □□□□□□

□□□□□root□□□□□□□□□□□□ - □□ □□□□□□□□□□□□□□□ROOT□□□□□□ROOT□□□□□ ROOT□□□□□□□□□□□□□□□□□□□□□ □□□□□□su□□□□□□□□□□□□□□□□□□ ROOT□

linux □ root □□□□□□□□□ - □□ Linux□□su□□□□□□□□□□ □□ Linux□□□□□□su□□□□□□□□□□sudo Linux□□□□□□su □switch user□ root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

[Guide] How to Root the Samsung Galaxy S5 - By rooting (aka gaining admin rights to) your Samsung Galaxy S5, you can install a custom ROM, run rooted apps, undervolt or overclock the processor and even remove all the

OPPO□□ROOT? - □□ OPPO□□□root□□□□□□□□□□□2□□□□□□□□BL□□□□□□□□BL□□□ □□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□

root□BL□□□□□□ - □□ □□root□□□□□□□□□□□□□□BT□□□□□□□□□□□□□□□□□

MIUI□□□□□□□□□□□□ROOT□□□ - □□ □□□□ROOT□□□□□□□□□ROOT□□□□□□□□ROOT□□□□□□□□□□□□□□□□□□□□ □ROOT□□□ □□□□□□□□□□□□□□□□□□□ □□□□□

□□ ROOT □□□□□□□□□□□□□□ - □□ □□ ROOT □□□□□□□□□□□□□□□□□□□ ROOT □□□□□□□□□ OPPO □□□□□□□□□□□

2021□□□□□□□root□□root□□□□□□□□□□ - □□ □□□□root□□□□□□□□□□□ SELinux □□□□□ enforcing□□□□□□□□□□ □app□□□□□root□□□□□□app□□□□□□□□□□□□□□□□□□□□□□□system□□□□□

□□□□□□□□□□□□□□□□□□root□ - □□ □□□□Android□root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□ □□□□□□□□□□□root□□ □□□□□□□□□□□

□□root□□□□□□□□□□□□□□root□□ - □□ □□root□□□□□□□□□□□□□□root□□ □□□□□□□□□□□□□□root□□□□□□□□□□□□□□□root □□ □□□□□□□□□□□□□□□□□□□□□□□□root□□□□ □□□□□□

□□□□□root□□□□□□□□□□□□□ - □□ □□□□□□□□□□□□□□□□ROOT□□□□□□ROOT□□□□□ ROOT□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□su□□□□□□□□□□□□□□□□□□□□□ ROOT□

linux □ root □□□□□□□□□□ - □□ Linux□□su□□□□□□□□□□ □□ Linux□□□□□□su□□□□□□□□□□sudo Linux□□□□□□su □switch user□ root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

[Guide] How to Root the Samsung Galaxy S5 - By rooting (aka gaining admin rights to) your Samsung Galaxy S5, you can install a custom ROM, run rooted apps, undervolt or overclock the processor and even remove all the

OPPO□□ROOT? - □□ OPPO□□□root□□□□□□□□□□□2□□□□□□□□BL□□□□□□□□BL□□□ □□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□

root□BL□□□□□□ - □□ □□root□□□□□□□□□□□□□□BT□□□□□□□□□□□□□□□□□

MIUI□□□□□□□□□□□□ROOT□□□ - □□ □□□□ROOT□□□□□□□□□ROOT□□□□□□□□ROOT□□□□□□□□□□□□□□□□□□□□ □ROOT□□□ □□□□□□□□□□□□□□□□□□□ □□□□□

□□ ROOT □□□□□□□□□□□□□□ - □□ □□ ROOT □□□□□□□□□□□□□□□□□□□ ROOT □□□□□□□□□ OPPO □□□□□□□□□□□

2021□□□□□□□root□□root□□□□□□□□□□ - □□ □□□□root□□□□□□□□□□□ SELinux □□□□□ enforcing□□□□□□□□□□ □app□□□□□root□□□□□□app□□□□□□□□□□□□□□□□□□□□□□□system□□□□□

□□□□□□□□□□□□□□□□□□root□ - □□ □□□□Android□root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□ □□□□□□□□□□□root□□ □□□□□□□□□□□

□□root□□□□□□□□□□□□□□root□□ - □□ □□root□□□□□□□□□□□□□□root□□ □□□□□□□□□□□□□□root□□□□□□□□□□□□□□□root □□ □□□□□□□□□□□□□□□□□□□□□□□□root□□□□ □□□□□□

□□□□□root□□□□□□□□□□□□□ - □□ □□□□□□□□□□□□□□□□ROOT□□□□□□ROOT□□□□□ ROOT□□□□□□□□□□□□□□□□□□□□□□□ □□□□□□□su□□□□□□□□□□□□□□□□□□□□□ ROOT□□

linux □ root □□□□□□□□□□ - □□ Linux□□su□□□□□□□□□□ □□ Linux□□□□□□su□□□□□□□□□□sudo Linux□□□□□□su □switch user□ root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

[Guide] How to Root the Samsung Galaxy S5 - By rooting (aka gaining admin rights to) your Samsung Galaxy S5, you can install a custom ROM, run rooted apps, undervolt or overclock the processor and even remove all the

OPPO□□ROOT? - □□ OPPO□□□root□□□□□□□□□□□2□□□□□□□□BL□□□□□□□□BL□□□ □□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□

root□BL□□□□□□ - □□ □□root□□□□□□□□□□□□□□BT□□□□□□□□□□□□□□□□□

MIUI□□□□□□□□□□□□ROOT□□□ - □□ □□□□ROOT□□□□□□□□□ROOT□□□□□□□□ROOT□□□□□□□□□□□□□□□□□□□□ □ROOT□□□ □□□□□□□□□□□□□□□□□□□ □□□□□

□□ ROOT □□□□□□□□□□□□□□ - □□ □□ ROOT □□□□□□□□□□□□□□□□□□□ ROOT □□□□□□□□□ OPPO □□□□□□□□□□□

2021□□□□□□□root□□root□□□□□□□□□□ - □□ □□□□root□□□□□□□□□□□ SELinux □□□□□ enforcing□□□□□□□□□□ □app□□□□□root□□□□□□app□□□□□□□□□□□□□□□□□□□□□□□system□□□□□

□□□□□□□□□□□□□□□□□□root□ - □□ □□□□Android□root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□ □□□□□□□□□□□root□□ □□□□□□□□□□□

□□**root**□□□□□□□□□□□□□**root**□□ **-** □□ □□root□□□□□□□□□□□□□root□□ □□□□□□□□□□□□□□root□□□□□□□□□□□□□□□root □□ □□□□□□□□□□□□□□□□□□□□□root□□□□ □□□□□□
□□□□□□**root**□□□□□□□□□□□□ **-** □□ □□□□□□□□□□□□□□□□ROOT□□□□□□ROOT□□□□□ ROOT□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□su□□□□□□□□□□□□□□□□□□□□ ROOT□□
linux □ root □□□□□□□□□□ - □□ Linux□□su□□□□□□□□□□ □□ Linux□□□□□□su□□□□□□□□□□sudo Linux□□□□□□su □switch user□ root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
[Guide] How to Root the Samsung Galaxy S5 - By rooting (aka gaining admin rights to) your Samsung Galaxy S5, you can install a custom ROM, run rooted apps, undervolt or overclock the processor and even remove all the
OPPO□□ROOT? - □□ OPPO□□□root□□□□□□□□□□□□2□□□□□□□□BL□□□□□□□□BL□□□ □□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□□□□
root□BL□□□□□□ - □□ □□root□□□□□□□□□□□□□□BT□□□□□□□□□□□□□□□□□
MIUI□□□□□□□□□□□□□ROOT□□□ - □□ □□□□ROOT□□□□□□□□□□ROOT□□□□□□□□ROOT□□□□□□□□□□□□□□□□□□□□ROOT□□□ □□□□□□□□□□□□□□□□□□ □□□□□
□□ **ROOT □□□□□□□□□□□□□ -** □□ □□ ROOT □□□□□□□□□□□□□□□□□ ROOT □□□□□□□□ OPPO □□□□□□□□□□
2021□□□□□□□root□□root□□□□□□□□□□ - □□ □□□□root□□□□□□□□□□□ SELinux □□□□□ enforcing□□□□□□□□□□□app□□□□□root□□□□□□app□□□□□□□□□□□□□□□□□□□□system□□□□□
□□□□□□□□□□□□□□□□□□**root**□ **-** □□ □□□□Android□root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□□□□□root□□ □□□□□□□□□□□
□□**root**□□□□□□□□□□□□□**root**□□ **-** □□ □□root□□□□□□□□□□□□□root□□ □□□□□□□□□□□□□□root□□□□□□□□□□□□□□□root □□ □□□□□□□□□□□□□□□□□□□□□root□□□□ □□□□□□
□□□□□□**root**□□□□□□□□□□□□ **-** □□ □□□□□□□□□□□□□□□□ROOT□□□□□□ROOT□□□□□ ROOT□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□su□□□□□□□□□□□□□□□□□□□□ ROOT□
linux □ root □□□□□□□□□□ - □□ Linux□□su□□□□□□□□□□ □□ Linux□□□□□□su□□□□□□□□□□sudo Linux□□□□□□su □switch user□ root□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
[Guide] How to Root the Samsung Galaxy S5 - By rooting (aka gaining admin rights to) your Samsung Galaxy S5, you can install a custom ROM, run rooted apps, undervolt or overclock the processor and even remove all the
OPPO□□ROOT? - □□ OPPO□□□root□□□□□□□□□□□□2□□□□□□□□BL□□□□□□□□BL□□□ □□□□□□□□□□□□□□□□□□□□□root□□□□□□□□□□□□□□□□□□□□□□□
root□BL□□□□□□ - □□ □□root□□□□□□□□□□□□□□BT□□□□□□□□□□□□□□□□□
MIUI□□□□□□□□□□□□□ROOT□□□ - □□ □□□□ROOT□□□□□□□□□□ROOT□□□□□□□□ROOT□□□□□□□□□□□□□□□□□□□□ROOT□□□ □□□□□□□□□□□□□□□□□□ □□□□□

Related to root system lie algebra

Simple Lie Algebras of Characteristic p with Dependent Roots (JSTOR Daily2y) We investigate finite dimensional simple Lie algebras over an algebraically closed field F of characteristic p ≥ 7 having a Cartan subalgebra H whose roots are dependent over F. We show that H must be
Simple Lie Algebras of Characteristic p with Dependent Roots (JSTOR Daily2y) We investigate finite dimensional simple Lie algebras over an algebraically closed field F of characteristic p ≥ 7 having a Cartan subalgebra H whose roots are dependent over F. We show that H must be