



# Lie Algebras and Lie Groups: 1964 Lectures given at Harvard University (Lecture Notes in Mathematics)

*Jean-Pierre Serre*

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The main general theorems on Lie Algebras are covered, roughly the content of Bourbaki's Chapter I. I have added some results on free Lie algebras, which are useful, both for Lie's theory itself (Campbell-Hausdorff formula) and for applications to pro-Lie groups. Time prevented me from including the more precise theory of Lie semisimple Lie algebras (roots, weights, etc.); but, at least, I have given, as a last Chapter, the typical case of a reductive Lie algebra. This part has been written with the help of F. Raggi and J. Tate. I want to thank them, and also Sue Golan, who did the typing for both parts. Jean-Pierre Serre Harvard, Fall 1964 Chapter I. Lie Algebras: Definition and Examples Let  $\mathfrak{L}$  be a commutative ring with unit element, and let  $A$  be a  $\mathfrak{L}$ -module, then  $A$  is said to be a Lie algebra if there is given a  $\mathfrak{L}$ -bilinear map  $A \times A \rightarrow A$  (i.e., a  $\mathfrak{L}$ -homomorphism  $A \otimes A \rightarrow A$ ). As usual we may define left, right and two-sided ideals and therefore quotients. Definition 1. A Lie algebra over  $\mathfrak{L}$  is an algebra with the following properties: 1) The map  $A \otimes A \rightarrow A$  admits a factorization  $A \otimes A \rightarrow A \otimes A \rightarrow A$  i.e., if we denote the image of  $(x, y)$  under this map by  $[x, y]$  then the condition becomes for all  $x, y \in A$ .  $[x, x] = 0$  2)  $([x, y], z) + (y, [x, z]) + (z, [x, y]) = 0$  (Jacobi's identity) The condition 1) implies  $[x, 1] = -[1, x]$

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