Postgraduate Course Book

Department of Mathematics

College: Education College

University: Salahaddin University

Subject: Lie Theory

Course Book Level: PhD course

First semester

Lecturer's name: Dr Hogir Mohammed Yaseen

Academic Year: 2023/2024

Course Book

1. Course name	**Lie theory**
2. Lecturer in charge	**Hogir Mohammed Yaseen**
3. Department/ College	**Mathematic: Education**
4. Contact	**e-mail:** hogr.yaseen@su.edu.krd **Tel: (optional)07504154982**
5. Time (in hours) per week	3 Hours per a Week
6. Office hours	**Saterday 10-12:30, 8-12 Sunday 10-12 Monday and 12-2 Wednesday**
7. Course code	
8. Teacher's academic profile	**1. B.Sc. in Mathematics, 2007, Salahaddin University-Erbil** **2. M.Sc. in Algebra, 2010, University of Salahaddin , UK.** **PhD, in representation of Lie algebras, University of Leicester 2018**
9. Keywords	**Algebra, Lie group and Lie group**

10. Course objectives:

In this course we study basic definitions and results a bout Lie algebras, Lie groups, and their correspondence and we have the following objectives:

1. Lie Algebra Fundamentals: Develop a deep understanding of Lie algebras, including their definition, axioms, and basic properties.

2. Matrix Lie Groups: Study important matrix Lie groups, such as SO(3), SU(2), and SL(2, C), and understand their Lie algebras.

3. Lie Group-Lie Algebra Correspondence:
study the one-to-one correspondence between Lie groups and Lie algebras.

4. Lie Group Exponentiation: Master the techniques for exponentiating elements of Lie algebras to obtain elements of the corresponding Lie groups.

5. Lie Group Representations: Investigate how Lie groups can be represented as matrices, including finite-dimensional and infinite-dimensional representations.

6. Lie Algebra Structure: Understand the structure of Lie algebras, including the concept of Lie brackets, Casimir operators, and the Killing form.

7. study main results about classification of simple Lie algebras by using Cartan matrices and Dynkin diagram .
8. Lie Group Classification: Explore the classification of simple Lie groups and their Lie algebras.

11 . Course overview:

In this course Lie Theory course, students will embark on a comprehensive journey through the realms of Lie algebras and Lie groups and their correspondence, with a primary focus on understanding their intricate relationship. First we study basic concepts and results algebras and we study some types and properties of it. Then we go to study Lie algebras, including their definition, key axioms, and essential properties. After that we study Lie groups and basic concepts and results of it . At the end we study main theorems about one-to-one correspondence between Lie groups and Lie algebras, and learn how to extract Lie algebras from Lie groups and vice versa.

12. Student's obligation

1. Students have an obligation to arrive on time and remain in the classroom for the duration of scheduled classes and activities.
2. Students have an obligation to write, homework's, tests and final examinations at the times scheduled by the teacher or the College. Students have an obligation to inform themselves of, and respect, College examination procedures.
3. Students have an obligation to show respectful behaviour with teacher and their class mates
4. Electronic/communication devices (including cell phones, mp3 players, etc.) have the effect of disturbing the teacher and other students. All these devices must be turned off and put away. Students who do not observe these rules will be asked to leave the classroom.

13. Forms of teaching

Different forms of teaching will be used to reach the objectives of these courses to the students: power point presentation for the course outline, head titles, definition, discussion and conclusions. Also, we shall use the blackboard for solving and explaining the examples.

14. Assessment scheme: The assessment is divided up as follows:

1- Article review, Quiz and Seminars 30%

2- Midterm test = 20%.

3- Final Examination 50% .

15. Student learning outcome:

learn basic definitions and results about Lie algebras, Lie groups, and their correspondence.

16. Course Reading List and References:

1) Hall, Brian C. "Lie Groups, Lie Algebras, and Representations: An Elementary Introduction." Springer, 2015.
2)Fulton, William, and Harris, Joe. "Representation Theory: A First Course." Springer, 1991.
3)Kirillov Jr., Alexander. "An Introduction to Lie Groups and Lie Algebras." Cambridge University Press, 2008.
4) Humphreys, James E. "Introduction to Lie Algebras and Representation Theory." Springer, 1972.
5)Erdmann, Karin, and Wildon, Mark J. "Introduction to Lie Algebras." Springer, 2006.
6)Serre, Jean-Pierre. "Lie Algebras and Lie Groups: 1964 Lectures Given at Harvard University." Springer, 2012.
7)Erdmann, Karin, and Thorsten Holm. "Algebras and Representation Theory." Springer, 2007.

17. Topics Program	Lecture's Name
Week 1: Definition of Algebras and Lie Algebras and some examples and properties of them.	
Week 2: Subalgebras, Ideals and Homomorphisms and Derivations and Structure Constants	
Week 3: Constructions with Ideals, Quotient Algebras, Correspondence between Ideals, Low-Dimensional Lie Algebras and their classifications	
Week 4: Solvable Lie Algebras and Nilpotent Lie Algebras	
Week 5: Division Algebras, Group Algebras, Path Algebras of Quivers, Subalgebras, Ideals and Factor Algebras , Algebra Homomorphisms, Some Algebras of Small Dimensions	

Week 6: Subalgebras of gl(V), Nilpotent Maps, Weights, The Invariance Lemma, An Application of it.	
Week 7: Some Representation Theory: Definitions and Examples of Representations, Modules for Lie Algebras, Submodules and Factor Modules Irreducible and Indecomposable Modules, Homomorphisms and Schur's Lemma and Weyl's Theorem	
Week 8: Midterm exam, Engel's Theorem and Lie's Theorem	
Week 9: Modules and Representations for Algebras , Simple Modules and the Jordan–Hölder Theorem and Semisimple Modules and Semisimple Algebras	
Week 10: Simple and semi simple Lie Algebras and their classification. Also, Classification of Dynkin Diagrams	
Week 11: Lie group and basics definitions and examples about it.	
Week 12: Matrix Lie Groups: Exploring important examples of Lie groups, such as SO(n), SU(n), and GL(n,R) and Properties of them.	
Week 13: Understanding how to map between a Lie group and its Lie algebra using the exponential and logarithm maps.	
Week 14: The Lie group-Lie algebra correspondence.	
18. Grading procedure: **19. Extra note:** **20 . Peer review:**	

* Must have permission of the Scientific and Higher Education Committee