Appendix B-2: Linear Algebra A Syllabus

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<table>
<tr><td>course title</td><td colspan="3">linear algebra A</td><td>Course number</td><td colspan="2">9092112091</td></tr>
<tr><td>Applicable specialties</td><td colspan="6">Science and engineering majors, management majors in the whole university</td></tr>
<tr><td>Nature of the course</td><td colspan="6">General education courses ☑ , subject foundation courses ☐ , professional core courses (elective ☑ required ☐), independent development courses (required ☐ and elective ☐), concentrated practical courses ☐</td></tr>
<tr><td>Unit offering the course</td><td colspan="6">School of Science</td></tr>
<tr><td>total class hours</td><td>60</td><td>credit</td><td>2</td><td>Contact hours</td><td>32</td><td>Self-study hours</td><td>28</td></tr>
<tr><td>Prerequisite courses</td><td colspan="6">Advanced Mathematics</td></tr>
<tr><td>Textbooks and teaching resources</td><td colspan="6">Course textbook: Chen Shubo et al. Linear Algebra [M]. Beijing: Peking University Press, 2022.
Reference: Department of Mathematics, Huazhong University of Science and Technology. Linear Algebra [M]. Beijing: Higher Education Press, 2008.
Zhou Yong. Linear Algebra [M]. Beijing: Peking University Press, 2018.
Liu Xianzhong. Linear Algebra (2nd Edition) [M]. Beijing: Higher Education Press, 2003.
MAO Gangyuan. Linear Algebra Problem solving Techniques [M]. Wuhan: Huazhong University of Science and Technology Press, 2015
Teaching website:http://open.163.com/special/Khan/linearalgebra.html
https://www.bilibili.com/video/av29971113</td></tr>
</table>

1. Course introduction

Linear algebra is an essential public foundational theory course for all majors in higher engineering institutions. Since linear problems are prevalent across various fields of science and technology, and certain nonlinear problems can be transformed into linear ones under specific conditions, the methods introduced in this course are widely applied across disciplines. With the development of modern science and technology, particularly computer science, solving large systems of linear equations, finding eigenvalues and eigenvectors of matrices have become common issues in engineering and technology. Therefore, learning and mastering the theories and methods of linear algebra is a crucial foundation and tool for understanding modern

science and technology and conducting scientific research. It is also a prerequisite for achieving the training objectives of our universitys engineering programs. Thus, the role and importance of linear algebra courses are even more significant. The primary task of this course is to learn commonly used matrix methods, systems of linear equations, and related basic computational techniques in science and technology. This will equip students with proficient matrix operation skills and the ability to solve practical problems using matrix methods. Consequently, it lays a necessary mathematical foundation for further studies and advanced learning.

2. The graduation requirements supported by this course and the implementation path

(1) Graduation requirements supported by this course

order number	Graduation requirement indicators	Specific content of graduation requirement indicators
1	Graduation requirements 1.1	Master mathematics and natural science knowledge, have the ability to calculate and deduce.
2	Graduation requirement 2.1	Be able to apply the basic principles of mathematics, natural science and engineering science to identify complex civil engineering problems.
3	Graduation requirement 5.2	Be able to use modern tools to model and calculate complex civil engineering problems, and analyze the effectiveness and limitations of prediction and simulation results.

(2) Achievement paths of graduation requirement indicator points in this course

1. Course objectives

Through the theoretical teaching and cognitive practice of this course, students will have basic knowledge and ability. The specific course objectives are as follows:

Course Ideological and Political Education Goals: On the basis of imparting linear algebra knowledge, guide students to transform the acquired knowledge and skills into inner virtues and qualities; focus on integrating students personal development with social and national progress, cultivating their patriotic sentiments

and dedication to serving the country through science and technology. In addition to teaching mathematical knowledge, integrate dialectical materialism into the curriculum to foster a dialectical materialist worldview in students. On the basis of imparting mathematical knowledge, incorporate the aesthetic value of mathematics and the treasures of Chinese traditional culture to promote higher-quality all-round development in moral, intellectual, physical, aesthetic, and labor aspects. Form a pattern of comprehensive education involving everyone, throughout the entire process, and in every aspect, achieving the fundamental educational goal of "nurturing virtue and fostering talent."

Course objective 1: Through learning, students can master the relevant concepts and properties of determinants, be able to skillfully use the properties of determinants to calculate determinants, and be able to apply the two basic methods of calculating determinants: triangle method and reduction method; understand algebraic sub-determinants and Cramers rule; cultivate students ability to calculate and deduce determinants.

Course objective 2: Through learning, students will understand the concept of matrices, master various laws of matrix operations, especially those involving square matrices and mixed operations with determinants; they will learn how to determine whether a matrix is invertible and how to find its inverse, and be able to use properties of the inverse matrix for matrix operations and solving simple matrix equations; they will understand the concept of elementary matrices and their relationship with elementary matrix transformations, and be able to skillfully compute the rank of a matrix. Students will also develop their ability to perform calculations and derivations involving matrices, as well as their capability to apply basic principles of matrices to identify complex engineering problems in civil engineering.

Course objective 3: Through learning, students will master the determination of solutions for systems of linear equations and the elimination method; they will learn how to identify linear dependence in vector sets and be proficient in finding the rank of vector sets and their maximal independent sets; they will understand the conditions

for non-zero solutions to homogeneous systems of linear equations and the structure of these solutions, as well as the conditions for non-homogeneous systems of linear equations and their solutions, and will be able to skillfully use elementary transformation methods to find solutions to systems of linear equations and fundamental solution sets. Students will also be trained to apply knowledge of systems of linear equations to model and solve complex engineering problems in civil engineering.

Course objective 4: Through teaching, students can understand the concept and properties of eigenvalues and eigenvectors of a matrix, the concept and properties of similar matrices and the necessary and sufficient conditions for a matrix to be similar to a diagonal matrix. Students can also develop their ability to calculate and deduce the diagonalization of a matrix.

2. The corresponding relationship between the course teaching objectives and graduation requirements

Graduation requirement indicators	**Course teaching objectives**
Graduation requirements 1.1	Course objectives 1, 2, 3, 4
Graduation requirements 2.1	Course objectives 2 and 3
Graduation requirements 5.2	Course objective 3

3. Intended learning outcomes and details of teaching links

(1) Intended learning outcomes

The intended learning outcomes of this course are as follows

train objective / blocks of knowledge	**knowledge point**	**Initial level**	**Degree of requirement**	Intended learning outcomes	**corresponding Graduation requirements**
1. determinant	Second order and third order determinants and Cramers	L1	L 2	**1.** Correctly calculate the second and third order determinant, and use the Cramers rule to solve the system of linear equations	1. 1

train objective / blocks of knowledge	knowledge point	Initial level	Degree of requirement	Intended learning outcomes	corresponding Graduation requirements
	rule				
	Properties of determinants	L1	L 2	**2.** Apply the properties of determinants to correctly calculate fourth order and higher order determinants	1. 1
	Calculation of n-order determinant	L1	L 2	**3.** Can use the appropriate method to correctly calculate the n-order determinant	1.1
2. Matrix	The concept and properties of matrices	L1	L2	**4.** Understand the concept of matrix, apply the operation rules and properties of matrix, solve the matrix equation	1. 1 2.1
	inverse matrix	L1	L2	**5.** To judge whether the matrix is reversible, the inverse matrix of a third-order matrix is solved by using the method of companion matrix	1.1 2.1
	Elementary transformation of matrix and rank of matrix	L1	L2	**6.** The application matrix elementary transformation is used to solve higher-order matrix equations and the rank of higher-order matrix	1. 1
3. Vectors and systems of linear equations	Elimination method of linear equation system	L 1	L2	**7.** It can analyze the solution of linear equations by using coefficient matrix and rank of augmented matrix, and can solve linear equation systems by using elimination method	1.1 2.1 5.2
	Vector groups and their linear correlation	L1	L2	**8.** The linear correlation of vector groups can be correctly solved by applying the theory of application correlation to analyze the linear correlation of vector groups	1.1
	Structure of solution of linear	L1	L3	**9.** The solution of linear equation system and the basic solution system are solved by elementary transformation of	2.1 5.2

train objective / blocks of knowledge	knowledge point	Initial level	Degree of requirement	Intended learning outcomes	corresponding Graduation requirements
	equations			application matrix	
4. Eigenvalues and eigenvectors	Inner product, length and orthogonality of vectors	L 1	L2	**10.** Understand the concept of vector inner product, length and orthogonality, be able to correctly calculate the inner product and length of vectors, be able to judge whether two vectors are orthogonal	1.1
	The eigenvalues and eigenvectors of the array	L 1	L2	**11.** The eigenvalues and eigenvectors are solved by using characteristic equations and linear equations	1. 1
	similar matrix	L 1	L2	**12.** The diagonalization form of the matrix is solved by using similar transformation and orthogonal similar transformation	1 .1

(2) Detailed rules for teaching links

Teaching Unit (2 periods)	Expected learning outcomes (ILO)	content of courses (knowledge point)	Implementation link (In class, projects, etc.)	instructional strategies
1	1. Correctly calculate the second and third order determinant, and use the Cramers rule to solve the system of linear equations	1. Second and third order determinants and Cramers rule	In-class teaching Extracurricular practice	Problem-oriented lecture
2	2. Apply the properties of determinants to correctly calculate the fourth order and higher order determinants	2. Properties of row matrices	In-class instruction Extracurricular practice	lecture Problem guidance Combine lecture with practice
3	3. Be able to choose the appropriate method and correctly calculate the	3. Calculation of n-order determinant (1)	In-class instruction Extracurric	lecture Problem-oriented guidance

Teaching Unit (2 periods)	Expected learning outcomes (ILO)	content of courses (knowledge point)	Implementation link (In class, projects, etc.)	instructional strategies
	n-order determinant		ular practice	Combine lecture with practice
4	3. Be able to choose the appropriate method to correctly calculate the n-order determinant	3. Calculation of 3-order determinant (2)	In-class instruction Extracurricular practice	Combine lecture with practice
5	4. Understand the concept of matrix, apply the operation rules and properties of matrix, and solve the matrix equation	4. The concept and properties of matrices	In-class instruction Extracurricular practice	lecture Problem-oriented guidance Combine lecture with practice
6	5. Determine whether the matrix is reversible, and apply the method of companion matrix to solve the inverse matrix of a third-order matrix	5. matrix inversion	In-class instruction Extracurricular practice	lecture Combine lecture with practice
7	6. Apply matrix elementary transformation to solve higher-order matrix equations and rank of higher-order matrix	6. Elementary transformation of matrix and rank of matrix (1)	In-class instruction Extracurricular practice	lecture Combine lecture with practice
8	The application matrix elementary transformation is used to solve higher-order matrix equations and the rank of higher-order matrix	6. Elementary transformations of matrices and rank of matrices (2)	In-class instruction Extracurricular exercises	lecture Combine lecture with practice
9	7. Be able to analyze the solution of linear equations by using the rank of coefficient matrix and augmented matrix, and be able to solve linear equation systems by using the elimination method	7. Elementary elimination of linear equations	In-class instruction Extracurricular practice	lecture Problem-oriented guidance Combine lecture with practice
10	8. The linear correlation of vector groups can be	8. Vector sets and their linear	In-class instruction	lecture Combine

Teaching Unit (2 periods)	Expected learning outcomes (ILO)	content of courses (knowledge point)	Implementation link (In class, projects, etc.)	instructional strategies
	correctly solved by applying the theory of correlation to analyze the linear correlation of vector groups	correlation (1)	Extracurricular exercises	lecture with practice
11	The linear correlation of vector groups can be correctly solved by applying the theory of application correlation to analyze the linear correlation of vector groups	8. Vector groups and their linear correlation (2)	In-class instruction Extracurricular practice	lecture Combine lecture with practice
12	9. Solve the solution and basic solution system of linear equation group by elementary transformation of application matrix	9. Structure of solution of linear equations	In-class instruction Extracurricular practice	lecture Problem-oriented Combine lecture with practice
13	10. Understand the concept of vector inner product, length and orthogonality, be able to correctly calculate the inner product and length of vectors, and be able to judge whether two vectors are orthogonal	10. Vector inner product, length and orthogonality	In-class instruction Extracurricular practice	lecture Combine lecture with practice
14	11. Solve eigenvalues and eigenvectors by using characteristic equations and linear equations	11. Eigenvalues and eigenvectors of a array	In-class instruction Extracurricular practice	lecture Combine lecture with practice
15	12. Apply similar transformation and orthogonal similar transformation to solve the diagonal form of the matrix	12. Similarity matrix (1)	In-class instruction Extracurricular practice	lecture Problem-oriented Combine lecture with practice
16	The diagonalization form of a matrix is solved by using similar transformation and orthogonal similar	12. Similarity matrix (2)	In-class instruction Extracurricular	lecture Combine lecture with practice

Teaching Unit (2 periods)	Expected learning outcomes (ILO)	content of courses (knowledge point)	Implementation link (In class, projects, etc.)	instructional strategies
	transformation		practice	

4. Course assessment

(1) Course assessment structure

Examination items		Scale	Requirement
usual performance	Homework	20%	Each knowledge unit (1-4) is assigned 1-2 times and completed independently by individuals
	In-class test	30%	Each knowledge unit (1-4) is tested once, focusing on the students mastery of the core knowledge points, with objective questions as the main part
	Pre-class study	10%	After learning knowledge units 1, 2 or (1, 2, 3), you will take a comprehensive test by computer in combination with the online examination system of the School of Science
final		40%	The students mastery of the first four knowledge units is comprehensively examined
amount to		100%	

(2) Course assessment rules

Assessment items	primary coverage	
	Knowledge units/points	Ability items
Homework	All knowledge units	Mathematical thinking ability/computation and reasoning ability
In-class test	All knowledge units	Computational and deductive skills
Pre-class study	All knowledge units	Computational and deductive ability/autonomous learning ability
Final	All knowledge units	Computational and deductive skills

5. Course teaching methods

In the teaching process, the focus is on introducing principles, methods, and

specific calculation procedures. Multimedia is utilized, and teaching methods such as problem-driven instruction, lectures combined with practice, are employed to help students master conventional computational methods and steps involved in linear algebra, enabling them to grasp mathematical tools related to solving systems of linear equations. The specific teaching methods and ideas are as follows:

1) Starting from the characteristics of second and third-order determinant expansions, introduce the definition of n-order determinants; determinants are fundamental in linear algebra, used in finding matrix inverses, solving systems of equations, and calculating eigenvalues. The calculation of determinants mainly relies on their properties, so the focus is on mastering these properties and their applications. Various methods and techniques for determinant calculations should be introduced through numerous examples, primarily using lecture-based and problem-driven approaches, with classroom discussions, student exercises (assignments), and teacher guidance and Q&A sessions.

2) Starting from the definition of matrix, the key points are to explain the operation of matrix, elementary transformation of matrix and rank of matrix. While explaining these knowledge, the way of solving linear equation sets is combined to reflect the advantages of overall processing. The teaching method is mainly based on lecture and practice.

3) Starting from the linear dependence of vector sets, the main topics include the maximum linearly independent set of a vector set, elimination method, and the structure of solutions to systems of linear equations; the section on the structure of solutions to homogeneous systems should be combined with vector spaces, reviewing the basis of vector spaces and the maximum linearly independent set of a vector set to deepen the understanding of basic concepts. The teaching method primarily relies on lectures, supplemented by classroom tests.

4) When introducing the definition of eigenvalues and eigenvectors, pay attention to the transformation of definitions and methods for calculating through definitions. Focus on explaining the application of eigenvalues and eigenvectors in

matrix diagonalization. The teaching method primarily combines lectures with practice, including classroom discussions, student exercises (assignments), and teacher guidance and Q&A sessions.

6. Course evaluation and continuous improvement mechanism

(1) Course evaluation

The course evaluation cycle is set to evaluate once per semester. The target value of achievement is 0.65, and the following two methods are used for comprehensive evaluation:

1. Analysis of results

The evaluation is made by the teaching teacher, and the average score of all students course objectives in this course is used as the basis for calculation. The calculation method and weight are shown in the Evaluation Method of Course Objectives Achievement of Civil Engineering Major.

2. Scoring method

The course teaching content, teaching methods, students mastery degree, etc. are evaluated by the college supervision team and department heads. See the scoring table in "Evaluation Method for Course Goal Achievement of Civil Engineering".

The weight of performance analysis method is 0.7, and the weight of scoring method is 0.3. The degree of achievement of curriculum objectives is calculated, and the evaluation results are used for continuous improvement.

(2) Continuous improvement mechanism

(1) Establish a continuous improvement system

① Establish a continuous improvement group for this course.

② The head of the course continuous improvement group is responsible for organizing and supervising the continuous improvement process.

③ Develop continuous improvement measures.

(2) Establish a course continuous improvement group

Team leader: course leader Team member: course team member

(3) Continuous improvement of the course

① Regular grade assessment mechanism: According to the learning situation of each class, teachers of the course group must summarize and calculate the indicators of regular grade assessment every 4 weeks, adjust the status of students in time, and make corresponding records.

② Final examination assessment mechanism: analyze the final examination paper, count the score of each part of the test, and use the statistical results to analyze the course as a whole, so as to make improvements in the next class of students.

(4) Continuous improvement measures of the course

① For the regular assessment of grades, measures such as symposium, discussion group, establishment of study groups and individual communication with students are adopted to improve.

② For the final examination, according to the problems that students have encountered in the exam and the key content of this course, unified guidance and other measures are taken to improve the students who take the make-up exam.

7. Teaching schedule

See the teaching calendar.

Appendix: Course teaching calendar

Formulator (signature):

Director of department (office) review (signature):

College leader review (signature and seal):