103 學年第 1 學期 線性代數 Linear Algebra for Scientist 課程綱要

課程名稱：（中文）線性代數 （英文）Linear Algebra for Scientist				開課單位	分子碩
				永久課號	IMO5108
授課教師： 魏恆理					
學分數	3	必/選修	選修	開課年級	*
先修科目或先備能力： Preliminaries: none					
課程概述與目標： Purpose: The main idea is to introduce to students the methods and techniques of modern linear algebra that can be efficiently used to study and analyze their data. Large part of the class deals with the proper understanding of basic concepts, such as basis sets, linear dependence, linear transformations, algebra of vectors and matrices, vector operations, matrix decompositions, etc, that are subsequently used to build useful mathematical tools allowing for fitting data, removing noise, finding trends, locating the extremal eigenvalues of large matrices, etc. The class is focused on problem solving. Outline: The course starts with the exposition of preliminaries such as the theory of complex numbers, vector and matrix operations, linear transformations, which finally take us to more complicated issues such as the solution of linear equations, the eigenvalue problem, theory of determinants, Jordan forms, and quadratic forms.					
教科書（請註明書名、作者、出版社、出版年等資訊）	no particular textbook will be used; various topics will be covered from various textbooks introduced during the class				

課程大綱		分配時數				備註
單元主題	內容綱要	講授	示範	習作	其他	
Complex numbers	Basic operations on complex numbers, additive, trigonometric, and exponential form of complex numbers, complex plane, introduction of the functions of complex variable	3				
Preliminaries	Scalars, vectors, matrices, tensors, operations on vectors, functions of vectors, angle between vectors, orthogonality and orthonormality, Gram-Schmidt orthogonalization process, linear dependence, basis sets, vector spaces, dimension of vector spaces,	12				

	coordinates of vectors, decomposition of vectors, transformation of basis, covariant and contravariant vectors, matrix of linear transformation, dual space, vector in dual space as forms, inner and outer products of vectors, projector operators, projectors onto vectors, projectors onto planes and hyperplanes, operators, idempotence and nilpotence of operators in vector spaces					
Algebra of matrices	Operations on matrices, function of matrices, inverse of a matrix, Hermitian matrices, symmetric matrices, antisymmetric matrices, orthogonal matrices, unitary matrices, vector spaces spanned by matrices, parametrization of vector spaces spanned by structured matrices, matrix groups, Lie groups, SO(3), SU(2), representation of continuous groups, determinants, properties of determinants, Cayley-Hamilton theorem, construction of inverse from Cayley-Hamilton theorem	9				
Midterm	Infinite time exam	3				
Systems of Linear Equations	Definition of the problem, naive solutions, Gaussian elimination, Gaussian elimination with partial pivoting, Gaussian elimination with full pivoting, LU decomposition, QR decomposition, Cholesky decomposition, underdetermined and overdetermined systems of linear equations, Cramer’ s theorem, generalized (Moore-Penrose) inverse, singular value decomposition, singular values of a matrix, constructing inverse matrix from singular value decomposition, large linear problems, application of iterative techniques in linear problems, Gauss-Seidel technique, successive over-relaxation technique, direct inverse of the iterative space (DIIS) approach, preconditioners	9				
Eigenvalue problem	Eigenequation, eigenvalues, eigenvectors, geometrical interpretation of eigenvalues and eigenvectors, generalized eigenvalue problem, solution of the eigenvalue problem, diagonalizing matrices, properties of eigenvalues and eigenvectors, eigendecomposition, spectral theorem, condition number of a matrix, Jordan forms, algebraic and geometric multiplicity of eigenvalues, fast techniques for computing exponents and square roots of matrices,	9				

	eigenspaces, eigenvectors of commuting operators, approximate techniques for finding eigenvalues and eigenvectors, iterative techniques, Davidson algorithm, preconditioners					
Advanced topics	Quadratic forms, Sylvester theorem, theory of linear mappings, kernel of an operator, equivalence relation, quotient spaces, spinors	3				
Final	Infinite time exam	3				

教學要點概述：

1.學期作業、考試、評量

Teaching details: Each class will start with a short (5 min) quiz covering the material from the previous class(es). The new material will be presented in the chalk-and-blackboard style. The last 45 minutes of each class will be devoted to solution of the homework problems.

Grading details: The final score will be a weighted average (weight of 25% each) of 4 components: midterm exam, final exam, quizzes, and homework. Out of 15 quizzes, the 2 worst do not count; the score from the remaining ones averages. The homework will be graded by solving the problems in the class with random selection of the solving student for each exercise. The score accumulated over all the semester averages to a single number.

2.教學方法及教學相關配合事項(如助教、網站或圖書及資料庫等)

	排定時間	地點	連絡方式
師生晤談	any time you find me in my office or by email appointments	Room 112, SB II.	e-mail to hwitek@mail.nctu.edu.tw

每週進度表

週次	上課日期	課程進度、內容、主題

※ 請同學遵守智慧財產權觀念及勿使用不法影印教科書。

備註：

1. 其他欄包含參訪、專題演講等活動。
2. 請同學遵守智慧財產權觀念及勿使用不法影印教科書。

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