

Hong Kong Baptist University
Faculty of Science
Department of Mathematics

Title (Units): MATH 3990/MATH7130 Advanced Topics in Mathematics (3,3,0)

Subtitle: Matrix Computation

Course Aims: This course gives an introduction to numerical linear algebra techniques and explains how, why and when they can be expected to work. This course also provides basic knowledge for solving fundamental numerical linear algebra problems and provides a sound

Prepared by: D.Chu

Course Intended Learning Outcomes (CILOs):

Upon successful completion of this course, students should be able to:

| No. | Course Intended Learning Outcomes (CILOs) |
|-----|---|
| | Knowledge |
| 1 | Understand numerical linear algebra techniques |
| | Skills |
| 2 | Manipulate the matrix computation software (e.g. Matlab) and apply basic numerical linear algebra technique to scientific computing |
| | Attitudes |
| 3 | Solve problems independently |

Teaching & Learning Activities (TLAs)

| CILO | TLAs will include the following: |
|------|--|
| 1-3 | Lectures will be used to introduce the subjects of the course's materials and ample of examples will be given in order to aid the learning of the subjects. |
| 1-3 | Programming assignments, when and where applicable, allow students to apply the numerical techniques learnt in the lecture and to solidify their understanding of the numerical methods and their limitations. |
| 1-3 | Weekly homework, quizzes, midterm and final examination allow students to measure their progress in learning the subjects of the course. |

Assessment:

| No. | Assessment Methods | Weighting | CILO Addressed | Remarks |
|-----|-----------------------|-----------|----------------|---|
| 1 | Continuous Assessment | 30% | 1-3 | Assignments are designed to measure students understanding of the matrix computation methods. |
| 2 | Final Examination | 70% | 1-3 | Final Examination is designed to see how far students have achieved their intended learning outcomes especially in the Knowledge domain. Students should have a thorough understanding of the knowledge and apply them correctly in different context to do well in the exam. |

Course Intended Learning Outcomes and Weighting:

| Content | CILO No. | Teaching (in hours) |
|--|----------|---------------------|
| Numerical Linear Algebra Problems: Their Importance and Computational Difficulties | 1-3 | 1 |
| QR Factorization | 1-3 | 7 |
| Singular Value Decomposition | 1-3 | 5 |
| Linear Least Squares Problem | 1-3 | 7 |
| Eigenvalue Problem | 1-3 | 7 |
| Conditioning and Stability | 1-3 | 2 |
| Iterative Methods for Solving Linear Systems of Equations | 1-3 | 9 |

References: James Demmel. Applied Numerical Linear Algebra, SIAM, 1997.
 Matrix Computations, G.H. Golub and C.F. Van Loan, 1996.
 Numerical Linear Algebra, Lloyd N. Trefethen and David Bau, 1997.
 David Watkins. Fundamental of Matrix Computations, Wiley, 1991.

Software: MATLAB

| Course Content in Outline: | | |
|---|--|--------------|
| Topic | | Hours |
| I. Numerical Linear Algebra Problems: Their Importance and Computational Difficulties | | 1 |
| A. Introduction; | | |
| B. Numerical linear algebra problems and their importance; | | |
| C. Solving numerical linear algebra problem using obvious approaches; | | |
| D. Conclusions. | | |
| II. QR Factorization | | 7 |
| A. Introduction; | | |
| B. GS Process and QR Factorization; | | |
| C. Householder Triangularization for QR factorization; | | |
| D. Givens Transformations for QR factorization. | | |
| III. Singular Value Decomposition | | 5 |
| A. Existence of SVD; | | |
| B. Important properties and applications of SVD; | | |
| IV. Linear Least Squares Problem | | 7 |
| A. Introduction; | | |
| B. Existence and uniqueness; | | |
| C. Normal equations; | | |
| D. Numerical methods; | | |
| E. Perturbation of linear systems of equations; | | |
| F. Perturbation of linear least squares problems. | | |
| V. Eigenvalue Problem | | 7 |
| A. Introduction; | | |
| B. Eigenvalue decomposition; | | |
| C. Perturbation theory; | | |
| D. Numerical methods for eigenvalue problems; | | |
| E. Power iteration; | | |
| F. Inverse iteration with shift; | | |
| G. Rayleigh quotient iteration; | | |
| H. QR algorithm without shifts; | | |
| I. QR algorithm with shifts. | | |
| VI. Conditioning and Stability | | 2 |
| VII: Iterative Methods for Solving Linear Systems of Equations | | 9 |