Course Specifications

Course Title:	**Numerical Analysis**
Course Code:	**30113702-3**
Program:	**B. Sc. Mathematics**
Department:	Mathematical Science
College:	Applied Sciences
Institution:	**Umm Al-Qura University**

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A. Course Identification

1. Credit hours: 3 hours
2. Course type **a.** University ☐ College ☐ Department ■ Others ☐ **b.** Required ■ Elective ☐
3. Level/year at which this course is offered: 6th Level
4. Pre-requisites for this course (if any)**:** Ordinary Differential Equations (30112502-4)
5. Co-requisites for this course (if any)**:** None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	**Traditional classroom**	3 Hours / Week	100%
2	**Blended**	0	0%
3	**E-learning**	0	0%
4	**Correspondence**	0	0%
5	**Other**	0	0%

7. Actual Learning Hours (based on academic semester)

No	Activity	Learning Hours
Contact Hours		
1	**Lecture**	(3 hours) x (15 weeks)
2	**Laboratory/Studio**	0
3	**Tutorial**	(1 hour) x (15 weeks)
4	**Others** (specify)	0
	Total	60 hours
Other Learning Hours*		
1	**Study**	(1 hour) x (15 weeks)
2	**Assignments**	(1 hour) x (15 weeks)
3	**Library**	(1 hour) x (15 weeks)
4	**Projects/Research Essays/Theses**	(1 hour) x (15 weeks)
5	**Others** (specify)	0
	Total	60 hours

* The length of time that a learner takes to complete learning activities that lead to achievement of course learning outcomes, such as study time, homework assignments, projects, preparing presentations, library times

B. Course Objectives and Learning Outcomes

1. Course Description

Numerical analysis is the branch of mathematics concerned with the theoretical foundations of numerical algorithms for the solution of problems arising in scientific applications. The subject addresses a variety of questions ranging from the approximation of functions and integrals to the approximate solution of algebraic, transcendental, differential and integral equations, with particular emphasis on the stability, accuracy, efficiency and reliability of numerical algorithms.

The purpose of this Course is to provide an elementary introduction into this active and exciting field, and is aimed at students in the third year of a university mathematics course.

2. Course Main Objective

The primary objective of the course is to develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge:**	
1.1	Describe different algorithm	
1.2	Recall numerical interpolation	
1.3	Recognize different iterative methods (Jacobi –Gauss Seidel)	
1.4	List "again" the values and eigenvectors of a symmetric matrix	
2	**Skills :**	
2.1	Discuss robustness and relative performance of different algorithm	
2.2	Apply interpolation methods for solving the problems numerically	
2.3	Calculate the errors and the rates of convergence	
2.4	Develop numerical algorithms for the solution of the algebraic eigenvalue problem	
3	**Competence:**	
3.1	Judge different tools used in ordinary differential equations course	
3.2	Evaluate the relationships between different areas of mathematics and the connections between mathematics and other disciplines	
3.3	Construct clear and organized written and verbal explanations of mathematical ideas to a variety of audiences	

C. Course Content

No	List of Topics	Contact Hours
1	**Introduction:** • Numbers representation on a computing machine with particularization to single precision, double precision, quadruple precision and the Intel 86 family of processors. • Definitions of numerical rounding error and chopping error • Discussion of major sources of error in numerical analysis	3
2	**Solution of algebraic equations:** • Description of : Bijection algorithm and its coding; Method of False Position and its coding; The Secant algorithm and its coding; The Newton-Raphson algorithm and its coding. Brief discussion of the robustness and relative performance of these algorithm. • Properties of the fixed point algorithm xn+1 = g(xn) given x0. Definition of the Lipshitz condition and the notion of a contraction algorithm. - Conditions for convergence of xn+1 = g(xn) • Error estimation for algorithm xn+1 = g(xn) • General notion of the order of an iterative algorithm • Aitken acceleration and Steffensen's algorithm • Solution of systems of algebraic equations	12

3	**Numerical Interpolation:** • Polynomial interpolation. • Definition of the Lagrange interpolating polynomial • Interpolation based on the Lagrange interpolating polynomial • Newton interpolation using divided differences • Error analysis underlying polynomial interpolation based on • Rolle's theorem. - The Chebyshev Economization and its optimality • Piecewise linear spline • Subpoint quadratic spline • Construction of the cubic spline • Least-squares data fitting; its use and implementation	9
4	**Solution of linear equations:** • Concept of Gaussian elimination, the concept of pivoting and a simple illustration of why pivoting is needed • LU factorization of matrices with and without partial/full pivoting • The Choleski factorization • Matrix inversion **Iterative methods** • The concept of a matrix norm with simple examples, e.g. the Frobenius norm • The Jacobi iteration algorithm • The Gauss-Seidel algorithm • The Gauss-Seidel algorithm with over-relaxation	9
5	**Numerical calculation of matrix eigenvalues:** • Gershgorin's theorem with an example - The Power algorithm • The Inverse Power algorithm • The Jacobi transformation • The Householder transformation • Construction of the Upper Hessenberg matrix • The QR algorithm	9
6	**Review**	3
Total		45

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge**		
1.1	Describe different algorithm	Lecture Tutorials	Exams (Quizzes, Midterm and Final). Written and possibly oral exam at the end of the course. In addition, compulsory work may be given during the course
1.2	Recall numerical interpolation		
1.3	Recognize different iterative methods (Jacobi –Gauss Seidel)		
1.4	List "again" the values and eigenvectors of a symmetric matrix		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.0			
2.1	Discuss robustness and relative performance of different algorithm	Lecture Individual or group work	Exams (Quizzes, Midterm and Final). Homework
2.2	Apply interpolation methods for solving the problems numerically		
2.3	Calculate the errors and the rates of convergence		
2.4	Develop numerical algorithms for the solution of the algebraic eigenvalue problem		
3.0	**Competence**		
3.1	Judge different tools used in ordinary differential equations course	Lecture Individual or group work	Exams (Quizzes, Midterm and Final). Research Essays
3.2	Evaluate the relationships between different areas of mathematics and the connections between mathematics and other disciplines		
3.3	Construct clear and organized written and verbal explanations of mathematical ideas to a variety of audiences		

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Midterm Test (1)	7^{th} week	20%
2	Midterm Test (2)	12^{th} week	20%
3	Homework + Reports +Quizzes	During the semester	10%
4	Final Examination	End of semester	50%

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :

- Office hours (scheduled 3hrs \ week).
- Contact with students by e-mail, and e-learning facilities.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	- Numerical Analysis. 9th ed. R.L. Burden and J.D. Faires: Edition Brooks / cole: -73563-538-0-978 .2011136 - An Introduction to Numerical Analysis. Endre Süli, David F. Mayers Cambridge : -0521810264 -2003 .0521007941

Essential References Materials	- Numerical Analysis. 9th ed. R.L. Burden and J.D. Faires: Edition Brooks / cole: -73563-538-0-978 .2011136
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	Classroom
Technology Resources (AV, data show, Smart Board, software, etc.)	Data show (projector)
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of Teaching	Students	Questionnaire feedback short tests
Teaching Evaluation	Department Instructor	Staff questionnaire feedback about the course

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	
Reference No.	
Date	