4/1/4. Course Specification:

COURSE SPECIFICATIONS

Form

Course Title: **Numerical Solutions of Differential Equations (1)**

Course Code: **4046703-4**

Course Specifications

Institution: Umm Al-Qura University Date: 31/1/2018
College/Department: Faculty of Applied Science/ Department of Mathematical Sciences

A. Course Identification and General Information

1. Course title and code: Numerical Solutions of Differential Equations (1) (4046703-3)				
2. Credit hours: 4hrs				
3. Program(s) in which the course is offered. (If general elective available in many programs indicate this rather than list programs) Master of Science in Mathematics				
4. Name of faculty member responsible for the course: Dr. Hala Ahmad Hejazi				
5. Level/year at which this course is offered: Level 2/ Master				
6. Pre-requisites for this course (if any): Numerical Analysis				
7. Co-requisites for this course (if any): Partial Differential Equations				
8. Location if not on main campus: Al-Abidiyah. and Al-Zahir				
9. Mode of Instruction (mark all that apply)				
a. traditional classroom	✓	What percentage?	85	
b. blended (traditional and online)		What percentage?		
c. e-learning	✓	What percentage?	15	
d. correspondence		What percentage?		
f. other		What percentage?		
Comments:				

B Objectives

1. What is the main purpose for this course? The main purpose of this course is to provide students with the introductory concepts, numerical techniques and programming skills that will allow them to solve many real world problems that involve differential equations. It is also designed to prepare them for study in the advanced courses in numerical methods for solving partial differential equations.
2. Briefly describe any plans for developing and improving the course that are being implemented. (e.g. increased use of IT or web based reference material, changes in content as a result of new research in the field) 1. Updating references used in teaching process. 2. Using e-learning facilities more efficiently. 3. Encouraging students to collect problems from web based references and supervise discussions in the class.

C. Course Description (Note: General description in the form used in Bulletin or handbook)

Course Description: The course gives knowledge to students of problem classes, basic mathematical and numerical concepts and properties, modern numerical methods, and software for solution of engineering and scientific problems formulated as differential equations.

1. Topics to be Covered		
List of Topics	No. of Weeks	Contact hours
Preliminaries • Discussion of sources of numerical error. Why use numerical methods even when an analytical solution is available. • Classification problem for partial differential equations, namely elliptic, parabolic and hyperbolic equations. Specification of suitable boundary conditions and initial conditions (if appropriate) for each of these problems. • Construction of finite difference formulae for first and second ordinary and partial derivatives with error analysis. Interplay between truncation and rounding error in choosing the length if intervals in the method of Finite Differences. • Efficacy of numerical algorithms.	3	12

Finite Difference Procedure for ODE • The tri-diagonal algorithm. • Measurement of numerical error, loss of significance leading to the concept of pivoting. • Treatment of equations with non-constant coefficients. • Treatment of gradient boundary conditions. 1. First order approximation 2. Second order approximation. 3. Fictitious nodes. ▪ The concept and use of Richardson extrapolation. ▪ Treatment of nonlinear equations. ▪ Fixed point procedure. 1. One dimension. 2. Many dimensions.	3	12
Elliptic Equations in Two Dimensions • Concept and construction of a computational molecule. • A general representation of a sparse matrix. • Iterative methods. 1. Gauss-Jacobi algorithm. 2. Gauss-Seidel algorithm. 3. Comparison of Gauss-Jacobi and Gauss-Seidel. 4. Diagonal dominance. 5. Convergence of Gauss-Jacobi and Gauss-Seidel algorithm. 6. The multi-grid procedure. • Treatment of non-rectangular domains.	3	12

Parabolic Equations in 1D
• Historical Introduction
  • Euler's method.
  • Richardson's method Dufort-Frankel method.
  • Crank-Nicolson method.
  • Summary of these various methods.
• Numerical consistency
  • Dufort-Frankel.
  • Crank-Nicolson.
• Numerical stability - The Fourier Method
  • Application to Euler method.
  • Application to Richardson method.
  • Application to Dufort-Frankel method.
  • Application to Crank-Nicolson method.
• Numerical stability - Matrix method
  • Application to Euler method.
  • Application to gradient boundary conditions.
• Numerical convergence - The Lax equivalence theorem.
	3	12

Parabolic Equations in 2D
• Historical Introduction.
• Alternating Direction Implicit (ADI)
  • Consistency of ADI.
  • Stability of the ADI algorithm.
	3	12

2. Course components (total contact hours and credits per semester):

	Lecture	Tutorial	Laboratory or Studio	Practical	Other:	Total
Contact Hours	60	--				60
Credit	4	--				4

3. Additional private study/learning hours expected for students per week.
Four hours weekly for homework and revision

4. Course Learning Outcomes in NQF Domains of Learning and Alignment with Assessment Methods and Teaching Strategy

On the table below are the five NQF Learning Domains, numbered in the left column.

First, insert the suitable and measurable course learning outcomes required in the appropriate learning domains (see suggestions below the table). **Second**, insert supporting teaching strategies that fit and align with the assessment methods and intended learning outcomes. **Third**, insert appropriate assessment methods that accurately measure and evaluate the learning outcome. Each course learning outcomes, assessment method, and teaching strategy ought to reasonably fit and flow together as an integrated learning and teaching process. (Courses are not required to include learning outcomes from each domain.)

Code #	NQF Learning Domains And Course Learning Outcomes	Course Teaching Strategies	Course Assessment Methods
1.0	**Knowledge** Upon completion of the course, the student is expected to		
1.1	Understand properties of different classes of differential equations and their impact on solutions and proper numerical methods	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
1.2	Be able to integrate related topics from separate parts of the course	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
2.0	**Cognitive Skills** Upon completion of the course, the student is expected to		
2.1	Be able to follow specialized and application-oriented technical literature in the area	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
2.2	Be able to apply the different learnt methods to solve mathematical problems	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
3.0	**Interpersonal Skills & Responsibility** Upon completion of the course, the student is expected to		
3.1	Design, implement and use numerical methods for computer solution of scientific problems involving differential equations	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
3.2			
4.0	**Communication, Information Technology, Numerical** Upon completion of the course, the student is expected to		
4.1	Be able to use commercial software with understanding of fundamental methods, properties, and limitations.	Lectures - Discussions, and homework	Short quizzes, periodical and final exams.
4.2	Effectively work alone and in groups on the solution of problems.	Lectures - Discussions, and	Short quizzes, periodical and

		homework	final exams.
5.0	**Psychomotor**		
5.1	Not Applicable	Not Applicable	Not Applicable

5. Schedule of Assessment Tasks for Students During the Semester			
	Assessment task (e.g. essay, test, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	Periodic exam (1)	8	20
2	Periodic exam (2)	14	20
3	Home work	During the semester	20
4	Final exam	End of semester	40

D. Student Academic Counseling and Support

1. Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice. (include amount of time teaching staff are expected to be available each week)
The subject's lecturers will be available for individual student consultations and advice in their specified office hours.

E Learning Resources

1. List Required Textbooks

- G.D. Smith, Numerical solution of partial differential equations: finite difference methods (3rd ed.). Oxford University Press (1985).
- L.N. Trefethen, Finite difference and spectral methods for ordinary and partial differential equations, unpublished text, (1996), available at http://people.maths.ox.ac.uk/trefethen/pdetext.html
- U.M. Ascher and L.R. Petzold, Computer Methods for Ordinary Differential Equations and Differential Algebraic Equations (1998).

2. List Essential References Materials (Journals, Reports, etc.)
Journal of Computational and Applied Mathematics

3. List Recommended Textbooks and Reference Material (Journals, Reports, etc)

4. List Electronic Materials, Web Sites, Facebook, Twitter, etc.
https://en.wikipedia.org/wiki/Numerical_partial_differential_equations

5. Other learning material such as computer-based programs/CD, professional standards or regulations and software. None

F. Facilities Required

Indicate requirements for the course including size of classrooms and laboratories (i.e. number of seats in classrooms and laboratories, extent of computer access etc.)
1. Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.) Classroom with the capacity of 10-20 students
2. Computing resources (AV, data show, Smart Board, software, etc.) Smart board. - Classroom is equipped with a computer. - Provide projectors and related items. Matlab software – Smart board
3. Other resources (specify, e.g. if specific laboratory equipment is required, list requirements or attach list) None

G Course Evaluation and Improvement Processes

1 Strategies for Obtaining Student Feedback on Effectiveness of Teaching Student feedback on effectiveness of teaching
2 Other Strategies for Evaluation of Teaching by the Instructor or by the Department Monitoring the achievement of the students in solving homework and periodical exams
3 Processes for Improvement of Teaching Following up the student's homework. Encouraging the students to read and practice more.
4. Processes for Verifying Standards of Student Achievement (e.g. check marking by an independent member teaching staff of a sample of student work, periodic exchange and remarking of tests or a sample of assignments with staff at another institution) The instructors watch and give their feedbacks to their students through all work done by them, including exams to verify standards of achievements for different domains of learning outcomes.
5 Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement. Reviewing the course reports submitted at the end of each semester

Name of Instructor: Dr. Hala Ahmad Hejazi
Signature: *Hala Ahmad Hejazi* Date Report Completed: 31/10/2018
Name of Field Experience Teaching Staff _____
Program Coordinator:_____
Signature: _____ Date Received:_____