Detailed Course Description - Course Plan Development and Updating Procedures/ Mathematics Department	QF01/0408-3.0E

Faculty	**Faculty of Science and Information Technology**	Department	**Mathematics**
Course number	**0101472**	Course title	**Numerical Analysis (2)**
Number of credit hours	**3**	Pre-requisite/co-requisite	**Numerical Analysis (1) (0101272)**

Brief course description
As a second course in numerical analysis, this course is designed to introduce the student to more numerical methods as well as to teach the student how to do some error analysis. These methods include finite difference methods for numerical differentiation; the trapezoidal rule, Simpson's rule and Gaussian quadrature for numerical integration and Euler's, Taylor series and Runge-Katta methods for solving differential equations.

	Course goals and learning outcomes
Goal 1	Introduce the student to various numerical methods
Learning outcomes	1.1 Being able to apply numerical methods to differentiation 1.2 Being able to apply numerical methods to integration (quadrature) 1.3 Being able to apply numerical methods to solve differential equations,
Goal 2	Appraise the different numerical methods used to solve problems.
Learning outcomes	2.1 Being able to apply error analysis to the numerical methods the student is introduced to during the course .

Textbook	"Numerical Methods", by J. H. Mathews, 2nd Edition
Supplementary references	1. "Applied Numerical Analysis", by Gerald & Wheatley , 7th Ed, (2004), Addison-Wesley Publishing Company. 2. "Numerical Analysis", by R. Burden & D. Fairs , 9th Ed., (2010). 3. "Numerical Methods and Computing", by Cheney & KinCaid , 6th Ed., (2008), Thomson Learning Academic Resource Center. 4. "Numerical Methodsfor Engineers", by S. K. Gupta, 3rd Ed., (2013), New Academic Science Ltd, United Kingdom.

Course timeline			
Week	**Number of hours**	**Course topics**	**Pages (textbook)**
01	**1 1 1**	**I. <u>Numerical Differentiation</u>** introduction; finite difference formulas to approximate $f'(x)$; forward and backward formulas of O(h); the central difference formula of $O(h^2)$.	315-339
02	**1 1 1**	Geometric interpretation of the forward, backward and central formulas; deriving difference formulas using Taylor's theorem; a central difference formula of order $O(h^4)$.	
03	**1 1 1**	A central difference formula of order $O(h^2)$ to approximate $f''(x)$; Analysis of the truncation error in the approximations of the different difference formulas.	
04	**1 1 1**	Interpolating polynomials (Lagrange's & Newton's); approximating the derivative via differentiation of interpolating polynomials.	
05	**1 1 1**	**II. <u>Numerical Integration (Quadrature)</u>** The trapezoidal rule; Simpson's 1/3-rule; deriving the the trapezoidal rule & Simpson's rule using Taylor's theorem .	346-399
06	**1 1 1**	Analyzing the truncation error in the approximations of the trapezoidal rule & Simpson's rule; showing that the trapezoidal rule has precision 1 & Simpson's rule has precision 2 .	
07	**1 1 1**	**First Exam 20%** Recursive relation between trapezoidal approximations with #panels=2^{k-1} ; Simpson's approximation as a linear combination of trapezoidal approximations; Romberg algorithm .	
08	**1 1 1**	Gaussian quadrature and Legendre polynomials; Gaussian quadrature formula with two nodes ; Gaussian quadrature formula with three nodes .	
09	**1 1 1**	Transforming a quadrature formula for integrals over [c, d] to a quadrature formula for integrals over [a, b]; comparison between different approximation formulas .	
10	**1 1 1**	finding precision of a formula by applying it to polynomials; approximating double integrals.	
11	**1 1 1**	**III. <u>Numerical Methods for Solving Differential Equations</u>:** Some review of exact methods for solving first-order ordinary differential equations; initial-value problems .	423-475
12	**1 1 1**	Euler's method; geometric interpretation of Euler's method ; analytic derivation of Euler's method; the modified Euler's method (Heun's method) ; Taylor's method.	

13	**1 1 1**	**Second Exam. 20%** Runge-Kutta method; Runge-Kutta formula of order 4; multi-step methods .	
14	**1 1 1**	**IV. Systems of First-Order Differential Equations** Transforming higher-order differential equations into a system of first order differential equations ; applying methods of single differential equations to solve systems of first-order differential equations .	475-497
15	**1 1 1**	Applications on second-order initial-value problems ; applications on second-order boundary-value problems;	
16	**1 1 1**	**Final Exam 50%**	

Theoretical course evaluation methods and weight	Participation = 10% First exam 20% Second exam 20% Final exam 50%	**Practical (clinical) course evaluation methods**	Semester students' work = 50% (Reports, research, quizzes, etc.) Final exam = 50%

Approved by head of department		**Date of approval**	

Extra information (to be updated every semester by corresponding faculty member)

Name of teacher	**Amal H. Al-Saket**	Office Number	**9114**
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Office hours			