4/1/4. Course Specification:

COURSE SPECIFICATIONS
Form

Course Title: ... **Advanced Mathematical Methods (1)**

Course Code:.. **4046502-4**.

Course Specifications

Institution: Umm Al-Qura University Date: 31/10/218
College/Department: Faculty of Applied Science/ Department of Mathematical Sciences

A. Course Identification and General Information

1. Course title and code: Advanced Mathematical Methods (1) (4046502-4)
2. Credit hours: 4 Hours
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. Muntaser Safan
5. Level/year at which this course is offered: Leve 1/ Master
6. Pre-requisites for this course (if any) :
7. Co-requisites for this course (if any):
8. Location if not on main campus: Al-Abidiyah campus and Al-Zahir campus
9. Mode of Instruction (mark all that apply)

Mode	Mark		Percentage
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:
The course is suitable for postgraduates at Masters level.

B Objectives

1. What is the main purpose for this course? The main purpose of this course is to introduce a selection of advanced mathematical methods that are of use in research in Applied Mathematics. It is assumed that students entering this course have previously taken courses in differential and integral Calculus for functions of many variables and have some familiarity with concepts from Complex Analysis such as the properties of analytic functions and the methods of residue Calculus.
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)

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

Course Description: This is a 4 credit course comprising approximately 60 hours of lectures.

1. Topics to be Covered		
List of Topics	No. of Weeks	Contact hours

Chapter 1 - Sturm-Liouville Theory - State the regular Sturm-Liouville problem. - Establish the orthogonality property of the eigenfunctions of a Sturm-Liouville operator. - Establish the interlacing property of the zeros of the eigenfunctions of a Sturm-Liouville operator. - Introduce the notion of a self-adjoint operator and establish some general properties of self-adjoint operators. - Give examples of well-known Sturm-Liouville operators, for example, the Bessel and Legendre differential equations expressed in Sturm-Liouville form among other examples. - Discuss the use of an integrating factor to re-express second order differential equations in Sturm-Liouville form. - Develop the spectral expansion of functions using the eigenfunctions of a Sturm-Liouville operator. Establish existence and convergence properties for this spectral series and the differentiated series (Dirichlet's Theorem). - Discuss the Spectral Parameter Power Series (SPPS) method (reduction of order)	3	12

Chapter 2 - Transform Theory - Introduce the concept of a transform as a tool for reducing the complexity of a linear ordinary or partial differential equation. - Define the Laplace transform, state sufficient conditions for a function to have a Laplace Transform, and establish many of its well-known properties. State the inversion theorem for the Laplace Transform and illustrate its validity by using Residue Calculus to invert several well-known Laplace Transforms. - Demonstrate the use of the Laplace transform in the solution of ordinary and partial differential equations, e.g. the diffusion equation. - Discuss the behaviour of the Laplace Transform in the case of small and large transform parameters. - Define the Fourier Transform and establish the Fourier inversion theorem. Establish the connection between the Fourier Transform and Fourier series. - State conditions for the existence of the Fourier transform. - Establish the Fourier Sine and Fourier Cosine transforms and derive their inversion formulae. - Give examples of the use of the Fourier Transform, the Fourier Sine transform and the Fourier Cosine transform in the context of solving partial differential equations. Explain when to use and when not to use the Fourier Sine and Cosine transforms. - Introduce the Discrete Fourier Transform (DFT) and derive the inversion result. - Introduce the Fast Fourier Transform (FFF), explain its relationship to the DFT and the underlying mechanism that contributes to its speed, say with reference to the all numbers with prime decomposition containing powers of 2, 3 or 5. - Define the Hankel Transform and derive its inversion result. Illustrate the use of the Hankel Transform, for example, with reference to the oscillations of a circular membrane with fixed perimeter. - Define the Mellin Transform and Z-Transform and derive their inversion result. Briefly Illustrate the use of theses transforms. For example, with reference to the oscillations of a circular membrane with fixed perimeter.	3	12

Chapter 3 - The Wiener-Hopf Technique - Introduce the Wiener-Hopf technique, named after Norbert Wiener and Eberhard Hopf, and give an example of a situation in which the technique is useful, say the solution of a mixed boundary problem for an elastic half-space. - Explain the strategy of the Wiener-Hopf technique in terms of a pair of singular integrals in the complex plain, the notion of analytic continuation and Liouville's theorem. - Use the Wiener-Hopf technique to solve the classical "punch" and "torsion" problems for the deformation of a linearly elastic half-space.	3	12
Chapter 4 - Floquet Theory - Introduce the class of problem described by Floquet Theory, named after its originator Gaston Floquet (1883). - Derive the basic results underlying the solution of the equation $\frac{dX}{dt} = A(t)X$ (1) where A(t) is an N x N matrix with fixed period T, i.e. $A(t+T) = A(t)$ for $t \in R$. Derive. Derive the condition for the stability of equations (1). - Illustrate the use of Floquet Theory with respect to a two dimension system of ordinary differential equations. - Use Floquet Theory to investigate the behaviour of Hill's equation $\frac{d^2X}{dt^2} + (a + \varphi(t))X = 0, \quad \varphi(t+T) = \varphi(t),$ where a is constant and $\phi(t)$ is a real-valued continuous function. - Discuss the particularization of Hill's equation to the Mathieu equation, namely the case in which $a = \omega^2 > 0$ and $\varphi(t) = \varepsilon \cos 2t$. The Mathieu equation describes the motion of an inverted undamped pendulum of natural frequency ω with forced motion at its point of support.	3	12

Chapter 5 - Numerical Optimisation - Describe the Golden Section algorithm and Brent's algorithm for the minimization of a unimodal function of a single variable. Discuss the speed of convergence of each algorithm. - Describe the Method of Steepest Descent as a minimisation tool and explain its advantages and disadvantages. - Introduce the notion of a Quasi-Newton algorithm. - Describe the mathematical details of the Davidson, Fletcher Powell (DFP) algorithm for function minimization. - Describe the mathematical details of the Broyden, Fletcher, Goldfarb and Shannon (BFGS) algorithm for function minimization. - Briefly discuss the advantages and disadvantages of the DFP and BFGS algorithms. - Describe the mathematical details and logical steps of the Nelder-Mead or downhill Simplex technique. Explain its advantages and disadvantages over the DFP and BFGS algorithms.	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**		
1.1	Develop knowledge and understanding on the Sturm-Liouville Theory and their applications.	Lectures and tutorials	Short quizzes, periodical and final exams
1.2	Be aware of Transform Theory ,Wiener-Hopf Technique, Floquet Theory and their applications.	Lectures and tutorials	Short quizzes, periodical and final exams
2.0	**Cognitive Skills**		
2.1	Establish the Fourier Sine and Fourier Cosine transforms and derive their inversion formulae	Lectures and tutorials	Short quizzes, periodical and final exams
2.2	Explain the strategy of the Wiener-Hopf technique in terms of a pair of singular integrals in the complex plain, the notion of analytic continuation and Liouville's theorem	Lectures and tutorials	Short quizzes, periodical and final exams
3.0	**Interpersonal Skills & Responsibility**		
3.1	Describe the Golden Section algorithm and Brent's algorithm for the minimization of a unimodal function of a single variable. Discuss the speed of convergence of each algorithm.	Lectures and tutorials	Short quizzes, periodical and final exams
3.2	Use the Wiener-Hopf technique to solve the classical "punch" and "torsion" problems for the deformation of a linearly elastic half-space	Lectures and tutorials	Short quizzes, periodical and final exams
4.0	**Communication, Information Technology, Numerical**		

4.1	Work effectively in groups and independently	Tasks assigned and homework	Marking the assignments.
4.2	Solve problems concerning the topics of the course.	Homework	Evaluating the homework
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	First midterm exam	6	20
2	Second midterm exam	10	20
3	Homework and tutorial activities	Over all weeks	20
4	Final exam		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 instructor is available for at least six hours per week. He is also available on appointments.

E Learning Resources

1. List Required Textbooks

The advanced mathematical methods in this course are specialized, and with the exception of the optimization chapter, are not to be found in a single textbook. Each technique requires a specialized text.

- James P. Keener - Principles Of Applied Mathematics: 2d (second) Edition (2001)
- Gill, Murray and Wright, Practical Optimization, Emerald Group Publishing Ltd, (1982).

2. List Essential References Materials (Journals, Reports, etc.)

- S I Hayek, Advanced mathematical methods in science and engineering (2nd edition), CRC Press by Taylor and Francis, 2010.
- **Journal of Advanced Mathematics and Applications**

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

Advanced Mathematical Methods for Scientists and Engineers I
4. List Electronic Materials, Web Sites, Facebook, Twitter, etc. **http://www.lmm.jussieu.fr/~lagree/COURS/M2MHP/Bender-Orszag-chap9-11.pdf --**
5. Other learning material such as computer-based programs/CD, professional standards or regulations and software.**-**

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
3. Other resources (specify, e.g. if specific laboratory equipment is required, list requirements or attach list)

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. Muntaser Safan

Signature:__ *Muntaser Safan* ___Date Report Completed: 20/2/1439

Name of Field Experience Teaching Staff ______________________________

Program Coordinator:____

Signature: ___________________________ Date Received:____________________