



**The University of Jordan**

**Accreditation & Quality Assurance Center**

## **Course Syllabus**

**Course Name:**  
**Fractional Calculus**

1	Course title	Fractional Calculus
2	Course number	0301906
3	Credit hours (theory, practical)	3
	Contact hours (theory, practical)	3
4	Prerequisites/requisites	none
5	Program title	Ph.D. in Mathematics
6	Program code	
7	Awarding institution	The University of Jordan
8	Faculty	Science
9	Department	Mathematics
10	Level of course	Elective specialization requirement
11	Year of study and semester (s)	2 <sup>nd</sup> year
12	Final Qualification	Ph.D. in Mathematics
13	Other department (s) involved in teaching the course	None
14	Language of Instruction	English
15	Date of production/revision	27/10/2020

**16. Course Coordinator:**

Name: Prof. Shaher Momani  
Office number :  
Phone number : 0799774979  
Email : s.momani@ju.edu.jo

**17. Other instructors:**

Dr. Banan Maayah

**18. Course Description:**

Special Functions of the Fractional Calculus, Riemann–Liouville Differential and Integral Operators, Grunwald–Letnikov Operators, Definition and Basic Properties of Caputo Fractional Derivative, Mittag-Leffler Functions, Existence and Uniqueness of Fractional Differential Equations (FDEs), Exact and Numerical Solution of FDEs, Nonclassical Definitions of Fractional Derivatives and Integral.

**19. Course aims and outcomes:****A- Aims:**

- 1- To study special functions and their properties.
- 2- To study Riemann–Liouville differential and integral operators
- 3- To study Caputo fractional derivative.
- 4 To examine existence and uniqueness for Riemann–Liouville fractional differential equations.
- 5- To find exact solution of some fractional differential equations.
- 6 To use numerical methods to find approximate solution of fractional differential equations.
- 7- To recognize some new nonclassical definitions of fractional derivatives and integrals.

**B- Intended Learning Outcomes (ILOs): Upon successful completion of this course students will be able to**

...

**B- Intended Learning Outcomes (ILOs):**

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

Successful completion of the course should lead to the following outcomes:

**A. Knowledge and Understanding Skills:** Student is expected to

A1) Master the basic concepts of some special functions.

A2) List some properties of Riemann–Liouville fractional derivative and integral.A3)

Define Caputo and Grunwald–Letnikov Operators.

A4) Recognize some new nonclassical definitions of fractional derivatives and integrals

**B. Intellectual Analytical and Cognitive Skills:** Student is expected to

B1) Construct the relations between Riemann–Liouville integrals and derivatives.

B2) Find fractional derivative and integral of some functions.B3)

Find Laplace transform of fractional derivatives.

**Subject- Specific Skills:** Student is expected to

C1) Prove the existence and uniqueness Riemann–Liouville fractional differential equations.C2)

Solve fractional differential equations.

C3) Reduce Fractional Differential Equations to ordinary differential equations.

**D. Creativity /Transferable Key Skills/Evaluation:** Student is expected to

D1) Read write and criticize mathematical proofs.

D2) Make critical comments on obtained results

D3) Use mathematical reasoning.

**20. Topic Outline and Schedule:**

Topic	Week	Instructor	Achieved ILOs	Evaluation Methods	Reference
Special Functions of the Fractional Calculus <ul style="list-style-type: none"> <li>• Gamma Function.</li> <li>• Mittag-Leffler Function.</li> <li>• Wright Function</li> </ul>	1+2		A1, D1		1
Riemann–Liouville Differential and Integral Operators <ul style="list-style-type: none"> <li>• Riemann–Liouville Integrals.</li> <li>• Riemann–Liouville Derivatives.</li> <li>• Relations Between Riemann–Liouville Integrals and Derivatives.</li> <li>• Grunwald–Letnikov Operators.</li> </ul>	3-5		A2, B1, C1, D3		1
Caputo's Approach <ul style="list-style-type: none"> <li>• Definition and Basic Properties</li> </ul>	6		A3, D1	Home work 1	1, 3
Fractional Differential Equations (FDE) <ul style="list-style-type: none"> <li>• Existence and Uniqueness Results for Riemann–Liouville Fractional Differential Equations.</li> <li>• Laplace Transform.</li> <li>• Linearly Independent Solutions.</li> <li>• Solutions of the Homogeneous Equations.</li> <li>• Solution of the Non-homogeneous Fractional Differential Equations.</li> <li>• Reduction of Fractional Differential Equations to ordinary differential equations.</li> </ul>	7-9		A2, B1, B2, C3, D2	Mid term Exam	1
Solving Fractional Differential Equations.	10-13		B3, C2, D2	Home work 2	1, 2, 4
Other Definitions of Fractional Calculus.	14+15		A4, D2		4

**21. Teaching Methods and Assignments:**

**Development of ILOs is promoted through the following teaching and learning methods:**

**In order to succeed in this course, each student each student need to be an active participant in learning- both in class and out of class.**

- Class time will be spent on lecture as well as discussion of homework problems and some groupwork
- To actively participate in class, you need to prepare by reading the textbook and doing all assigned homework before class.
- You should be prepared to discuss your homework.
- You are encouraged to work together with other students and to ask questions and seek help from the professor, both in and out of class

**22. Evaluation Methods and Course Requirements:**

**Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:**

ILO/s	Learning Methods	Evolution Methods	Related ILO/s to the program
	Lectures	Exam	
	Published Papers	Presentation	
		Home work	

**23. Course Policies:**

Class attendance of students at the beginning of the lecture is recoded.

Assignment is given to the students at regular intervals for them to solve and submit. Late or no submission of assignments carries penalties or loss of grade points.

Absences recorded in each lecture with making excuses, if any.

**24. Required equipment:**

**25. References:**

A- Required book (s), assigned reading and audio-visuals:

1. *Kai Diethelm*, The Analysis of Fractional Differential Equations, Springer, 2010.

B- Recommended books, materials, and media:

2. K.S. Miller & B.Ross. ,An Introduction to the Fractional Calculus and Fractional Differential Equations Hardcover , Wiley-Blackwell, 1993.
3. I. Podlubny, Fractional Differential Equations, Academic Press, San Diego 1999.
4. Selected Papers.

**26. Additional information:**

Name of Course Coordinator : Prof. Shaher Momani      Signature : ----- Date : -----

Head of curriculum committee/Department : -----      Signature : -----

Head of Department : Dr. Morad Ahmad      Signature : -----

Head of curriculum committee/Faculty : -----      Signature : -----

Dean : Prof. Mahmoud AlJaghoub      Signature : -----

Copy to:

Head of Department  
Assistant Dean for Quality Assurance  
Course File