University of Kerala

Discipline	Mathematics				
Course Code	UK4DSCMAT200				
Course Title	Introduction to Real Analysis and Multiple Integrals				
Type of Course	DSC				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	3		2	5
Pre-requisites	1. Knowledge of number systems 2. Awareness of Calculus				
Course Summary	This course includes introductary Real Analysis and Multiple Integrals				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Real Numbers**	**9**
	1	The Completeness Property of $\mathbb{R}$, Applications of the Supremum Property, Intervals	
	Chapter 2: Sections 2.3, 2.4, 2.5 (up to the uncountability of $\mathbb{R}$. Binary Representations and the rest of the section 2.5 may be omitted) of Text [1]		
II		**Sequences**	**9**
	2	Sequences and their Limits, Limit Theorems, Monotone Sequences Subsequences and the Bolzano-Weierstrass Theorem	
	(Chapter 3: Sections 3.1, 3.2, 3.3 (The Calculation of Square Roots and the rest of section 3.3 may be omitted), Section 3.4 (Limit Superior and Limit Inferior and the rest of section 3.4 may be omitted) of Text [1]		
III		**Multiple Integrals**	**9**

Module	Unit	Contents	Hrs
	3	Double Integrals, Double Integrals over Non-rectangular Regions, Double Integrals In Polar Coordinates	
	(Chapter 14: Sections 14.1 to 14.3 of Text [2])		
IV	**Line Integrals and Green's Theorem**		**9**
	4	Line integrals, Integrating a vector field along a curve - Exercise Set 15.2- problems 15-30, 33-36, 41-46, Independence of Path; Conservative Vector Fields, Green's Theorem (up to finding areas using Green's theorem)	
	Chapter 15: Section 15.2, 15.3, 15.4 of Text[1]		
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	5	The Algebraic and Order Properties of $\mathbb{R}$, Absolute Value and the Real Line (Chapter 2section 2.1, 2.2 of Text[1], The Cauchy Criterion, (Chapter 3: Section 3.5 of Text [1] (up to 3.5.6 exclude contractive sequences) Surface Area, Parametric Surfaces (Chapter 14 section 14.4) Vector fields (chapter 15 section 15.1, Greens theorem for multiply connected regions (Chapter 15 section 15.4) of Text [2]	

Topics and problems for Practical sessions and practical examinations using SageMath software – 30 hours

1. Defining sequences, and finding its initial terms
2. Finding N for a given ϵ so that the proposed limit x satisfies $|x_n - x| < \epsilon$ after N.
3. Forming subsequence by composing functions
4. Verifying Bolzano-Weierstrass theorem
5. Evaluating double integrals
6. Evaluating double integrals over non-rectangular regions
7. Evaluating double integrals in polar co-ordinates
8. Evaluating line integrals
9. Check if a vector field is conservative
10. Verifying Green's theorem

A record should be maintained with atleast 7 problems from the above. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, the student should be able to answer two problems selected by the examiner from the 7 available in the record .

SageMath Problem resources

1. **SageMath — Documentation**
   https://doc.sagemath.org/html/en/tutorial/introduction.html
2. **Online SageMath Server**
   https://sagecell.sagemath.org/
3. Tuan A. Le, Hieu D. Nguyen, *SageMath Advice for Calculus*
   https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf
4. **Linear Algebra — SageMath Tutorial**
   https://doc.sagemath.org/html/en/tutorial/tour_linalg.html
5. *Sage for Undergraduates* — Gregory V. Bard (Online Version)
   https://www.faculty.luther.edu/~bernatzr/Courses/M351/sage_for_ug_color.pdf
6. P. Zimmermann *et al.*, *Computational Mathematics with SageMath*
   https://www.sagemath.org/sagebook/english.html
7. **SageMath Tutorial for Advanced 2D Plotting**
   https://doc.sagemath.org/html/en/prep/Advanced-2DPlotting.html
8. **SageMath Reference Manual — Vector Calculus in the Euclidean Plane**
   https://doc-10-7--sagemath.netlify.app/html/en/thematic_tutorials/vector_calculus/vector_calc_plane.html

Texts

Text 1 R. G. Bartle, Donald R. Sherbert, Introduction to Real Analysis, Fourth Edition, John Wiley & Sons, Inc., 2010.

Text 2 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10th Edition, John Wiley & Sons.

References

Ref. 1 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company, 2004.

Ref. 2 W. Rudin, Principles of Mathematical Analysis, Second Edition, McGraw-Hill, 1964.

Ref. 3 Stephen Abbot, Understanding Analysis, 2nd Edition, Springer, 2015.

Ref. 4 J Stewart, Calculus with Early Transcendental Functions, 7th Edition, Cengage India Private Limited, 2008.

Ref. 5 Terrence Tao, Analysis I, Hindustan Book Agency, 2022

Ref. 6 G B Thomas, R L Finney, Calculus, 9th Edition, Addison-Weseley Publishing Company, 2004.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understanding fundamental properties of real numbers that contributes to formal development of Real Analysis	PSO1, PO1, 2, 3, 4, 5, 6, 7	R, U	F, C	L	
CO 2	Demonstrates and understand the concept of sequence of real numbers and categorize them into convergent and divergent sequence	PSO1, PO1, 2, 3, 4, 5, 6, 7	U, An	C, F	L	
CO 3	Describe the concepts of multiple integration	PSO2, PO1, 2, 3, 4, 5, 6, 7	U, E	C, P	L	
CO 4	Apply double and triple integrals to solve real life problems	PSO3, PO1, 2, 3, 4, 5, 6, 7	Ap	P	L	

(R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create)
(F-Factual, C-Conceptual, P-Procedural, M-Metacognitive)

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	2	1	1	2	1	3	1	2	1
CO2	3	2	1	2	2	1	2	2	1	3	1	2	1
CO3	2	3	1	2	1	1	2	2	2	3	1	2	2
CO4	2	2	3	2	1	1	2	3	2	2	1	2	2

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓