NILKANTHA MULTIPLE CAMPUS
Dhading
Annual Teaching Plan
Academic Session: 2079/080

Level: Bachelor Degree (B. Ed.) **Subject: Real Analysis** **Subject Teacher: Hari Lamsal**	**Year: 2nd** **Subject code no: Math. Ed. 423**

Time/ Teaching hours	Unit	Objectives	Methodology	Materials	Evaluation (Questions)	Reference book / Resources
12 Hours	**Unit 1** **Real Numbers** 1.1 System of real numbers 1.2 Algebraic structure of **R** 1.3 Order axioms and properties of **R** 1.4 Absolute value of a real number and its properties. 1.5 Boundedness of subsets of **R** 1.6 Completeness axioms in **R** 1.7 Archimedian property 1.8 Dedekind's construction of the set of real numbers 1.9 Representation of real numbers on a line.	● To describe different system of real numbers ● To describe algebraic structure of real numbers ● To explain the properties of real numbers ● To describe order axioms of real numbers and their properties ● To explain and prove properties of supremum and infimum of a set of numbers ● To explain completeness property, Archimedian property and Dedekind property of real numbers ● To explain absolute value of a real number and its properties	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Describe different system of real numbers with examples. 2. Describe algebraic structure of real numbers. 3. Explain the properties of real numbers. 4. Describe order axioms of real numbers and their properties 5. Explain and prove properties of supremum and infimum of a set of numbers. 6. Explain completeness property, Archimedian property and Dedekind property of real numbers.	**Recommended Books** 1. Gupta, S. L. & Gupta, N. R.(1993). *Fundamentals of real analysis.* New Delhi, Vikas Publishing House Pvt. Ltd. 2. Maskey S.M. (2007), *Principles of real analysis* (Second ed.). Kathmandu : Ratna Pustak Bhandar **(For Units I-VIII).** 3. Pandey U. N. (2003). *Real analysis* (Fourth revised ed. 2015) Kathmandu : Vidyarthi Prakashan Pvt. Ltd. **(For units I - VIII).**

					7. Explain absolute value of a real number and its properties.	**References Books**
15 Hours	**Unit-II** **Open and Closed Sets** 2.1 Open and closed intervals 2.2 Neighborhoods 2.3 Interior points and interior of a set 2.4 Open sets 2.5 Limit points of a set 2.6 Bolzano-Weierstrass's theorem 2.7 Closed sets 2.8 Covering of a set 2.9 Compact sets 2.10 Cantor sets 2.11 Connectedness	● To explain neighborhood of a point rove properties of open sets in **R** ● To explain and prove properties of interior of a set ● To explain limit point of a set ● To prove the properties of limit points of a set and derived set ● To prove the properties of closed sets ● To prove properties of compact sets connected sets and perfect sets	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain neighbourhood of a point with an example. 2. Prove that the properties of open sets in **R.** 3. Explain and prove the properties of interior of a set. 4. Explain limit point of a set with an example. 5. Prove the properties of limit points of a set and derived set. 6. Prove the properties of closed sets. 7. Prove properties of compact sets connected sets and perfect sets.	1. Apstol, T. M. (1997). *Mathematical analysis.* Tokyo: Addison Wesly Publishing Company 2. Bartle, R. G. & Sherbert, D. R. (1982). *Introduction to real analysis.* New York: John Wiley and Sons 3. Bhattarai, B. N. & Shrestha, B. K., (2072). *A textbook of real analysis* (revised edition) Kathmandu: Shuvakamana Prakashan Pvt. Ltd. 4. Jain, P. K. & Kaushik S.K. (2001). *An introduction to real analysis,* New Delhi: S. Chand and Comp. Ltd.
20 Hours	**Unit-III** **Real Sequences** 3.1 Convergent sequences 3.2 Cauchy Sequence 3.3 Cauchy's Criterion for convergence 3.4 Non-convergent sequences 3.5 Cauchy's first and second theorems on limit 3.6 Monotonic sequences, monotone convergence theorem, Cantor's intersection theorem 3.7 Subsequences 3.8 Uniform convergence 3.9 Summability of sequences	● To explain convergence of a sequence ● To prove properties of convergent sequence of real numbers ● To prove properties of a Cauchy sequence ● To explain non-convergent sequences and their properties ● To prove properties of monotonic sequences ● To describe subsequences and prove properties of subsequences ● To explain uniform convergence of a sequence	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain the convergence of a sequence with an example. 2. Prove the properties of convergent sequence of real numbers. 3. Prove the properties of a Cauchy sequence. 4. Explain non-convergent sequences and their properties. 5. Prove the properties of monotonic sequences. 6. Describe subsequences and prove properties of subsequences.	5. Narayan, S. (1971). *A course of mathematical analysi.,* Delhi: S. Chand and Com. Ltd. 6. Rudin W. (194), *Principles of mathematical analysis,* Newyork; Mc. Graw Hill

		● To describe the concept of Cesaro summability for sequences			7. Explain uniform convergence of a sequence. 8. Describe the concept of Cesaro summability for sequences.	
25 Hours	**Unit-IV** **Infinite Series** 4.1 Meaning of an infinite series 4.2 Sequence of partial sums of a series 4.3 Convergence of an infinite series 4.4 Cauchy's general principle of convergence of series 4.5 Series of positive terms 4.6 Different tests of convergence of series (comparison test, P-test, D-Alembert's ratio test, root test, Rabee's test, Kummer's test, logarithmic ratio test) 4.7 Series of positive and negative terms 4.8 Alternative series and Leibnitz' test 4.9 Absolute convergent and conditionally convergent of series 4.10 Arbitrary series and infinite products, (Dirichlet's theorems), Abel's theorem) 4.11 Grouping of terms of a series 4.12 Re-arrangement of terms of series 4.13 Infinite product and its convergence 4.14 Summability of series	● To explain the conditions for the convergence of an infinite series ● To establish different tests for the convergence of infinite series ● To explain the convergence of an infinite series with positive and negative terms ● To explain absolute convergence and conditionally convergent of a series ● To prove properties of the re-arrangement of the terms of an infinite series ● To prove the properties of the convergence of an infinite product ● To discuss the Cesaro summability of series	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain the conditions for the convergence of an infinite series with an example. 2. Establish different tests for the convergence of infinite series. 3. Explain the convergence of an infinite series with positive and negative terms. 4. Explain absolute convergence and conditionally convergent of a series. 5. Prove the properties of the re-arrangement of the terms of an infinite series. 6. Prove the properties of the convergence of an infinite product. 7. Discuss the Cesaro summability of series.	
10 Hours	**Unit-V** **Functions and Limits** 5.1 Types of functions 5.2 Boundedness of function 5.3 Monotonic functions 5.4 Limit of functions 5.5 Properties of limits of functions	● To explain the types of functions with an example ● To discuss boundedness of functions with an example	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain the types of functions with example. 2. Discuss the boundedness of functions with an example.	

	5.6 One sided infinite limits	● To prove the properties of limits of functions ● To explain $\varepsilon - \delta$ definition of limit of functions			3. Prove the properties of limits of functions. 4. Explain $\varepsilon - \delta$ definition of limit of functions.	
18 Hours	**Unit-VI** **Continuity of Functions** 6.1 Continuous functions 6.2 Continuity of intervals and sets 6.3 Properties of continuous functions 6.4 Discontinuous functions 6.5 Sign preserving theorem, intermediate value theorem, Bolzano theorem and fixed point theorem 6.6 Continuity of inverse functions 6.7 Continuity of monotonic functions 6.8 Uniform continuity of functions 6.9 Lipschitz functions	● To explain the concept of continuity of a function at a point and on interval with an example ● To prove theorems on algebra of continuous functions ● To classify discontinuous functions at a point ● To prove theorems on properties of continuous functions ● To prove the theorems on properties of monotonic functions ● To prove theorems on properties of uniform continuity of functions	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain the concept of continuity of a function at a point and on interval with an example. 2. Prove the theorems on algebra of continuous functions. 3. Classify discontinuous functions at a point with examples. 4. Prove the theorems on properties of continuous functions. 5. Prove the theorems on properties of monotonic functions. 6. Prove the theorems on properties of uniform continuity of functions.	
22 Hours	**Unit-VII** **Derivability** 7.1 Derivative of a function 7.2 Derivative of inverse function 7.3 Darboux theorem 7.4 Mean value theorems (Rolle's theorem, Lagrange's theorem, Cauchy's theorem) 7.5 Deductions from mean value theorems 7.6 Generalized mean value theorems 7.7 Taylor Polynomial 7.8 Power series representation of functions 7.9 Extreme values of a functions 7.9 Indeterminate forms 7.10 L-Hospital's rule.	● To explain the concept of derivative with an example ● To establish the relation between continuity and derivability ● To prove properties of derivability in relation to algebraic compositions ● To prove Darboux theorem and its consequences ● To establish and illustrate mean value theorems ● To prove Taylor's series (finite and infinite) and Maclaurin's series ● To discuss extreme values of function with an example	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Explain the concept of derivative with an example. 2. Establish the relation between continuity and derivability. 3. Prove the properties of derivability in relation to algebraic compositions. 4. Prove the Darboux theorem and its consequences. 5. Establish and illustrate mean value theorems. 6. Prove Taylor's series (finite and infinite) and Maclaurin's series.	

		● To discuss and prove various types of intermediate forms and their properties			7. Discuss extreme values of function with an example. 8. Discuss and prove various types of intermediate forms and their properties.	
28 Hours	**Unit-VIII Riemann Integral** 8 .Partitions 8.2 Lower and upper Darboux sums and properties of Darboux sums. 8.3 Upper and lower integrals 8.4 Riemann Integral 8.5 Necessary and sufficient condition for integrability 8.6 Properties of integrable functions 8.7 Mean value theorems (Mean value theorems of integral calculus, generalized mean value theorem) 8.8 Bonnet's and Weierstrass' mean value theorem. 8.9 Continuity and derivability of integrable functions 8.10 Fundamental theorems of integral calculus 8.11 Integration by parts 8.12 Change of variable	● To establish relationship between lower and upper Darboux sums of a bounded function on a closed interval ● To compute lower and upper Darboux sums of functions with a partition defined on the domain of definition of the function ● To establish the properties of lower and upper Riemann integrals ● To establish the necessary and sufficient condition for integrability of a function ● To prove the properties of integrable functions ● To establish fundamental theorem of integral calculus ● To establish the techniques of evaluating the definite integrals : by integration of parts and change of variable of integration	● Lecture with illustrations ● Inquiry and question answer ● Demonstration ● Individual and group work presentation for illustrations and exercise for all units ● Discussion ● Problem solving	1. Curriculum and syllabus 2. Reference books 3. Table and charts	1. Establish relationship between lower and upper Darboux sums of a bounded function on a closed interval. 2. Compute lower and upper Darboux sums of functions with a partition defined on the domain of definition of the function. 3. Establish the properties of lower and upper Riemann integrals. 4. Establish the necessary and sufficient condition for integrability of a function. 5. Prove the properties of integrable functions. 6. Establish fundamental theorem of integral calculus. 7. Establish the techniques of evaluating the definite integrals, by integration of parts and change of variable of integration.	