Annexure-12

Math - 199
13-07-23

Date: 13.07.2023

To

The Controller of Examinations
Central University of South Bihar
Panchanpur, Gaya

Gaya. 14/7/2023

Subject: Submission of an approved B.Sc. Mathematics NEP 2020 and the Minutes of Board of Studies meeting held on 30th June 2023, Department of Mathematics

Dear Sir,

As per the direction of the Academic Council, the Department of Mathematics has prepared the syllabus of B.Sc. Mathematics Honours / Research Programme in NEP-2020 framework. In this regard, Board of Studies meeting was held on 30th June 2023 in online mode.

Please find enclosed herewith the approved syllabus of B.Sc. Mathematics Honours / Research Programme in NEP-2020 along with the minutes of BoS meeting held on 30th June 2023 in online mode.

With regards,

Roushan Kumar 13/07/2023

(Dr. Roushan Kumar)
Head
Department of Mathematics
Central University of South Bihar, Gaya

Head,
Department of Mathematics

Minutes of the Board of Studies Meeting

Department of Mathematics

June 30, 2023 (Friday)

An online meeting of the Board of Studies of Department of Mathematics was held 30.06.2023 (Friday) under the Convenership of Prof. Roushan Kumar, Head (Department of Mathematics), Central University of South Bihar, Gaya.

The following persons were present:

1.	Prof. Roushan Kumar	Convener
2.	Prof. R. P. Shukla	External Member
3.	Prof. N. Sukavanam	External Member
4.	Prof. H. K. Nigam	Member
5.	Dr. Vivek Kumar Jain	Member
6.	Dr. Rajesh Pratap Singh	Member
7.	Dr. Shubh Narayan Singh	Member
8.	Dr. Pankaj Mishra	Member

The Board of Studies (BoS) members discussed the draft syllabus of B.Sc. Mathematics Honors/Research programme and finalized it.

The Board of Studies members decided to replace the course in M.Sc. DBCC course "Human Values of famous Mathematician" (MTH91DC01304) by a course "Human Values And Professional Ethics" in M.Sc. third semester.

The Board of Studies members decided to open all core courses in M.Sc. as open elective to M.A./M.Sc. students of other Departments provided they have learned Mathematics in BA/B.Sc. course in all three years of their bachelor degree.

The meeting ended with vote of thanks to the Chair.

Dr. Pankaj Mishra

Dr. Shubh Narayan Singh

Dr. Rajesh Pratap Singh

Dr. Vivek Kumar Jain

Prof. H. K. Nigam

Prof. N. Sukavanam

Prof. R. P. Shukla 10/07/2023

Prof. Roushan Kumar 30/6/2023

B.SC. MATHEMATICS

NEP 2020

Department of Mathematics
Central University of South Bihar
Gaya

Table of Contents

Bachelor of Science (B.Sc.) Degree / Honours / Research Programme in Mathematics

Credit Distribution Chart

Semester / Course Type	I	II	III	IV	V	VI	Total (I to VI)	VII	VIII	Total
Major (Mathematics)	4	4	4, 4	4,4,4,2	4,4,4,2	4,4,4,4	60	4,4,4	4,4	80
Minor	4	4	4	4	4	4	24	4	4	32
Interdisciplinary	3	3	3		Internship 2 (credits)		9	Research Project 12 credits***		9
AEC*	2	2	2	2			8			8
SEC**	3	3	3				9			9
Value Added	2,2	2,2					8			8
Total Credit	20	20	20	20	20	20	120	40		160

* Ability Enhancement Courses(AEC)

** Skill Enhancement Courses (SEC)

***Those will not take project will take extra three four credit courses from Swayam Portal.

Course Structure (Major – Mathematics)

Semester I: Introduction to Mathematics (4 Credits)

Semester II: Real Analysis -I (4 Credits)

Semester III: Differential Calculus (4 Credits)
Introduction to Group Theory (4 Credit)

Semester IV: Real Analysis - II (4 Credits)
Linear Algebra (4 Credits)
Ordinary Differential Equations (4 Credits)
Analytical Geometry (2 credits)

Semester V: Real Analysis - III (4 Credits)
Statics (4 Credits)
Complex Analysis and Partial Differential Equations (4 Credits)
Vector Calculus (2 credits)

Semester VI: Dynamics (4 Credits)
Introduction to Rings and Fields (4 Credits)
Numerical Methods (4 Credits)
Probability and Statistics (4 credits)

Semester VII: Research Methodology (4 Credits)
Metric Space (4 Credits)

Elective 1 (4 Credits)/Swayam

List of Elective courses: Introduction to Combinatorics
Linear Programming Problems

Semester 8: Elective 1 (4 Credits)/Swayam
Elective 2 (4 Credits)/Swayam

Extra three 4 credit elective courses from Swayam have to be taken by those who will not take the 12 credit project.

List of Elective courses: Introduction to Information Theory and Coding
Graph Theory
Number Theory
Calculus of Variations and Integral Equations

Semester I

Introduction to Mathematics

Course Details			
Course Title: Introduction to Mathematics			
Course Code		**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester		**Contact Hours**	45 (L) + 15 (T) Hours
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To develop the fundamental concepts for further studies in mathematics.
- To develop basic concepts of real numbers, integers and set theory.

Learning Outcomes

After completion of the course the learners should be able to:

Understand basic concepts of real numbers: supremum, infimum, Archimedean property, neighbourhoods.

- Understand fundamental of number theory.

Course Contents

Unit I
Sets, relation, Equivalence relation, Functions, domain, codomain and range of a function, graph of functions, injection, surjection and bijection, composition of functions, Countability,

Unit II
Axiomatic introduction to R, Natural Numbers, Integers, Rational numbers and irrational numbers, Archimedean property, density of rational numbers and irrational numbers in R, Intervals,

Unit III
Divisibility, The Division Algorithm, The greatest common divisors, The Euclidean algorithm, Linear Diophantine equations, Primes and their distribution,

Unit IV
The fundamental theorem of arithmetic, Congruence, The Chinese remainder theorem, Fermat Little theorem, Wilson theorem, Euler's Phi- function,

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-3	Sets, relation, Equivalence relation,
4-11	Functions, domain, codomain and range of a function, graph of functions, injection, surjection and bijection, composition of functions,
12-15	Countability
12-16	Axiomatic introduction to R, Natural Numbers, Integers,
17-20	Rational numbers and irrational numbers,
21-25	Archimedean property, density of rational numbers and irrational numbers in R, Intervals,
26-30	Divisibility, The Division Algorithm, The greatest common divisors,
31-35	The Euclidean algorithm, Linear Diophantine equations.

36-38	Primes and their distribution, The fundamental theorem of arithmetic.
39-42	Congruence, The Chinese remainder theorem, Fermat Little theorem.
43-45	Wilson theorem, Euler's Phi- function, Number theoretic functions.

Texts/References

1. K. K. Jha, *Advanced Set Theory, Axiomatic Set Theory and Boolean Algebra*, Navbharat Publishing House, Patna.

2. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Sigapore, 2002.

3. John M. Howie, Real Analysis, SUMS, 2001.

5. David M. Burton, *Elementary Number Theory*, McGraw - Hill Higher Education, 2007.

Semester II
Real Analysis - I

Course Code	Analysis I	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	II	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Core		
Nature of the Course	Theory		

Special Nature/ Category of the Course (*if applicable*)	NA
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)
Prerequisite	• Calculus of intermediate level

Course Objectives

- The main emphasis of this course is to introduce the real number sequences. The relation between the convergent and Cauchy sequences has been explained
- Convergence of different type of real series
- To orient the students with the concept of Limit, Continuity, Uniform Continuity

Learning Outcomes

After completion of the course the learners should be able to:

- The students will be familiar with the concept of sequences, series.
- They will be able to test the convergence and divergence of series using the ratio test, Leibnitz test.
- Learn the concept and applications of Limit, Continuity, Uniform Continuity

Course Contents

Unit I **(weightage 25%)**

Real sequences, Convergence, Sum and product of convergent sequences, Order preservation and squeeze theorem; Monotone sequences and their convergence; Proof of convergence of some simple sequences, Subsequences and the Bolzano-Weierstrass theorem; Limit superior and limit inferior of a bounded sequence; Cauchy sequences, Cauchy convergence criterion for sequences.

Unit II **(weightage 25%)**

Definition and a necessary condition for convergence of an infinite series, Geometric series, Cauchy convergence criterion for series; Positive term series, The integral test, Convergence

of p-series, Comparison test, Limit comparison test, D'Alembert's Ratio test, Cauchy's Root test; Alternating series, Leibniz test; Absolute and conditional convergence.,

Unit III **(weightage 25%)**

Limits and continuity, properties of continuous functions, uniform continuity,

Unit IV **(weightage 25%)**

Differentiability, Properties of Differentiable functions, Mean Value Theorem and its consequences

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-15	Real sequences, Convergence, Sum and product of convergent sequences. Order preservation and squeeze theorem; Monotone sequences and their convergence; Proof of convergence of some simple sequences, Subsequences and the Bolzano-Weierstrass theorem; Limit superior and limit inferior of a bounded sequence; Cauchy sequences, Cauchy convergence criterion for sequences
15--30	Definition and a necessary condition for convergence of an infinite series, Geometric series, Cauchy convergence criterion for series; Positive term series, The integral test, Convergence of p-series, Comparison test, Limit comparison test, D'Alembert's Ratio test, Cauchy's Root test; Alternating series, Leibniz test; Absolute and conditional convergence.
31-37	Limits and continuity, properties of continuous functions, uniform continuity
38-45	Differentiability, Properties of Differntiable functions, Mean Value Theorem and its consequences
15	Tutorials

Texts/ References Books Recommended
1. Robert G. Bartle,, & Donald R. Sherbert, *Introduction to Real Analysis (4th ed.)*, Wiley India Edition. 2015
2. Charles G. Denlinger, *Elements of analysis*. Jones & Bartlett India Pvt. Ltd. 2015.
3. Kenneth A. Ross, *Elementary Analysis: The theory of calculus (2nd ed.)*, Undergraduate Texts in Mathematics, Springer. Indian Reprint, 2013
4. Shanti Narayan, M. D. Raisinghana, *Elements of Real Analysis*, S Chand and Co Ltd. 2015

Semester III
Differential Calculus

Course Code	Differential Calculus	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	III	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Core		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	NA		
Methods of Content Interaction	Lecture, Tutorials, Group discussion; self-study, seminar, presentations by students, individual and group drills, group and individual field based assignments followed by workshops and seminar presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		
Prerequisite	• Calculus of intermediate level		

Course Objectives

- The main emphasis of this course is to equip the student with necessary analytic and technical skills.
- main target of this course is to explore the different tools for higher order derivatives, to plot the various curves and to solve the problems associated with differentiation
- To orient the students with major link between mathematics and its applications.

Learning Outcomes

After completion of the course the learners should be able to:

- Use Leibnitz's rule to evaluate derivatives of higher order.
- able to study the geometry of various types of functions
- Trace the curve

Course Contents

Unit I **(weightage 25%)**

Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions. Tangents and normals.

Unit II **(weightage 25%)**

Curvature, Asymptotes, Singular points, Concavity and point of inflexion, Envelopes,

Unit III **(weightage 25%)**

Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of $\sin x$, $cos\ x, e^x$, $\log(1+x)$, $(1+x)^m$, Maxima and Minima, Indeterminate forms.

Unit IV **(weightage 25%)**

Tracing of curves, Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-10	Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions. Tangents and normal.

11-20	Curvature, Asymptotes, Singular points, Concavity and point of inflexion, Envelopes,
21-35	Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of $\sin x$, $\cos x$, e^x, $\log(1+x)$, $(1+x)^m$, Maxima and Minima, Indeterminate forms.
36-45	Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates

Texts/ References Books Recommended

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc.. 2002.

2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,.2007.

3. Shanti Narayan, P. K. Mittal, *Differential Calculus*, S. Chand. 2014

Introduction to Group Theory

Course Code		**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester		**Contact Hours**	45 (L) + 15 (T) Hours
Course Type			
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	NA		
Methods of Content Interaction	Lectures, Tutorials, Group discussions, Self-study, Seminars, and Presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

- To give the foundation of the mathematical object groups;
- To study the different types of groups and their properties;
- To train the students in problem-solving in group theory.

Learning Outcomes

On completion of the course, a student will be able to:

- recognize the mathematical objects called groups;
- link the fundamental concepts of groups and symmetries of geometrical objects;
- explain the significance of the notions of cosets, normal subgroups, and factor groups;
- analyze the consequences of Lagrange's theorem;
- describe structure-preserving maps between groups and their consequences.

Course Contents

(20% Weightage)

Unit I:

Symmetries of a square, Dihedral groups, Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), Elementary properties of groups.

(25% Weightage)

Unit II:

Subgroups and examples of subgroups, Centralizer, Normalizer, Center of a group, Product of two subgroups, Generation of groups, Cyclic groups and their properties, Classification of subgroups of cyclic groups.

(30% Weightage)

Unit III:

Cycle notation for permutations, Properties of permutations, Even and odd permutations, Alternating groups; Definitions and properties of cosets, Coset decomposition, Lagrange's theorem and its consequences including Fermat's Little theorem and Euler's theorem, External direct product of a finite number of groups, Normal subgroups, Factor groups, Cauchy's theorem for finite abelian groups.

(25% Weightage)

Unit IV:

Group homomorphisms and their properties, Group Isomorphisms and automorphisms, Cayley's theorem, Properties of group Isomorphisms, First, Second, and Third Isomorphism theorems for groups.

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-3	Symmetries of a square, Dihedral groups.

4-8	Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices).
9-12	Elementary properties of groups.
13-15	Subgroups and examples of subgroups.
16-17	Centralizer, Normalizer, Center of a group.
18-19	Product of two subgroups, Generation of groups.
20-23	Cyclic groups and their properties, Classification of subgroups of cyclic groups.
24-27	Cycle notation for permutations, Properties of permutations, Even and odd permutations, Alternating groups.
28-32	Definitions and properties of cosets, Coset decomposition, Lagrange's theorem and its consequences including Fermat's Little theorem and Euler's theorem.
33-36	External direct product of a finite number of groups, Normal subgroups, Factor groups, Cauchy's theorem for finite abelian groups.
37-39	Group homomorphisms and their properties.
40-42	Group Isomorphisms and automorphisms, Cayley's theorem, Properties of group Isomorphisms.
43-45	First, Second, and Third Isomorphism theorems for groups.
15 Hours	*Tutorials*

Suggested References:

1. J. A. Gallian, *Contemporary Abstract Algebra, 8th Ed.*, Cengage Learning India Private Limited, 2013.
2. I. N. Herstein, *Topics in Algebra, 4th Ed.*, Wiley Eastern Limited, 2003.
3. D. S. Dummit and R. M. Foote, *Abstract Algebra*, John Wiley & Sons, 2003.
4. M. Artin, *Algebra*, Prentice Hall of India, 1994.
5. J. J. Rotman, *An Introduction to The Theory of Groups*, 4th ed., Springer-Verlag, 1995.
6. J. B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.

Semester IV
Real Analysis II

Course Code		**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester

Semester		**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Core		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	NA		
Methods of Content Interaction	Lecture, Tutorials, Group discussion, Self-study, Seminar, Presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives

• To understand the concept of Riemann Integral and Improper integral. Able to differentiate between them.

• To understand the difference between the behaviour of sequence of functions in case of pointwise convergence and uniform convergence.

Learning Outcomes

Upon completion of this course, the student will be able to:

- determine the convergence of improper integrals,
- decide the convergence of series and sequence of functions.
- Calculate Riemann integral (if exists)

Course **Contents**

Unit I **(25% Weightage)**

Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.

Unit II **(25% Weightage)**

Improper integrals and their convergence, Comparison test, Abel's and Dirichlet's test, Beta and Gamma functions.

Unit III **(25% Weightage)**

Point wise and uniform convergence of sequence of functions, uniform convergence and continuity, uniform convergence and differentiation, Uniform convergence and integration,

Unit IV **(25% Weightage)**

Series of functions, Weierstrass M-test, Abel's Test, Dirichlet's Test, Weierstrass approximation theorem (statement only).

Content Interaction Plan:

Lecture cum Discussion (Each session of 1 Hour)	Unit/Topic/Sub-Topic
1-7	Riemann integral: definition, properties and equivalent conditions; Integrability of continuous and monotonic functions,
8-11	Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.
12-16	Improper integrals and their convergence, Comparison test,
17-22	Abel's and Dirichlet's test, Beta and Gamma functions and their relations.
22-27	Point wise and uniform convergence of sequence of functions,
27-33	Uniform convergence and continuity, uniform convergence and differentiation, Uniform convergence and integration,
34-40	Series of functions, Weierstrass M-test, Abel's Test,
40-45	Dirichlet's Test, Weierstrass approximation theorem (statement only).
15 Hours	*Tutorials*

Suggested References:

- S. C. Malik, Savita Arora, *Mathematical Analysis*, Revised Edition, New Age International, New Delhi, 2018.
- Tom M. Apostol, *Mathematical Analysis*, Narosa Publications, NewDelhi, 2002.
- Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill International Editions, 1976.
- S. K. Mappa, *Introduction to Real Analysis*, Levant Books, 2019.

Linear Algebra